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Performance Assessment for a Hypothetical Low-Level Waste Disposal Facility

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Performance Assessment for a Hypothetical Low-Level Waste Disposal Facility

1. INTRODUCTION

Disposing of low-level waste (LLW) is a concern for many states throughout the United States. A common disposal method is below-grade concrete vaults. Performance assessment analyses make predictions of contaminant release, transport, ingestion, inhalation, or other routes of exposure, and the resulting doses for various disposal methods such as the below-grade concrete vaults. Numerous assumptions are required to simplify the processes associated with the disposal facility to make predictions feasible. In general, these assumptions are made conservatively so as to underestimate the performance of the facility.

The objective of this report is to describe the methodology used in conducting a performance assessment for a hypothetical waste facility located in the northeastern United States using real data as much as possible. This report consists of the following: (a) a description of the disposal facility and site, (b) methods used to analyze performance of the facility, (c) the results of the analysis, and (d) the conclusions of this study.

2. DISPOSAL FACILITY DESCRIPTION

The hypothetical LLW site was assumed to be located in the northeastern United States. The exact location was not chosen for political sensitivities. However, meteorological data necessary for the analysis were taken from Harrisburg, Pennsylvania. The facility was designed to contain class A, B, and C wastes.

The design consists of two types of modular disposal units, which will be constructed of reinforced concrete. The larger vault (122 m by 610 m by 7.6 m thick) will contain class A and B waste, while the smaller vault (24 m by 49 m by 3 m thick) will contain class C waste. These units will consist of a base pad, supporting walls, and a sloping roof. The roof will be sloped to promote drainage of any water from the top of the modules. Upon closure, the units will be collectively covered with an engineered barrier intended to function throughout the period of institutional control (a 100-year period following the end of the facility operational period).

The engineered earth cover will consist of several layers designed to minimize water infiltration and intrusion of biota down to the concrete modules. Infiltrating water will be diverted by encouraging evapotranspiration and redirecting water away from the disposal units.

3. ANALYSIS OF PERFORMANCE

This section describes the methodology used to evaluate the long-term performance of the facility. Each model component is described in this section of the report. These components are the inventory, exposure pathways, flow and transport models, and model simulations and assumptions. The source term describes the expected waste stream from generators, divided into two different classes of commercial LLW: class A and B wastes and class C wastes. Following the source term description is a detailed explanation of each pathway considered. The final two sections describe the conceptual and numerical models chosen to estimate the doses for each pathway.

3.1 Inventory

The inventory of disposed radionuclides was provided by W. P. Dornsife, of the Pennsylvania Department of Environmental Protection on May 20, 1996 (Appendix A). Representative annual average inventories were derived from the combined inventories of expected waste shipments from a variety of commercial generators for an average year. This was then multiplied by the operating period for the facility, 30 years, to achieve the total inventory considered in this analysis.

3.2 Exposure Pathways and Scenarios

The exposure pathways considered in this analysis were external exposure, inhalation, ingestion, and airborne immersion. These exposure pathways were applied to different exposure scenarios depending on the assumptions used to generate the scenario. The scenarios considered were the following:

1. Exposure to members of the public through accidental release during operations (operational accidents).
2. Intrusion by a member of the public at the end of institutional control (post-operational intruder).
3. Groundwater ingestion by a member of the public living downgradient from the facility (post-operational groundwater).

The first exposure scenario was considered to occur only during the operational period of the facility. The operational period of the facility starts at the first shipment of waste and continues thereafter for 30 years. This exposure scenario considered exposure to the public through accidental releases only and evaluated the inhalation, external exposure, and air immersion exposure pathways.

The second exposure scenario considered doses to an individual member of the public who inadvertently intrudes into the closed facility following the facility's operational and institutional control period. Inhalation, external exposure, and ingestion exposure pathways are considered.

The third exposure scenario considered doses to the public that results from consumption of contaminated groundwater derived from a well located downgrading from the disposal the facility. Ingestion is the only exposure pathway included in this scenario. Each of these exposure scenarios are described in detail in the next sections.

3.2.1 Operational Accidents (Off-Site Doses)

Operational accident scenarios originally developed for the North Carolina disposal facility license application were used to estimate potential doses caused by accidents at the Pennsylvania facility. The design and planned operations for these disposal facilities are assumed to be similar, so adjustments to the source/receptor distances represented most of the adaptation of the North Carolina design basis accident scenarios to the Pennsylvania case. The sequence of events occurring in accidents initiated by natural events (e.g., earthquakes and tornadoes) is also assumed to be the same—in particular, the exposure of individuals to released radioactive materials or penetrating radiation. The pathways by which individuals located off the Pennsylvania disposal facility site might be exposed are summarized in Table 1. Descriptions of the accident scenarios are provided in Sections 3.2.1.1 through 3.2.1.4.

3.2.1.1 Fire in the Waste Packaging Building A number of human actions and natural events could cause a fire in the Waste Packaging Building. If a fire occurred, as-received, ungrouted, unsolidified waste would be more significantly affected than the stabilized waste packages. To bound these accidents, it is assumed that a liner of dewatered resin is exposed to a fire caused by ignition of the truck tractor fuel tanks. It is assumed that the fire lasts 30 minutes, which corresponds to a Severity II accident with a release fraction of 0.01 (Transportation EIS—NRC, 1977). Although dewatered resins consist primarily of millimeter diameter beads with a small quantity of crushed material (called fines), an aerosol fraction of 0.1 corresponding to fine powder is assumed (Neuhauser and Knipe, 1992). Per the North Carolina Safety Analysis Report (SAR),¹ the product of the release fraction and aerosol fraction, 0.001, corresponds to the flammability factor (as described in Oztunali and Roles, 1986). Radionuclide-specific release fractions (Oztunali and Roles, 1986) for materials involved in fires are also applied to determine the amount of radioactive material released to the air.

The fire is assumed to destroy the high-efficiency particulate air filters servicing the Waste Packaging Building and result in the release of a contaminated plume. An earlier analysis of a similar disposal site showed that the inventory of radioactive material already present on the high-efficiency particulate air filters at the time of the accident would be small when compared to that in the waste and can be ignored (CNSI, 1990). The release point is a vent on the roof of the building and is treated as a ground level release. Building wake effects were not considered, resulting in lower dispersion and a more conservative dose estimate. The minimum distance from the packaging building to the facility boundary is 1,600 ft, and an individual is assumed to remain at this position for 10 minutes during plume passage. Atmospheric stability and winds are assumed to be class F and 2 m/s during the fire, resulting in relatively little dilution of the released radioactive material.

Table 1. Off-site exposure pathways for operational accidents at the Pennsylvania LLW facility.

Scenario	Inhalation	Immersion	Direct radiation ^a
Fire in waste packaging building	Yes	Yes	No
Crane malfunction -- suspended container	No	No	Yes
Crane malfunction -- dropped container	No	No	Yes
Tornado	No	No	Yes
Earthquake	Yes	Yes	Yes

a. Direct radiation is penetrating radiation (photons) originating from materials contained within the Pennsylvania Low-Level Waste Disposal facility buildings or intact waste containers.

3.2.1.1. Crane Malfunction. Two overhead bridge cranes will be used during Facility operations. A 40-ton overhead bridge crane in the Waste Packaging Building will be used to (a) off-

1. Personal Communication from Don Ballman to Paul Ritter, "Transmittal of Accident Scenario Information from the North Carolina License Application (referred to as the North Carolina SAR), December 28, 1995.

load liners and some drums and boxes and (b) place the waste containers inside overpacks prior to grouting. A 50-ton overhead bridge crane will be used in the Movable Building to place the stabilized and better shielded waste packages into the disposal modules. Contact exposure rates on waste packages will be limited to 1 roentgen per hour, and the structural integrity of the waste packages is sufficient to sustain any possible drop with little chance of releases. Accordingly, the consequences of crane malfunctions in the Movable Building are less severe than those in the Waste Packaging Building, and only accidents in the Waste Packaging Building were considered. A failure of Waste Packaging Building overhead bridge crane during transfers could result in a radiation source being suspended above work areas in the Waste Packaging Building or cause waste containers to be dropped to the floor.

Liners with contact exposure rates of 20 roentgen per hour or more will be lifted with the liner inside a shield bell for transfer to a shielded overpack. Liners with contact exposure rates of more than 500 roentgen per hour will not be accepted at the Facility without special review and are outside the scope of this evaluation.

3.2.1.2.1 Container Suspended from the Overhead Bridge Crane A container suspended from the overhead crane could cause exposure of the public to gamma radiation. It is assumed that the shield bell containing a 500-roentgen-per-hour source is suspended 16 ft above the Waste Packaging Building floor. This source was modeled in the MicroShield computer program (Grove Engineering, Inc., 1990; 1992) as a cylindrical source with a 3-in.-thick cylindrical iron shield to represent the shield bell. A member of the public is assumed to stand along the restricted area fence 1,600 ft away from the source for 15 minutes.

The North Carolina SAR scenario involves a 97-ft³ resin liner generating a 500-r/h radiation field near contact (i.e., at 10 cm from the midline on the side of the container). For this performance assessment, the liner was assumed to be cylindrical with the height equal to its diameter. The liner was assumed to contain radionuclides in the proportions in Table 6-28 of the North Carolina LLW Facility SAR, with total activity sufficient to generate a 500-r/h field at 10 cm from the surface of the liner. The liner was also modeled assuming the presence of ⁶⁰Co only, at the activity required to generate 500 r/h at 10 cm. The results for the latter case were somewhat greater and are reported in Section 4.1.

3.2.1.2.2 Container Dropped from the Overhead Crane The dropped container bounds accidents involving rupture of containers after receipt at the Facility in situations where only direct radiation exposure occurs, i.e., where there is no release of radioactivity from a building. The dropped container results in loss of the shielding provided by the 3-in.-thick iron shield bell described in Section 3.2.1.2.1. A container could be ruptured because of a drop initiated by (a) the same events that result in a suspended container, (b) a plane crashing into the Waste Packaging Building, or (c) a tornado. Since the greatest force would be generated by a drop from the crane to the floor, this scenario bounds accidents involving container rupture.

It is assumed that a member of the public stands in the unrestricted area 1,600 ft from the liner for 15 minutes, which is the length of time required to place temporary shielding. The high-efficiency particulate air filters prevent release of airborne contamination from the building. No credit is taken for the shielding provided by the building in estimating dose to the individual standing 1,600 ft away in the unrestricted area.

3.2.1.3 Tornado. Tornadoes could cause considerable damage to buildings at the Facility. They may also generate projectiles that could damage waste containers or waste packages causing the

release of radioactive material. Respirable radioactive material released during a tornado would be very rapidly dispersed, so the effects of container damage caused by wind-driven missiles are bounded by the dropped container accident. After the storm has passed, a member of the public or rescue worker could approach a container thrown into the unrestricted area and be exposed to direct radiation before facility workers could locate and retrieve the container. For the Pennsylvania LLW Performance Assessment, a tornado is assumed to destroy the Waste Packaging Building and throw a hypothetical drum of dry active waste, described in Table 6-29 of the North Carolina LLW SAR, into the unrestricted area where it is examined at a distance of 1 m for 30 seconds by a member of the general public. The exposure rate is 512 milliroentgen per hour, resulting in a dose of 4.3 millirem.

3.2.1.4 Earthquake. Earthquakes could also cause the overhead bridge cranes to malfunction, which could result in suspension or dropping of one or more waste containers or waste packages. Collapse of an overhead bridge crane or the concrete walls of the Waste Packaging Building could crush waste containers and result in release of radioactive material. Containers could also be shaken off trucks and rupture, releasing radioactive material. It is very unlikely that these events would cause release of radioactive material from the better-stabilized waste packages.

An earthquake with a ground acceleration in excess of the facility design specifications is assumed to occur and destroy the Waste Packaging Building. The overhead bridge crane collapses, crushing a group of 14 hypothetical drums of dry active waste that have been removed from a shipping cask.

3.2.2 Post-Operational Intruder Scenarios

3.2.2.1 End of the Institutional Control Period. An individual was assumed to construct a house above a disposal module at the end of the institutional control period (100 years post-closure). The roof of the module was assumed to be intact and prevent the intruder from excavating into waste. The intruder was assumed to use the roof of the module as the floor of the foundation for the house, and to use the basement of the house for routine household activities and for bedrooms. The module was assumed to contain the typical inventory of waste radionuclides at the time of closure. The intruder would receive a dose caused by penetrating radiation fields (gamma and x-ray photons) emitted by the 100-year decayed inventory of the module.

3.2.2.2 500 Years After the End of Institutional Control. An individual was assumed to construct a house above a disposal module 500 years after the end of operations. The concrete roof of the module was assumed to resemble soil. The intruder excavates a vertical-sided 10-ft-deep basement hole, removing the former roof material (61 cm thick) and a 0.3-m thick layer of waste from an area 10 m by 10 m. The intruder spreads the waste and soil over the 2200 m² yard that surrounds the house. The intruder raises vegetables grown in the contaminated soil and consumes meat from animals given fodder grown on the contaminated soil. The intruder receives doses caused by penetrating radiation fields (gamma and x-ray photons) emitted by the undisturbed portion of the 500-year decayed inventory of the module (below and surrounding the lower part of the foundation) and the disturbed portion of this inventory (present in the top 15 cm of the soil in the yard). The intruder also receives doses because of consumption of contaminated home-grown foods and inadvertent ingestion of contaminated soil.

The disposal modules are designed to withstand the maximum credible earthquake. After the end of the institutional control period, the eventual consequences of damage from a severe earthquake are bounded by the assumptions made in estimating the source term caused by excavation.

3.2.3 Post-Operational Groundwater Scenario

For the post-operational groundwater scenario, the receptor is assumed to reside at the waste buffer zone which is 100 m from the downgradient edge of the waste vaults. The receptor is assumed to have drilled a well at that location and used the water derived from that well as their primary source of water. The well is screened from the surface of the aquifer down to 15 m. The receptor is assumed to drink 2 L of water a day for 365 days per year. Exposure is achieved by consumption of well water containing dissolved radionuclides.

3.3 Conceptual Models

Conceptual models are used to describe model compartments, flow paths, transport pathways, sources, and sinks, or may be simply a verbal description of the system to be modeled. A conceptual model should state the simplifying limiting assumptions that translate the real world into a mathematical formulation of the processes that control contaminant movement. The conceptual model for water movement and dissolved mass transport used in this study is illustrated in Figure 1.

3.3.1 Operational Accidents

3.3.1.1 Crane Accidents. The severity level of this type of accident depends on the impact or crush force to which the container is subjected. Assuming that the liner weighs 6,000 lb, the force of impact would be 27,000 Newtons. This is Severity Level III with a release fraction of 0.1 that, when combined with the aerosol fraction of 0.1, yields a volume release fraction of 0.01. A dispersibility factor or respirable fraction of 0.05 for small powder is assumed.

3.3.1.2 Earthquakes. It was assumed that the earthquake causes the crane beam to drop, crushing 14 containers and releasing 0.001 of the radioactivity in the containers (per the North Carolina SAR). It was also assumed that the Waste Packaging Building is destroyed and that the airborne material could reach a member of the general public in the unrestricted area. Atmospheric dispersion was modeled for class F stability conditions with 2-m/s wind speed in the direction of the nearest facility boundary, where a member of the public was assumed to remain for the duration of the passage of the contaminated plume.

3.3.2 Post-Closure Intruders

3.3.2.1 100 Years Post-Closure. For the 100-year post-closure intrusion scenario, penetrating radiation from buried waste causes doses to the intruders. The doses were estimated assuming 1/3 time occupancy (2922 h/y) of the basement of a house that uses the waste module roof as the basement floor. For modeling purposes, the waste volume was treated as a rectangular prism with 2 ft of concrete shielding provided over the entire extent of the upper surface of the waste. Additional shielding that would be provided by the soil surrounding the basement walls was not included in the model.

3.3.2.2 500 Years Post-Closure. Doses to the intruder for the 500-year post-closure scenario would be caused by the undisturbed waste under and surrounding the lower part of the foundation, and by waste relocated to the ground surface by excavation of a basement for a house. Other processes that might cause upward migration of the waste from deep soil are considered to be of minor importance as compared to excavation. The GENII model for estimating doses to an intruder requires input of soil concentrations -- these soil concentrations are derived from the estimated amounts of waste radioactivity brought to the surface by excavation work. A complete description of the GENII model for estimating intruder doses is provided in Napier et al. (1988).

Doses caused by penetrating radiation from the undisturbed waste were modeled by subdividing the source volume into subvolumes that could be more easily managed with MicroShield. The shielding provided by the concrete foundation was accounted for in the modeling.

A 10 foot (3.05 m) deep excavation was assumed to be made in the center of a module. This results in the transfer of a 0.3-m by 10-m by 10-m (30 m³) volume of waste to the surface soil. The excavated soil and waste was assumed to be evenly distributed around the house in a 2,200-m² yard, resulting in a contaminated layer of soil approximately 6 in. thick.

Figure 1. Conceptual model for hypothetical waste facility. The gravel and clay cap divert most of the infiltrating water away from the concrete vault. A small amount of water migrates through the cap and concrete vault and into the waste while the facility is intact. After complete failure (1000 years), water is not diverted by the cap or restricted by the concrete vault and is allowed to migrate freely through the facility.

3.3.3 Post-Operational Groundwater

The conceptual model developed for the groundwater pathway analysis is a simplification of a natural groundwater system, thus providing feasible solutions, yet is complex enough to provide adequate physical description. The groundwater pathway system in this analysis is simplified by dividing the modeling domain into three parts; a waste zone, unsaturated zone, and aquifer.

The waste zone consists of waste-containing vaults surrounded by a thin layer of sand and buried in homogeneous, isotropic, unconsolidated backfill and native soil (Figure 1). The unsaturated zone consists of the native soil between the base of the backfill soil and the upper surface of the aquifer. The backfill, native soil, and aquifer materials are assumed to have the properties of loam. The model is simplified by examining a single vault. Although a single conceptual model describes the waste and unsaturated zone processes for this analysis, two sets of numerical models were actually required since the designs differ for class A and B waste vaults and class C waste vaults. Land surface provides the physical upper boundary of the system, while the top of the hypothetical aquifer provides the lower boundary. Natural precipitation infiltrates from land surface and reaches the buried waste vault. Contaminants leach from the vault at rates proportional to the amount of water that comes in contact with the waste, and the sorptive properties of the nuclide. The amount of water that comes in contact with waste is dependent on the integrity of the vault.

The conceptual model for the waste zone includes three integrity scenarios. The vault is assumed to be fully intact for the first 500 years of service. From 500 years to 1,000 years following closure of the facility, it is assumed that several fractures have formed in the vault, providing increased contact between infiltrating water and waste. After 1,000 years, the vault fails completely and water is allowed to infiltrate as if no barriers or containment existed.

Based on the assumptions of a uniform mixture of vault contents, uniform vault material properties, and homogeneous and isotropic soil properties, it was determined that the waste zone system could adequately be described by a two-dimensional profile model that considers the width and height of a waste vault but not the vault's length. Therefore, all input fluxes and resulting concentrations required correction to a unit length basis; however, this proved less cumbersome and less resource-intensive than modeling the system in all three spatial dimensions. The design of both classes of vaults is symmetrical with respect to vault width. The apex of the sloped roof is at the centerline of the vault (Figure 1). It was assumed that this symmetry of design, when constructed of uniform materials and placed in homogeneous, isotropic medium, would perform with similar symmetry. It was therefore determined that the numerical model setup could be further simplified by limiting the conceptual model to only one-half of a vault. The final conceptual model for the vault and unsaturated zone is depicted in Figure 1.

To complete the groundwater pathway model, the contaminant fluxes from the waste and unsaturated models are used as input to the saturated zone model. The saturated portion conceptually consists of a homogeneous, isotropic fully saturated porous media of finite thickness where flow is uniform and constant throughout the model domain. The system is bounded at top by the aquifer surface. The flux of leached radionuclides provides a transient mass flux into the aquifer system. The lower boundary of the aquifer was arbitrarily chosen as the typical well screen thickness in drinking water wells. The upgradient boundary to this model is defined by the natural flux of groundwater into the system while the downgradient boundary consists of the natural flux of groundwater out of the system. Instantaneous complete vertical mixing in the aquifer is assumed.

Concentrations are evaluated at a point, 100 m downgradient from the downgradient edge of the waste facility. A receptor is assumed to drill a well at that location. The conceptual model provides for advective transport and dispersion of contaminants from where they enter the aquifer (below the source) to the downgradient location of the receptor well.

3.3.4 Screening

The inventory of LLW radionuclides was subjected to a screening procedure in order to reduce the number of radionuclides for which a detailed analysis was required. Screening was based on an absolute method where groundwater concentrations and the 50-year Committed Effective Dose Equivalent (CEDE) are conservatively estimated and compared to a set criteria. The criteria used in this analysis was 4 mrem/y CEDE for the beta-gamma emitting nuclides. The 4 mrem/y standard as stated in 40 CFR 141 is based on a *whole body* dose computed using the International Commission on Radiation Protection (ICRP) 2 methodology. Proposed changes to the drinking water standard as stated in the July 18, 1991 Federal Register uses the same dose limit (4 mrem/y), but computes the dose using ICRP 30 methodology, which calculated the 50-year CEDE. For this analysis, we have used the more recent ICRP 30 methodology to compute the 50-year CEDE and compared this value to the 4 mrem/y limit. The receptor is assumed to drink 2 Liters of water per day for 365 days per year. Actinides were also compared to this standard, along with the limit for maximum alpha activity in water of 15 pCi/L (excluding uranium and radon) and maximum Ra-226/Ra-228 concentrations of 5 pCi/L as stated in 40 CFR 141.

3.4 Models and Assumptions

Five computer models were used for this analysis. For the screening of contaminants via the groundwater pathway, the GWSCREEN (Rood, 1994) code was used. For the detailed groundwater pathway analysis, the PORFLOW code (Runchal and Sagar, 1991) was used to model contaminant leaching from the vaults, transport through the unsaturated zone, and transport in the aquifer. Intruder doses were calculated using the GENII code (Napier et al., 1988) and MicroShield code. Operational accident doses were calculated with the RSAC5 code (Wenzel, 1995). Each code is described at the end of this section. Input parameters and model assumptions are also discussed in this section.

3.4.1 Soil Hydraulic Parameters

The soil hydraulic parameters define the interaction between the water and the soil matrix. Thin layers of soils with large grains, such as sand and gravel, provide less resistance to vertical water flow than layers with smaller pore sizes, such as clay, concrete, and grout material. There exists functional relationships describing the interaction between water and the soil such as given by van Genuchten (1978) and presented here in the following equations.

$$\theta = \theta_r + \frac{(\theta_s - \theta_r)}{[1 - (\alpha h)^n]^{1-\frac{1}{n}}}$$

where

- h = suction head
- θ = volumetric moisture content
- θ_r = residual moisture content
- θ_s = effective porosity
- n = pore-size distribution index
- α = inverse air-entry potential.

The equation for the hydraulic conductivity curve is

$$K(h) = K_s \frac{(1 - (\alpha h)^{n-1} [1 + (\alpha h)^n]^{1-1/n})^2}{[1 + (\alpha h)^n]^{n(1-1/n)}}$$

where

$K(h)$ = unsaturated hydraulic conductivity
 K_s = saturated hydraulic conductivity
 l = pore interaction term.

Thus, a fine-grained material will tend to retard the movement of infiltrating water more than a coarse-grained material; this, of course, assumes a homogeneous material. Proper characterization of the porous media to be used in the facility would have to be done before a final analysis could be completed. However, for the purpose of this analysis, the following soil moisture characteristics described in the ensuing sections were assumed to represent the soils at the facility. Table 2 lists each soil type and the source for the parameters that define the soil moisture characteristic curve.

3.4.1.1 Loam. Carsel and Parrish (1988) used a statistical multiple regression technique for estimating hydraulic parameters for various soils types. Because the actual location of the hypothetical site is not yet known, proxy data for a typical sandy clay loam was selected. However, since the soil will be compacted as it is backfilled around the concrete vaults, it is reasonable to expect the hydraulic properties to change during this compaction. The compacted hydraulic parameters were determined in four steps from the uncompacted parameters. First, the porosity and the pore size distribution index (n) were reduced 25% to account for the reduction of pore space sizes during compaction. After compaction, the reduction in pore sizes will cause the soil to behave similar to a finer textured soil, which will tend to drain through larger range of capillary pressures corresponding to a soil with a smaller n value.

Table 2. Hydraulic parameter sources for simulation of unsaturated zone performance analysis.

Material Type	Source of Hydraulic Parameters
Compacted backfill (loam)	Calculated using technique described by Carsel and Parrish (1988)
Fractures	Assumed
Sand	IAEA (1995)
Concrete	Yu et al. (1993)
Waste	Assumed to be the same as concrete

Second, the compacted bulk density was calculated from the particle density and compacted porosity using the relation

$$\rho_p = \frac{\rho_{bc}}{1 - \theta_s}$$

where

ρ_p = particle density

ρ_{bc} = compacted bulk density

θ_s = compacted porosity.

Third, the inverse air entry potential (α) in Equation (3) was calculated from the uncompacted loam air entry potential and from an empirical relation (Campbell, 1985). The relation is

$$\psi_e = \psi_{es} (\rho_{bc} / \rho_{buc})^{0.67b}$$

where

ψ_{es} = uncompacted silt air-entry potential

ρ_{bc} = compacted bulk density

ρ_{buc} = uncompacted bulk density

$b = -2\psi_{es} + 0.2\sigma_g$ in which σ_g is the particle size geometric standard deviation.

Fourth, the saturated hydraulic conductivity was reduced to represent the reduced porosity and increased tortuosity. The residual moisture content was unchanged after compaction because the residual moisture content is a function of the total surface area of the soil particles, which is not changed by compaction. Table 3 lists the hydraulic parameters used in Equations (1) and (2) for each soil type.

Table 3. Hydraulic parameter values for each material type.

Soil Type		K_s (cm/s)	θ_s (cc/cc)	θ_r (cc/cc)	α (1/cm)	n	ρ_b (g/cc)
Compacted and loam	backfill	3.64×10^{-4}	0.39	0.1	0.059	1.48	1.6
Fractures		5.00×10^{-3}	0.38	0.372	5.98×10^{-4}	3.43	1.6
Sand		5.00×10^{-3}	0.38	0.04	0.155	2.43	1.6
Concrete		1.00×10^{-10}	0.15	0.147	5.98×10^{-4}	3.43	1.6
Waste		1.00×10^{-10}	0.50	0.497	5.98×10^{-4}	3.43	0.8

3.4.1.2 Fractures. The concrete degradation process developed for this analysis assumes fractures in module concrete walls begin to affect facility performance approximately 500 years after they were built. The introduction of fractures into the simulation model after the first 500 years necessitated defining a moisture characteristic curve that allows water to flow through an element of

the model domain that had previously been defined as concrete or waste. The flow and transport code PORFLOW, used to prepare these simulations, implements fractures using an equivalent porous media approach. As a result, the fracture and surrounding matrix capillary pressures are the same. The moisture characteristic curve defined for the fracture zone must allow for flow under capillary pressures common to the concrete in the unsaturated zone. Defining the fracture's moisture characteristic curve parameters with the values used for the larger pore-space sand results in a tension head in the fracture that is insufficient to draw flow into the fracture; likewise, if the fracture is described using concrete parameters only, the resulting hydraulic conductivity does not allow sufficient flow through the fracture. To circumvent the code's equivalent porous media implementation of fractures, it was necessary to assign the fracture's hydraulic conductivity a value similar to that of sand and to assign the moisture characteristic curve parameters the values used for concrete. By doing this, the fracture remains saturated under high capillary pressures, yet is able to transmit water at the higher hydraulic conductivity rate. The hydraulic conductivities and moisture characteristic curve parameters used to represent the various materials are summarized in Table 3.

3.4.1.3 Sand. The purpose for the sand placed around the vault was to drain water away from the system. As with the other materials, it was not known the exact type of material that will be used in the final design, so we defined generic parameters to this material.

3.4.1.4 Concrete and Waste. A low-level radioactive waste containment system consisting of a concrete outer shell and concrete overpacks around the waste with sand backfill has been developed for use in disposal in Pennsylvania. The concrete overpacks provide primary containment during vault operations, and the concrete shell provides structural stability for the disposal and will also act as a hydrologic barrier until failure due to fracturing or other degradation processes. Models have been applied to provide estimates of concrete degradation and rebar corrosion due to reactions with soil water chemical constituents in contact with the concrete vault. The models described by Walton et al. (1990) were used to estimate concrete degradation and rebar corrosion processes. Concrete degradation processes considered are (a) magnesium and sulfate attack, (b) calcium leaching (both geologically and concrete controlled), and (c) carbonation. Rebar corrosion due to chloride attack and oxygen-limited corrosion is also considered for the vaults. A brief discussion of each process considered is provided (Appendix B), along with estimated degradation and corrosion rates for the concrete and rebar, respectively.

The degradation processes have been modeled separately rather than integrated because degradation is typically dominated by a single process. Parametric estimates of degradation are used to evaluate wide ranges of scenarios. Through-running fractures are assumed to occur at 500 years, and complete hydrologic failure occurs at 1,000 years as a first approximation. This assumption was based on calculations made for the Savannah River Plant Intermediate Level Non-Tritium waste vaults. The degradation model estimates support the assumption that the vaults will provide the described hydrologic isolation under the assumed conditions. Magnesium and sulfate attack has the greatest impact on the concrete and is predicted to reach the rebar in approximately 3,000 years. This would result in more rapid corrosion of the rebar, but will not impact the vault performance if the vault interior is backfilled (i.e., limited tensile stress).

Results indicate that moving the steel reinforcement deeper into the concrete would enhance the long-term durability of the vaults by keeping the passivation layer stable for a longer period of time. The concrete mix design might be modified after site selection to optimize the long-term performance of the vault. Because the vault design has not been finalized, the effort for this level of calculation is not warranted.

The concrete hydraulic parameters were assumed to be similar to those used for the concrete vaults constructed to contain low and intermediate waste at the Savannah River Site (Yu et al., 1993). Because the waste is placed in concrete containers and the containers are grouted into the vaults, it was assumed that the waste's hydrological properties were the same as the concrete. Thus, all of the parameters were the same except for the bulk density. The bulk density of the waste was assigned half the value in the waste as that for the concrete. The rationale for this was to account for voids in the concrete waste containers and the waste itself. The actual values for the hydraulic parameters are also listed in Table 3.

Table 4. Sorption coefficients (mL/g) for loam, concrete, and grouted waste

Element	Backfill (loam) and aquifer ^d	Concrete	Waste
Actinium	15	0	0
Americium	9,600	5,000 ^a	5,000 ^a
Antimony	150	0	0
Cadmium	40	100 ^b	100 ^b
Carbon	20	100 ^a	100 ^a
Cesium	4600	20 ^c	20 ^c
Cobalt	1,300	100 ^b	100 ^b
Curium	18,000	100 ^b	100 ^b
Europium	0	5,000 ^a	5,000 ^a
Hydrogen (Tritium)	0	0	0
Iodine	5	5 ^a	5 ^a
Iron	800	100 ^d	100 ^d
Lead	0	16,000	16,000
Neptunium	25	5,000 ^a	5,000 ^a
Niobium	550	1,000 ^a	1,000 ^a
Nickel	300	100 ^a	100 ^a
Plutonium	1200	5,000 ^a	5,000 ^a
Promethium	0	5,000 ^a	5,000 ^a
Protactinium	15	1,500 ^a	1,500 ^a
Radium	36,000	100 ^a	100 ^a
Sodium	0	0	0
Strontium	20	3 ^a	3 ^a
Technetium	0.1	1.0 ^c	1.0 ^c
Thorium	3,300	5,000 ^a	5,000 ^a
Uranium	15	1,500 ^a	1,500 ^a

^a Krupka 1996
^b DOE/ID-10521/2 1996
^c Allard 1985
^d Sheppard and Thibault 1990

3.4.2 Sorption Coefficients

Transport of radionuclides out of the vaults and in the subsurface environment is modeled using distribution coefficients to describe the partitioning between the aqueous and solid phases in the porous media. Contaminants that are released from their primary containment will come into contact with the concrete vault. The current mix design consists of Type II OPC with sand, fly ash, and aggregate. The properties of concrete provide a good transport barrier for many radionuclides (Table 4) and many of the long-lived radionuclides are readily immobilized (highly sorbed) within the concrete. Addition of slag into the cement would improve the retention of reducible contaminants like technetium. This may be an option to enhance performance if technetium is shown to be a problem.

The concrete K_d 's respond to changes in the concrete pH. However, the change in concrete pH is gradual (thousands to millions of years [Walton et al., 1990]), and variation in the chemical control on contaminants will remain stable for an extended period of time. The location of the facility has not been selected, and site-specific distribution coefficients for the backfill and porous media are not available. Because of the lack of site-specific information, conservative K_d values from available literature were selected for the backfill and porous media (Table 4). For further information on K_d selection for Performance Assessments, see Appendix C.

3.4.3 Initial and Boundary Conditions

For the flow and transport simulation in the unsaturated zone model, the saturation level of the backfill and native soil surrounding the waste vault was set to a value of 1.0; that is, the surrounding backfill and soil were assumed to be fully saturated and, as the simulations progressed, the soil was allowed to come to a value of saturation consistent with the infiltration rate of precipitation and the specified moisture characteristic curve defined for this material type. Initial contaminant conditions were simulated with unit concentration to minimize the number of simulations. The vertical boundaries of the unsaturated zone were fixed spatially and temporally as no-flux boundaries. The top horizontal boundary was set as a fixed flux of 58 cm/yr of infiltrating precipitation. The bottom horizontal boundary was simulated as specified-concentration boundary; that is, the contaminant concentrations just beneath this boundary were always set to zero. This, in effect, conservatively maximizes the flux of contaminants to the aquifer.

Initial conditions for contaminant transport in the saturated zone were based largely upon output from the unsaturated zone simulations. The upper boundary of the aquifer was established as the output flux of the unsaturated simulations. The lower boundary was specified as no-flux. The vertical upgradient and downgradient boundaries were each established as specified-concentration boundaries, with the contaminant concentrations just outside the boundaries specified as zero concentration. This conservatively maximized transport of contaminants to the downgradient receptor locations. Groundwater velocity in the horizontal direction was specified as 25 m/yr throughout the aquifer, while the vertical velocity was set to 0 m/yr. Initial conditions for contaminant concentrations were always set as zero-concentration everywhere in the aquifer. The flow field was assumed to be uniform throughout the aquifer.

3.4.3.1 Screening Model Assumptions The groundwater contaminant transport code, GWSCREEN (Rood 1994) was used to perform the screening calculations. The following simplifying, and conservative assumptions were made for these calculations:

- All waste was assumed to be placed instantaneously into a volume comprising the open pit area of the waste facility.

- The waste was assumed to be homogeneously mixed with a soil matrix that has the same hydrologic properties as backfill soil (loam) and the same sorptive properties of the waste grout (cement).
- No credit was taken for engineered barriers to restrict water movement in and out of the waste.
- Leaching of radionuclides from the soil was described by first-order kinetics which is a function of the net infiltration and sorptive properties of the nuclide.
- The waste vaults were placed directly over the aquifer.
- Transport in the saturated zone is described by a semi-analytical solution to the advection-dispersion equation for an aquifer of infinite lateral extent, finite thickness, and constant, steady-state flow.
- A receptor was placed at the edge of the waste facility buffer zone which is 100 downgradient from the downgradient edge of the waste. This distance was 405 m downgradient from the center of the AB vaults and 125 m downgradient from the center of the C vaults.
- The receptor was assumed to drink 2 L of water per day for 365 days per year.
- Impacts are calculated for the year the groundwater concentration peaks
- Radioactive progeny are assumed to travel at the same rate of the parent.

Values for GWSCREEN input variables are summarized in Table 5. GWSCREEN output files for these screening calculations are presented in Appendix D. A prescreening procedure was applied to the inventory prior to running GWSCREEN. Any nuclide with a half-life less than 1 year was eliminated from consideration. Nuclides with half-lives less than 1 year are essentially decayed away at the end of the 100 year institutional control period.

Table 5. Input parameters for the GWSCREEN screening simulations.

Parameter Name	Value for AB Vaults	Value for C Vaults
Source length parallel to groundwater flow (m)	610	49
Source width perpendicular to groundwater flow (m)	122	24
Source thickness (m)	7.6	3
Bulk Density of source material (g/cm ³)	1.6	1.6
Percolation (infiltration) rate (m/y)	0.58	0.58
α for source material (1/cm)	0.059	0.059
n for source material	1.48	1.48
Saturated hydraulic conductivity for source material (m/y)	114.8	114.8
Residual moisture content for source material	0.1	0.1
Total porosity for source material (m ³ /m ³)	0.39	0.39
Aquifer pore velocity (m/y)	62.5	62.5
Longitudinal dispersivity (m)	10	10
Transverse dispersivity (m)	5	5
Well screen thickness (m)	15	15
Aquifer bulk density (g/cm ³)	1.6	1.6

3.4.4 Numerical Models

3.4.4.1 GWSCREEN The GWSCREEN model is a groundwater assessment code that was developed for assessment of the groundwater pathway from the leaching of radioactive and non-radioactive contaminants from surface or buried sources. The code was designed for implementation in the Track 1 and Track 2 assessment of Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites identified as low probability hazard at the Idaho National Engineering Laboratory. The code has been adapted to many other applications including low-level waste performance assessment.

The model calculates the limiting soil concentration and inventory so that after leaching and transport of the contaminant to the aquifer, regulatory contaminant levels in groundwater are not exceeded. It can also calculate groundwater concentrations and corresponding health impacts (radiological dose) as a function of time and distance away from the source. The code uses a mass conservation approach to model three processes: (a) contaminant release from a source volume, (b) contaminant transport in the unsaturated zone, and (c) contaminant transport in the saturated zone. The source model considers the sorptive properties and solubility of the contaminant. Transport in the unsaturated zone is described by a plug flow model. Transport in the saturated zone is calculated using a semi-analytical solution to the advection dispersion equation in groundwater for transient mass fluxes. Transport of radioactive progeny is accomplished by assuming the radioactive progeny travel at the same rate as their parent.

GWSCREEN results are comparable with results from other codes using similar algorithms and have also been shown to provide bounding estimates of groundwater concentrations when compared to results from numerical codes. A formal verification and validation report was completed (Smith and Whitaker 1993). GWSCREEN was not intended to be a predictive tool. Rather, it provides a framework to calculate bounding impacts to groundwater from the leaching of surficial and buried contamination.

3.4.4.2 PORFLOW. The PORFLOW computer code, Version 2.39 (Runchal and Sagar 1991) was developed to evaluate hazardous and radioactive waste problems. The computer code is based on the numerical solution of the general equations for (a) time-dependent, porous flow, (b) transport of a reactive solute, and (c) coupled heat transport. The governing equations describing these processes are approximated by an integrated finite-difference technique. Both direct and iterative solution approaches are available and can be used to solve the finite-difference equations.

The code is capable of solving for fluid flow, heat, and mass transport in porous media, which can be heterogenous, anisotropic, variably saturated, and/or discretely fractured. Specific capabilities of the code include the ability to simulate the following: multiple phases, up to four species at a time, chemical reactions, four-member chain decay with differential transport of decay members, arbitrary sources and sinks, and variable density as a function of either concentration or temperature.

Limitations of the model include (a) single temperature for all phases, (b) one-phase heat and mass transport so that there is no heat transfer between phases, (c) reversible linear Freundlich isotherm to describe partitioning, and (d) one-way chain decay so that daughter products can only occur along one chain per simulation.

An earlier version of the PORFLOW code, called PORFLO-3, was verified against a number of known analytical solutions and benchmarked tested by making code-to-code comparisons for several

flow and transport simulations. The results of the verification and benchmark testing are documented in Magnuson et al. (1990).

3.4.4.3 MicroShield. The MicroShield model (Grove Engineering, 1992) was used to estimate doses to individuals occupying the basement of a house built such that the basement floor slab is the existing roof of a class A and B waste module. The waste in the module was the only source of penetrating radiation accounted for in the MicroShield calculations (penetrating radiation from surface soil contamination is accounted for by GENII, see Section 3.4.3.4). The inventory in the module was estimated by taking the entire class A and B inventory, calculating the inventory following 100 years of decay, and dividing the decayed inventory by the projected waste volume. The changes in the inventories of the waste radionuclides caused by decay and daughter ingrowth were evaluated using the decay routine in MicroShield. Because of the geometry of the source and basement, the penetrating radiation doses were evaluated for several sub-volumes and summed to arrive at the total dose. The same approach was used to estimate penetrating radiation doses for the intrusion scenario at 500 years.

MicroShield was also used to estimate doses for the crane accident scenarios (occurring during operations). In these scenarios, a waste container is either suspended from the crane with a small shield, or dropped and left temporarily unshielded, but not breached. The waste container was assumed to be a 97-ft³ resin liner with the radionuclide composition specified in the North Carolina SAR, generating a 500-r/h field at 10 cm from the surface (midline of axis). The inventory of the container was determined by scaling the total activity in the proportions specified in the North Carolina SAR to generate the 500-r/h field specified in the North Carolina SAR.

3.4.4.4 GENII. The GENII model (Napier et al., 1988) accounts for internal and penetrating radiation caused by contaminated surface soil. The concentration of radionuclides in waste excavated 500 years post-closure was estimated using RSAC-5. Electronic data transfers were used to copy the RSAC-5 inventory output to the GENII input.

Penetrating radiation doses were estimated using a point-kernel subroutine in GENII that is based on the IsoShield model, which is similar to MicroShield. GENII also calculates doses caused by intake of radionuclides in plant and animal products that are consumed by individuals, inhalation of resuspended soil, and inadvertent ingestion of soil. Intakes of radionuclides in foodstuffs is modeled using U.S. NRC Regulatory Guide 1.07 methods and a set of environmental parameters developed for the Hanford site in western Washington state.

3.4.4.5 RSAC-5. The RSAC-5 code calculates doses caused by brief releases of radionuclides to the atmosphere. RSAC-5 has been validated and verified in accordance with ANSI/ANS-10.4 (1987), "American National Standard Guidelines for the Verification and Validation of Scientific and Engineering Programs for the Nuclear Industry." The code performs Gaussian plume dispersion modeling applying Pasquill-Gifford diffusion parameters, and calculates doses through inhalation, ingestion, immersion, ground surface, and cloud gamma radiation. The RSAC-5 code was used to calculate the doses caused by the fire and earthquake accident scenarios. RSAC-5 was also used to generate the decayed waste inventories for input to GENII.

4. RESULTS OF ANALYSIS

4.1 Operational Accidents

Table 6 summarizes the results of analysis of accidents at the Pennsylvania disposal facility. The

results are presented for intake through inhalation, exposure to penetrating radiation caused by immersion in contaminated air, and exposure to penetrating radiation emitted by waste that is contained but is either closer than usual to the dose receptor, or unshielded, i.e., direct radiation.

4.2 Post-Closure Intrusion

Table 7 summarizes the results of analysis of intrusion into the Pennsylvania disposal facility following closure. The results are presented as calculated by GENII for intake through inhalation, exposure to penetrating radiation caused by immersion in contaminated air, and exposure to direct

Table 6. Off-site doses (mrem) caused by bounding hypothetical operational accidents at the Pennsylvania disposal facility.

Scenario	Inhalation (mrem)	Immersion (mrem)	Direct radiation (mrem)	Total (mrem)
Fire in waste packaging building	8.6×10^{-2}	8.2×10^{-4}	---	8.7×10^{-4}
Crane malfunction -- suspended container			1.2×10^{-3}	1.2×10^{-3}
Crane malfunction -- dropped container			2.8×10^{-2}	2.8×10^{-2}
Tornado			4.3×10^0	4.3×10^0
Earthquake	2.5×10^{-1}	8.3×10^{-3}	---	2.5×10^{-1}

Table 7. Doses (mrem) to individuals intruding into the Pennsylvania disposal facility.

	Ingestion (mrem)	Inhalation (mrem)	Direct radiation surface soil (mrem)	Direct radiation buried waste (mrem)	Total EDE (mrem)
Class A and B 100-year post-closure	--	--	--	0.21	0.21
Class C 100-year post-closure	--	--	--	1.6	1.6
Class A and B 500-year post-closure	8.8	0.4	2.8	7.8	20
Class C 500-year post-closure	337	1.8	183	175	697

radiation, which is penetrating radiation emitted by buried waste that is undisturbed but is either closer to the dose receptor, or relatively unshielded. The GENII code separately calculates 50 year committed

effective dose equivalent (EDE) for inhalation and ingestion, and the external EDE for immersion and direct radiation. The total EDE is defined as the sum of the committed and external EDEs. The total EDE reported by GENII and presented in Table 6 may not be the exact sum of the committed and external EDEs because of rounding.

Tables 5 and 6 present doses for the 100 year post closure and 500 year post closure scenarios. For the 100 year post closure scenario, 100% of the dose is from direct radiation. Class AB waste would cause a dose of 0.21 mrem and Class C waste would cause 1.6 mrem. For both AB and C waste, most of the dose would be caused by ¹³⁷Cs. For the 500 year post closure scenario, the ingestion pathway was the highest contributor for both AB and C waste. The percent of dose attributed to each pathway is given in Table 8. The primary ingestion dose contributor was ²²⁸Ra for the class AB waste and ⁶³Ni for class C waste. ⁹⁴Nb was the major contributor to the direct radiation pathway for class C waste intrusion at 500 years -- ²²⁸Ra and progeny were the major direct radiation contributors for class AB waste.

Table 8. Percentage of dose from each intruder pathway for Class AB and C waste..

Waste Type	Ingestion	Inhalation	Direct radiation surface soil	Direct radiation buried waste
Class AB	61%	4%	2%	33%
Class C	80%	2%	7%	11%

4.3 Post-Closure Groundwater Pathway

Groundwater pathway impacts were evaluated using the assumptions and conceptual model described in Section 3.4.3.1 and the GWSCREEN code. Only nuclides that had a half-life of greater than one year were analyzed. The CEDE for each nuclide in Class AB waste (Table 9) and Class C waste (Table 10) was below the 4 mrem/y beta gamma dose criteria except ³H. The ¹⁴C CEDE was close enough to the 4 mrem/y limit (3.7 mrem/y) for Class C waste that this nuclide was included in the more detailed analysis. Tritium had maximum CEDE values of 1.4×10^4 mrem for Class AB waste and 1.3×10^3 mrem/y for class C waste. Carbon-14 had maximum doses of 1.7 mrem/y and 3.7 mrem/y for Class AB and C waste respectively. Gross alpha activities were below the 15 pCi/L limit for all alpha-emitting nuclides (excluding radium and radon) in Class AB and C waste (Table 11 and 12) and Ra-226/228 concentrations were below the 5 pCi/L limit.

Table 9. Maximum committed effective dose equivalents calculated with GWSCREEN for Class AB waste.

Nuclide	Progeny	Inventory	Dose	Half Life	Kd Source	Kd	Maximum	Peak Time
			Factor			Aquifer	CEDE	
		(Ci)	(rem/Ci)	(years)	(mL/g)	(mL/g)	(mrem/y)	(years)
Am-241		1.29E-01	4.50E+06	4.32E+02	5.00E+03	5.00E+03	3.24E-13	7.71E+03
	Np-237		3.90E+06	2.10E+06		2.50E+01	2.67E-09	
	U-233		2.70E+05	1.59E+05		1.50E+01	9.32E-12	
	Th-229		3.91E+06	7.34E+03		3.30E+03	1.71E-13	
Total							2.68E-09	
Am-243		1.00E-05	4.50E+06	7.38E+03	5.00E+03	5.00E+03	7.07E-09	3.44E+04

Nuclide	Progeny	Inventory	Dose	Half Life	Kd Source	Kd Aquifer	Maximum CEDE	Peak Time
		(Ci)	Factor (rem/Ci)	(years)	(mL/g)	(mL/g)	(mrem/y)	(years)
	Pu-239		4.30E+06	2.41E+04		1.20E+03	1.05E-07	
	U-235		2.51E+05	7.04E+08		1.50E+01	1.66E-11	
	Pa-231		1.10E+07	3.28E+04		1.50E+01	1.94E-10	
	Ac-227		1.46E+07	2.18E+01		1.50E+01	2.56E-10	
	Total						1.12E-07	
Ba-133		1.85E-02	3.20E+03	1.05E+01	1.00E+01	0.00E+00	1.32E-03	1.03E+01
C-14		2.31E+02	2.10E+03	5.70E+03	1.00E+02	2.00E+01	1.70E+00	9.35E+02
Cd-109		4.20E-02	1.20E+04	1.27E+00	1.00E+02	4.00E+01	1.61E-21	3.64E+01
Cl-36		1.39E-01	3.00E+03	3.01E+05	1.00E+00	0.00E+00	1.38E-01	1.19E+01
Cm-243		3.30E-02	1.10E+05	2.85E+01	1.00E+02	1.80E+04	0.00E+00	0.00E+00
	U-235		2.50E+05	7.04E+11		1.50E+01	0.00E+00	
	Pa-231		1.10E+07	3.28E+04		1.50E+01	0.00E+00	
	Ac-227		1.46E+07	2.18E+01		1.50E+01	0.00E+00	
	Total						0.00E+00	
Cm-244		1.32E-01	2.30E+06	1.81E+01	1.00E+02	1.80E+04	0.00E+00	0.00E+00
	Pu-240		2.29E+06	6.56E+03		1.20E+03	0.00E+00	
	U-236		2.50E+05	2.43E+07		1.50E+01	0.00E+00	
	Th-232		2.80E+06	1.41E+10		3.30E+03	0.00E+00	
	Ra-228		1.20E+06	5.75E+00		3.60E+04	0.00E+00	
	Th-228		7.50E+05	1.91E+00		3.30E+03	0.00E+00	
	Total						0.00E+00	
Co-60		4.73E+04	2.60E+04	5.75E+00	1.00E+02	1.30E+03	0.00E+00	0.00E+00
Cs-134		7.63E+03	7.40E+04	2.06E+00	2.00E+01	4.60E+03	0.00E+00	0.00E+00
Cs-137		1.27E+04	5.00E+04	3.00E+01	2.00E+01	4.60E+03	0.00E+00	0.00E+00
Eu-155		1.60E-03	1.30E+03	4.96E+00	5.00E+03	0.00E+00	4.96E-08	7.61E+00
Fe-55		1.71E+05	5.80E+01	2.73E+00	1.00E+02	8.00E+02	0.00E+00	0.00E+00
H-3		3.53E+05	6.30E+01	1.23E+01	0.00E+00	0.00E+00	1.37E+04	6.60E+00
I-129		4.11E-03	2.80E+05	1.57E+07	5.00E+00	5.00E+00	4.58E-02	1.95E+02
Na-22		1.36E-01	1.20E+04	2.60E+00	0.00E+00	0.00E+00	3.49E-01	4.06E+00
Nb-94		2.67E-01	5.10E+03	2.00E+04	1.00E+03	5.50E+02	1.92E-04	1.76E+04
Ni-63		5.03E+01	5.40E+01	1.00E+02	1.00E+02	3.00E+02	1.77E-08	9.47E+02
Ni-59		5.03E+01	2.10E+02	7.50E+04	1.00E+02	3.00E+02	9.05E-03	7.09E+03
Pb-210		7.39E-01	6.70E+06	2.23E+01	0.00E+00	1.60E+04	0.00E+00	0.00E+00
Pm-147		9.05E+00	9.50E+01	2.62E+00	5.00E+03	0.00E+00	9.59E-06	5.05E+00
Pu-238		3.15E-01	3.80E+06	8.77E+01	5.00E+03	1.20E+03	7.77E-14	1.69E+03
	U-234		2.60E+05	2.45E+05		1.50E+01	9.58E-11	
	TH-230		5.30E+05	7.54E+03		3.30E+03	1.21E-13	
	RA-226		1.10E+06	1.60E+03		3.60E+04	6.48E-15	
	PB-210		6.70E+06	2.23E+01		1.60E+04	8.56E-14	
	Total						9.61E-11	
Pu-239		2.28E-01	4.30E+06	2.41E+04	5.00E+03	1.20E+03	2.07E-02	3.32E+04
	U-235		2.50E+05	7.04E+11		1.50E+01	5.17E-09	
	Pa-231		1.10E+07	3.28E+04		1.50E+01	7.28E-08	

Nuclide	Progeny	Inventory	Dose	Half Life	Kd Source	Kd Aquifer	Maximum CEDE	Peak Time
		(Ci)	Factor (rem/Ci)	(years)	(mL/g)	(mL/g)	(mrem/y)	(years)
	Ac-227		1.46E+07	2.18E+01		1.50E+01	9.65E-08	
Total							2.07E-02	
Pu-240		4.70E-02	2.29E+06	6.56E+03	5.00E+03	1.20E+03	4.21E-04	1.63E+04
	U-236		2.50E+05	2.43E+07		1.50E+01	4.51E-06	
	Th-232		2.80E+06	1.41E+10		3.30E+03	1.19E-13	
	Ra-228		1.20E+06	5.75E+00		3.60E+04	4.69E-15	
	Th-228		7.50E+05	1.91E+00		3.30E+03	3.19E-14	
Total							4.26E-04	
Pu-241		2.63E+02	8.20E+04	1.44E+01	5.00E+03	1.20E+03	0.00E+00	0.00E+00
	Am-241		4.50E+06	4.32E+02		5.00E+03	0.00E+00	
	Np-237		3.90E+06	2.10E+06		2.50E+01	0.00E+00	
	U-233		2.70E+05	1.59E+05		1.50E+01	0.00E+00	
	Th-229		3.91E+06	7.34E+03		3.30E+03	0.00E+00	
Total							0.00E+00	
Ra-226		7.40E-03	1.10E+06	1.60E+03	1.00E+02	3.60E+04	7.06E-18	3.80E+04
	Pb-210		6.70E+06	2.23E+01		1.60E+04	9.81E-17	
Total							1.05E-16	
Sb-125		9.95E+01	2.60E+03	2.73E+00	0.00E+00	1.50E+02	8.93E-22	9.99E+01
Sr-90		1.73E+02	1.30E+05	2.91E+01	3.00E+00	2.00E+01	3.81E+00	1.29E+02
Tc-99		1.09E-01	1.30E+03	2.13E+05	1.00E+00	1.00E-01	4.30E-02	1.60E+01
Th-228		7.37E-04	7.50E+05	1.91E+00	3.30E+03	3.30E+03	0.00E+00	0.00E+00
Th-230		3.98E-03	5.30E+05	7.54E+03	3.30E+03	3.30E+03	1.78E-06	2.82E+04
	RA-226		1.10E+06	1.60E+03		3.60E+04	4.31E-07	
	PB-210		6.70E+06	2.23E+01		1.60E+04	5.92E-06	
Total							8.13E-06	
Th-232		3.78E-01	2.80E+06	1.41E+10	3.30E+03	3.30E+03	6.67E-02	1.23E+05
	Ra-228		1.20E+06	5.75E+00		3.60E+04	2.62E-03	
	Th-228		7.50E+05	1.91E+00		3.30E+03	1.79E-02	
Total							8.71E-02	
U-232		2.47E-03	1.30E+06	7.00E+01	1.50E+03	1.50E+01	3.18E-05	1.93E+02
	Th-228		7.51E+05	1.91E+00		3.30E+03	8.73E-08	
Total							3.19E-05	
U-233		1.92E-01	2.70E+05	1.59E+05	1.50E+03	1.50E+01	1.74E-02	9.43E+02
	Th-229		1.00E+06	7.34E+03		3.30E+03	2.55E-05	
Total							1.75E-02	
U-234		8.27E-02	2.60E+05	2.45E+05	1.50E+03	1.50E+01	7.24E-03	9.46E+02
	TH-230		5.30E+05	7.54E+03		3.30E+03	5.69E-06	
	RA-226		1.10E+06	1.60E+03		3.60E+04	1.97E-07	
	PB-210		6.70E+06	2.23E+01		1.60E+04	2.54E-06	
Total							7.25E-03	
U-235		2.81E-03	2.50E+05	7.04E+11	1.50E+03	1.50E+01	2.38E-04	9.60E+02
	Pa-231		1.10E+07	3.28E+04		1.50E+01	2.10E-04	
	Ac-227		1.46E+07	2.18E+01		1.50E+01	2.70E-04	
Total							7.17E-04	

Nuclide	Progeny	Inventory	Dose	Half Life	Kd Source	Kd Aquifer	Maximum Peak Time
			Factor				CEDE
		(Ci)	(rem/Ci)	(years)	(mL/g)	(mL/g)	(mrem/y) (years)
U-238		2.51E-01	2.30E+05	4.47E+09	1.50E+03	1.50E+01	1.95E-02 9.60E+02
	U-234		2.60E+05	2.45E+05		1.50E+01	5.98E-05
	TH-230		5.30E+05	7.54E+03		3.30E+03	2.41E-08
	RA-226		1.10E+06	1.60E+03		3.60E+04	5.79E-10
	PB-210		6.70E+06	2.23E+01		1.60E+04	7.22E-09
Total							1.96E-02

Table 10. Maximum committed effective dose equivalents calculated with GWSCREEN for Class C waste.

Nuclide	Progeny	Inventory	Dose	Half Life	Kd Source	Kd Aquifer	Maximum Peak Time
			Factor				CEDE (years)
		(Ci)	(rem/Ci)	(years)	(mL/g)	(mL/g)	(mrem/y)
Am-241		1.50E-02	4.50E+06	4.32E+02	5.00E+03	5.00E+03	3.16E-12 7.61E+03
	Np-237		3.90E+06	2.10E+06		2.50E+01	2.23E-08
	U-233		2.70E+05	1.59E+05		1.50E+01	7.68E-11
	Th-229		3.91E+06	7.34E+03		3.30E+03	1.39E-12
Total							2.24E-08
Am-243		1.43E-05	4.50E+06	7.38E+03	5.00E+03	5.00E+03	4.20E-07 3.00E+04
	Pu-239		4.30E+06	2.41E+04		1.20E+03	4.48E-06
	U-235		2.51E+05	7.04E+08		1.50E+01	5.65E-10
	Pa-231		1.10E+07	3.28E+04		1.50E+01	5.73E-09
	Ac-227		1.46E+07	2.18E+01		1.50E+01	7.59E-09
Total							4.92E-06
Ba-133		1.00E-04	3.20E+03	1.05E+01	1.00E+01	0.00E+00	5.83E-05 3.81E+00
C-14		8.84E+01	2.10E+03	5.70E+03	1.00E+02	2.00E+01	3.70E+00 2.98E+02
Cd-109		7.63E-04	1.20E+04	1.27E+00	1.00E+02	4.00E+01	2.77E-21 3.62E+01
Cm-243		5.74E-03	1.10E+05	2.85E+01	1.00E+02	1.80E+04	0.00E+00 0.00E+00
	Pu-239		4.30E+06	2.41E+04		1.20E+03	0.00E+00
	U-235		2.50E+05	7.04E+11		1.50E+01	0.00E+00
	Pa-231		1.10E+07	3.28E+04		1.50E+01	0.00E+00
	Ac-227		1.46E+07	2.18E+01		1.50E+01	0.00E+00
Total							0.00E+00
Cm-244		1.86E-02	2.30E+06	1.81E+01	1.00E+02	1.80E+04	0.00E+00 0.00E+00
	Pu-240		2.29E+06	6.56E+03		1.20E+03	0.00E+00
	U-236		2.50E+05	2.43E+07		1.50E+01	0.00E+00
	Th-232		2.80E+06	1.41E+10		3.30E+03	0.00E+00
	Ra-228		1.20E+06	5.75E+00		3.60E+04	0.00E+00
	Th-228		7.50E+05	1.91E+00		3.30E+03	0.00E+00
Total							0.00E+00
Co-60		7.75E+05	2.60E+04	5.75E+00	1.00E+02	1.30E+03	0.00E+00 0.00E+00
Cs-134		5.75E+01	7.40E+04	2.06E+00	2.00E+01	4.60E+03	0.00E+00 0.00E+00
Cs-137		4.23E+02	5.00E+04	3.00E+01	2.00E+01	4.60E+03	0.00E+00 0.00E+00

Nuclide	Progeny	Inventory	Dose	Half Life	Kd Source	Kd Aquifer	Maximum CEDE	Peak Time (years)
		(Ci)	Factor (rem/Ci)	(years)	(mL/g)	(mL/g)	(mrem/y)	
Fe-55		1.03E+06	5.80E+01	2.73E+00	1.00E+02	8.00E+02	0.00E+00	0.00E+00
H-3		3.77E+03	6.30E+01	1.23E+01	0.00E+00	0.00E+00	1.30E+03	2.56E+00
I-129		8.65E-04	2.80E+05	1.57E+07	5.00E+00	5.00E+00	6.08E-02	5.91E+01
Nb-94		1.58E+00	5.10E+03	2.00E+04	1.00E+03	5.50E+02	1.04E-02	6.48E+03
Ni-59		5.90E+02	3.50E+03	7.50E+04	1.00E+02	3.00E+02	1.43E+01	2.75E+03
Ni-63		4.38E+04	5.40E+01	1.00E+02	1.00E+02	3.00E+02	9.57E-04	9.14E+02
Np-237		7.86E-05	3.90E+06	2.10E+06	5.00E+03	2.50E+01	1.55E-04	6.24E+02
	U-233		2.70E+05	1.59E+05		1.50E+01	4.84E-08	
	Th-229		3.91E+06	7.34E+03		3.30E+03	9.35E-11	
Total							1.55E-04	
Pb-210		2.00E-01	6.70E+06	2.23E+01	0.00E+00	1.60E+04	0.00E+00	0.00E+00
Pu-238		1.21E-01	3.80E+06	8.77E+01	5.00E+03	1.20E+03	2.58E-12	1.68E+03
	U-234		2.60E+05	2.45E+05		1.50E+01	2.77E-09	
	TH-230		5.30E+05	7.54E+03		3.30E+03	3.47E-12	
	RA-226		1.10E+06	1.60E+03		3.60E+04	1.84E-13	
	PB-210		6.70E+06	2.23E+01		1.60E+04	2.43E-12	
Total							2.78E-09	
Pu-239		9.70E-03	4.30E+06	2.41E+04	5.00E+03	1.20E+03	1.05E-02	1.47E+04
	U-235		2.50E+05	7.04E+11		1.50E+01	8.62E-10	
	Pa-231		1.10E+07	3.28E+04		1.50E+01	5.66E-09	
	Ac-227		1.46E+07	2.18E+01		1.50E+01	7.48E-09	
Total							1.05E-02	
Pu-241		1.86E+01	8.20E+04	1.44E+01	5.00E+03	1.20E+03	0.00E+00	0.00E+00
	Am-241		4.50E+06	4.32E+02		5.00E+03	0.00E+00	
	Np-237		3.90E+06	2.10E+06		2.50E+01	0.00E+00	
	U-233		2.70E+05	1.59E+05		1.50E+01	0.00E+00	
	Th-229		3.91E+06	7.34E+03		3.30E+03	0.00E+00	
Total							0.00E+00	
Pu-242		7.93E-08	4.10E+06	8.30E+07	5.00E+03	1.20E+03	1.29E-07	1.75E+04
	U-238		2.30E+05	4.47E+09		1.50E+01	1.55E-12	
	U-234		2.60E+05	2.45E+05		1.50E+01	4.28E-14	
	TH-230		5.30E+05	7.54E+03		3.30E+03	1.52E-16	
	RA-226		1.10E+06	1.60E+03		3.60E+04	2.07E-17	
	PB-210		6.70E+06	2.23E+01		1.60E+04	2.82E-16	
Total							1.29E-07	
Sb-125		3.55E+02	2.60E+03	2.73E+00	0.00E+00	1.50E+02	1.75E-19	9.89E+01
Sr-90		1.30E+00	1.30E+05	2.91E+01	3.00E+00	2.00E+01	9.24E-01	1.09E+02
Tc-99		5.61E-03	1.30E+03	2.13E+05	1.00E+00	1.00E-01	1.18E-02	4.91E+00

Table 11. Maximum gross alpha activity in groundwater (excluding radium and radon) for Class AB waste using the GWSCREEN code and screening model assumptions and methodology.

Radionuclide	Progeny	Maximum Alpha Activity (pCi/L)
Am-241		9.86E-14
	Np-237	9.39E-10
	U-233	4.73E-11
	Th-229	5.98E-14
Total		9.86E-10
Am-243		2.15E-09
	Pu-239	3.34E-08
	U-235	9.05E-11
	Pa-231	2.41E-11
Total		3.56E-08
Cm-243		0.00E+00
	Pu-239	0.00E+00
	U-235	0.00E+00
	Pa-231	0.00E+00
Total		0.00E+00
Cm-244		0.00E+00
	Pu-240	0.00E+00
	U-236	0.00E+00
	Th-232	0.00E+00
	Th-228	0.00E+00
Total		0.00E+00
Pu-238		2.80E-14
	U-234	5.05E-10
	TH-230	3.13E-13
Total		5.05E-10
Pu-239		6.59E-03
	U-235	2.83E-08
	Pa-231	9.06E-09
Total		6.59E-03
Pu-240		2.52E-04
	U-236	2.47E-05
	Th-232	5.84E-14
	Th-228	5.83E-14
Total		2.77E-04
Pu-241		0.00E+00
	Am-241	0.00E+00

Radionuclide	Progeny	Maximum Alpha Activity (pCi/L)
Total	Np-237	0.00E+00
	U-233	0.00E+00
	Th-229	0.00E+00
		0.00E+00
Th-228		0.00E+00
Th-230		4.61E-06
Th-232		3.26E-02
Total	Th-228	3.26E-02
		6.52E-02
U-232		3.35E-05
Total	Th-228	1.59E-07
		3.37E-05
U-233		8.85E-02
Total	Th-229	3.49E-05
		8.85E-02
U-234		3.82E-02
Total	Th-230	1.47E-05
		3.82E-02
U-235		1.30E-03
Total	Pa-231	2.61E-05
		1.33E-03
U-238		1.16E-01
Total	U-234	3.15E-04
	Th-230	6.24E-08
		1.16E-01

Table 12. Maximum gross alpha activity in groundwater (excluding radium and radon) for Class C waste using the GWSCREEN code and screening model assumptions and methodology.

Radionuclide	Progeny	Maximum Alpha Activity (pCi/L)
Am-241		9.62E-13
Total	Np-237	7.84E-09
	U-233	3.90E-10
	Th-229	4.87E-13
		8.23E-09

Radionuclide	Progeny	Maximum Alpha Activity (pCi/L)
Am-243		1.28E-07
	Pu-239	1.43E-06
	U-235	3.09E-09
	Pa-231	7.13E-10
	Ac-227	7.12E-10
Total		1.56E-06
Cm-243		0.00E+00
	Pu-239	0.00E+00
	U-235	0.00E+00
	Pa-231	0.00E+00
	Ac-227	0.00E+00
Total		0.00E+00
Cm-244		0.00E+00
	Pu-240	0.00E+00
	U-236	0.00E+00
	Th-232	0.00E+00
	Ra-228	0.00E+00
	Th-228	0.00E+00
Total		0.00E+00
Np-237		5.46E-05
	U-233	2.45E-07
	Th-229	3.28E-11
Total		5.48E-05
Pu-238		9.30E-13
	U-234	1.46E-08
	Th-230	8.97E-12
	Ra-226	2.29E-13
	Pb-210	4.97E-13
Total		1.46E-08
Pu-239		3.34E-03
	U-235	4.72E-09
	Pa-231	7.05E-10
	Ac-227	7.02E-10
Total		3.34E-03
Pu-241		0.00E+00
	Am-241	0.00E+00
	Np-237	0.00E+00
	U-233	0.00E+00

Radionuclide	Progeny	Maximum Alpha Activity (pCi/L)
	Th-229	0.00E+00
Total		0.00E+00
Pu-242		4.32E-08
	U-238	9.24E-12
	U-234	2.25E-13
	TH-230	3.92E-16
	RA-226	2.58E-17
	PB-210	5.77E-17
Total		4.32E-08

The PORFLO model was employed to better simulate the actual performance of the facility for ^3H and ^{14}C . Waste grouting, engineered barriers, and cover emplacement were accounted for in the PORFLO simulation. These simulations were performed early in the project for inventory and sorption coefficient estimates that were different from those received as the "best estimate values" in May, 1996 (see Appendix A). The initial inventory estimate did not include ^{14}C and the sorption coefficients assigned to each element were different than were in the best estimate. Tritium was included in the initial inventory estimate and a K_d value of 0 was assumed in all cases. Therefore, the ^3H dose needed only to be adjusted for the final inventory. Because ^{14}C was not included in the initial inventory estimate, a "surrogate" nuclide that had similar sorptive properties was selected to be used in its place. The dispersive behavior of the surrogate nuclide would then mimic that of ^{14}C thereby providing a means to estimate the ^{14}C concentration in groundwater. Once a ^{14}C groundwater concentration was estimated, the CEDE for ^{14}C could be determined. Uranium was investigated as a possible surrogate. The uranium sorption coefficient used in the initial analysis was 100 mL/g for concrete and 0.03 mL/g for loam. The carbon K_d values used in this analysis were 100 mL/g for concrete and 20 mL/g for loam. A higher K_d value has the effect of reducing the aqueous phase concentration. Therefore, using uranium as the surrogate contaminant with the previously stated K_d values will result in overestimates of the ^{14}C concentration in groundwater because carbon has a higher sorption coefficient in loam (20 mL/g compared to 0.03 mL/g). The ^{234}U isotope was used as the surrogate because it was represented in Class AB and C waste. Corrections were made for the different nuclide specific decay rates.

For tritium, the dose based on the best estimate inventory is given by

$$D = D_{\text{old}} \times I_{\text{new}}/I_{\text{old}} \quad (5)$$

where

D = radiological dose (50-year committed effective dose equivalent, mrem) for best estimate inventory

D_{old} = dose calculated using initial inventory estimate (mrem)

I_{new} = best estimate inventory (Ci)

I_{old} = initial inventory (Ci).

For Class AB waste, the ^3H dose calculated from the PORFLO generated groundwater concentrations and the initial inventory of 4,650 Ci was 1.3×10^{-10} mrem. The best estimate ^3H inventory was 353,309 Ci. The best estimate ^3H dose is then 1.3×10^{-10} mrem $\times$ 353,309 Ci/4,650 Ci

= 9.9×10^{-9} mrem. For Class C waste, the dose calculated from PORFLO generated groundwater concentrations and an inventory of 7 Ci was 9.8×10^{-13} mrem. The best estimate inventory was 3,770 Ci. Therefore, the ^3H dose for Class C waste is 9.8×10^{-13} mrem $\times$ 3,770 Ci/7 Ci = 5.2×10^{-10} mrem. These doses are notably lower than the 4 mrem/y dose limit.

For the ^{14}C dose calculation, the following equation was used to estimate the dose:

$$D = D_{\text{old}} \times \text{DCF}_{\text{C-14}} \times I_{\text{C-14}} \times \text{DC} / (\text{DCF}_{\text{U-234}} I_{\text{U-234}}) \quad (6)$$

where

D = radiological dose (50-year committed effective dose equivalent, mrem) for best estimate inventory

D_{old} = dose calculated for U-234 using initial inventory (mrem)

$\text{DCF}_{\text{U-234}}$ = dose conversion factor for ^{234}U (mrem/Ci)

$\text{DCF}_{\text{C-14}}$ = dose conversion factor for ^{14}C (mrem/Ci)

$I_{\text{U-234}}$ = initial inventory for ^{234}U (Ci)

$I_{\text{C-14}}$ = ^{14}C inventory (Ci)

DC = decay correction

The decay correction term (DC) is the ratio of the term, $e^{\lambda t}$ for ^{234}U and ^{14}C ($^{234}\text{U}/^{14}\text{C}$) where λ = the decay rate constant and t = the time to maximum (peak) concentration for ^{234}U .

Estimates of the maximum ^{14}C dose using ^{234}U as a surrogate and Equation 6 were 0.77 mrem/y for Class AB waste and 0.016 mrem/y for Class C waste (Table 13). The estimated doses for ^{14}C and ^3H are all below the 4 mrem/y EDE groundwater dose criteria for fission and activation products..

Table 13. Initial and best estimate inventory, peak times, and maximum drinking water doses for ^{234}U and ^{14}C , Class AB and C waste.

	Class AB C-14	Class AB U-234	Class C C-14	Class C U-234
Dose Conversion Factor (mrem/Ci)	2.1E+06	2.8E+08	2.1E+06	2.8E+08
Initial Inventory Estimate (Ci)	none	3.96E-01	none	3.96E-01
Best Estimate Inventory (Ci)	231	n/a	3.77E+03	n/a
Initial ^{234}U Dose Estimate (mrem)	n/a	0.19	n/a	0.01
Peak Time (years)	n/a	1.3E+03	n/a	1.18E+03
Maximum ^{14}C dose (mrem)	0.77	n/a	0.016	n/a
n/a = not applicable				

Note that the ratio of the ^3H dose based on the PORFLO model to that based on the GWSCREEN model was much greater than the similar ratio for ^{14}C . For example, the ^3H dose for Class AB waste and the GWSCREEN model was 1.4×10^4 mrem. The dose using groundwater concentrations calculated with PORFLO was 9.9×10^{-9} mrem. The ratio of the two doses is 1.4×10^{12} . The dose ratio for Class AB ^{14}C was 1.7 mrem/0.77 mrem = 2.2. This difference is due to two factors:

- Tritium has a much shorter half-life than ^{14}C (12.3 years to 5740 year for ^{14}C) Therefore, waste containment increases hold-up time and allows more of the nuclide to decay before coming in contact with water.
- The ^{14}C groundwater concentrations calculated with PORFLO used a K_d value of 0.03 mL/g for the aquifer (loam) compared to 20 mL/g used in the GWSCREEN analysis.

Accounting for the waste facility's engineered barriers and containment structures have a greater effect on doses estimated for short lived nuclides because a greater fraction of the activity decays before water comes in contact with the waste material and leaching begins. For longer lived nuclides (half life >1,000 years), engineered barriers are not as effective in reducing estimated doses. Higher sorption coefficients in the waste form have a greater impact on reducing doses than engineered barriers for long half-lived nuclides because the nuclide leach rates are reduced both before and after failure of the containment system.

6. REFERENCES

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Appendix A

Best Estimate Inventory for Class AB and C Waste

Best estimate inventories for Class AB and C waste were received from W. P. Dornsife of the Pennsylvania Department of Environmental Resources on May 20, 1996. Nuclides were prescreened for the groundwater pathway based on the half-life (see the last column in Tables A-1 and A-2). If the half-life was less than one year, then the nuclide was eliminated from the groundwater pathway analysis.

Table A-1 Best estimate inventories for Class AB waste. The 30 year total is 10 times the "Total A+B" column and was used in the groundwater analysis.

Nuclide	Half-Life		Class A (mCi)	Class B (mCi)	Total A+B (mCi)	30 year total (mCi)	Pre-Screened?
AG-110M	2.50E+02	d	1.06E+04	6.80E+04	7.86E+04	7.86E+05	yes
AM-241	4.32E+02	yr	9.72E+00	3.19E+00	1.29E+01	1.29E+02	
AM-243	7.38E+03	yr	1.00E-03		1.00E-03	1.00E-02	
BA-133	1.05E+01	yr	1.85E+00	4.29E-03	1.85E+00	1.85E+01	
BA-140	1.28E+01	d	3.88E+04	3.33E+03	4.21E+04	4.21E+05	yes
BE-7	5.34E+01	d	1.00E+03		1.00E+03	1.00E+04	yes
C-14	5.73E+03	yr	2.03E+04	2.79E+03	2.31E+04	2.31E+05	
CA-45	1.63E+02	d	3.17E+02		3.17E+02	3.17E+03	yes
CD-109	1.27E+00	yr	4.25E+00	1.32E-02	4.26E+00	4.26E+01	
CE-139	1.38E+02	d	6.42E-01		6.42E-01	6.42E+00	yes
CE-141	3.25E+01	d	3.43E+03	3.47E+02	3.78E+03	3.78E+04	yes
CE-144	2.84E+02	d	1.78E+03	2.70E+02	2.05E+03	2.05E+04	yes
CF-252	2.64E+00	yr	1.00E-03		1.00E-03	1.00E-02	
CL-36	3.01E+05	yr	1.31E+01		1.31E+01	1.31E+02	
CM-242	1.63E+02	d	2.86E+01	3.82E+01	6.67E+01	6.67E+02	yes
CM-243	2.85E+01	yr	3.10E+00	2.12E-01	3.32E+00	3.32E+01	
CM-244	1.81E+01	yr	7.41E+00	5.82E+00	1.32E+01	1.32E+02	
CO-57	2.71E+02	d	4.27E+02	4.45E+03	4.88E+03	4.88E+04	yes
CO-58	7.08E+01	d	2.37E+05	1.02E+06	1.26E+06	1.26E+07	yes
CO-60	5.27E+00	yr	1.76E+06	2.97E+06	4.73E+06	4.73E+07	
CR-51	2.77E+01	d	8.16E+05	1.40E+06	2.21E+06	2.21E+07	yes
CS-134	2.06E+00	yr	1.76E+05	5.87E+05	7.63E+05	7.63E+06	
CS-137	3.00E+01	yr	4.09E+05	8.56E+05	1.27E+06	1.27E+07	
EU-152	1.36E+01	yr	2.53E+01		2.53E+01	2.53E+02	
EU-154	8.60E+00	yr	1.15E-01		1.15E-01	1.15E+00	
EU-155	4.96E+00	yr	1.61E-01		1.61E-01	1.61E+00	
FE-55	2.70E+00	yr	5.20E+06	1.19E+07	1.71E+07	1.71E+08	
FE-59	4.46E+01	d	1.23E+05	5.26E+04	1.76E+05	1.76E+06	yes
GD-153	2.42E+02	d	1.91E+02	2.91E+02	4.83E+02	4.83E+03	yes
GE-68	2.71E+02	d	2.41E-01		2.41E-01	2.41E+00	yes
H-3	1.23E+01	yr	3.11E+06	3.22E+07	3.53E+07	3.53E+08	
HF-181	4.24E+01	d	5.07E+02		5.07E+02	5.07E+03	yes
I-125	6.01E+01	d	1.26E+04	1.11E+02	1.27E+04	1.27E+05	yes

Nuclide	Half-Life		Class A (mCi)	Class B (mCi)	Total A+B (mCi)	30 year total (mCi)	Pre-Screened?
I-129	1.57E+07	yr	3.31E-01	8.06E-02	4.11E-01	4.11E+00	
I-131	8.04E+00	d	1.62E+05	1.87E+04	1.81E+05	1.81E+06	yes
IR-192	7.40E+01	d	1.12E+01		1.12E+01	1.12E+02	yes
MN-54	3.13E+02	d	1.82E+06	1.58E+06	3.40E+06	3.40E+07	yes
NA-22	2.60E+00	yr	1.37E+01	2.02E-02	1.37E+01	1.37E+02	
NB-94	2.03E+04	yr	7.74E+00	1.90E+01	2.68E+01	2.68E+02	
NB-95	3.51E+01	d	2.33E+03	1.48E+03	3.81E+03	3.81E+04	yes
NI-59	7.50E+04	yr	1.52E+03	3.52E+03	5.03E+03	5.03E+04	
NI-63	1.00E+02	yr	1.25E+05	4.69E+05	5.94E+05	5.94E+06	
NP-237	2.10E+06	yr	0.00E+00		0.00E+00	0.00E+00	
P-32	1.43E+01	d	1.87E+03	1.25E+02	2.00E+03	2.00E+04	yes
P-33	2.54E+01	d	1.20E+01	1.00E-01	1.21E+01	1.21E+02	yes
PB-210	2.23E+01	yr	7.33E+00	6.50E-02	7.39E+00	7.39E+01	
PM-147	2.62E+00	yr	9.04E+02	1.73E+00	9.05E+02	9.05E+03	
PO-210	1.38E+02	d	1.06E+01		1.06E+01	1.06E+02	yes
PU-238	8.78E+01	yr	1.33E+01	1.82E+01	3.15E+01	3.15E+02	
PU-239	2.41E+04	yr	1.73E+01	5.51E+00	2.28E+01	2.28E+02	
PU-240	6.57E+03	yr	3.49E+00	1.29E+00	4.79E+00	4.79E+01	
PU-241	1.44E+01	yr	1.51E+03	1.12E+03	2.63E+03	2.63E+04	
PU-242	8.30E+07	yr	0.00E+00		0.00E+00	0.00E+00	
RA-226	1.60E+03	yr	7.43E-01		7.43E-01	7.43E+00	
RB-86	1.02E+00	min	1.25E+02	1.00E-02	1.25E+02	1.25E+03	yes
RU-103	3.94E+01	d	3.26E+01	3.11E+02	3.44E+02	3.44E+03	yes
RU-106	3.68E+02	d	3.48E+02		3.48E+02	3.48E+03	yes
S-35	8.74E+01	d	4.89E+03	1.43E+02	5.03E+03	5.03E+04	yes
SB-124	6.02E+01	d	2.92E+03	9.41E+03	1.23E+04	1.23E+05	yes
SB-125	2.77E+00	yr	4.17E+03	5.78E+03	9.95E+03	9.95E+04	
SC-46	8.38E+01	d	2.16E+01		2.16E+01	2.16E+02	yes
SE-75	1.20E+02	d	5.42E-01		5.42E-01	5.42E+00	yes
SN-113	2.14E+01	min	4.51E+01	2.28E+03	2.32E+03	2.32E+04	yes
Sr-85	6.48E+01	d	1.66E+01		1.66E+01	1.66E+02	yes
Sr-89	5.05E+01	d	3.56E+03	2.78E+04	3.14E+04	3.14E+05	yes
Sr-90	2.91E+01	yr	4.04E+03	1.32E+04	1.73E+04	1.73E+05	
Ta-182	1.15E+02	d	2.85E+01	1.00E-03	2.85E+01	2.85E+02	yes
Tc-99	2.13E+05	yr	6.99E+00	3.94E+00	1.09E+01	1.09E+02	
Te-125M	5.80E+01	d	2.02E+01	4.91E+00	2.51E+01	2.51E+02	yes
Th (NAT.)	---	---	2.39E+01		2.39E+01	2.39E+02	yes
TH-228	1.91E+00	yr	7.37E-02		7.37E-02	7.37E-01	
Th-230	7.70E+04	yr	3.98E-01		3.98E-01	3.98E+00	
Th-232	1.41E+10	yr	3.79E+01		3.79E+01	3.79E+02	
Th-234	2.41E+01	d	1.63E+01		1.63E+01	1.63E+02	yes
TRU	---	---	3.97E+01		3.97E+01	3.97E+02	yes
U (NAT.)	---	---	1.87E+01		1.87E+01	1.87E+02	yes
U-232	7.20E+01	yr	2.48E-01		2.48E-01	2.48E+00	
U-233	1.59E+05	yr	1.92E+01		1.92E+01	1.92E+02	
U-234	2.45E+05	yr	8.28E+00		8.28E+00	8.28E+01	

Nuclide	Half-Life		Class A (mCi)	Class B (mCi)	Total A+B (mCi)	30 year total (mCi)	Pre-Screened?
U-235	7.04E+08	yr	2.81E-01		2.81E-01	2.81E+00	
U-236	2.43E+07	yr	0.00E+00		0.00E+00	0.00E+00	
U-238	4.47E+09	yr	2.52E+01		2.52E+01	2.52E+02	
Y-88	1.07E+02	d	5.45E-01		5.45E-01	5.45E+00	yes
Zn-65	2.44E+02	d	1.79E+06	2.59E+06	4.39E+06	4.39E+07	yes
Zr-95	6.40E+01	d	6.14E+02	3.06E+02	9.20E+02	9.20E+03	yes

Table A-2 Best estimate inventories for Class C waste. The 30 year total is 10 times the "Total Class C" column and was used in the groundwater analysis.

Nuclide	Half-Life		Class C (mCi)	Total Class C (mCi)	Pre-Screened?
Ag-110M	2.50E+02	d	1.42E+03	1.42E+04	yes
Am-241	4.32E+02	yr	1.51E+00	1.51E+01	
Am-243	7.38E+03	yr	1.44E-03	1.44E-02	
Ba-133	1.05E+01	yr	1.00E-02	1.00E-01	
Ba-140	1.28E+01	d	1.73E+01	1.73E+02	yes
Be-7	5.34E+01	d	1.22E+03	1.22E+04	yes
C-14	5.73E+03	yr	8.84E+03	8.84E+04	
CD-109	1.27E+00	yr	7.63E-02	7.63E-01	
CE-139	1.38E+02	d	2.30E-03	2.30E-02	yes
Ce-141	3.25E+01	d	6.99E-01	6.99E+00	yes
Ce-144	2.84E+02	d	3.86E+04	3.86E+05	yes
CM-242	1.63E+02	d	3.46E+01	3.46E+02	yes
CM-243	2.85E+01	yr	5.74E-01	5.74E+00	
CM-244	1.81E+01	yr	1.86E+00	1.86E+01	
Co-57	2.71E+02	d	3.03E+03	3.03E+04	yes
Co-58	7.08E+01	d	9.19E+05	9.19E+06	yes
Co-60	5.27E+00	yr	7.75E+07	7.75E+08	
Cr-51	2.77E+01	d	1.23E+06	1.23E+07	yes
Cs-134	2.06E+00	yr	5.73E+03	5.73E+04	
Cs-137	3.00E+01	yr	4.22E+04	4.22E+05	
Eu-154	8.60E+00	yr	0.00E+00	0.00E+00	
Eu-155	4.96E+00	yr	0.00E+00	0.00E+00	
Fe-55	2.70E+00	yr	1.03E+08	1.03E+09	
Fe-59	4.46E+01	d	8.15E+04	8.15E+05	yes
H-3	1.23E+01	yr	3.77E+05	3.77E+06	
I-129	1.57E+07	yr	8.65E-02	8.65E-01	
I-131	8.04E+00	d	9.48E+02	9.48E+03	yes
Mn-54	3.13E+02	d	1.08E+07	1.08E+08	yes
Nb-94	2.03E+04	yr	1.58E+02	1.58E+03	
Nb-95	3.51E+01	d	3.06E+04	3.06E+05	yes
Ni-59	7.50E+04	yr	5.90E+04	5.90E+05	
Ni-63	1.00E+02	yr	4.38E+06	4.38E+07	
Np-237	2.10E+06	yr	7.86E-03	7.86E-02	

Nuclide	Half-Life		Class C (mCi)	Total Class C (mCi)	Pre-Screened?
P-32	1.43E+01	d	1.59E+03	1.59E+04	yes
Pb-10	2.23E+01	yr	2.00E+01	2.00E+02	
Pm-47	2.62E+00	yr	0.00E+00	0.00E+00	
Pu-238	8.78E+01	yr	1.22E+01	1.22E+02	
Pu-239	2.41E+04	yr	9.71E-01	9.71E+00	
Pu-240	6.57E+03	yr	0.00E+00	0.00E+00	
Pu-241	1.44E+01	yr	1.86E+03	1.86E+04	
Pu-242	8.30E+07	yr	7.93E-06	7.93E-05	
Ra-226	1.60E+03	yr	0.00E+00	0.00E+00	
Ru-103	3.94E+01	d	2.08E+03	2.08E+04	yes
Ru-106	3.68E+02	d	3.03E+03	3.03E+04	yes
Sb-124	6.02E+01	d	2.54E+02	2.54E+03	yes
Sb-125	2.77E+00	yr	3.55E+04	3.55E+05	
Sn-113	2.14E+01	min	2.74E+02	2.74E+03	yes
Sr-89	5.05E+01	d	6.09E+02	6.09E+03	yes
Sr-90	2.91E+01	yr	1.30E+02	1.30E+03	
Tc-99	2.13E+05	yr	5.61E-01	5.61E+00	
Te-125M	5.80E+01	d	9.02E+01	9.02E+02	yes
TRU	---	---	4.67E-01	4.67E+00	yes
U-234	2.45E+05	yr	0.00E+00	0.00E+00	
U-235	7.04E+08	yr	0.00E+00	0.00E+00	
U-236	2.43E+07	yr	0.00E+00	0.00E+00	
U-238	4.47E+09	yr	0.00E+00	0.00E+00	
Y-88	1.07E+02	d	7.60E-03	7.60E-02	yes
Zn-65	2.44E+02	d	3.93E+05	3.93E+06	yes
Zr-95	6.40E+01	d	4.04E+03	4.04E+04	yes

Appendix B

Concrete Degradation and Steel Reinforcement Corrosion

A waste containment system consisting of a concrete outer shell, concrete overpacks, and sand backfill has been developed for use in the disposal of low-level radioactive waste (LLW) in Pennsylvania. The concrete overpacks provide primary containment during vault operations, and the concrete shell provides structural stability for the disposal and will also act as a hydrologic barrier until failure due to fracturing or complete degradation. The models described below provide estimates of concrete degradation and rebar corrosion due to reactions with soil water chemical constituents in contact with the concrete vault. A water composition data set was selected based on availability because a site has not been selected for the facility. The degradation processes have been modeled separately rather than integrated because degradation is typically dominated by a single process. Parametric estimates of degradation are used to evaluate wide ranges of scenarios. Fractures that run the entire height of the vaults are assumed to occur at 500 years, and complete hydrologic failure occurs at 1,000 years as a first approximation. This assumption was based on calculations made for the Savannah River Plant Intermediate Level Non-Tritium waste vaults. Because the vault design has not been finalized, the effort for this level of calculation is not warranted.

Disposal Vault Description

As discussed previously in the document, the vaults that will contain the Class A and B waste have dimensions of 122 m x 610 m x 7.6 m and Class C vaults have dimensions of 24 m x 49 m x 3 m. Vault floors and roofs will be comprised of 24-inch thick steel reinforced concrete, and the sidewalls will be 20-inch thick steel reinforced concrete with a minimum rebar coverage of 3 inches. The mix design used in the concrete degradation estimates is shown in Table 1.

Table 1. Concrete mix design for low-level waste vaults.

Component	Weight Percent	Lbs/Yd ³
Type II OPC	14.7	674
Fly Ash	3.67	168.3
Sand	29.88	1370
Fine Aggregate	5.75	263.6
Small Aggregate	14.7	674
Medium Aggregate	31.25	1432.8
Water	NA	256
Total		4841

Groundwater Chemistry Data

A groundwater composition was selected from the literature based on availability because no site has been selected for the LLW facility at the time of these calculations. The groundwater composition selected (Table 2) is from a Mississippian Sandstone from Crawford County, PA (Todd 1980). How representative this water composition is of waters that will be present at the selected site is unknown. Degradation estimates have been made with varying component concentrations to evaluate the impact of different water compositions. The key component concentrations for concrete degradation are calcium, inorganic carbon, magnesium, sulfate, chloride, and oxygen. Refinements to the calculations based on site-specific water composition data may be needed upon final site selection.

Table 2. Groundwater composition data.

Component	Concentration (mg/L)	Concentration (M)
SiO ₂	14	2.33E-4
Fe	1.3	2.32E-5
Ca	44	1.10 E-3
Mg	11	4.53E-4
Na	60	2.61E-3
K	4.1	1.05E-4
HCO ₃	327	5.36E-3
SO ₄	22	2.30E-4
Cl	4.4	1.24E-4
F	0.2	1.05E-5
NO ₃	2.0	3.22E-5

Other parameters: Specific Conductance 533, pH 7.4, PO₄, Al, Mn, Cu, Zn, and CO₃ were below detection limits.

Concrete Degradation Modeling Approach

The models described by Walton et al. (1990) were used to estimate concrete degradation and rebar corrosion processes. Concrete degradation processes considered are (1) magnesium and sulfate attack, (2) calcium leaching (both geologically and concrete controlled), and (3) carbonation. Rebar corrosion due to chloride attack and oxygen limited corrosion are also considered for the vaults. A brief discussion of each process considered is provided along with estimated degradation and corrosion rates for the concrete and rebar, respectively.

Magnesium and Sulfate Attack

Degradation of cement can involve reaction of magnesium (Mg) and sulfate (SO_4) contained in contact water with a solid phase in the cement. The solid formed by the reaction has a greater volume than the solid it replaced (e.g., sulfate reacting with portlandite to form gypsum, monosulphoaluminate, and ettringite) causing stress, and possible cracking and/or exfoliation of the concrete. This type of concrete degradation has been modeled based on observations made during the Norwick Park study in which the loss of cement at concrete block corners was measured after 5 years of exposure to a 0.19 mole/L Na_2SO_4 solution. The loss rate indicates a linear relationship with time and is assumed to be proportional to SO_4 concentration in the solution and tricalciumaluminate (C3A) content in the cement. Concrete degradation in a MgSO_4 solution is approximately twice that found in comparable Na_2SO_4 solutions. This is attributed to reactions between magnesium (Mg) and C3A as well as sulfate and C3A reactions. Therefore, the depth of degradation is estimated based on Mg and SO_4 concentrations in the contact water and the amount of C3A in the cement (Equation 1).

$$MS_x = 0.55 \times C3A \times C_{MgSO_4} \times t \quad (1)$$

where: MS_x penetration depth of Mg plus SO_4 attack (cm).
C3A weight percent of C3A in unhydrated cement (unitless)
 C_{MgSO_4} concentration of Mg plus SO_4 in contact water (mole/L)
t time (years).

Initial estimates of MgSO_4 degradation used a C3A value of 8 weight percent (Rust Geotech) and a Mg plus SO_4 concentration of $6.83\text{E-}4$ mole/Liter (see groundwater composition section), respectively. The C3A value is an upper bound as specified in the concrete mix design. These parameter values result in approximately 15-cm (6 inches) of concrete degradation and does not impact the hydrologic integrity of the vault until well after the failure time of 1,000 years used in the transport modeling.

A parametric evaluation of magnesium and sulfate attack was conducted in order to address some of the uncertainties in the model and the parameter values used in the calculation. Concrete degradation as a function of MgSO_4 concentration in the contact water and time is shown in Figure 2. These parameters were selected because all other parameters are constants in this case. The estimate was conducted for the time to complete hydrologic failure (1,000 years) used in the transport modeling. Contact water Mg plus SO_4 concentrations were varied an order of magnitude above and below the concentration indicated in the water chemistry data ($\sim 10^{-3}$ M).

Figure 1. Magnesium and sulfate attack on concrete using 8 weight percent tricalcium aluminate and a Mg plus SO₄ concentration of 6.83E-4 M.

Figure 2. Concrete degradation as a function of time and magnesium plus sulfate water concentrations.

The parametric evaluation indicates that over the time period of interest, magnesium plus sulfate concentrations less than 10^{-3} M have negligible impact on the concrete vaults from a hydrologic performance perspective (20-inch or 50-cm thickness). Mg plus SO_4 concentrations between 10^{-3} to 10^{-2} M predicted degradation ranges from approximately 30 to 100 percent degradation at 5,000 years. At the maximum concentration used, the vault will be severely degraded at 1,000 years. Without site-specific information, it is not possible to determine the potential for these high concentrations of Mg plus SO_4 . In general, Mg and SO_4 concentrations in the upper range selected in this evaluation are present in arid environments and are not likely in the northeastern U.S. Sulfur resistant cements, which contain less C3A, could be used to lessen the impact of high concentration Mg plus SO_4 solution - if these are found to be a problem after a site has been selected. It has also been found that reducing the water-to-cement ratio will improve the lifetime of concrete significantly due to the associated decrease in cement porosity and permeability (Stark, 1982).

Calcium Leaching

Leaching of cement components occurs due to water contact with the cements under conditions of high water percolation. The movement of water through the cement causes the initial loss of alkali components (e.g., Na and K) with later removal of calcium hydroxide, which results in reduced cement strength. Experimental and modeling techniques (Atkinson, 1985; Atkinson et al., 1988) of the leaching process have resulted in the identification of four stages in the leaching process:

- 1) Alkali metal oxides and hydroxides control pH at approximately 13.
- 2) Controls pH at 12.5 following leaching of alkali metals.
- 3) Calcium silicate hydrate gel phases begin to dissolve incongruently following loss of $\text{Ca}(\text{OH})_2$ and the pH slowly moves to 10.5.
- 4) Congruent dissolution of calcium silicate hydrate gel holds pH at 10.5.

Two models have been developed to describe leaching based on the material controlling the rate of degradation (i.e., concrete and geology controlled leaching). Each of these models have some common parameters, although the geology controlled leaching model requires additional parameters that involve the properties of the surrounding material. Concrete controlled leaching has been described by a shrinking core model (Atkinson and Hearne, 1984). This model assumes that removal of Ca from the exterior of the concrete is rapid relative to the movement of Ca through the concrete (i.e., diffusion controlled release). This results in the formation of a sharply delineated rind of altered concrete surrounding an intact inner zone of concrete.

Concrete controlled leaching assumes that water tends to flow through the more permeable materials that surround the intact concrete structure rather than into the concrete. The permeability and subsequent flow rate in leached/degraded concrete will be greater than for intact concrete. This may lead to conditions such that diffusion is no longer the dominant mode of transport. The intrinsic diffusion coefficient (D_i) in the model is for the degraded portion of the concrete (Equation 2). An initial estimate of 10^{-6} cm^2/s for the diffusion coefficient was used for modeling. This is a conservative value considering that the free water diffusion coefficient is 10^{-5} cm^2/s . Calcium concentrations in the pore water, groundwater, and bulk concrete are $2.7\text{E-}3$ moles/Liter (Walton et al., 1990), $1.1\text{E-}3$ moles/Liter (44 ppm), and 1.85 moles/L, respectively.

$$CL_x = \left(2Di \left(\frac{Ca_{pw} - Ca_{gw}}{Ca_{cs}} \right) t \right)^{1/2} \quad (2)$$

CL _x	leaching penetration depth (cm)
Di	intrinsic diffusion coefficient of Ca in concrete (cm ² /second)
Ca _{pw}	concentration of Ca in concrete pore water liquid (moles/cm ³)
Ca _{gw}	concentration of Ca in groundwater or soil water (moles/cm ³)
Ca _{cs}	bulk concentration of Ca in concrete solid (moles/cm ³)
t	time (seconds).

Estimated degradation resulting from concrete controlled leaching with the parameter values listed is negligible. At 5,000 years, the depth of degradation is approximately half a centimeter (0.2 inches). Increasing the diffusion coefficient to its maximum value of 10⁻⁵ cm²/s results in only 1.5-cm of degradation (see Appendix B Attachment I for degradation plots). The diffusion coefficient was varied to this extent because this is the parameter that is the most poorly defined. Using the free water diffusion coefficient insures that the evaluation is conservative from this perspective.

Geologically Controlled Calcium Leaching becomes important when diffusion of calcium into the material surrounding the concrete controls the leaching rate. Atkinson and Hearne (1984) developed a model to evaluate leaching under these conditions (Equation 3). In this case, the parameters related to transport are for the geologic material and not the concrete.

The lack of site information requires the use of hypothetical parameter values for the media properties that surround the concrete vaults. The porosity of the geologic material is assumed to be 30 percent, the retardation factor for calcium in the geologic material is 5, and the effective diffusion coefficient is assumed to be 10⁻⁶ cm²/s.

$$GL_x = 2\phi \frac{Ca_{pw} - Ca_{gw}}{Ca_{cs}} \left(\frac{R_d D_e t}{\pi} \right)^{1/2} \quad (3)$$

GL _x	distance of leaching penetration (cm)
Ca _{pw}	calcium concentration in the concrete pore water (moles/cm ³)
Ca _{gw}	calcium concentration in the groundwater (moles/cm ³)
Ca _{cs}	concentration of calcium in the bulk concrete (solid + pores) (moles/cm ³)
R _d	retardation factor (unitless)
φ	porosity of the geologic material (unitless)
D _e	effective diffusion coefficient for the geologic material (cm ² /second)
t	time (seconds).

As with concrete controlled leaching, no significant loss of concrete is predicted considering geologically controlled leaching. The leaching evaluation may need to be updated after a site has been selected and characterized for the low-level radioactive waste disposal facility to determine if the assumed values are appropriate.

Carbonation

Carbonation involves the reaction of carbonate in infiltrating water or carbon dioxide in the vapor phase with calcium hydroxide in cement to form carbonates. This process does not decrease the effective thickness of the concrete as other degradation processes, but it can cause minor shrinkage or decrease the pH of the cement. Shrinkage due to carbonation is thought to occur as minerals are removed from the areas of compressive stress and redeposited in regions of lower stress. The strength of concrete generally increases under carbonation with the exception of high sulfate concretes. Carbonation forces the local pH toward neutrality, going from over 12 to about 8, thereby removing some chemical barrier benefits of the concrete and providing a potentially corrosive environment for steel reinforcements if water, moisture and oxygen can penetrate.

The rate of carbonation is dependent upon water saturation or relative humidity of the environment. As relative humidity increases from 0 to 100%, the rate of carbonation passes through a maximum at 50% (Verbeck, 1958). The maximum rate of carbonation occurs because the availability of water limits the reaction of carbon dioxide with calcium hydroxide to form calcium carbonate up to a relative humidity of 50%. The decrease in carbonation above 50% relative humidity results from the decrease in the diffusion rate of carbon dioxide as the water content increases in the concrete (vapor phase diffusion is approximately four orders of magnitude more rapid than aqueous diffusion). Aqueous phase diffusion generally controls the transport of carbon dioxide in concrete even in the vadose zone because the concrete tends to stay saturated due to small pore sizes relative to surrounding material.

A shrinking core model for carbonation can be formulated by evaluating the migration rate of carbon dioxide into the saturated concrete in relation to the initial amount of calcium hydroxide (Equation 4). The assumption that 40% of the total CaO is hydrated ($\text{Ca}(\text{OH})_2$) has been used in the calculations. Complete hydration of the cement seldom occurs and a value of 40% is a reasonable approximation of the probable hydration level. The range of CaO for portland cement ranges from 60 to 67% with a value of 65% being selected for the carbonation estimates. The range of diffusion coefficient for carbonate used in the calculations was from 10^{-8} to 10^{-5} cm^2/sec . These values bound the diffusion of carbonate in intact concrete to the free water diffusion coefficient, respectively. The bicarbonate concentration in the Pennsylvania groundwater composition used in the calculations is $5.36\text{E-}3$ M (327 ppm).

$$\text{Carb}_x = \left(2D_i \frac{C_{gw}}{C_{ab}} t \right)^{1/2} \quad (4)$$

Carb_x	distance of carbonation penetration (cm)
D_i	intrinsic diffusion coefficient of Ca in concrete ($\text{cm}^2/\text{second}$)
C_{gw}	concentration of total inorganic carbon in ground or soil water (moles/cm^3)
C_{ab}	bulk concentration of calcium hydroxide in concrete solid (moles/cm^3)
t	time (seconds).

Carbonation evaluations were made over a range of inorganic carbon concentrations of 5×10^{-2} to 5×10^{-4} M to estimate the impact of variation in this parameter on the carbonation penetration over time. Results using a diffusion coefficient of 10^{-6} cm^2/s indicate that the lower concentration will not penetrate the vault wall thickness until well after the 5,000 year time period. Also, the depth of carbonation will not reach the

steel reinforcement (assuming a 3-inch coverage) before 4,000 years after the vaults are capped. High carbon concentrations show a much more rapid carbonation of the vault. In this case, the entire wall thickness will be carbonated in 1,400 years. Using the groundwater concentration for carbon estimates a 30-cm carbonation depth at 5,000 years and approximately 300 years to reach the steel reinforcement. It is important to keep in mind that the diffusion coefficient used in these calculations is conservative for intact concrete and the that carbon concentrations may be higher than the groundwater at the actual site location.

The depth of carbonation has also been evaluated over a range of carbon diffusion coefficients ranging from intact concrete to diffusion in water (Figure 3). Results indicate that for diffusion coefficients pertaining to intact to partially intact concrete carbonation will not penetrate the entire vault wall thickness until after 5,000 years. The steel reinforcement may be subjected to reduced pH due to carbonation after 1,000 years for all but the completely intact concrete case. It may be beneficial to place the rebar deeper into the concrete to provide longer protection to the reinforcing steel if this does not pose a construction problem.

Figure 3. Depth of carbonation over a range of diffusion coefficients representing intact concrete to diffusion in water.

Steel Reinforcement Corrosion

One of the properties of concrete that makes it an attractive material for use in low-level radioactive waste disposal structures is its high compressive strength. However, concrete has a relatively low tensile strength. Steel reinforcement is used in concrete to increase tensile strength of structures. The concrete cover over the steel reinforcement provides a protective environment from corrosive agents such as oxygen and chloride by creating a passivation layer around the steel. Breakdown of the passivation layer allows corrosion to occur, which over time will reduce the tensile strength of the concrete structure and may result in structural instability. Also, the steel corrosion products have a greater molar volume than the solids they replace. This expansion can cause spalling or cracking of the concrete, thereby increasing the permeability of the concrete.

Prediction of steel reinforcement corrosion is conducted by viewing the time to breakup of the passivation layer (initiation of corrosion) and corrosion rate subsequent to breakup of the passivation layer separately. An empirical model for time to onset of corrosion and a corrosion rate model are used to calculate these processes.

Chloride Attack involves the disruption of the passive layer that has historically been associated with contacting the steel reinforcement with chloride ions (ACI, 1985). The chloride concentration that will lead to steel corrosion decreases with reduced alkalinity in the concrete because the passivation layer is less stable. Depassivation of steel reinforcement can occur when the pH near the rebar drops below 9 (Papadakis et al., 1989). As stated previously, carbonation and leaching are processes that will lead to gradual lowering of pH and eventual loss of passivity. In low chloride environments, carbonation or leaching may be important processes in depassivation. For the Pennsylvania vaults, carbonation and leaching are not significant processes over the time frame requiring an intact hydrologic barrier. Decreasing the pH of the concrete below 9 generally takes on the order of thousands to millions of years because the processes that cause the pH to drop are slow (Walton et al., 1990).

The empirical model to predict the time to depassivation was developed by Stratful and modified by Clear (1976). Clear's study of steel corrosion in concrete slabs indicates a link between the time until depassivation with the depth of cover over the reinforcement and the water cement ratio. The chloride content of the contact water is also a factor in the estimating the time to onset of steel corrosion (Equation 5). Potential limitations of this model are that the observations that were used as a basis for the model are for corrosion of bridge decks and that soils do not typically have chloride concentrations in this range. Also, the model does not consider a chloride threshold that would negate corrosion at some low chloride concentrations (thought to be a conservative limitation).

The parameters required for this model are the concrete coverage over the steel reinforcement, the water to cement ratio, and the chloride concentration in the contact water. The concrete mix design and the vault design specify a water-to-cement ratio of 0.38 and a minimum steel reinforcement coverage of 3 inches. The chloride concentration used in the corrosion estimate (1.24×10^{-4} M or 4.4 ppm) is taken from the water chemistry described above.

$$CL_t = \frac{129cov^{1.22}}{wcrcl_{gw}^{0.42}} \quad (5)$$

CL_t	time to onset of corrosion (year)
cov	thickness of concrete over the rebar (inches)
wcr	water to cement ratio (by mass)
cl_{gw}	chloride ion concentration in the groundwater (ppm)

These model parameters were used as a basis to estimate time to onset of steel reinforcement corrosion. The time to onset of corrosion was evaluated by varying the chloride concentration from 10^{-4} to 10^{-2} moles/L at the concrete coverage at the water-to-cement ratio listed above. Time to depassivation ranges from 700 to 100 years under these conditions (see Attachment I, Appendix B). The reference water composition for the evaluation is approximately 10^{-4} moles/L indicating that depassivation could take a significant amount of time.

Time to onset of corrosion was also evaluated for a range of reinforcement depths from 2.5 to 20 cm (1 to 8 inches) within the concrete using the reference water chloride concentration. Results indicate that placing the reinforcement deeper into the concrete (20 cm or 8 inches) would increase the time to onset of corrosion from 700 years to 2,400 years. Increasing the coverage would also provide additional time before leaching or carbonation could increase corrosion.

Figure 4. Time to onset of corrosion for variable coverages of steel reinforcement at 1.24×10^{-4} M chloride concentrations.

Oxygen Diffusion Limited Rebar Corrosion can begin following the disruption of the passivation layer surrounding the rebar by chloride attack. The smoothest way of modeling corrosion of rebar is to assume that diffusion limits the supply of oxygen to the rebar for reaction. Corrosion is then a factor of the diffusion rate and contact water concentration of oxygen, the diameter and spacing of the rebar, and the coverage thickness of concrete over the rebar (Equation 6). The model does not account for the increased transport rate of oxygen to the rebar as the effective thickness of the concrete is decreased due to concrete degradation processes. This is not practical given the lack of site-specific data available for use in the modeling. To compensate for this, the time to onset of corrosion is neglected and corrosion is initiated at the time of emplacement.

The rebar used in the modeling is assumed to be #4 (0.5-inch diameter) in size on 1-foot spacing with 3 inches of concrete coverage. The oxygen concentration in water in equilibrium with the atmosphere is approximately 10 ppm or 3.125E-4 moles/Liter and will be used in the corrosion calculations because no other data are available. Several diffusion coefficients for oxygen in concrete have been used because this is the parameter with the most uncertainty.

$$RR = \left(1 - \frac{4 \times 9 \frac{cm^3}{mole} sr D_i o_{gw} t}{\pi d^2 cov} \right) 100 \quad (6)$$

RR	percent rebar remaining
cov	depth of reinforcement below surface (cm)
D_i	oxygen diffusion coefficient in concrete (cm ² /second)
o_{gw}	concentration of oxygen in surrounding groundwater (mole/cm ³)
d	diameter of reinforcement (cm)
sr	spacing between reinforcement bars (cm)
t	time (seconds).

Results of these calculations show that 4 percent of the rebar is lost using an intact concrete diffusion coefficient of 10⁻⁷ cm²/s. A diffusion coefficient of 2 x 10⁻⁶ cm²/s causes a significant increase in the degradation rate. At 1,000 years, only 40 percent of the rebar remains. The worst-case scenario, which uses the free water diffusion coefficient, indicates that all the rebar will be corroded after 350 years. This is highly conservative and should be used only as an estimate of the upper bound. If we consider the time to onset of corrosion (700 years), the amount of rebar remaining at 1,000 years is approximately 90 percent using a diffusion coefficient appropriate for degraded concrete (2 x 10⁻⁶ cm²/s).

Figure 5. Percent steel reinforcement remaining considering three oxygen diffusion coefficients.

Summary of Degradation and Corrosion Estimates

Magnesium and sulfate attack, calcium leaching, carbonation of the concrete and rebar corrosion are not significant degradation processes in the "Proposed Environment." Based on these "Environmental" assumptions, the concrete vault shell will not be degraded due to any of the modeled processes for at least 1,000 years. Magnesium and sulfate attack has the greatest impact on the concrete and is predicted to reach the rebar in approximately 3,000 years. This would result in more rapid corrosion of the rebar, but will not impact the vault performance if the vault interior is backfilled.

Results indicate that moving the steel reinforcement deeper into the concrete would enhance the long-term durability of the vaults by keeping the passivation layer stable for a longer period of time. The concrete mix design might be modified after site selection to optimize the long-term performance of the vault.

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Appendix C

Engineering Design File for Sorption Coefficients

ENGINEERING DESIGN FILE

Project/Task Pennsylvania Performance Assessment SupportSubtask Distribution Coefficients Selection for PA'sEDF Page 1 of 13

TITLE: Distribution Coefficients

SUMMARY

This EDF documents the definition of distribution coefficients (K_d) and how K_d 's are determined by experimental methods or selected by literature review for use in Performance Assessments (PA). This document describes how distribution coefficients are determined by batch and column experiments and how K_d 's are selected for use in performance assessments. The primary focus will be on selection K_d 's for use in PA and the important aspects to consider during the selection process. Contaminant movement is a function of water movement through the subsurface and geochemical interactions between the porous media, groundwater, and contaminant. The majority of current transport models depend upon K_d 's to predict the geochemical interactions between contaminants and porous media because it is the least complex numerical means of describing sorption. The K_d used in transport modeling is a bulk term that encompasses all processes that remove a contaminant from the solution and is defined as the amount of contaminant removed from solution per mass of solid (S) divided by the amount of contaminant in a volume of solution (C) (typical units are mL/g).

$$K_d = \frac{S}{C}$$

Distribution coefficients are used in all phases of the groundwater pathway analysis in PA. Screening calculations use K_d 's to determine which contaminants are key to the performance of the facility. Soil or geologic material K_d values required for screening are generally taken from available literature because site specific K_d 's are not available. Key contaminants are modeled using a numerical flow and transport code to predict movement considering the wide variety of materials associated with the disposal facility (e.g. grout/concrete, clay, sand and gravel). The equation that forms the basis for both screening and numerical contaminant movement evaluations is given below. More detailed evaluation of the K_d is recommended for this portion of the PA and may require experimental determinations with site-specific materials.

$$V_c = \frac{V_w}{1 + \frac{\rho_b}{\theta} K_d}$$

where ρ_b = bulk density of geologic material, θ = porosity of geologic material,
 V_c = velocity of the contaminant, V_w = velocity of the water

Controls on contaminant removal from solution can be separated into solid characteristics and solution composition for field conditions. Laboratory experiments have additional controls such as the solid solution ratio and contact time in addition to the field controls. Ion exchange, non-specific adsorption, specific adsorption, and precipitation are the mechanisms that are associated with the solid phase characteristics. Solution characteristics are inorganic or organic complexation and colloid formation that result in changes in solution speciation. A brief description of each mechanism that contributes to the partitioning of contaminants is given in the EDF.

Distribution (complete package):
 Distribution (summary page only):

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DISTRIBUTION COEFFICIENTS IN PERFORMANCE ASSESSMENT

Regulations for the siting and design of Low-Level Waste (LLW) facilities requires that the movement of contaminants in the local environment be addressed as part of a Performance Assessment (PA). Contaminant movement is a function of water movement through the subsurface and geochemical interactions between the porous media, groundwater, and contaminant. The majority of current transport models depend upon distribution coefficients (K_d) derived from linear isotherms to predict the geochemical interactions between contaminants and the porous media. The distribution coefficient is defined as the amount of contaminant removed from solution per mass of solid divided by the amount of contaminant in a volume of solution (typical units are mL/g).

Distribution coefficients are used in all phases of the groundwater pathway analysis in Performance Assessment. Screening calculations use K_d 's to determine which contaminants are key to the performance of the facility (Seitz, 1995). Soil or geologic material K_d values are required for this portion of the PA and are often taken from available literature because site specific K_d 's are not available. The movement of key contaminants identified in the screening calculations are modeled using a groundwater flow and transport code to predict if regulatory limits will be exceeded. A more rigorous evaluation of the distribution coefficients used in this portion of the PA is often necessary. Also, a wide variety of materials associated with the disposal facility (e.g. grout/concrete, clay, sand and gravel) as well as the local soil or geologic material will need distribution coefficients for transport modeling. These values are obtained from site specific experiments if available, literature review, or calculated using available information.

This document describes how distribution coefficients are determined by batch and column experiments and how K_d 's are selected for use in performance assessments. The primary focus will be on selection K_d 's for use in PA and the important aspects to consider during the selection process. The Langmuir and Freundlich isotherms that are used in some transport codes to describe sorption will be briefly described in Appendix A.

Sorption in Contaminant Transport Modeling

Contaminant mobility is one of the key criteria in evaluating performance assessment of Low-Level Waste (LLW) disposal facilities. Mobility of contaminants is generally incorporated into transport codes by means of the Retardation Factor (R_f). The Retardation Factor is used to approximate the movement of contaminants in groundwater (Equation 1).

$$R_f = 1 + \frac{\rho_b S}{\theta C} \quad (1)$$

where R_f = retardation factor,
 ρ_b = bulk density of geologic material,
 θ = porosity of geologic material,
 S = mass of contaminant adsorbed per unit mass of geologic material, and
 C = mass of contaminant in solution per unit volume of solute.

The average velocity of a contaminant is then calculated based on the groundwater velocity and retardation factor (Equation 2). This estimate assumes that the contaminant concentration is much lower than the total concentration of cations in the groundwater (i.e. competition is not a factor). It is also important to remember that this calculation provides the location of the mean concentration in the plume and not the leading edge of the plume.

$$V_c = \frac{V_w}{R_f} \quad (2)$$

where V_c = velocity of the contaminant,
 V_w = velocity of the water, and
 R_f = retardation factor.

This basic equation for predicting the contaminant velocity is used in the screening process discussed by Seitz (1995). For the screening process the distance to the receptor and groundwater velocity is used to determine the groundwater travel time. The radionuclide travel time (RTT) is estimated by Equation 3 as shown in Seitz (1995). This method can be used for the waste inventory as discussed by Seitz (1995) to identify key contaminants.

$$RTT = \frac{X}{V_w} R_f \quad (3)$$

where RTT = radionuclide travel time for mean concentration.
 X = distance to compliance point.
 V_w = velocity of the water, and
 R_f = retardation factor.

Inventories often contain many radionuclides (hundreds), some metals (tens), and miscellaneous organic and inorganic constituents (tens). Ideally sorption data would be available for all contaminants in the inventory for site conditions. This is unlikely due to the cost and time involved in conducting this level of experimentation. Therefore, it is usually necessary to use K_d 's from literature to establish a list of contaminants that represent the most risk in the performance of the facility. The lack of data during the screening phase of Performance Assessments precludes the use of more refined isotherms, but this is generally not a problem because the difference between linear and non-linear isotherms is minimal under normal environmental conditions (Sheppard and Thibault, 1990). It is recommended that values from Sheppard and Thibault (1990) be used for screening purposes because the distribution coefficients should represent generic conditions assumed at this point in the PA process.

Groundwater pathway calculations for Performance Assessment are also based on Equation 2 for estimating the contaminant mobility in the numeric models. The numerical modeling requires distribution coefficients for many types of adsorbents. Construction of Low-Level Waste disposal facilities often involves the use of concrete. Concrete is a very good sorbing environment for many radionuclides, particularly actinides. Also, the concrete mix can be adjusted to optimize the sorption capability for mobile constituents like technetium. Addition of materials like blast furnace slag and fly ash that create reducing conditions in the concrete will cause reduction of the technetium to a less soluble phase. Clay and gravel may also be used in the construction of the drainage system at the disposal facility. Distribution coefficients for these materials is often taken from the literature. Site specific sorption parameters may need to be determined for specific contaminants for the soil at the facility location. This can be kept to a minimum by conducting sensitivity calculations using the flow and transport code.

Factors That Influence Distribution Coefficients

One of the major problems with the use of K_d 's in modeling is that variations of several orders of magnitude have been measured for a site-specific material with no insight into the reason for the variation (Kent et al., 1988). Controls on contaminant removal from solution can be separated into

solid characteristics and solution composition for field conditions. Laboratory experiments have additional controls like the solid solution ratio and contact time in addition to the field controls. Ion exchange, non-specific adsorption, specific adsorption, and precipitation are the mechanisms that are associated with the solid phase characteristics. The sorption mechanism that controls contaminant removal is dependent on the solid types that are present in the solid material. Removal of contaminants from solution by these mechanisms also depends on the form that the contaminant takes in solution which is a response to the composition of the solution. Solution speciation can effect the removal of contaminants from solution by decreasing the availability of the contaminant form that could be removed from solution to another form that will remain in solution (e.g. UO_2 complexing to UO_2CO_3). Three mechanisms, inorganic or organic complexation and colloid formation, result in changes in solution speciation (Figure 1). A brief description of each mechanism that contributes to the partitioning of contaminants is given below.

Figure 1. Mechanisms that control solid/solution partitioning of contaminants.

Ion Exchange: Fixed charge sorption sites will have an ion of opposite charge associated with it. Changes in the solution composition can cause the ions in these exchange sites to be replaced by other ions based on concentration and affinity of the available ions. These reactions are not tied to pH as are the non-specific adsorbed ions because the charge is fixed. The cation exchange capacity, CEC, is a measure of a material's capacity to bind cations. These types of bonds are more easily broken and the cation is then mobilized due to changes in the solution chemistry.

Non-Specific Adsorption: Non-specific adsorption occurs to compensate for charges associated with specifically adsorbed ions. The ion exchange is conceptualized to occur between the solution and the specifically adsorbed ions due to adjustments in the electrostatics brought on changes in solution chemistry. These types of bonds are associated with variably charged surfaces and form to neutralize the overall surface charge (i.e. surface charge plus non-specific charge equals zero). Most porous media have a net negative charge which results in preferential sorption of cations.

Specific Adsorption: This type of sorption involves both physical and electrostatic binding to the solid surface. The adsorbent is positioned closer to the solid surface than occurs in ion exchange reactions and the bond is stronger.

Precipitation: Removal by precipitation can occur within the solution or on the solid surface. Precipitation occurs due to the reaction of two solution components when present in concentrations that exceed the solubility product for the reaction. Surface precipitating occurs when the concentration of a contaminant on the solid surface builds to a high level and precipitates on the solid surface.

Organic Complexation: Organic matter in soils can serve as a removal mechanism for contaminants and will therefore contribute to the K_d . Another issue that must be considered in many Performance Assessments is the presence of man-made organic compounds in the inventory. These compounds are generally solvents (e.g. trichloroethylene, carbon tetrachloride, and trichloroethane) used in materials processing and decontamination activities (e.g. citrate and ethylenediaminetetraacetic acid (EDTA)). Compounds such as EDTA form strong bonds with many cation and do not interact with solids because the charge of the complex is balanced.

Inorganic Complexation: Most metals and radionuclides will interact with solution components to some degree. Formation of hydroxide, carbonate, sulfate, chloride or nitrate species is common due to the higher concentration of these anions in solution. Often the sorbing phase of a contaminant is either a free ion or a hydroxide complex which is a function of the solution pH. Formation of other complexes will then decrease the concentration of contaminant in the form that will sorb resulting in higher mobility of the contaminant (i.e. lower K_d).

Colloid Formation: A colloid is a substance made up of particles that are larger than molecules, but are too small to be seen with an optical microscope (approximately 1 to 200 nm). These particles can be either positively or negatively charged and will attract oppositely charged ions to neutralize the charge. Colloids can be an important transport process because contaminants can attach to the colloid and neutralize the charge of the particles. The particles will then move at approximately the speed of water with little or no interaction with the porous media.

Solid Material Characteristics

The mechanism or mechanisms that control sorption is dependent on the solid phases present in contact with the solution. The mineralogy of the geologic material or soil that control sorption include primary and secondary crystalline minerals and amorphous coatings such as hydrous iron, manganese, and aluminium oxides. Minerals important in sorption can be broken into four general categories (oxides, multiple site-type oxides, fixed charge, and salt type) based on the type of adsorption sites available on the solid. Secondary minerals and amorphous phases tend to dominate sorption when present even when present at low concentrations in comparison to mass of primary minerals. This is due in large part to the very high surface areas of these types of minerals.

Oxides have been characterized more extensively than any other of adsorbent type. Common minerals that are included in this category are: gibbsite, ferrihydrite, hematite, goethite, organic matter, cristobalite, opal, and quartz. These minerals are present in sediments and rock either as primary or secondary minerals (Kent et al., 1988). An important characteristic of these minerals is that their adsorption sites are surface hydroxyl groups that are amphoteric (i.e. act as acid or base by adsorbing protons in response to changes in pH). At low pH the sorption sites will have a high concentration of protons making the surface charge positive. At high pH protons leave sorption sites to come into equilibrium with the solution. Therefore, cations will sorb more readily on oxides in higher pH solutions because the surface charge will tend to be negative.

Multiple site-type oxides have not been characterized to the extent of simple oxides. These minerals exhibit both variable and fixed charge types making them more difficult to characterize. Some common minerals from this type of solid are: ilmenite, orthoclase, plagioclase, pyroxene, sanidine, zircon. Many of these minerals are feldspars formed as primary minerals and do not have the sorptive capacity of their alteration products (Kent et al., 1988). The fixed negative charge of these minerals is generated by the SiO_4 and AlO_4 tetrahedra framework that forms the basis of the feldspar minerals. The interstitial sites of the feldspars are filled by Ca^{2+} , Na^+ , and K^+ ions that balance the negative charge. Fixed charge at the surface occurs when one of the interstitial cations is removed from the solid leaving a negatively charged site to be filled. Hydration of surface layers may result in the formation of surface hydroxyl sites of variable charge as with the simple oxides.

Fixed charge minerals have sorption sites that remain negative even with changes in solution composition and the sorption of contaminants on these minerals is controlled by ion exchange. Many of the minerals of this type are secondary minerals with open crystal structures, high surface area, high ion-exchange capacities, and high sorption capacities making them important in porous and fractured media. Examples of fixed charge minerals include: epidote, glass, biotite, chlorite, kaolinite, smectites, and zeolites.

Sorption related to salt type minerals is different from the mineral types listed above in that the solid coordination is a cation to anion bond as apposed to a cation to 4 or six oxide ions (Kent et al., 1988). Sorption may result from exchange of cations or anions between the solid and solution (e.g. Sr^{2+} replaces Ca^{2+} at the calcite surface). Examples of these minerals are: apatite, calcite, and dolomite.

It seems reasonable to assume that surface area would be a major controlling factor in the uptake of contaminants by solids, but this is not always the case as shown in Sheppard and Thibault (1990). They provide a breakdown of distribution coefficients for a wide variety of elements for the main soil types (i.e. sand, loam, clay, and organic rich) and found that increased distribution coefficients are not the rule for decreasing grain size (increased surface area). This is possibly a result of not looking at the mineralogic aspect of the sorbing material. Wide variations in sorption can be accounted for by minimal concentrations of highly reactive minerals such as oxides (e.g. iron, manganese, aluminum, and silica) and clays (e.g. smectites, zeolites, illite, kaolinite, etc.). This information is often unavailable. Also, oxide contents of only several percent can control the sorption of many elements as seen in the results of hydrous ferric oxide modeling by Dzombak and Morel (1990).

Solution Characteristics

Water properties that impact the sorption of contaminants are: pH, Eh, temperature, dissolved organic content, major cation concentration (Ca, Mg, Na, K), major anion concentration (Cl, HCO_3 , CO_3 , SO_4), and minor constituents such as naturally occurring stable isotopes of Sr, Cs, and I. All of these properties affect the speciation of solution components as discussed in general terms above.

The pH of the solution will impact the sorption of a contaminant in several ways. Solids with variable charged sorption sites in contact with the solution will equilibrate to changes in the solution pH. This may result in increased or decreased sorption depending on the charge of the contaminant and the change in the pH. Also, changes in the pH will lead to changing speciation of solution components. Increasing pH may lead to formation of hydroxide species that do not sorb to solids in contact with the solution or precipitation of carbonate species may become important. In general cations sorb better as pH is increased.

The redox potential symbolized by Eh measures the tendency of a solution to allow a reaction to proceed. Therefore, this potential is important for elements that can exist in more than one oxidation state such as technetium, chromium, uranium, plutonium, neptunium, and americium. Elements such as technetium and chromium that are insoluble in reducing conditions are very soluble in their oxidized state. The other radionuclides listed can exist in as many as four oxidation states. Each oxidation state may sorb to different degrees because the controlling mechanism may change with the oxidation state.

Temperature variations are not as critical for sorption in low-level waste storage facilities because the waste package does not generate the heat as seen in the high-level waste program. Organic content can impact sorption by complexing with the contaminant thereby reducing the concentration in solution. Organic material may not be part of the solid matrix, but is present as fine particles that will move with the water. Sorption onto this material will provide a means of rapid transport with minimal interaction with solids in the flow path. This is essentially colloidal transport.

Solution composition can impact sorption dramatically. Generally this is reflected by the major cation (Ca, Mg, Na, K) and anion (Cl, HCO_3 , CO_3 , SO_4) concentrations. High concentrations of cations can reduce sorption of positively charged contaminants by competing for available sorption sites. Anion concentrations may result in complexation of positively charged contaminants in forms that will not sorb. Precipitation of contaminants as carbonate or sulfate species will remove contaminants from solution. This is the one of the reasons why the solution composition should be considered in selecting K_d 's from literature. The concentration of the contaminant itself is also important because in general the K_d decreases with increased contaminant concentration due to competition for adsorption sites.

Experimental Sorption Conditions

The experimental conditions used to generate a distribution coefficient should also be evaluated to determine that the experiment is applicable to the field conditions. The contact time used in the experiment should be long enough to ensure equilibrium is attained. This requires experimental work to determine the time period required for equilibrium. A series of sorption experiments are run under the same conditions for differing time intervals. Plotting the concentration sorbed versus time should yield a curve that flattens out at a specific time. After this point equilibrium is assumed for the experiment.

The solid/solution ratio used in the experiment can also impact the K_d produced. This will be seen as decreased sorption as the ratio decreases for the same contaminant concentration due to competition. The decrease is not always seen because it is also a function of the sorption capacity of the solid in comparison to the concentration of the contaminant. Consideration should be given to the solid/solution ratio used in experiments versus what is present in the field. In most cases this is significantly different.

Batch experiments often use a soil/solution ratio of 1 gram of adsorbent to 10 mL of solute. This does not represent the conditions seen in the field which are more in line with 50 g of soil to 10 mL of solution. Assuming 50 percent saturation in a soil results in a ratio of 100 g of soil to 10 mL of solution. Column experiments provide a more realistic view of transport, but are often not practical because of the long duration of experiments involving moderate to highly reactive contaminants.

Distribution Coefficients and Sorption

For the purposes of this report the term sorption is used to describe all processes that result in removal of a contaminant from the aqueous phase. Adsorption refers to an actual chemical process that bonds contaminants to a solid. The distribution coefficient (K_d) used in transport modeling is a bulk term that encompasses all processes that remove a contaminant from the solution. This coefficient results from fitting a Linear Isotherm to experimental results and neglects the actual mechanism or mechanisms responsible for the contaminant removal.

The distribution coefficient is the least complex numerical means of describing sorption and for this reason has been widely incorporated into transport codes. Distribution coefficients are determined by measuring the amount of a known contaminant that remains in solution after contact with a known mass of a solid (Equation 3). The contaminant K_d is then determined by simply recasting Equation 3 (Equation 4).

$$S = K_d C \quad (4)$$

or

$$K_d = \frac{S}{C} \quad (5)$$

where S = mass of contaminant adsorbed per unit mass of geologic material,
 C = mass of contaminant in solution per unit volume of solute, and
 K_d = distribution coefficient.

Several shortcomings must be kept in mind when using K_d 's for Performance Assessments (PA) and other modeling activities. First, K_d 's partition the contaminant into the solid and liquid phases with no upper limit to the amount of contaminant that can be sorbed. This implies that there is an infinite number of adsorption sites in the soil or geologic material. In dilute plumes this assumption is generally not a problem because the number of adsorption sites will be numerous in relation to the contaminant concentration. Experiments should be conducted to determine the contaminant concentration that causes the linear relationship to breakdown (Figure 2). Nonlinear experimental results require a different isotherm like the Freundlich to describe the sorption (See Appendix A).

Figure 2. Characteristic adsorption isotherm. Linear portion of the plot can be described by a K_d . To capture the information in the remainder of the plot another isotherm like the Langmuir Isotherm.

An example of an adsorption isotherm is given in Figure 2 where C represents the concentration of the contaminant in moles/L and Γ is the site density in moles/mole. The gray zone represents the portion of the isotherm that can be described by a K_d (i.e. the relationship is between C and Γ is linear). The line begins to flatten because the concentration of available adsorption sites are becoming limited. Often a series of isotherms are produced for different pH conditions in order to determine the sensitivity of the contaminant to pH variations.

Distribution coefficients range from 0 mL/g, no sorption, for conservative contaminants like tritium to 100's of thousands for reactive contaminants on high surface area materials (e.g. plutonium sorption on tuff). It is important to keep the amount of contaminant actually being removed from solution in perspective particularly with high K_d values (Figure 3). Almost all of the contaminant is sorbed by the time the K_d reaches a value of 100 mL/g. After this point the relative gain in percent sorbed is very low in comparison to the K_d value. However, the K_d range above 100 mL/g can be significant when dealing with very long lived radionuclides that have high dose conversion factors (i.e. represent a significant hazard in small quantities for extended periods of time).

Figure 3. Relationship of distribution coefficient to the percent of contaminant sorbed.

Distribution Coefficient Determination

A variety of methods can be used to determine the distribution coefficient for a specific contaminant, solution and solid. Batch experiments are the most predominant method because results can be obtained relatively quickly at reasonable costs for most contaminants. Column experiments require more time to setup and can take extensive time periods to complete for reactive contaminants (i.e. achieve breakthrough of the tracer). In situ studies are potentially the most useful, but are not often feasible due to costs and regulatory constraints. Estimating a K_d using existing values for non-site specific materials is the least favorable method.

Experimental Methods

The first requirement in conducting batch or column experiments is to determine the procedure to be used in the investigation. This entails determining the appropriate mineralogy, solution composition, solid/solution ratio (batch), contact time (batch) or flow velocity (column), particle size, temperature, and atmospheric conditions. The preparation of the solid and solution including the contaminant concentration to be used must also be determined. The first part of defining the procedures should involve some basic modeling of the system to evaluate possible complicating factors in the experiment such as precipitation of the contaminant. When actinide or other elements that can be present in more than one oxidation state are the targeted contaminant it is critical to prepare the contaminant correctly to ensure that oxidation states are maintained.

Batch

Solid Preparation: Batch experiments are conducted by contacting the solid phase of interest with a contaminant in the selected solution chemistry. The solid phase is ground or crushed if it is consolidated material and the material is sieved to collect the size distribution of interest in the study. Typically the fine grained particles are removed from use in the batch experiments. The remaining solid is then contacted with the water selected for use in the batch experiment to bring the freshly ground sample to equilibrium with the water composition. A split sample from the solid material is often used to equilibrate a water sample with the solid. Both types of samples are then centrifuged to separate the phases and the equilibrated water is also filtered to ensure no fine materials are included in the water. The filtered water is then used to prepare the tracer solution for the batch experiment.

Experiment: The prepared solid and tracer solution are then mixed at the specified solid solution ratio. Solution volumes of between 10 to 50 ml are often used in contact with 1 gram of solid. Batch experiments are usually conducted in either polyethylene or polycarbonate tubes with sealed tops. The tube or group of tubes are placed on a shaker and agitated for the required contact time. The tubes are then centrifuged and the liquid is extracted and the soluble contaminant concentration is determined. This procedure is followed for all solid/solution ratios and solution compositions of interest.

Column

In order to conduct a useful column experiment it is necessary to have an understanding of system that is being investigated. Therefore, batch experiments are conducted prior to the column experiment to determine if the time period required to conduct the experiment is reasonable (i.e. weeks or months and not years). Highly sorptive materials and reactive contaminants will not show contaminant concentrations (i.e. breakthrough) for extensive periods of time and are not practical for column studies. Column experiments are particularly useful in determining retardation of contaminants that do not show appreciable sorption on a solid because the breakthrough of the contaminant can be monitored more precisely.

Solid Preparation: The preparation for column experiments is similar to batch experiments. Unconsolidated material will be sieved and the grain size distribution of interest will be collected and contacted with the solution water to bring the water and solid into equilibrium. Unconsolidated material is packed in the column in lifts at specified compaction pressures to obtain the hydraulic properties that are of interest. Core samples may also be used in column experiments, but may be restricted to relatively permeable materials in order to obtain results in a reasonable time frame. Consolidated materials may also be ground or crushed and used in column experiments. In these

experiments the ground material must be equilibrated with the solution composition prior to addition of the tracer.

Experiment: Column experiments begin by saturating the column with the water composition of interest. This should be done by gradually pushing water up through the bottom of the column to reduce the potential of air pockets forming within the column. After the column is saturated the flow field is established in the column and the contaminant is added after steady-state conditions have been achieved. The effluent water is sampled at prescribed intervals for contaminant analysis and the resulting plot of time versus concentration will allow distribution coefficient to be determined using Equations 2, 3, and 4.

Literature Review

Several compendia of distribution coefficients from the literature (Sheppard and Thibault, 1990; Coughtrey et al., 1985; Ames and Rai, 1978; Isherwood, 1981) and a database containing K_d 's for a wide variety of geologic material, single mineral phases and solution compositions (Ticknor and Ruegger, 1989) are available. A literature review should first focus on any sorption work that has been done to characterize the facility site. However, site-specific information is often not available particularly during the screening phase of a PA. Lacking site specific information the next approach is to use the available literature values after comparing the experimental conditions (e.g. mineralogy, solution composition, contaminant concentration, etc.) of the literature value with site conditions. A more detailed description of the affects of solid and solution characteristics is provided in the next section. Most of the compendium's do not detail the experimental conditions and only give K_d ranges and a suggested value for a given contaminant.

Sheppard and Thibault (1990) have used soil grain size classifications and organic content as a means of further separating their K_d listing. The NEA database (Ticknor and Ruegger, 1989) provides mineralogic and water chemistry data for each K_d in the listing. This provides the user with the opportunity to try to match site conditions when selecting a K_d . If no site specific information is available a generic approach must be taken. For this it is recommended that the sand values of Sheppard and Thibault (1990) be used. These values should be conservative for most conditions.

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Appendix D

GWSCREEN Model Simulation Output

TIME OF RUN 10:39:52.8
DATE OF RUN 11/05/96

=====

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Subroutines QSIMP, QGAUS, and TRAP2D are Copyright © 1992, Numerical
Recipes Software. Reproduced by permission from the book
Numerical Recipes, Cambridge University Press.

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.....

•

• This output was produced by the model: •

•

• GWSCREEN •

• Version 2.5; Menu Driven Version •

• 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 •

• 03-96 •

• Copyright 1992 Lockheed Martin Idaho •

• Technologies Corporation •

•

.....

>>> TITLE OF PROJECT:

Am-241 :PAPA REV 2 CLASS AB WASTE

GAUSSIAN QUADRATURE SOLUTION

MODEL OPTIONS

IMODE: 1

KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC

IMODEL: 1 (1) SURF OR BURIED SOURCE; 2) POND SOURCE; (3) TABULATED SOURCE FUNCTION

ITYPE: 0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO 2D

>>> INPUT DATA

.....

NUMBER OF RADIOACTIVE PROGENY	3
LENGTH OF SOURCE PARALLEL TO GW FLOW (m)	6.10E+02
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m)	1.22E+02
THICKNESS OF SOURCE (m)	7.60E+00
PERCOLATION RATE (darcy vel m/y)	5.80E-01
VOLUMETRIC WATER CONTENT IN SOURCE	2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE	1.00E-01
BULK DENSITY AT SOURCE (g/cm**3)	1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g)	5.00E+03
BULK DENSITY IN UNSAT ZONE (g/cm**3)	1.50E+00
UNSATURATED ZONE THICKNESS (m)	1.00E-03
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g)	0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1)	0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci)	1.29E-01
MOLECULAR WEIGHT (g/mole)	2.41E+02
SOLUBILITY LIMIT (mg/L)	1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y)	4.32E+02 2.10E+06 1.59E+05 7.34E+03
BULK DENSITY OF AQUIFER (g/cm**3)	1.60E+00
POROSITY OF AQUIFER	4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g)	5.00E+03 2.50E+01 1.50E+01 3.30E+03
DISPERSIVITY X DIRECTION (m)	1.00E+01
DISPERSIVITY Y DIRECTION (m)	5.00E+00
DISPERSIVITY Z DIRECTION (m)	1.00E+00
PORE VELOCITY (m/y)	6.25E-01
WELL SCREEN THICKNESS (m)	1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS (m)	4.00E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m)	2.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m)	0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci)	4.50E-06 0.00E-06 2.70E+05 3.91E+06
UNITS OF CONTAMINANT	Ci

LIMITING SOIL CONCENTRATION CALCULATION

>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 3.75E+01

>>> VALUES CALCULATED IN SOURCE SUBROUTINE

.....

LEACH RATE CONSTANT (1/y)	9.5391E-06
UNSATURATED PORE VELOCITY (m/y)	5.8000E-01
DECAY CONSTANT(S) (1/y)	1.6045E-03 3.3007E-07 4.3594E-06 9.4434E-05
RETARDATION FACTOR(S) SATURATED)	0.0001E+04 1.0000E+02 6.1000E+01 1.3201E+04
RETARDATION FACTOR (UNSATURATED)	1.0000E+00
SOLUBILITY LIMITED MASS (mg)	4.5249E+18
SOLUBILITY LIMITED ACTIVITY (Ci)	1.5550E+16
TRANSIT TIME IN UNSAT ZONE (years)	1.7241E-04
FRACTION DECAYED DURING UNSAT TRANSPORT	2.7664E-07

>>> EXPOSURE DATA FOR LIMITING SOIL CONCENTRATION

.....

INTEGRATION TIME (years)	1
BODY WEIGHT (kg)	7.000E+01


```

AVERAGING TIME (days)      0.650E+02
WATER INTAKE RATE (L/d)    2.000E+00
EXPOSURE FREQUENCY (days/year) 3.650E+02
EXPOSURE DURATION (years)  1.000E+00
RADIOLOGICAL DOSE LIMIT (rem/y) 1.000E+04
CARCINOGENIC RISK CRITERIA 1.000E+04
HAZARD QUOTIENT             1.000E+04
=====
>>> RESULTS OF CALCULATIONS
=====
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
DECAY-INGROWTH FACTORS 4.2794E-06 2.0523E-04 6.2463E-06 1.7087E-06
COMPOSITE DOSE CONVERSION FACTOR (rem/Ci): 3.73E+10
LIMITING GROUNDWATER CONCENTRATION (Ci/L): 3.68E-18
NOTE: PROGENY CONCENTRATIONS ARE REPORTED AT THE TIME OF THE MAXIMUM PARENT CONCENTRATION
MAXIMUM GW CONCENTRATION FOR MBR #1: 9.86E-06 Ci/L CEDE = 3.24E-16 rem
MAXIMUM GW CONCENTRATION FOR MBR #2: 9.19E-02 Ci/L CEDE = 2.67E-12 rem
MAXIMUM GW CONCENTRATION FOR MBR #3: 4.70E-03 Ci/L CEDE = 9.32E-15 rem
MAXIMUM GW CONCENTRATION FOR MBR #4: 5.49E-06 Ci/L CEDE = 1.71E-16 rem
MAXIMUM CEDE 2.68E-12 rem
PEAK TIME (y): 7.705E+11E+03
LIMITING SOIL CONCENTRATION (Ci m**3): 9.504E+03
LIMITING SOIL CONCENTRATION (Ci kg): 5.315E+03
LIMITING INVENTORY IN SOIL (Ci): 4.810E+06
LIMITING INVENTORY IN SOIL (mg): 1.400E+09
SPECIFIC ACTIVITY (Ci/g): 3.437E+00
EXECUTION TIME (seconds)  )
TIME OF RUN 10:39:53.0
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Am-243 :PAPA REV 1 CLASS AB WASTE=====
=====
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 0 CONC VS TIME; (1)PEAK CONC AND LIMITING SOIL CONC
IMODEL:1 (1) SURF OR BURIED SOURCE; 2 POND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE:0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO ZD
>>> INPUT DATA
=====
NUMBER OF RADIOACTIVE PROGENY 4
LENGTH OF SOURCE PARALLEL TO GW FLOW (m) 6.10E+02
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 1.22E+02
THICKNESS OF SOURCE (m) 7.60E+00
PERCOLATION RATE (darcy vel m/y) 5.80E+01
VOLUMETRIC WATER CONTENT IN SOURCE 2.79E+01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E+01
BULK DENSITY AT SOURCE (g/cm**3) 1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g) 5.00E+03
BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.50E+00
UNSATURATED ZONE THICKNESS (m) 1.00E+03
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) 0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci) 1.00E+05
MOLECULAR WEIGHT (g/mole) 2.43E+02
SOLUBILITY LIMIT (mg/L) 1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 7.38E+03 2.41E+04 7.04E+08 3.28E+04 2.18E+01
BULK DENSITY OF AQUIFER (g/cm**3) 1.60E+00
POROSITY OF AQUIFER 4.00E+01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g) 5.00E+03 1.20E+03 1.50E+01 1.50E+01 1.50E+01
DISPERSIVITY X DIRECTION (m) 1.00E+01
DISPERSIVITY Y DIRECTION (m) 5.00E+00
DISPERSIVITY Z DIRECTION (m) 1.00E+00
PORE VELOCITY (m/y) 6.15E+01
WELL SCREEN THICKNESS (m) 1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS (m) 4.15E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m) 1.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m) 1.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 4.10E+06 4.30E+06 2.51E+05 1.10E+07 1.40E+07
UNITS OF CONTAMINANT Ci
=====
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 5.01E+02
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
=====
LEACH RATE CONSTANT (1/y) 9.5391E-06
UNSATURATED PORE VELOCITY (m/y) 5.8000E+00
DECAY CONSTANT(S) (1/y) 9.3922E-05 2.8761E-05 9.8458E-10 2.1133E-05 3.1796E-02
RETARDATION FACTOR(S) (SATURATED) 2.0001E+04 4.8010E+03 6.1000E+01 6.1000E+01 6.1000E+01
RETARDATION FACTOR (UNSATURATED) 1.0000E+00
SOLUBILITY LIMITED MASS (mg) 4.5049E+18
SOLUBILITY LIMITED ACTIVITY (Ci) 9.0077E+14
TRANSIT TIME IN UNSAT ZONE (years) 1.7241E+04
FRACTION DECAYED DURING UNSAT TRANSPORT 1.6194E-08
=====
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
DECAY-INGROWTH FACTORS 3.9385E-02 1.4655E-01 5.9531E-06 1.3448E-06 1.3424E-06
COMPOSITE DOSE CONVERSION FACTOR (rem/Ci): 7.15E+07
LIMITING GROUNDWATER CONCENTRATION (Ci/L): 1.92E-15
NOTE: PROGENY CONCENTRATIONS ARE REPORTED AT THE TIME OF THE MAXIMUM PARENT CONCENTRATION
MAXIMUM GW CONCENTRATION FOR MBR #1: 2.15E-21 Ci/L CEDE = 7.07E-12 rem
MAXIMUM GW CONCENTRATION FOR MBR #2: 3.34E-20 Ci/L CEDE = 1.95E-10 rem
MAXIMUM GW CONCENTRATION FOR MBR #3: 9.05E-23 Ci/L CEDE = 1.66E-14 rem

```

MAXIMUM GW CONCENTRATION FOR MBR #4: 2.41E-23 Ci/L CEDE = 1.03E-13 rem
 MAXIMUM GW CONCENTRATION FOR MBR #5: 2.41E-23 Ci/L CEDE = 0.56E-13 rem
 MAXIMUM CEDE 1.12E-10 rem
 PEAK TIME (y): 3.443668E-04
 LIMITING SOIL CONCENTRATION (Ci/m**3): 1.575E-05
 LIMITING SOIL CONCENTRATION (Ci/kg): 9.843E-09
 LIMITING INVENTORY IN SOIL (Ci): 9.957E-03
 LIMITING INVENTORY IN SOIL (mg): 4.165E-04
 SPECIFIC ACTIVITY (Ci/g): 1.995E-01
 EXECUTION TIME (seconds))
 TIME OF RUN 10:39:53.1
 DATE OF RUN 11/05/96
 >>> TITLE OF PROJECT:
 Ba-133 :PAPA REV 2 CLASS AB WASTE*****

 GAUSSIAN QUADRATURE SOLUTION
 MODEL OPTIONS
 IMODE: 1
 KFLAG: 1 (0) CONC VS TIME; 1 PEAK CONC AND LIMITING SOIL CONC
 IMODEL: 1 (1) SURF OR BURIED SOURCE; (2) POND SOURCE; 3 TABULATED SOURCE FUNCTION
 ITYPE: 0 (0) VERT AVG; (1) NON-VERT AVG; 2 AVG FROM 0 TO 20
 >>> INPUT DATA

 NUMBER OF RADIOACTIVE PROGENY)
 LENGTH OF SOURCE PARALLEL TO GW FLOW (m) 6.11E+02
 WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 1.22E+02
 THICKNESS OF SOURCE (m) 7.60E+00
 PERCOLATION RATE (darcy vel m/y) 5.80E-01
 VOLUMETRIC WATER CONTENT IN SOURCE 2.79E-01
 VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
 BULK DENSITY AT SOURCE (g/cm**3) 1.60E+00
 SORPTION COEFFICIENT AT SOURCE (ml/g) 1.00E+01
 BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.50E+00
 UNSATURATED ZONE THICKNESS (m) 1.00E+03
 SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) 1.00E+00
 OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
 INITIAL MASS OR ACTIVITY (mg or Ci) 1.85E-02
 MOLECULAR WEIGHT (g/mole) 1.33E+02
 SOLUBILITY LIMIT (mg/L) 1.00E+06
 HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 1.35E+01
 BULK DENSITY OF AQUIFER (g/cm**3) 1.60E+00
 POROSITY OF AQUIFER 4.00E-01
 SORPTION COEFFICIENT(S) IN AQUIFER (ml/g) 0.00E+00
 DISPERSIVITY X DIRECTION (m) 1.00E+01
 DISPERSIVITY Y DIRECTION (m) 5.00E+00
 DISPERSIVITY Z DIRECTION (m) 1.00E+00
 PORE VELOCITY (m/y) 6.25E+01
 WELL SCREEN THICKNESS (m) 1.50E+01
 DISTANCE TO RECEPTOR ALONG X AXIS (m) 4.05E+02
 DISTANCE TO RECEPTOR ALONG Y AXIS (m) 0.00E+00
 DISTANCE TO RECEPTOR ALONG Z AXIS (m) 0.00E+00
 RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 3.20E+03
 UNITS OF CONTAMINANT Ci

 LIMITING SOIL CONCENTRATION CALCULATION
 >>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 7.25E-02
 >>> VALUES CALCULATED IN SOURCE SUBROUTINE

 LEACH RATE CONSTANT (1/y) 4.6880E-03
 UNSATURATED PORE VELOCITY (m/y) 5.8000E+00
 DECAY CONSTANT(S) (1/y) 6.5763E-02
 RETARDATION FACTOR(S) (SATURATED) 1.0000E+00
 RETARDATION FACTOR UNSATURATED) 1.0000E+00
 SOLUBILITY LIMITED MASS (mg) 9.2973E-15
 SOLUBILITY LIMITED ACTIVITY (Ci) 0.3570E-15
 TRANSIT TIME IN UNSAT ZONE (years) 1.7241E-04
 FRACTION DECAYED DURING UNSAT TRANSPORT 1.1338E-05

 COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
 COMPOSITE DOSE CONVERSION FACTOR (rem/Ci) 3.20E+03
 LIMITING GROUNDWATER CONCENTRATION (Ci/L) 4.19E-11
 MAXIMUM GW CONCENTRATION FOR MBR #1: 5.64E-13 Ci/L CEDE = 1.02E-06 rem
 MAXIMUM CEDE 1.32E-06 rem
 PEAK TIME (y): 1.026996E+01
 LIMITING SOIL CONCENTRATION (Ci/m**3): 2.481E-06
 LIMITING SOIL CONCENTRATION (Ci/kg): 1.550E-09
 LIMITING INVENTORY IN SOIL (Ci): 1.433E+00
 LIMITING INVENTORY IN SOIL (mg): 5.497E+00
 SPECIFIC ACTIVITY (Ci/g): 2.552E-02
 EXECUTION TIME (seconds) 0
 TIME OF RUN 10:39:53.3
 DATE OF RUN 11/05/96
 >>> TITLE OF PROJECT:
 C-14 :PAPA REV 2 CLASS AB WASTE*****

 GAUSSIAN QUADRATURE SOLUTION
 MODEL OPTIONS
 IMODE: 1
 KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC
 IMODEL: 1 (1) SURF OR BURIED SOURCE; (2) POND SOURCE; 3 TABULATED SOURCE FUNCTION
 ITYPE: 0 (0) VERT AVG; (1) NON-VERT AVG; 2 AVG FROM 0 TO 20
 >>> INPUT DATA

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NUMBER OF RADIOACTIVE PROGENY          0
LENGTH OF SOURCE PARALLEL TO GW FLOW (m) 6.10E-02
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 1.22E-02
THICKNESS OF SOURCE (m) 7.60E-00
PERCOLATION RATE (darcy vel m/y) 5.80E-01
VOLUMETRIC WATER CONTENT IN SOURCE 2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
BULK DENSITY AT SOURCE (g/cm**3) 1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g) 1.00E+02
BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.51E+00
UNSATURATED ZONE THICKNESS (m) 1.00E-03
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) 0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci) 2.31E+02
MOLECULAR WEIGHT (g/mole) 1.40E+01
SOLUBILITY LIMIT (mg/L) 1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 5.70E+03
BULK DENSITY OF AQUIFER (g/cm**3) 1.60E+00
POROSITY OF AQUIFER 4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g) 2.00E-01
DISPERSIVITY X DIRECTION (m) 1.00E-01
DISPERSIVITY Y DIRECTION (m) 5.00E+00
DISPERSIVITY Z DIRECTION (m) 1.00E+00
PORE VELOCITY (m/y) 0.25E+01
WELL SCREEN THICKNESS (m) 1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS (m) 4.05E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m) 0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m) 0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 2.10E+03
UNITS OF CONTAMINANT Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 5.16E+04
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
-----
LEACH RATE CONSTANT (1/y) 4.7014E-04
UNSATURATED PORE VELOCITY (m/y) 5.8000E+00
DECAY CONSTANT(S) (1/y) 1.2160E-04
RETARDATION FACTOR(S) (SATURATED) 3.1000E+01
RETARDATION FACTOR (UNSATURATED) 1.0000E+00
SOLUBILITY LIMITED MASS (mg) 9.0653E+16
SOLUBILITY LIMITED ACTIVITY (Ci) 4.0645E+14
TRANSIT TIME IN UNSAT ZONE (years) 1.7211E-04
FRACTION DECAYED DURING UNSAT TRANSPORT 2.0966E-08
-----
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
COMPOSITE DOSE CONVERSION FACTOR (rem/Ci): 2.10E+03
LIMITING GROUNDWATER CONCENTRATION (Ci/L): 6.52E-11
MAXIMUM GW CONCENTRATION FOR MBR #1: 1.11E-09 Ci/L CEDE = 1.70E-03 rem
MAXIMUM CEDE 1.70E-03 rem
PEAK TIME (y): 3.349487E+02
LIMITING SOIL CONCENTRATION (Ci/m**3): 2.403E-05
LIMITING SOIL CONCENTRATION (Ci/kg): 1.502E-08
LIMITING INVENTORY IN SOIL (Ci): 1.359E+01
LIMITING INVENTORY IN SOIL (mg): 3.032E+03
SPECIFIC ACTIVITY (Ci/g): 4.484E+00
EXECUTION TIME (seconds) 0
TIME OF RUN 10:39:53.4
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Cd-109 :PAPA REV 2 CLASS AB WASTE*****
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 0 CONC VS TIME; 1/PEAK CONC AND LIMITING SOIL CONC
IMODEL: 1 1 SURF OR BURIED SOURCE; 2 POND SOURCE; 3 TABULATED SOURCE FUNCTION
ITYPE: 0 0 VERT AVG; 1 NON-VERT AVG; 2 AVG FROM 0 TO 2D
>>> INPUT DATA
-----
NUMBER OF RADIOACTIVE PROGENY          0
LENGTH OF SOURCE PARALLEL TO GW FLOW (m) 6.10E-02
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 1.22E-02
THICKNESS OF SOURCE (m) 7.60E+00
PERCOLATION RATE (darcy vel m/y) 5.80E-01
VOLUMETRIC WATER CONTENT IN SOURCE 2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
BULK DENSITY AT SOURCE (g/cm**3) 1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g) 1.00E+02
BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.51E+00
UNSATURATED ZONE THICKNESS (m) 1.00E-03
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) 0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci) 4.20E+02
MOLECULAR WEIGHT (g/mole) 1.00E+02
SOLUBILITY LIMIT (mg/L) 1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 1.27E+00
BULK DENSITY OF AQUIFER (g/cm**3) 1.60E+00
POROSITY OF AQUIFER 4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g) 4.00E+01
DISPERSIVITY X DIRECTION (m) 1.00E+01
DISPERSIVITY Y DIRECTION (m) 5.00E+00
DISPERSIVITY Z DIRECTION (m) 1.00E+00

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PORE VELOCITY (m/y) 6.25E+01
WELL SCREEN THICKNESS (m) 1.55E+01
DISTANCE TO RECEPTOR ALONG X AXIS (m) 4.05E+00
DISTANCE TO RECEPTOR ALONG Y AXIS (m) 9.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m) 0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR rem/Ci 1.20E-04
UNITS OF CONTAMINANT 1
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 1.00E+01
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
-----
LEACH RATE CONSTANT (1/y) 4.7614E-04
UNSATURATED PORE VELOCITY (m/y) 5.8000E+00
DECAY CONSTANT (S) (1/y) 5.4761E-01
RETARDATION FACTOR(S) (SATURATED) 1.0102E+02
RETARDATION FACTOR (UNSATURATED) 1.0000E+00
SOLUBILITY LIMITED MASS (mg) 9.0653E+16
SOLUBILITY LIMITED ACTIVITY (Ci) 2.3504E+17
TRANSIT TIME IN UNSAT ZONE (years) 1.7241E-04
FRACTION DECAYED DURING UNSAT TRANSPORT 9.4394E-05
-----
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
COMPOSITE DOSE CONVERSION FACTOR (rem/Ci) 1.20E-04
LIMITING GROUNDWATER CONCENTRATION (Ci/L) 1.14E-11
MAXIMUM GW CONCENTRATION FOR MBR #1: 1.83E-31 Ci/L CEDE = 1.61E-24 rem
MAXIMUM CEDE 1.61E-24 rem
PEAK TIME (y): 3.634651E+01
LIMITING SOIL CONCENTRATION (Ci/m**3): 4.021E+12
LIMITING SOIL CONCENTRATION (Ci/kg): 2.888E+09
LIMITING INVENTORY IN SOIL (Ci): 2.614E+18
LIMITING INVENTORY IN SOIL (mg): 1.008E+18
SPECIFIC ACTIVITY (Ci/g): 2.593E+03
NOTE: THE LIMITING SOIL CONCENTRATION OF 2.888E+06 Ci/g
EXCEEDS THE SPECIFIC ACTIVITY OF THE NUCLIDE.
WARNING !!! THE LIMITING SOIL MASS OF 1.008E+18 mg
EXCEEDS THE SOLUBILITY LIMITED SOURCE MASS OF 9.065E+16 mg
EXECUTION TIME (seconds) 0
TIME OF RUN 10:39:53.6
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
C1-36 :PAPA REV 2 CLASS AB WASTED
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC
IMODEL: 1 (1) SURF OR BURIED SOURCE; 2 PCND SOURCE; 3 TABULATED SOURCE FUNCTION
ITYPE: 0 (0) VERT AVG; (1) NON-VERT AVG; 2) AVG FROM 0 TO ED
>>> INPUT DATA
-----
NUMBER OF RADIOACTIVE PROGENY 0
LENGTH OF SOURCE PARALLEL TO GW FLOW (m) 6.10E+02
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 1.22E+02
THICKNESS OF SOURCE (m) 7.60E+00
PERCOLATION RATE (darcy vel m/y) 5.80E-01
VOLUMETRIC WATER CONTENT IN SOURCE 2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
BULK DENSITY AT SOURCE (g/cm**3) 1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g) 1.00E+00
BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.50E+00
UNSATURATED ZONE THICKNESS (m) 1.00E+03
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) 0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci) 1.00E+01
MOLECULAR WEIGHT (g/mole) 3.65E+01
SOLUBILITY LIMIT (mg/L) 1.00E+00
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 0.01E+00
BULK DENSITY OF AQUIFER (g/cm**3) 1.60E+00
POROSITY OF AQUIFER 4.00E-01
SORPTION COEFFICIENT (S) IN AQUIFER (ml/g) 0.00E+00
DISPERSIVITY X DIRECTION (m) 0.00E+00
DISPERSIVITY Y DIRECTION (m) 0.00E+00
DISPERSIVITY Z DIRECTION (m) 0.00E+00
PORE VELOCITY (m/y) 6.25E+01
WELL SCREEN THICKNESS (m) 1.55E+01
DISTANCE TO RECEPTOR ALONG X AXIS (m) 4.05E+00
DISTANCE TO RECEPTOR ALONG Y AXIS (m) 9.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m) 0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 1.20E-04
UNITS OF CONTAMINANT 1
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 4.21E+03
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
-----
LEACH RATE CONSTANT (1/y) 4.0615E-02
UNSATURATED PORE VELOCITY (m/y) 5.8000E+00
DECAY CONSTANT(S) (1/y) 5.4761E-01
RETARDATION FACTOR(S) (SATURATED) 1.0000E+00
RETARDATION FACTOR (UNSATURATED) 1.0000E+00
SOLUBILITY LIMITED MASS (mg) 1.0627E+15
SOLUBILITY LIMITED ACTIVITY (Ci) 3.5091E+10

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TRANSIT TIME IN UNSAT ZONE (years)      1.7241E-04
FRACTION DECAYED DURING UNSAT TRANSPORT 3.9704E-10
-----
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
COMPOSITE DOSE CONVERSION FACTOR (rem/Ci): 3.00E+03
LIMITING GROUNDWATER CONCENTRATION (Ci/L): 4.57E-11
MAXIMUM GW CONCENTRATION FOR MBR #1: 6.31E-11 Ci/L CEDE = 1.28E-04 rem
MAXIMUM CEDE 1.38E-04 rem
PEAK TIME (y): 1.192649E+01
LIMITING SOIL CONCENTRATION (Ci m**3): 1.777E-07
LIMITING SOIL CONCENTRATION (Ci kg): 1.111E-10
LIMITING INVENTORY IN SOIL (Ci): 1.005E-01
LIMITING INVENTORY IN SOIL (mg): 3.045E+03
SPECIFIC ACTIVITY (Ci g): 3.302E-02
EXECUTION TIME seconds 1
TIME OF RUN 10:39:53.7
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Cm-243 :PAPA REV 2 CLASS AB WASTE*****
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC
IMODEL: 1 (1) SURF OR BURIED SOURCE; (2) POND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE: 0 (0) VERT AVG; 1, NON-VERT AVG; (2) AVG FROM 0 TO ZD
>>> INPUT DATA
-----
NUMBER OF RADIOACTIVE PROGENY 4
LENGTH OF SOURCE PARALLEL TO GW FLOW (m) 6.10E+02
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 1.22E+02
THICKNESS OF SOURCE (m) 7.60E+00
PERCOLATION RATE (darcy vel m/y) 5.80E-01
VOLUMETRIC WATER CONTENT IN SOURCE 2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
BULK DENSITY AT SOURCE (g/cm**3) 1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g) 1.00E+02
BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.50E+00
UNSATURATED ZONE THICKNESS (m) 1.00E-03
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) 3.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci) 3.30E-02
MOLECULAR WEIGHT (g/mole) 2.43E+02
SOLUBILITY LIMIT (mg/L) 1.00E+06
HALF-LIFE (S) OF CONTAMINANT AND PROGENY (y) 2.85E+01 2.41E+04 7.04E+11 3.28E+04 2.18E+01
BULK DENS. OF AQUIFER (g/cm**3) 1.60E+00
POROSITY OF AQUIFER 4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g) 1.80E+04 1.20E+03 1.50E+01 1.50E+01 1.50E+01
DISPERSIVITY X DIRECTION (m) 1.00E+01
DISPERSIVITY Y DIRECTION (m) 5.00E+00
DISPERSIVITY Z DIRECTION (m) 1.00E+00
PORE VELOCITY (m/y) 6.25E+01
WELL SCREEN THICKNESS (m) 1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS (m) 4.05E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m) 0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m) 0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 1.10E+05 4.30E+06 2.50E+05 1.10E+07 1.46E+07
UNITS OF CONTAMINANT Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 6.39E-01
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
-----
LEACH RATE CONSTANT (1/y) 4.7614E-04
UNSATURATED PORE VELOCITY (m/y) 5.8000E+00
DECAY CONSTANT (1/y) 2.4301E-02 2.3761E-05 9.3458E-13 2.1133E-06 1.1440E-02
RETARDATION FACTOR S SATURATED: 7.711E+04 4.8010E+00 6.1000E-01 6.1000E+01 6.1000E+01
RETARDATION FACTOR UNSATURATED: 1.0000E+00
SOLUBILITY LIMITED MASS (mg) 4.6500E-16
SOLUBILITY LIMITED ACTIVITY (Ci) 4.6834E-15
TRANSIT TIME IN UNSAT ZONE (years) 1.7241E-04
FRACTION DECAYED DURING UNSAT TRANSPORT 4.1933E-06
-----
PEAK CONCENTRATION CANNOT BE FOUND WITH PEAK FINDER ROUTINE:
USE CONCENTRATION VS TIME MODE TO DETERMINE PEAK
NO SOIL CONCENTRATION LIMITS CALCULATED SINCE THE
AVERAGE INTEGRATED CONCENTRATION IS ZERO
TIME OF RUN 10:39:53.8
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Cm-244 :PAPA REV 2 CLASS AB WASTE*****
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC
IMODEL: 1 (1) SURF OR BURIED SOURCE; (2) POND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE: 0 (0) VERT AVG; 1, NON-VERT AVG; (2) AVG FROM 0 TO ZD
>>> INPUT DATA
-----
NUMBER OF RADIOACTIVE PROGENY 5
LENGTH OF SOURCE PARALLEL TO GW FLOW (m) 6.10E+02
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 1.22E+02

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THICKNESS OF SOURCE (m) 7.60E+00
PERCOLATION RATE (darcy vel m/y) 5.80E-01
VOLUMETRIC WATER CONTENT IN SOURCE 2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
BULK DENSITY AT SOURCE (g/cm**3) 1.60E-00
SORPTION COEFFICIENT AT SOURCE (ml/g) 1.00E+02
BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.50E-00
UNSATURATED ZONE THICKNESS (m) 1.00E-03
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) 0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci) 1.30E-01
MOLECULAR WEIGHT (g/mole) 2.44E+02
SOLUBILITY LIMIT (mg/L) 1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 1.91E-01 6.56E-03 2.43E-07 1.41E+10 5.75E+00 1.91E-01
BULK DENSITY OF AQUIFER (g/cm**3) 1.60E-00
POROSITY OF AQUIFER 4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g) 1.80E-04 1.20E+03 1.50E+01 3.30E+03 3.60E+04 3.30E-03
DISPERSIVITY X DIRECTION (m) 1.00E+01
DISPERSIVITY Y DIRECTION (m) 5.00E+00
DISPERSIVITY Z DIRECTION (m) 1.00E+00
PORE VELOCITY (m/y) 6.25E-01
WELL SCREEN THICKNESS (m) 1.50E-01
DISTANCE TO RECEPTOR ALONG X AXIS (m) 4.05E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m) 0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m) 0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 2.30E+06 2.29E+06 2.50E+05 2.80E+06 1.20E+06 7.50E+05
UNITS OF CONTAMINANT Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 1.63E+00
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
-----
LEACH RATE CONSTANT (1/y) 4.7614E-04
UNSATURATED PORE VELOCITY (m/y) 5.8000E+00
DECAY CONSTANT(S) (1/y) 3.8295E-02 1.0560E-04 2.8525E-08 4.9159E-11 1.2055E-01 3.6290E-01
RETARDATION FACTOR (SATURATED) 7.2001E+04 4.9010E+03 6.1900E+01 1.3291E+04 1.4400E+05 1.0001E-04
RETARDATION FACTOR (UNSATURATED) 1.0000E+00
SOLUBILITY LIMITED MASS (mg) 9.0653E+16
SOLUBILITY LIMITED ACTIVITY (Ci) 7.3441E+15
TRANSIT TIME IN UNSAT ZONE (years) 1.7241E-04
FRACTION DECAYED DURING UNSAT TRANSPORT 6.6026E-06
-----
PEAK CONCENTRATION CANNOT BE FOUND WITH PEAK FINDER ROUTINE:
USE CONCENTRATION VS TIME MODE TO DETERMINE PEAK
NO SOIL CONCENTRATION LIMITS CALCULATED SINCE THE
AVERAGE INTEGRATED CONCENTRATION IS ZERO
TIME OF RUN 10:39:53.9
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Co-60 :PAPA REV 2 CLASS AB WASTE*****
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC
IMODEL: 1 (1) SURF OR BURIED SOURCE; (2) POND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE: 0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO ZD
>>> INPUT DATA
-----
NUMBER OF RADIOACTIVE PROGENY 0
LENGTH OF SOURCE PARALLEL TO GW FLOW (m) 6.10E+02
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 1.22E+02
THICKNESS OF SOURCE (m) 7.60E+00
PERCOLATION RATE (darcy vel m/y) 5.80E-01
VOLUMETRIC WATER CONTENT IN SOURCE 2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
BULK DENSITY AT SOURCE (g/cm**3) 1.60E-00
SORPTION COEFFICIENT AT SOURCE (ml/g) 1.00E+02
BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.50E-00
UNSATURATED ZONE THICKNESS (m) 1.00E-03
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) 0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci) 4.73E+04
MOLECULAR WEIGHT (g/mole) 6.00E+01
SOLUBILITY LIMIT (mg/L) 1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 5.75E+00
BULK DENSITY OF AQUIFER (g/cm**3) 1.60E+00
POROSITY OF AQUIFER 4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g) 1.30E+03
DISPERSIVITY X DIRECTION (m) 1.00E+01
DISPERSIVITY Y DIRECTION (m) 5.00E+00
DISPERSIVITY Z DIRECTION (m) 1.00E+00
PORE VELOCITY (m/y) 6.25E-01
WELL SCREEN THICKNESS (m) 1.50E-01
DISTANCE TO RECEPTOR ALONG X AXIS (m) 4.05E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m) 0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m) 0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 2.60E+04
UNITS OF CONTAMINANT Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 4.50E+04
>>> VALUES CALCULATED IN SOURCE SUBROUTINE

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*****
LEACH RATE CONSTANT (1/y)          4.7614E-04
UNSATURATED PORE VELOCITY (m/y)    5.8000E+00
DECAY CONSTANT(S) (1/y)            1.2055E-01
RETARDATION FACTOR(S) (SATURATED)  5.2010E+03
RETARDATION FACTOR (UNSATURATED)    1.3060E+00
SOLUBILITY LIMITED MASS (mg)         2.0651E+10
SOLUBILITY LIMITED ACTIVITY (Ci)     2.4214E+16
TRANSIT TIME IN UNSAT ZONE (years)   1.7241E-04
FRACTION DECAYED DURING UNSAT TRANSPORT 2.2791E-15
*****
PEAK CONCENTRATION CANNOT BE FOUND WITH PEAK FINDER ROUTINE:
USE CONCENTRATION VS TIME MODE TO DETERMINE PEAK
NO SOIL CONCENTRATION LIMITS CALCULATED SINCE THE
AVERAGE INTEGRATED CONCENTRATION IS ZERO
TIME OF RUN 10:39:53.9
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Cs-134 :PAPA REV 2 CLASS AB WASTE*****
*****
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC
IMODEL: 1 (1) SURF OR BURIED SOURCE; (2) POND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE: 0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO ZD
>>> INPUT DATA
*****
NUMBER OF RADIOACTIVE PROGENY          1
LENGTH OF SOURCE PARALLEL TO GW FLOW (m) 6.10E+02
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 1.22E+02
THICKNESS OF SOURCE (m)                7.00E+00
PERCOLATION RATE (arcy vel m/y)        5.80E+01
VOLUMETRIC WATER CONTENT IN SOURCE      2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.22E-01
BULK DENSITY AT SOURCE (g/cm**3)        1.00E+00
SORPTION COEFFICIENT AT SOURCE (ml/g)    2.30E+01
BULK DENSITY IN UNSAT ZONE (g/cm**3)    1.50E+00
UNSATURATED ZONE THICKNESS (m)          1.30E+03
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) 0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci)      7.63E+03
MOLECULAR WEIGHT (g/mole)               1.34E+02
SOLUBILITY LIMIT (mg/L)                 1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 2.06E+00
BULK DENSITY OF AQUIFER (g/cm**3)       1.60E+00
POROSITY OF AQUIFER                    4.30E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g) 4.00E+03
DISPERSIVITY X DIRECTION (m)            1.30E+01
DISPERSIVITY Y DIRECTION (m)            5.30E+00
DISPERSIVITY Z DIRECTION (m)            1.30E+00
PORE VELOCITY (m/y)                    6.25E+01
WELL SCREEN THICKNESS (m)               1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS (m) 4.35E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m) 0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m) 0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 7.40E+04
UNITS OF CONTAMINANT                    Ci
*****
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 5.89E+03
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
*****
LEACH RATE CONSTANT (1/y)          2.3643E-03
UNSATURATED PORE VELOCITY (m/y)    5.8000E+00
DECAY CONSTANT(S) (1/y)            3.3615E-01
RETARDATION FACTOR(S) (SATURATED)  1.8421E+04
RETARDATION FACTOR (UNSATURATED)    1.3000E+00
SOLUBILITY LIMITED MASS (mg)         1.8257E+16
SOLUBILITY LIMITED ACTIVITY (Ci)     2.0641E+16
TRANSIT TIME IN UNSAT ZONE (years)   1.7241E-04
FRACTION DECAYED DURING UNSAT TRANSPORT 5.7356E-15
*****
PEAK CONCENTRATION CANNOT BE FOUND WITH PEAK FINDER ROUTINE:
USE CONCENTRATION VS TIME MODE TO DETERMINE PEAK
NO SOIL CONCENTRATION LIMITS CALCULATED SINCE THE
AVERAGE INTEGRATED CONCENTRATION IS ZERO
TIME OF RUN 10:39:54.0
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Cs-137 :PAPA REV 2 CLASS AB WASTE*****
*****
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC
IMODEL: 1 (1) SURF OR BURIED SOURCE; (2) POND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE: 0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO ZD
>>> INPUT DATA
*****
NUMBER OF RADIOACTIVE PROGENY          1
LENGTH OF SOURCE PARALLEL TO GW FLOW (m) 6.10E+02
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 1.22E+02

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THICKNESS OF SOURCE (m) 7.60E+00
PERCOLATION RATE (darcy vel m/y) 5.80E-01
VOLUMETRIC WATER CONTENT IN SOURCE 2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
BULK DENSITY AT SOURCE (g/cm**3) 1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g) 2.00E+01
BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.50E+00
UNSATURATED ZONE THICKNESS (m) 1.00E-03
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) 0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci) 1.45E+04
MOLECULAR WEIGHT (g/mole) 1.55E+02
SOLUBILITY LIMIT (mg/L) 1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 3.00E+01
BULK DENSITY OF AQUIFER (g/cm**3) 1.60E+00
POROSITY OF AQUIFER 4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g) 4.60E+03
DISPERSIVITY X DIRECTION (m) 1.00E+01
DISPERSIVITY Y DIRECTION (m) 5.00E+00
DISPERSIVITY Z DIRECTION (m) 1.00E+00
PORE VELOCITY (m/y) 6.25E+01
WELL SCREEN THICKNESS (m) 1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS (m) 4.05E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m) 0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m) 0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 5.00E+04
UNITS OF CONTAMINANT Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 1.45E+05
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
-----
LEACH RATE CONSTANT (1/y) 2.3643E-03
UNSATURATED PORE VELOCITY (m/y) 5.8000E+00
DECAY CONSTANT(S) (1/y) 2.3105E-02
RETARDATION FACTOR(S) (SATURATED) 1.8401E+04
RETARDATION FACTOR (UNSATURATED) 1.0000E+00
SOLUBILITY LIMITED MASS (mg) 1.8257E+16
SOLUBILITY LIMITED ACTIVITY (Ci) 1.5893E+15
TRANSIT TIME IN UNSAT ZONE (years) 1.7241E-04
FRACTION DECAYED DURING UNSAT TRANSPORT 3.9836E-06
-----
NO SOIL CONCENTRATION LIMITS CALCULATED SINCE THE
AVERAGE INTEGRATED CONCENTRATION IS ZERO
TIME OF RUN 10:39:54.2
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Eu-155 :PAPA REV 1 CLASS AB WASTE
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC
IMODEL: 1 (1) SURF OR BURIED SOURCE; 2. PCND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE: 0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO 2D
>>> INPUT DATA
-----
NUMBER OF RADIOACTIVE PROGENY 0
LENGTH OF SOURCE PARALLEL TO GW FLOW (m) 6.10E+02
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 1.22E+02
THICKNESS OF SOURCE (m) 7.60E+00
PERCOLATION RATE (darcy vel m/y) 5.80E-01
VOLUMETRIC WATER CONTENT IN SOURCE 2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
BULK DENSITY AT SOURCE (g/cm**3) 1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g) 2.00E+01
BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.50E+00
UNSATURATED ZONE THICKNESS (m) 1.00E-03
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) 0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci) 1.45E+04
MOLECULAR WEIGHT (g/mole) 1.55E+02
SOLUBILITY LIMIT (mg/L) 1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 3.00E+01
BULK DENSITY OF AQUIFER (g/cm**3) 1.60E+00
POROSITY OF AQUIFER 4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g) 4.60E+03
DISPERSIVITY X DIRECTION (m) 1.00E+01
DISPERSIVITY Y DIRECTION (m) 5.00E+00
DISPERSIVITY Z DIRECTION (m) 1.00E+00
PORE VELOCITY (m/y) 6.25E+01
WELL SCREEN THICKNESS (m) 1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS (m) 4.05E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m) 0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m) 0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 1.30E+03
UNITS OF CONTAMINANT Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 3.44E+03
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
-----
LEACH RATE CONSTANT (1/y) 9.5391E-06

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UNSATURATED PORE VELOCITY (m/y)          5.8000E+00
DECAY CONSTANT(S) (1/y)                  1.3975E-01
RETARDATION FACTOR(S) (SATURATED)        1.0000E+00
RETARDATION FACTOR (UNSATURATED)         1.0000E+00
SOLUBILITY LIMITED MASS (mg)              4.5249E+18
SOLUBILITY LIMITED ACTIVITY (Ci)          2.1258E+18
TRANSIT TIME IN UNSAT ZONE (years)        1.7241E-04
FRACTION DECAYED DURING UNSAT TRANSPORT  0.4244E-15
-----
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
COMPOSITE DOSE CONVERSION FACTOR rem/Ci:  1.00E+03
LIMITING GROUNDWATER CONCENTRATION Ci/L:  1.05E-10
MAXIMUM GW CONCENTRATION FOR MBR #1: 5.23E-17 Ci/L CEDE = 4.96E-11 rem
MAXIMUM CEDE 4.96E-11 rem
PEAK TIME (y): 7.625320E+10
LIMITING SOIL CONCENTRATION Ci.m**3: 5.703E-03
LIMITING SOIL CONCENTRATION Ci.kg: 3.565E-06
LIMITING INVENTORY IN SOIL Ci: 3.226E+03
LIMITING INVENTORY IN SOIL mg: 6.931E+03
SPECIFIC ACTIVITY (Ci/g): 4.654E+02
EXECUTION TIME (seconds) 0
TIME OF RUN 10:39:54.4
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Fe-55 :PAPA REV 2 CLASS AB WASTE
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC
IMODEL: 1 (1) SURF OR BURIED SOURCE; (2) POND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE: 0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO 10
>>> INPUT DATA
-----
NUMBER OF RADIOACTIVE PROGENY 0
LENGTH OF SOURCE PARALLEL TO GW FLOW (m) 9.13E+02
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 1.22E+02
THICKNESS OF SOURCE (m) 7.60E+00
PERCOLATION RATE (darcy vel m/y) 5.80E-01
VOLUMETRIC WATER CONTENT IN SOURCE 2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
BULK DENSITY AT SOURCE (g/cm**3) 1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g) 1.00E+02
BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.50E+00
UNSATURATED ZONE THICKNESS (m) 1.00E-03
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) 2.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci) 1.71E+05
MOLECULAR WEIGHT (g/mole) 5.50E+01
SOLUBILITY LIMIT (mg/L) 1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 2.73E+00
BULK DENSITY OF AQUIFER (g/cm**3) 1.60E+00
POROSITY OF AQUIFER 4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g) 8.00E+02
DISPERSIVITY X DIRECTION (m) 1.00E+01
DISPERSIVITY Y DIRECTION (m) 5.00E+00
DISPERSIVITY Z DIRECTION (m) 1.00E+00
PORE VELOCITY (m/y) 6.25E+01
WELL SCREEN THICKNESS (m) 1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS (m) 4.05E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m) 0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m) 0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR rem/Ci 5.80E+01
UNITS OF CONTAMINANT Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 7.18E+04
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
-----
LEACH RATE CONSTANT (1/y) 4.7614E-04
UNSATURATED PORE VELOCITY (m/y) 5.8000E+00
DECAY CONSTANT(S) (1/y) 1.3975E-01
RETARDATION FACTOR(S) (SATURATED) 1.0000E+03
RETARDATION FACTOR (UNSATURATED) 1.0000E+03
SOLUBILITY LIMITED MASS (mg) 9.0653E+16
SOLUBILITY LIMITED ACTIVITY (Ci) 2.1602E+17
TRANSIT TIME IN UNSAT ZONE (years) 1.7241E-04
FRACTION DECAYED DURING UNSAT TRANSPORT 4.3775E-05
-----
PEAK CONCENTRATION CANNOT BE FOUND WITH PEAK FINDER ROUTINE:
USE CONCENTRATION VS TIME MODE TO DETERMINE PEAK
NO SOIL CONCENTRATION LIMITS CALCULATED SINCE THE
AVERAGE INTEGRATED CONCENTRATION IS ZERO
TIME OF RUN 10:39:54.4
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
H-3 :PAPA REV 2 CLASS AB WASTE
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC
IMODEL: 1 (1) SURF OR BURIED SOURCE; (2) POND SOURCE; (3) TABULATED SOURCE FUNCTION

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ITYPE:0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO 2D
>>> INPUT DATA
.....
NUMBER OF RADIOACTIVE PROGENY                0
LENGTH OF SOURCE PARALLEL TO GW FLOW (m)      6.10E+02
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m)   1.22E+02
THICKNESS OF SOURCE (m)                       7.00E+00
PERCOLATION RATE (darcy vel m/y)              5.80E+01
VOLUMETRIC WATER CONTENT IN SOURCE            2.79E+01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE   1.00E+01
BULK DENSITY AT SOURCE (g/cm**3)              1.60E+00
SORPTION COEFFICIENT AT SOURCE ml/g            0.00E+00
BULK DENSITY IN UNSAT ZONE (g/cm**3)          1.50E+00
UNSATURATED ZONE THICKNESS (m)                 1.00E+03
SORPTION COEFFICIENT IN UNSAT ZONE ml/g        0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci)            3.50E+05
MOLECULAR WEIGHT (g/mole)                     3.00E+00
SOLUBILITY LIMIT (mg/L)                       1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y)    1.23E+01
BULK DENSITY OF AQUIFER (g/cm**3)             1.60E+00
POROSITY OF AQUIFER                           4.00E+01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g)      0.00E+00
DISPERSIVITY X DIRECTION (m)                  1.00E+01
DISPERSIVITY Y DIRECTION (m)                  5.00E+00
DISPERSIVITY Z DIRECTION (m)                  1.00E+00
PORE VELOCITY (m/y)                           6.25E+01
WELL SCREEN THICKNESS (m)                     1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS (m)        4.05E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m)        0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m)        0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci)   6.39E+01
UNITS OF CONTAMINANT                          Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg)    3.04E+04
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
.....
LEACH RATE CONSTANT (1/y)                     2.7353E-01
UNSATURATED PORE VELOCITY (m/y)               5.8000E+00
DECAY CONSTANT(S) (1/y)                      5.6353E-02
RETARDATION FACTOR(S) (SATURATED)             1.0000E+00
RETARDATION FACTOR (UNSATURATED)              1.0000E+00
SOLUBILITY LIMITED MASS (mg)                   1.5780E+14
SOLUBILITY LIMITED ACTIVITY (Ci)               1.5301E+15
TRANSIT TIME IN UNSAT ZONE (years)             1.7241E-04
FRACTION DECAYED DURING UNSAT TRANSPORT        9.7161E-06
-----
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
COMPOSITE DOSE CONVERSION FACTOR (rem/Ci):     6.30E+01
LIMITING GROUNDWATER CONCENTRATION (Ci/L):     2.17E-09
MAXIMUM GW CONCENTRATION FOR MBR #1: 2.97E-04 Ci/L CEDE = 1.37E+01 rem
MAXIMUM CEDE 1.37E+01 rem
PEAK TIME (y):                                6.596615E+00
LIMITING SOIL CONCENTRATION (Ci/m**3):         4.572E-06
LIMITING SOIL CONCENTRATION (Ci/kg):            2.858E-09
LIMITING INVENTORY IN SOIL (Ci):               2.586E+00
LIMITING INVENTORY IN SOIL (mg):               2.667E-01
SPECIFIC ACTIVITY (Ci/g): 9.696E+03
EXECUTION TIME (seconds)                        0
TIME OF RUN 10:39:54.5
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
I-129 :PAPA REV 2 CLASS AB WASTE.....
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC
IMODEL: 1 (1) SURF OR BURIED SOURCE; (2) POND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE:0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO 2D
>>> INPUT DATA
.....
NUMBER OF RADIOACTIVE PROGENY                0
LENGTH OF SOURCE PARALLEL TO GW FLOW (m)      6.10E+02
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m)   1.22E+02
THICKNESS OF SOURCE (m)                       7.00E+00
PERCOLATION RATE (darcy vel m/y)              5.80E+01
VOLUMETRIC WATER CONTENT IN SOURCE            2.79E+01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE   1.00E+01
BULK DENSITY AT SOURCE (g/cm**3)              1.60E+00
SORPTION COEFFICIENT AT SOURCE ml/g            0.00E+00
BULK DENSITY IN UNSAT ZONE (g/cm**3)          1.50E+00
UNSATURATED ZONE THICKNESS (m)                 1.00E+03
SORPTION COEFFICIENT IN UNSAT ZONE ml/g        0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci)            4.11E+03
MOLECULAR WEIGHT (g/mole)                     1.29E+02
SOLUBILITY LIMIT (mg/L)                       1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y)    1.57E+07
BULK DENSITY OF AQUIFER (g/cm**3)             1.60E+00
POROSITY OF AQUIFER                           4.00E+01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g)      5.00E+00

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DISPERSIVITY X DIRECTION (m) 1.00E+01
DISPERSIVITY Y DIRECTION (m) 5.00E+00
DISPERSIVITY Z DIRECTION (m) 1.00E+00
PORE VELOCITY (m/y) 6.25E+01
WELL SCREEN THICKNESS (m) 1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS (m) 4.05E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m) 0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m) 0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 2.80E+05
UNITS OF CONTAMINANT 71
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 2.33E+04
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
-----
LEACH RATE CONSTANT (1/y) 9.2180E-03
UNSATURATED PORE VELOCITY (m/y) 5.8900E+00
DECAY CONSTANT(S) (1/y) 4.4150E-08
RETARDATION FACTOR(S) SATURATED 2.1500E+01
RETARDATION FACTOR (UNSATURATED) 1.0000E+00
SOLUBILITY LIMITED MASS (mg) 4.6825E+15
SOLUBILITY LIMITED ACTIVITY (Ci) 8.2702E+08
TRANSIT TIME IN UNSAT ZONE (years) 1.7241E-04
FRACTION DECAYED DURING UNSAT TRANSPORT 7.6120E-10
-----
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
COMPOSITE DOSE CONVERSION FACTOR (rem/Ci): 2.80E+05
LIMITING GROUNDWATER CONCENTRATION (Ci/L): 4.89E-13
MAXIMUM GW CONCENTRATION FOR MBR #1: 2.24E-13 Ci/L CEDE = 4.58E-05 rem
MAXIMUM CEDE 4.58E-05 rem
PEAK TIME (y): 1.947919E+02
LIMITING SOIL CONCENTRATION (Ci/m**3): 1.58E+08
LIMITING SOIL CONCENTRATION (Ci/Kg): 7.913E-12
LIMITING INVENTORY IN SOIL (Ci): 8.971E+03
LIMITING INVENTORY IN SOIL (mg): 5.078E+04
SPECIFIC ACTIVITY (Ci/g): 1.767E-04
EXECUTION TIME (seconds) 0
TIME OF RUN 10:39:54.6
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Na-22 :PAPA REV 2 CLASS AB WASTE*****
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC
IMODEL: 1 (1) SURF OR BURIED SOURCE; (2) PCND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE: 0 (0) VERT AVG; 1, NON-VERT AVG; 2 AVG FROM 0 TO 2D
>>> INPUT DATA
-----
NUMBER OF RADIOACTIVE PROGENY 3
LENGTH OF SOURCE PARALLEL TO GW FLOW (m) 6.10E+02
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 1.22E+02
THICKNESS OF SOURCE (m) 7.60E+00
PERCOLATION RATE (darcy vel m/y) 5.80E-01
VOLUMETRIC WATER CONTENT IN SOURCE 2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
BULK DENSITY AT SOURCE (g/cm**3) 1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g) 0.00E+00
BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.50E+00
UNSATURATED ZONE THICKNESS (m) 1.00E+03
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) 0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci) 1.26E+01
MOLECULAR WEIGHT (g.mole) 22.9E+01
SOLUBILITY LIMIT (mg/L) 1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 2.60E+00
BULK DENSITY OF AQUIFER (g/cm**3) 1.60E+00
POROSITY OF AQUIFER 4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g) 0.00E+00
DISPERSIVITY X DIRECTION (m) 1.00E+01
DISPERSIVITY Y DIRECTION (m) 5.00E+00
DISPERSIVITY Z DIRECTION (m) 1.00E+00
PORE VELOCITY (m/y) 6.25E+01
WELL SCREEN THICKNESS (m) 1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS (m) 4.05E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m) 0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m) 0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 1.20E+04
UNITS OF CONTAMINANT 71
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 2.17E+02
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
-----
LEACH RATE CONSTANT (1/y) 2.7353E-01
UNSATURATED PORE VELOCITY (m/y) 5.8900E+00
DECAY CONSTANT(S) (1/y) 2.6660E-01
RETARDATION FACTOR(S) SATURATED 1.0000E+00
RETARDATION FACTOR (UNSATURATED) 1.0000E+00
SOLUBILITY LIMITED MASS (mg) 1.5780E+14
SOLUBILITY LIMITED ACTIVITY (Ci) 9.8706E+14
TRANSIT TIME IN UNSAT ZONE (years) 1.7241E-04

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FRACTION DECAYED DURING UNSAT TRANSPORT 4.5964E-05
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COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
COMPOSITE DOSE CONVERSION FACTOR (rem/Ci): 1.22E+04
LIMITING GROUNDWATER CONCENTRATION (Ci/L): 1.14E-11
MAXIMUM GW CONCENTRATION FOR MBR #1: 3.98E-11 Ci/L CEDE = 3.49E-04 rem
MAXIMUM CEDE 3.49E-04 rem
PEAK TIME (y): 4.558907E+00
LIMITING SOIL CONCENTRATION (Ci/m**3): 6.889E-08
LIMITING SOIL CONCENTRATION (Ci/kg): 4.306E-11
LIMITING INVENTORY IN SOIL (Ci): 3.896E-32
LIMITING INVENTORY IN SOIL (mg): 6.229E-03
SPECIFIC ACTIVITY (Ci/g): 6.255E+03
EXECUTION TIME (seconds) )
TIME OF RUN 10:39:54.7
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Nb-94 :PAPA REV 2 CLASS AB WASTE
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC
IMODEL: 1 (1) SURF OR BURIED SOURCE; (2) POND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE: 0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO ED
>>> INPUT DATA
*****
NUMBER OF RADIOACTIVE PROGENY 0
LENGTH OF SOURCE PARALLEL TO GW FLOW (m) 6.10E+02
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 1.22E+02
THICKNESS OF SOURCE (m) 7.60E+00
PERCOLATION RATE (darcy vel m/y) 5.93E-11
VOLUMETRIC WATER CONTENT IN SOURCE 2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.30E-01
BULK DENSITY AT SOURCE (g/cm**3) 1.50E+00
SORPTION COEFFICIENT AT SOURCE (ml/g) 1.00E+03
BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.53E+00
UNSATURATED ZONE THICKNESS (m) 1.30E+03
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) 0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci) 2.67E-01
MOLECULAR WEIGHT (g/mole) 9.40E+01
SOLUBILITY LIMIT (mg/L) 1.30E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 2.00E+04
BULK DENSITY OF AQUIFER (g/cm**3) 1.60E+00
POROSITY OF AQUIFER 4.30E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g) 5.50E+02
DISPERSIVITY X DIRECTION (m) 1.00E+01
DISPERSIVITY Y DIRECTION (m) 5.00E+00
DISPERSIVITY Z DIRECTION (m) 1.00E+00
PORE VELOCITY (m/y) 6.25E+01
WELL SCREEN THICKNESS (m) 1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS (m) 4.05E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m) 2.30E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m) 9.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 5.10E+03
UNITS OF CONTAMINANT Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 1.40E+03
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
*****
LEACH RATE CONSTANT (1/y) 4.7689E-05
UNSATURATED PORE VELOCITY (m/y) 5.8300E+00
DECAY CONSTANT(S) (1/y) 3.4657E-05
RETARDATION FACTOR(S) SATURATED) 2.2010E+03
RETARDATION FACTOR UNSATURATED) 1.1000E+00
SOLUBILITY LIMITED MASS (mg) 9.0511E+17
SOLUBILITY LIMITED ACTIVITY (Ci) 1.7225E+14
TRANSIT TIME IN UNSAT ZONE (years) 1.7241E-04
FRACTION DECAYED DURING UNSAT TRANSPORT 5.9754E-09
-----
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
COMPOSITE DOSE CONVERSION FACTOR (rem/Ci): 5.10E+03
LIMITING GROUNDWATER CONCENTRATION (Ci/L): 2.69E-11
MAXIMUM GW CONCENTRATION FOR MBR #1: 5.15E-14 Ci/L CEDE = 1.32E-07 rem
MAXIMUM CEDE 1.32E-07 rem
PEAK TIME (y): 1.757458E+04
LIMITING SOIL CONCENTRATION (Ci/m**3): 2.462E-04
LIMITING SOIL CONCENTRATION (Ci/kg): 1.539E-07
LIMITING INVENTORY IN SOIL (Ci): 1.393E+02
LIMITING INVENTORY IN SOIL (mg): 7.318E+05
SPECIFIC ACTIVITY (Ci/g): 1.903E+01
EXECUTION TIME (seconds) )
TIME OF RUN 10:39:54.8
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
N1-63 :PAPA REV 2 CLASS AB WASTE
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC

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IMODEL:1 (1) SURF OR BURIED SOURCE; (2) POND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE:0 0 VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO 2D
>>> INPUT DATA
.....
NUMBER OF RADIOACTIVE PROGENY 0
LENGTH OF SOURCE PARALLEL TO GW FLOW m 6.10E+02
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW m 1.22E+02
THICKNESS OF SOURCE (m) 7.60E+00
PERCOLATION RATE (darcy vel m/y) 5.80E-01
VOLUMETRIC WATER CONTENT IN SOURCE 2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
BULK DENSITY AT SOURCE (g/cm**3) 1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g) 1.00E+02
BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.50E+00
UNSATURATED ZONE THICKNESS (m) 1.00E+03
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) 0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci) 5.03E+01
MOLECULAR WEIGHT (g/mole) 5.00E+01
SOLUBILITY LIMIT (mg/L) 1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 1.00E+02
BULK DENSITY OF AQUIFER (g/cm**3) 1.60E+00
POROSITY OF AQUIFER 4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g) 0.00E+02
DISPERSIVITY X DIRECTION (m) 1.00E+01
DISPERSIVITY Y DIRECTION (m) 5.00E+00
DISPERSIVITY Z DIRECTION (m) 1.00E+00
PORE VELOCITY (m/y) 6.25E+01
WELL SCREEN THICKNESS (m) 1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS (m) 4.05E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m) 0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m) 0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 5.40E-01
UNITS OF CONTAMINANT Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 9.86E+02
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
.....
LEACH RATE CONSTANT (1/y) 4.7614E-04
UNSATURATED PORE VELOCITY (m/y) 5.8000E+00
DECAY CONSTANT(S) (1/y) 6.9315E-03
RETARDATION FACTOR(S) (SATURATED) 1.2010E+03
RETARDATION FACTOR (UNSATURATED) 1.0000E+00
SOLUBILITY LIMITED MASS (mg) 2.0653E+16
SOLUBILITY LIMITED ACTIVITY (Ci) 5.1484E+15
TRANSIT TIME IN UNSAT ZONE (years) 1.7241E-04
FRACTION DECAYED DURING UNSAT TRANSPORT 1.1951E-06
-----
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
COMPOSITE DOSE CONVERSION FACTOR (rem/Ci): 5.40E+01
LIMITING GROUNDWATER CONCENTRATION (Ci/L): 2.54E-09
MAXIMUM GW CONCENTRATION FOR MBR #1: 4.48E-16 Ci/L CEDE = 1.77E-11 rem
MAXIMUM CEDE 1.77E-11 rem
PEAK TIME (y): 9.470807E+02
LIMITING SOIL CONCENTRATION (Ci/m**3): 5.040E+02
LIMITING SOIL CONCENTRATION (Ci/kg): 3.150E-01
LIMITING INVENTORY IN SOIL (Ci): 2.851E+08
LIMITING INVENTORY IN SOIL (mg): 5.020E+09
SPECIFIC ACTIVITY (Ci/g): 5.679E+01
EXECUTION TIME (seconds) 0
TIME OF RUN 10:39:55.0
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
N1-59 :PAPA REV D CLASS AB WASTE*****
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 0) CONC VS TIME; 1) PEAK CONC AND LIMITING SOIL CONC
IMODEL:1 (1) SURF OR BURIED SOURCE; 2) POND SOURCE; 3) TABULATED SOURCE FUNCTION
ITYPE:0 0) VERT AVG; 1) NON-VERT AVG; 2) AVG FROM 0 TO 2D
>>> INPUT DATA
.....
NUMBER OF RADIOACTIVE PROGENY 0
LENGTH OF SOURCE PARALLEL TO GW FLOW m 6.10E+02
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW m 1.22E+02
THICKNESS OF SOURCE (m) 7.60E+00
PERCOLATION RATE (darcy vel m/y) 5.80E-01
VOLUMETRIC WATER CONTENT IN SOURCE 2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
BULK DENSITY AT SOURCE (g/cm**3) 1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g) 1.00E+02
BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.50E+00
UNSATURATED ZONE THICKNESS (m) 1.00E+03
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) 0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci) 5.03E+01
MOLECULAR WEIGHT (g/mole) 5.00E+01
SOLUBILITY LIMIT (mg/L) 1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 1.00E+02
BULK DENSITY OF AQUIFER (g/cm**3) 1.60E+00
POROSITY OF AQUIFER 4.00E-01

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SORPTION COEFFICIENT(S) IN AQUIFER (ml/g)      3.00E+02
DISPERSIVITY X DIRECTION (m)                   1.00E+01
DISPERSIVITY Y DIRECTION (m)                   5.00E+00
DISPERSIVITY Z DIRECTION (m)                   1.00E+00
PORE VELOCITY (m/y)                            6.25E-01
WELL SCREEN THICKNESS (m)                      1.50E-01
DISTANCE TO RECEPTOR ALONG X AXIS            m  4.05E+02
DISTANCE TO RECEPTOR ALONG Y AXIS            m  0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS            m  0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem Ci)    2.10E+02
UNITS OF CONTAMINANT                           Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg)  6.23E+05
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
-----
LEACH RATE CONSTANT (1/y)                      4.7614E-04
UNSATURATED PORE VELOCITY (m/y)                5.8000E+00
DECAY CONSTANT(S) (1/y)                       9.2420E-06
RETARDATION FACTOR(S) (SATURATED)              1.2010E+03
RETARDATION FACTOR (UNSATURATED)              1.0000E+00
SOLUBILITY LIMITED MASS (mg)                   9.0653E+16
SOLUBILITY LIMITED ACTIVITY (Ci)               7.3299E+12
TRANSIT TIME IN UNSAT ZONE (years)             1.7241E-04
FRACTION DECAYED DURING UNSAT TRANSPORT        1.5934E-09
-----
COMMITTEE EFFECTIVE DOSE EQUIVALENT CALCULATION
COMPOSITE DOSE CONVERSION FACTOR (rem/Ci):      2.10E+02
LIMITING GROUNDWATER CONCENTRATION (Ci/L):      6.52E-13
MAXIMUM GW CONCENTRATION FOR MBR #1: 5.90E-11 Ci/L CEDE = 9.04E-06 rem
MAXIMUM CEDE 9.04E-06 rem
PEAK TIME (y):                                 7.997811E+03
LIMITING SOIL CONCENTRATION (Ci/m**3):          9.841E-04
LIMITING SOIL CONCENTRATION (Ci/kg):            6.150E-07
LIMITING INVENTORY IN SOIL (Ci):               5.566E+02
LIMITING INVENTORY IN SOIL (mg):               6.883E+06
SPECIFIC ACTIVITY (Ci/g): 8.086E-02
EXECUTION TIME (seconds)                        3
TIME OF RUN 10:39:55.1
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Pb-210 :PAPA REV 2 CLASS AB WASTE=====
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC
IMODEL: 1 (1) SURF OR BURIED SOURCE; (2) POND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE: 0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO ZD
>>> INPUT DATA
-----
NUMBER OF RADIOACTIVE PROGENY                  0
LENGTH OF SOURCE PARALLEL TO GW FLOW (m)       6.10E+02
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m)   1.22E+02
THICKNESS OF SOURCE (m)                       7.60E+00
PERCOLATION RATE (darcy vel m/y)              5.80E-01
VOLUMETRIC WATER CONTENT IN SOURCE             2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE   1.00E-01
BULK DENSITY AT SOURCE (g/cm**3)              1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g)          0.00E+00
BULK DENSITY IN UNSAT ZONE (g/cm**3)          1.50E+00
UNSATURATED ZONE THICKNESS (m)                1.00E-03
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g)      1.60E+04
OPTIONAL LOSS RATE CONSTANT FOR SOURCE Y**=1: 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci)           7.33E+12
MOLECULAR WEIGHT (g/mole)                     2.10E+02
SOLUBILITY LIMIT (mg/L)                       1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y)    2.23E+01
BULK DENSITY OF AQUIFER (g/cm**3)             1.60E+00
POROSITY OF AQUIFER                           4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g)      1.60E+04
DISPERSIVITY X DIRECTION (m)                   1.00E+01
DISPERSIVITY Y DIRECTION (m)                   5.00E+00
DISPERSIVITY Z DIRECTION (m)                   1.00E+00
PORE VELOCITY (m/y)                            6.25E-01
WELL SCREEN THICKNESS (m)                      1.50E-01
DISTANCE TO RECEPTOR ALONG X AXIS            m  4.05E+02
DISTANCE TO RECEPTOR ALONG Y AXIS            m  0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS            m  0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci)    6.70E+06
UNITS OF CONTAMINANT                           Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg)  9.67E+00
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
-----
LEACH RATE CONSTANT (1/y)                      2.7353E-01
UNSATURATED PORE VELOCITY (m/y)                5.8000E+00
DECAY CONSTANT(S) (1/y)                       3.1083E-02
RETARDATION FACTOR(S) (SATURATED)              6.4001E+04
RETARDATION FACTOR (UNSATURATED)              2.4000E+05
SOLUBILITY LIMITED MASS (mg)                   1.5780E+14
SOLUBILITY LIMITED ACTIVITY (Ci)               1.2056E+13

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TRANSIT TIME IN UNSAT ZONE (years)      4.1379E+01
FRACTION DECAYED DURING UNSAT TRANSPORT 7.2368E-01
-----
PEAK CONCENTRATION CANNOT BE FOUND WITH PEAK FINDER ROUTINE:
USE CONCENTRATION VS TIME MODE TO DETERMINE PEAK
NO SOIL CONCENTRATION LIMITS CALCULATED SINCE THE
AVERAGE INTEGRATED CONCENTRATION IS ZERO
TIME OF RUN 10:39:55.1
DATE OF RUN 11/05/96
*** TITLE OF PROJECT:
Pm-147 :PAPA REV 2 CLASS AB WASTE
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 0) CONC VS TIME; 1) PEAK CONC AND LIMITING SOIL CONC
IMODEL: 1 1) SURF OR BURIED SOURCE; 2) POND SOURCE; 3) TABULATED SOURCE FUNCTION
ITYPE: 0 0) VERT AVG; 1) NON-VERT AVG; 2) AVG FROM 0 TO 2D
*** INPUT DATA
*****
NUMBER OF RADIOACTIVE PROGENY              0
LENGTH OF SOURCE PARALLEL TO GW FLOW (m)   6.10E+02
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 1.22E+02
THICKNESS OF SOURCE (m)                   7.60E+00
PERCOLATION RATE (darcy vel m/y)           5.80E-01
VOLUMETRIC WATER CONTENT IN SOURCE          2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
BULK DENSITY AT SOURCE (g/cm**3)           1.00E+00
SORPTION COEFFICIENT AT SOURCE (ml/g)       5.00E+03
BULK DENSITY IN UNSAT ZONE (g/cm**3)        1.50E+00
UNSATURATED ZONE THICKNESS (m)              1.00E+03
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g)    0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci)         0.05E+00
MOLECULAR WEIGHT (g/mole)                  1.47E+02
SOLUBILITY LIMIT (mg/L)                    1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 2.62E+00
BULK DENSITY OF AQUIFER (g/cm**3)           1.00E+00
POROSITY OF AQUIFER                        0.30E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g)    0.00E+00
DISPERSIVITY X DIRECTION (m)               1.00E-01
DISPERSIVITY Y DIRECTION (m)              5.00E+00
DISPERSIVITY Z DIRECTION (m)              1.00E+00
PORE VELOCITY (m/y)                       6.25E-01
WELL SCREEN THICKNESS (m)                  1.00E-01
DISTANCE TO RECEPTOR ALONG X AXIS (m)     4.05E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m)     0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m)     0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 0.50E+01
UNITS OF CONTAMINANT                       Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
*** INITIAL ACTIVITY CONVERTED TO MASS (mg) 0.05E+00
*** VALUES CALCULATED IN SOURCE SUBROUTINE
*****
LEACH RATE CONSTANT (1/y)                  0.5391E-06
UNSATURATED PORE VELOCITY (m/y)            5.8000E+00
DECAY CONSTANT(S) (1/y)                    2.6456E-01
RETARDATION FACTOR(S) (SATURATED)          1.0000E+00
RETARDATION FACTOR (UNSATURATED)           1.0000E+00
SOLUBILITY LIMITED MASS (mg)                4.5249E+18
SOLUBILITY LIMITED ACTIVITY (Ci)            4.2936E+18
TRANSIT TIME IN UNSAT ZONE (years)          1.7241E-04
FRACTION DECAYED DURING UNSAT TRANSPORT 4.5613E-05
-----
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
COMPOSITE DOSE CONVERSION FACTOR (rem/Ci) : 0.50E+01
LIMITING GROUNDWATER CONCENTRATION (Ci/L) : 0.044E-09
MAXIMUM GW CONCENTRATION FOR MBR #1: 0.000E-10 Ci/L CEDE = 0.59E-09 rem
MAXIMUM CEDE 0.59E-09 rem
PEAK TIME (y):                             5.051796E+00
LIMITING SOIL CONCENTRATION (Ci/m**3) :    1.677E-01
LIMITING SOIL CONCENTRATION (Ci/kg):        1.044E-04
LIMITING INVENTORY IN SOIL (Ci):            0.445E+04
LIMITING INVENTORY IN SOIL (mg):            1.017E+05
SPECIFIC ACTIVITY (Ci/g): 0.290E+02
EXECUTION TIME (seconds)                    0
TIME OF RUN 10:39:55.2
DATE OF RUN 11/05/96
*** TITLE OF PROJECT:
Pu-238 :PAPA REV 2 CLASS AB WASTE
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 0) CONC VS TIME; 1) PEAK CONC AND LIMITING SOIL CONC
IMODEL: 1 1) SURF OR BURIED SOURCE; 2) POND SOURCE; 3) TABULATED SOURCE FUNCTION
ITYPE: 0 0) VERT AVG; 1) NON-VERT AVG; 2) AVG FROM 0 TO 2D
*** INPUT DATA
*****
NUMBER OF RADIOACTIVE PROGENY              4
LENGTH OF SOURCE PARALLEL TO GW FLOW (m)   6.10E+02
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 1.22E+02

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THICKNESS OF SOURCE (m) 7.60E+00
PERCOLATION RATE (darcy vel m/y) 5.80E-01
VOLUMETRIC WATER CONTENT IN SOURCE 2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
BULK DENSITY AT SOURCE (g/cm**3) 1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g) 5.00E-03
BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.50E+00
UNSATURATED ZONE THICKNESS (m) 1.00E-03
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) 0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci) 3.15E-01
MOLECULAR WEIGHT (g/mole) 2.38E-02
SOLUBILITY LIMIT (mg/L) 1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 8.75E-01 2.45E+05 7.54E+03 1.60E+03 2.23E-01
BULK DENSITY OF AQUIFER (g/cm**3) 1.60E+00
POROSITY OF AQUIFER 4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g) 1.20E+03 1.50E+01 3.30E+03 3.60E+04 1.60E+04
DISPERSIVITY X DIRECTION (m) 1.00E+01
DISPERSIVITY Y DIRECTION (m) 5.00E+00
DISPERSIVITY Z DIRECTION (m) 1.00E+00
PORE VELOCITY (m/y) 6.25E-01
WELL SCREEN THICKNESS (m) 1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS (m) 4.05E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m) 0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m) 0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 3.80E+06 2.60E+05 5.30E+05 1.10E+06 6.70E+06
UNITS OF CONTAMINANT Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 1.84E+01
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
-----
LEACH RATE CONSTANT (1/y) 9.5391E-06
UNSATURATED PORE VELOCITY (m/y) 5.8000E+00
DECAY CONSTANT(S) (1/y) 7.9036E-03 2.8292E-06 9.1929E-05 4.3322E-04 3.1083E-02
RETARDATION FACTOR(S) (SATURATED) 4.8010E+03 6.1000E+01 1.3201E+04 1.4400E+05 6.4001E+04
RETARDATION FACTOR (UNSATURATED) 1.0000E+00
SOLUBILITY LIMITED MASS (mg) 4.5249E+18
SOLUBILITY LIMITED ACTIVITY (Ci) 7.7564E+16
TRANSIT TIME IN UNSAT ZONE (years) 1.7241E-04
FRACTION DECAYED DURING UNSAT TRANSPORT 1.3627E-06
-----
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
DECAY-INGROWTH FACTORS 1.5577E-06 3.5638E-04 4.7847E-05 1.3447E-05 1.2974E-05
COMPOSITE DOSE CONVERSION FACTOR (rem/Ci) 4.70E+09
LIMITING GROUNDWATER CONCENTRATION (Ci/L) 2.92E-17
NOTE: PROGENY CONCENTRATIONS ARE REPORTED AT THE TIME OF THE MAXIMUM PARENT CONCENTRATION
MAXIMUM GW CONCENTRATION FOR HBR #1: 2.80E-26 Ci/L CEDE = 7.77E-17 rem
MAXIMUM GW CONCENTRATION FOR HBR #2: 5.05E-22 Ci/L CEDE = 9.58E-14 rem
MAXIMUM GW CONCENTRATION FOR HBR #3: 3.13E-25 Ci/L CEDE = 1.21E-16 rem
MAXIMUM GW CONCENTRATION FOR HBR #4: 8.06E-27 Ci/L CEDE = 6.48E-18 rem
MAXIMUM GW CONCENTRATION FOR HBR #5: 1.75E-26 Ci/L CEDE = 9.56E-17 rem
MAXIMUM CEDE 9.61E-14 rem
PEAK TIME (y): 1.691923E+03
LIMITING SOIL CONCENTRATION (Ci/m**3): 5.798E+02
LIMITING SOIL CONCENTRATION (Ci/kg): 3.624E-01
LIMITING INVENTORY IN SOIL (Ci): 3.279E+08
LIMITING INVENTORY IN SOIL (mg): 1.913E+10
SPECIFIC ACTIVITY (Ci/g): 1.714E+01
EXECUTION TIME (seconds) 0
TIME OF RUN 10:39:55.5
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Pu-239 :PAPA REV 2 CLASS AB WASTE
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 0) CONC VS TIME; 1 PEAK CONC AND LIMITING SOIL CONC
IMODEL: 1 1) SURF OR BURIED SOURCE; 2 POND SOURCE; 3 TABULATED SOURCE FUNCTION
ITYPE: 0 0) VERT AVG; 1) NON-VERT AVG; 2) AVG FROM 0 TO 2D
>>> INPUT DATA
-----
NUMBER OF RADIOACTIVE PROGENY 3
LENGTH OF SOURCE PARALLEL TO GW FLOW (m) 0.10E+02
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 1.00E+01
THICKNESS OF SOURCE (m) 7.60E+00
PERCOLATION RATE (darcy vel m/y) 5.80E-01
VOLUMETRIC WATER CONTENT IN SOURCE 2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
BULK DENSITY AT SOURCE (g/cm**3) 1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g) 5.00E-03
BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.50E+00
UNSATURATED ZONE THICKNESS (m) 1.00E-03
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) 0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci) 2.38E-01
MOLECULAR WEIGHT (g/mole) 2.39E-02
SOLUBILITY LIMIT (mg/L) 1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 2.41E+04 7.04E+11 3.28E+04 2.18E+01
BULK DENSITY OF AQUIFER (g/cm**3) 1.60E+00
POROSITY OF AQUIFER 4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g) 1.20E+03 1.50E+01 1.50E+01 1.50E+01

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DISPERSIVITY X DIRECTION (m) 1.00E+01
DISPERSIVITY Y DIRECTION (m) 5.00E+00
DISPERSIVITY Z DIRECTION (m) 1.00E+00
PORE VELOCITY (m/y) 6.25E+01
WELL SCREEN THICKNESS (m) 1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS m 4.05E+02
DISTANCE TO RECEPTOR ALONG Y AXIS m 0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS m 0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR rem/Ci 4.30E+06 2.50E+05 1.10E+07 1.46E+07
UNITS OF CONTAMINANT Ci
*****
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS mg 1.0E+03
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
*****
LEACH RATE CONSTANT (1/y) 9.5391E-06
UNSATURATED PORE VELOCITY m/y 5.5000E+00
DECAY CONSTANT(S) (1/y) 2.8761E-05 9.8458E-13 2.1133E-05 3.1840E-02
RETARDATION FACTOR(S) (SATURATED) 4.8010E+03 6.1000E+01 6.1000E+01 6.1000E+01
RETARDATION FACTOR (UNSATURATED) 1.0000E+00
SOLUBILITY LIMITED MASS (mg) 4.5249E+18
SOLUBILITY LIMITED ACTIVITY (Ci) 2.8108E+14
TRANSIT TIME IN UNSAT ZONE (years) 1.7241E-04
FRACTION DECAYED DURING UNSAT TRANSPORT 4.9588E-09
*****
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
DECAY-INGROWTH FACTORS 3.8524E-01 2.1045E-08 6.7308E-09 6.7213E-09
COMPOSITE DOSE CONVERSION FACTOR (rem/Ci) 4.30E+06
LIMITING GROUNDWATER CONCENTRATION (Ci/L) 3.19E-14
NOTE: PROGENY CONCENTRATIONS ARE REPORTED AT THE TIME OF THE MAXIMUM PARENT CONCENTRATION
MAXIMUM GW CONCENTRATION FOR MBR #1: 6.59E-15 Ci/L CEDE = 2.07E-05 rem
MAXIMUM GW CONCENTRATION FOR MBR #2: 2.63E-20 Ci/L CEDE = 5.17E-12 rem
MAXIMUM GW CONCENTRATION FOR MBR #3: 9.06E-21 Ci/L CEDE = 7.28E-11 rem
MAXIMUM GW CONCENTRATION FOR MBR #4: 9.05E-21 Ci/L CEDE = 9.64E-11 rem
MAXIMUM CEDE 2.07E-05 rem
PEAK TIME (y): 3.316603E+04
LIMITING SOIL CONCENTRATION (Ci/m**3): 1.949E-06
LIMITING SOIL CONCENTRATION (Ci/kg): 1.218E-09
LIMITING INVENTORY IN SOIL (Ci): 1.102E+00
LIMITING INVENTORY IN SOIL (mg): 1.774E+04
SPECIFIC ACTIVITY (Ci/g): 6.212E-02
EXECUTION TIME (seconds) 0
TIME OF RUN 10:39:55.6
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Pu-240 :PAPA REV 2 CLASS AB WASTE*****
*****
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC
IMODEL: 1 (1) SURF OR BURIED SOURCE; (2) PCND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE: 0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO ZD
>>> INPUT DATA
*****
NUMBER OF RADIOACTIVE PROGENY 4
LENGTH OF SOURCE PARALLEL TO GW FLOW (m) 6.10E+02
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 1.22E+02
THICKNESS OF SOURCE (m) 7.60E+00
PERCOLATION RATE (darcy vel m/y) 5.80E-01
VOLUMETRIC WATER CONTENT IN SOURCE 2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
BULK DENSITY AT SOURCE (g/cm**3) 1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g) 5.00E+03
BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.50E+00
UNSATURATED ZONE THICKNESS (m) 1.00E+03
SORPTION COEFFICIENT IN UNSAT ZONE ml/g 1.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE y**1 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci) 4.77E+02
MOLECULAR WEIGHT (g/mole) 244E+02
SOLUBILITY LIMIT (mg/L) 1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY y 6.56E+03 2.43E+07 1.41E+10 5.75E+00 1.91E+00
BULK DENSITY OF AQUIFER (g/cm**3) 1.60E+00
POROSITY OF AQUIFER 4.30E-01
SORPTION COEFFICIENT(S) IN AQUIFER ml/g 1.00E+03 1.50E+01 3.30E+03 3.60E+04 3.30E+03
DISPERSIVITY X DIRECTION (m) 1.00E+01
DISPERSIVITY Y DIRECTION (m) 5.00E+00
DISPERSIVITY Z DIRECTION (m) 1.00E+00
PORE VELOCITY (m/y) 6.25E+01
WELL SCREEN THICKNESS (m) 1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS m 4.05E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m) 0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m) 0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 2.29E+06 2.50E+05 2.80E+06 1.20E+06 7.50E+05
UNITS OF CONTAMINANT Ci
*****
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 2.97E+02
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
*****
LEACH RATE CONSTANT (1/y) 9.5391E-06
UNSATURATED PORE VELOCITY (m/y) 5.5000E+00
DECAY CONSTANT(S) (1/y) 1.0566E-04 2.8525E-08 4.9159E-11 1.2055E-01 3.6290E-01

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RETARDATION FACTOR(S) (SATURATED)      4.8010E+03 6.1000E+01 1.3201E+04 1.4400E+05 1.3201E+04
RETARDATION FACTOR (UNSATURATED)        1.0000E+00
SOLUBILITY LIMITED MASS (mg)             4.5249E+18
SOLUBILITY LIMITED ACTIVITY (Ci)         1.0283E+15
TRANSIT TIME IN UNSAT ZONE (years)       1.7241E-04
FRACTION DECAYED DURING UNSAT TRANSPORT 1.8218E-08
-----
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
DECAY-INGROWTH FACTORS 1.7808E-01 2.2182E-04 1.1347E-10 1.1338E-10 1.1335E-10
COMPOSITE DOSE CONVERSION FACTOR (rem/Ci): 2.31E-06
LIMITING GROUNDWATER CONCENTRATION (Ci/L): 5.30E-14
NOTE: PROGENY CONCENTRATIONS ARE REPORTED AT THE TIME OF THE MAXIMUM PARENT CONCENTRATION
MAXIMUM GW CONCENTRATION FOR MBR #1: 2.52E-16 Ci/L CEDE = 4.21E-07 rem
MAXIMUM GW CONCENTRATION FOR MBR #2: 2.47E-17 Ci/L CEDE = 4.51E-09 rem
MAXIMUM GW CONCENTRATION FOR MBR #3: 5.84E-26 Ci/L CEDE = 1.19E-16 rem
MAXIMUM GW CONCENTRATION FOR MBR #4: 5.35E-27 Ci/L CEDE = 4.63E-18 rem
MAXIMUM GW CONCENTRATION FOR MBR #5: 5.83E-26 Ci/L CEDE = 3.19E-17 rem
MAXIMUM CEDE 4.26E-07 rem
PEAK TIME (y): 1.633057E+04
LIMITING SOIL CONCENTRATION (Ci/m**3): 1.952E-05
LIMITING SOIL CONCENTRATION (Ci/kg): 1.220E-08
LIMITING INVENTORY IN SOIL (Ci): 1.104E+01
LIMITING INVENTORY IN SOIL (mg): 4.858E+04
SPECIFIC ACTIVITY (Ci/g): 2.273E-01
EXECUTION TIME (seconds) 0
TIME OF RUN 10:39:55.7
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Pu-241 :PAPA REV 2 CLASS AB WASTE*****
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0) CONC VS TIME; 1) PEAK CONC AND LIMITING SOIL CONC
IMODEL: 1 (1) SURF OR BURIED SOURCE; 2) POND SOURCE; 3) TABULATED SOURCE FUNCTION
ITYPE: 0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO 2D
>>> INPUT DATA
*****
NUMBER OF RADIOACTIVE PROGENY 4
LENGTH OF SOURCE PARALLEL TO GW FLOW (m) 6.10E+02
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 1.22E+02
THICKNESS OF SOURCE (m) 7.60E+00
PERCOLATION RATE (darcy vel m/y) 5.80E-01
VOLUMETRIC WATER CONTENT IN SOURCE 2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
BULK DENSITY AT SOURCE (g/cm**3) 1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g) 5.00E+03
BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.50E+00
UNSATURATED ZONE THICKNESS (m) 1.00E-03
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) 0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci) 2.63E+02
MOLECULAR WEIGHT (g/mole) 2.41E+02
SOLUBILITY LIMIT (mg/L) 1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 1.44E+01 4.32E+02 2.10E+06 1.59E+05 7.34E+03
BULK DENSITY OF AQUIFER (g/cm**3) 1.60E+00
POROSITY OF AQUIFER 4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g) 1.20E+03 5.00E+03 2.50E+01 1.50E+01 3.30E+03
DISPERSIVITY X DIRECTION (m) 1.00E+01
DISPERSIVITY Y DIRECTION (m) 5.00E+00
DISPERSIVITY Z DIRECTION (m) 1.00E+00
PORE VELOCITY (m/y) 6.25E+01
WELL SCREEN THICKNESS (m) 1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS (m) 4.05E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m) 0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m) 0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem Ci) 4.20E-04 4.50E-06 3.90E-06 2.70E-05 0.40E-06
UNITS OF CONTAMINANT 1
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 1.55E+03
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
*****
LEACH RATE CONSTANT (1/y) 2.5391E-06
UNSATURATED PORE VELOCITY (m/y) 5.9000E+00
DECAY CONSTANT(S) (1/y) 4.8135E-02 1.6045E-03 3.3007E-07 4.3594E-06 4.4434E-05
RETARDATION FACTOR(S) (SATURATED) 4.8010E+03 6.1000E+01 1.3201E+04 1.4400E+05 1.3201E+04
RETARDATION FACTOR (UNSATURATED) 1.0000E+00
SOLUBILITY LIMITED MASS (mg) 4.5249E+18
SOLUBILITY LIMITED ACTIVITY (Ci) 4.6651E-17
TRANSIT TIME IN UNSAT ZONE (years) 1.7241E-04
FRACTION DECAYED DURING UNSAT TRANSPORT 8.2991E-06
-----
NO SOIL CONCENTRATION LIMITS CALCULATED SINCE THE
AVERAGE INTEGRATED CONCENTRATION IS ZERO
TIME OF RUN 10:39:56.0
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Ra-226 :PAPA REV 2 CLASS AB WASTE*****
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1

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KFLAG: 1 (0)CONC VS TIME; (1)PEAK CONC AND LIMITING SOIL CONC
IMODEL:1 (1) SURF OR BURIED SOURCE; (2)POND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE:0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO 2D
>>> INPUT DATA
*****
NUMBER OF RADIOACTIVE PROGENY                1
LENGTH OF SOURCE PARALLEL TO GW FLOW (m)    6.10E+02
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 1.22E+02
THICKNESS OF SOURCE (m)                     7.60E+00
PERCOLATION RATE (darcy vel m/y)            5.30E-01
VOLUMETRIC WATER CONTENT IN SOURCE          2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.30E-01
BULK DENSITY AT SOURCE (g/cm**3)           1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g)       1.30E+02
BULK DENSITY IN UNSAT ZONE (g/cm**3)        1.50E+00
UNSATURATED ZONE THICKNESS (m)              1.00E+03
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g)    3.60E+04
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci)          7.40E+03
MOLECULAR WEIGHT (g/mole)                   2.26E+02
SOLUBILITY LIMIT (mg/L)                     1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 1.60E+03 2.23E+01
BULK DENSITY OF AQUIFER (g/cm**3)           1.60E+00
POROSITY OF AQUIFER                         4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g)    3.60E+04 1.60E+04
DISPERSIVITY X DIRECTION (m)                1.00E+01
DISPERSIVITY Y DIRECTION (m)                5.00E+00
DISPERSIVITY Z DIRECTION (m)                1.00E+00
PORE VELOCITY (m/y)                         0.25E+01
WELL SCREEN THICKNESS (m)                   1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS (m)      4.25E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m)      7.30E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m)      7.30E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 1.10E+06 6.70E+06
UNITS OF CONTAMINANT                        Ci
*****
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 7.48E+00
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
*****
LEACH RATE CONSTANT (1/y)                   4.7614E-04
UNSATURATED PORE VELOCITY (m/y)             5.8000E+00
DECAY CONSTANT(S) (1/y)                     4.3322E-04 3.1083E-02
RETARDATION FACTOR(S) (SATURATED)           1.4400E+05 6.4001E+04
RETARDATION FACTOR (UNSATURATED)            5.4000E+05
SOLUBILITY LIMITED MASS (mg)                 9.0653E+16
SOLUBILITY LIMITED ACTIVITY (Ci)             8.9698E+13
TRANSIT TIME IN UNSAT ZONE (years)           3.3104E+01
FRACTION DECAYED DURING UNSAT TRANSPORT      3.9531E-02
*****
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
DECAY-INGROWTH FACTORS 7.2306E-08 7.3328E-08
COMPOSITE DOSE CONVERSION FACTOR (rem/Ci):   1.64E+07
LIMITING GROUNDWATER CONCENTRATION (Ci/L):   8.36E-15
NOTE: PROGENY CONCENTRATIONS ARE REPORTED AT THE TIME OF THE MAXIMUM PARENT CONCENTRATION
MAXIMUM GW CONCENTRATION FOR MBR #1: 3.79E-30 Ci/L CEDE = 7.36E-21 rem
MAXIMUM GW CONCENTRATION FOR MBR #2: 2.01E-29 Ci/L CEDE = 9.81E-20 rem
MAXIMUM CEDE 1.05E-19 rem
PEAK TIME (y):                              3.795408E+04
LIMITING SOIL CONCENTRATION (Ci/m**3):       1.245E+07
LIMITING SOIL CONCENTRATION (Ci/kg):          7.778E+03
LIMITING INVENTORY IN SOIL (Ci):             7.339E+12
LIMITING INVENTORY IN SOIL (mg):             7.114E+15
SPECIFIC ACTIVITY (Ci/g): 9.895E-01
NOTE: THE LIMITING SOIL CONCENTRATION OF 7.778E+03 Ci/kg
      EXCEEDS THE SPECIFIC ACTIVITY OF THE NUCLIDE.
EXECUTION TIME seconds.                      )
TIME OF RUN 10:39:56.3
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Sb-125                                     :PAPA REV 2 CLASS AB WASTE*****
*****
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0)CONC VS TIME; (1)PEAK CONC AND LIMITING SOIL CONC
IMODEL:1 (1) SURF OR BURIED SOURCE; (2)POND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE:0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO 2D
>>> INPUT DATA
*****
NUMBER OF RADIOACTIVE PROGENY                )
LENGTH OF SOURCE PARALLEL TO GW FLOW (m)    6.10E+02
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 1.22E+02
THICKNESS OF SOURCE (m)                     7.60E+00
PERCOLATION RATE (darcy vel m/y)            5.30E-01
VOLUMETRIC WATER CONTENT IN SOURCE          2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.30E-01
BULK DENSITY AT SOURCE (g/cm**3)           1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g)       0.30E+00
BULK DENSITY IN UNSAT ZONE (g/cm**3)        1.50E+00
UNSATURATED ZONE THICKNESS (m)              1.00E-03
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g)    0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00

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INITIAL MASS OR ACTIVITY (mg or Ci)          9.95E+01
MOLECULAR WEIGHT (g/mole)                   1.25E+02
SOLUBILITY LIMIT (mg/L)                     1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 2.73E+00
BULK DENSITY OF AQUIFER (g/cm**3)           1.60E+00
POROSITY OF AQUIFER                         4.00E-01
SORPTION COEFFICIENT(S, IN AQUIFER ml/g)     1.50E+02
DISPERSIVITY X DIRECTION m)                 1.00E+01
DISPERSIVITY Y DIRECTION m)                 5.00E+00
DISPERSIVITY Z DIRECTION m)                 1.00E+00
PORE VELOCITY (m/y)                         6.25E+01
WELL SCREEN THICKNESS (m)                   1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS          m) 4.05E+02
DISTANCE TO RECEPTOR ALONG Y AXIS          m) 0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS          m) 0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 1.60E+03
UNITS OF CONTAMINANT                         Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS mg, 9.49E+01
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
-----
LEACH RATE CONSTANT (1/y)                   2.7353E-01
UNSATURATED PORE VELOCITY (m/y)             5.8000E+00
DECAY CONSTANT(S) (1/y)                    2.5390E-01
RETARDATION FACTOR(S) (SATURATED)           6.0100E+02
RETARDATION FACTOR (UNSATURATED)            1.0000E+00
SOLUBILITY LIMITED MASS (mg)                 1.5780E+14
SOLUBILITY LIMITED ACTIVITY (Ci)             1.6545E+14
TRANSIT TIME IN UNSAT ZONE (years)           1.7241E+04
FRACTION DECAYED DURING UNSAT TRANSPORT     4.3775E-05
-----
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
COMPOSITE DOSE CONVERSION FACTOR (rem/Ci): 2.60E+03
LIMITING GROUNDWATER CONCENTRATION Ci/L: 5.27E-11
MAXIMUM GW CONCENTRATION FOR MBR #1: 4.71E-31 Ci/L CEDE = 3.94E-25 rem
MAXIMUM CEDE 8.94E-25 rem
PEAK TIME (y): 9.988840E+01
LIMITING SOIL CONCENTRATION (Ci/m**3): 1.769E+16
LIMITING SOIL CONCENTRATION (Ci/kg): 1.230E+13
LIMITING INVENTORY IN SOIL (Ci): 1.113E+22
LIMITING INVENTORY IN SOIL (mg): 1.062E+22
SPECIFIC ACTIVITY (Ci/g): 1.048E+03
NOTE: THE LIMITING SOIL CONCENTRATION OF 1.230E+10 Ci/g
EXCEEDS THE SPECIFIC ACTIVITY OF THE NUCLIDE.
WARNING !!! THE LIMITING SOIL MASS OF 1.062E+22 mg
EXCEEDS THE SOLUBILITY LIMITED SOURCE MASS OF 1.578E+14 mg
EXECUTION TIME (seconds) 9
TIME OF RUN 10:39:56.5
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Sr-90 :PAPA REV 2 CLASS AB WASTE
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC
IMODEL: 1 (1) SURF OR BURIED SOURCE; (2) POND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE: 0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO 2D
>>> INPUT DATA
-----
NUMBER OF RADIOACTIVE PROGENY 0
LENGTH OF SOURCE PARALLEL TO GW FLOW (m) 6.10E+02
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW m) 1.00E+02
THICKNESS OF SOURCE m) 7.60E+00
PERCOLATION RATE darcy vel m/y) 5.30E-01
VOLUMETRIC WATER CONTENT IN SOURCE 0.79E+01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E+01
BULK DENSITY AT SOURCE (g/cm**3) 1.60E+00
SORPTION COEFFICIENT AT SOURCE ml/g) 0.00E+00
BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.50E+00
UNSATURATED ZONE THICKNESS (m) 1.00E+03
SORPTION COEFFICIENT IN UNSAT ZONE ml/g) 0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE /y**1 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci) 1.73E+02
MOLECULAR WEIGHT (g/mole) 9.00E+01
SOLUBILITY LIMIT (mg/L) 1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY /y 2.91E+01
BULK DENSITY OF AQUIFER (g/cm**3) 1.60E+00
POROSITY OF AQUIFER 4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER ml/g) 0.00E+01
DISPERSIVITY X DIRECTION m) 1.00E+01
DISPERSIVITY Y DIRECTION (m) 5.00E+00
DISPERSIVITY Z DIRECTION (m) 1.00E+00
PORE VELOCITY (m/y) 6.25E+01
WELL SCREEN THICKNESS (m) 1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS m) 4.05E+02
DISTANCE TO RECEPTOR ALONG Y AXIS m) 0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS m) 0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 1.30E+05
UNITS OF CONTAMINANT Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION

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>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 1.26E+03
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
.....
LEACH RATE CONSTANT (1/y) 1.5026E-02
UNSATURATED PORE VELOCITY (m/y) 5.8000E+00
DECAY CONSTANT(S) (1/y) 2.3803E-02
RETARDATION FACTOR(S) (SATURATED) 3.1002E+01
RETARDATION FACTOR (UNSATURATED) 1.1002E+00
SOLUBILITY LIMITED MASS (mg) 3.8726E+15
SOLUBILITY LIMITED ACTIVITY (Ci) 3.9217E+14
TRANSIT TIME IN UNSAT ZONE (years) 1.7241E-04
FRACTION DECAYED DURING UNSAT TRANSPORT 4.1042E-06
.....
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
COMPOSITE DOSE CONVERSION FACTOR rem/Ci: 1.00E+05
LIMITING GROUNDWATER CONCENTRATION Ci/L: 1.05E-12
MAXIMUM GW CONCENTRATION FOR MBR #1: 4.01E-11 Ci/L CEDE = 3.81E-03 rem
MAXIMUM CEDE 3.81E-03 rem
PEAK TIME (y): 1.291475E+02
LIMITING SOIL CONCENTRATION Ci/m**3: 8.910E-06
LIMITING SOIL CONCENTRATION Ci/kg: 5.106E-09
LIMITING INVENTORY IN SOIL (Ci): 4.531E+00
LIMITING INVENTORY IN SOIL (mg): 3.319E+01
SPECIFIC ACTIVITY (Ci/g): 1.365E+02
EXECUTION TIME (seconds) 0
TIME OF RUN 10:39:56.7
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Tc-99 :PAPA REV 2 CLASS AB WASTE.....
.....
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
<FLAG: 1 (0, CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC
IMODEL: 1 (1, SURF OR BURIED SOURCE; (2) POND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE: 0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO ZD
>>> INPUT DATA
.....
NUMBER OF RADIOACTIVE PROGENY 0
LENGTH OF SOURCE PARALLEL TO GW FLOW (m) 6.10E+02
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 1.22E+02
THICKNESS OF SOURCE (m) 7.60E+00
PERCOLATION RATE (darcy vel m/y) 5.80E-01
VOLUMETRIC WATER CONTENT IN SOURCE 2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
BULK DENSITY AT SOURCE (g/cm**3) 1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g) 1.00E+00
BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.50E+00
UNSATURATED ZONE THICKNESS (m) 1.00E+03
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) 0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE y**(-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci) 1.00E+01
MOLECULAR WEIGHT (g/mole) 9.90E+01
SOLUBILITY LIMIT (mg/L) 1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 2.13E+05
BULK DENSITY OF AQUIFER (g/cm**3) 1.60E+00
POROSITY OF AQUIFER 4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g) 1.00E-01
DISPERSIVITY X DIRECTION (m) 1.00E+01
DISPERSIVITY Y DIRECTION (m) 5.00E+00
DISPERSIVITY Z DIRECTION (m) 1.00E+00
PORE VELOCITY (m/y) 6.25E+01
WELL SCREEN THICKNESS (m) 1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS m 4.75E+02
DISTANCE TO RECEPTOR ALONG Y AXIS m 1.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS m 1.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR rem/Ci 1.00E+05
UNITS OF CONTAMINANT 0
.....
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS mg 6.42E+03
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
.....
LEACH RATE CONSTANT (1/y) 4.3615E-02
UNSATURATED PORE VELOCITY (m/y) 5.8000E+00
DECAY CONSTANT(S) (1/y) 2.2542E-06
RETARDATION FACTOR(S) (SATURATED) 1.4300E+00
RETARDATION FACTOR (UNSATURATED) 1.0000E+00
SOLUBILITY LIMITED MASS (mg) 1.0627E+15
SOLUBILITY LIMITED ACTIVITY (Ci) 1.8032E+13
TRANSIT TIME IN UNSAT ZONE (years) 1.7241E-04
FRACTION DECAYED DURING UNSAT TRANSPORT 5.6107E-10
.....
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
COMPOSITE DOSE CONVERSION FACTOR rem/Ci: 1.30E+03
LIMITING GROUNDWATER CONCENTRATION Ci/L: 1.05E-12
MAXIMUM GW CONCENTRATION FOR MBR #1: 4.53E-11 Ci/L CEDE = 4.30E-05 rem
MAXIMUM CEDE 4.30E-05 rem
PEAK TIME (y): 1.597249E+01
LIMITING SOIL CONCENTRATION (Ci/m**3): 4.479E-07
LIMITING SOIL CONCENTRATION (Ci/kg): 2.799E-10
LIMITING INVENTORY IN SOIL (Ci): 2.533E-01
LIMITING INVENTORY IN SOIL (mg): 1.493E+04

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SPECIFIC ACTIVITY (Ci/g): 1.697E-02
 EXECUTION TIME (seconds) 0
 TIME OF RUN 10:39:56.8
 DATE OF RUN 11/05/96
 >>> TITLE OF PROJECT:
 Th-228 :PAPA REV 2 CLASS AB WASTE

GAUSSIAN QUADRATURE SOLUTION
 MODEL OPTIONS
 IMODE: 1
 KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC
 IMODEL: 1 (1) SURF OR BURIED SOURCE; 2: POND SOURCE; 3: TABULATED SOURCE FUNCTION
 ITYPE: 0 (0) VERT AVG; (1) NON-VERT AVG; 2: AVG FROM 0 TO 2D
 >>> INPUT DATA

.....
 NUMBER OF RADIOACTIVE PROGENY 0
 LENGTH OF SOURCE PARALLEL TO GW FLOW m 6.13E+02
 WIDTH OF SOURCE PERPENDICULAR TO GW FLOW m 1.22E+02
 THICKNESS OF SOURCE (m) 7.60E+00
 PERCOLATION RATE darcy vel m/y 5.83E+01
 VOLUMETRIC WATER CONTENT IN SOURCE 2.79E+01
 VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.30E+01
 BULK DENSITY AT SOURCE (g/cm**3) 1.63E+00
 SORPTION COEFFICIENT AT SOURCE (ml/g) 3.30E+03
 BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.50E+00
 UNSATURATED ZONE THICKNESS (m) 1.30E+03
 SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) 0.00E+00
 OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
 INITIAL MASS OR ACTIVITY (mg or Ci) 7.37E+04
 MOLECULAR WEIGHT (g/mole) 2.28E+02
 SOLUBILITY LIMIT (mg/L) 1.30E+06
 HALF-LIFE(S) OF CONTAMINANT AND PROGENY y 1.91E+30
 BULK DENSITY OF AQUIFER (g/cm**3) 1.60E+00
 POROSITY OF AQUIFER 4.30E+01
 SORPTION COEFFICIENT(S) IN AQUIFER ml/g 3.30E+03
 DISPERSIVITY X DIRECTION (m) 1.30E+01
 DISPERSIVITY Y DIRECTION (m) 5.30E+00
 DISPERSIVITY Z DIRECTION (m) 1.30E+00
 PORE VELOCITY (m/y) 6.25E+01
 WELL SCREEN THICKNESS (m) 1.50E+01
 DISTANCE TO RECEPTOR ALONG X AXIS (m) 4.35E+02
 DISTANCE TO RECEPTOR ALONG Y AXIS (m) 0.00E+00
 DISTANCE TO RECEPTOR ALONG Z AXIS (m) 0.00E+00
 RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 7.50E+05
 UNITS OF CONTAMINANT Ci

LIMITING SOIL CONCENTRATION CALCULATION
 >>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 8.97E+04
 >>> VALUES CALCULATED IN SOURCE SUBROUTINE

.....
 LEACH RATE CONSTANT (1/y) 1.4453E-05
 UNSATURATED PORE VELOCITY (m/y) 5.8000E+00
 DECAY CONSTANT(S) (1/y) 3.6290E-01
 RETARDATION FACTOR(S) (SATURATED) 1.3201E+04
 RETARDATION FACTOR (UNSATURATED) 1.0000E+00
 SOLUBILITY LIMITED MASS (mg) 2.9865E+18
 SOLUBILITY LIMITED ACTIVITY (Ci) 2.4537E+18
 TRANSIT TIME IN UNSAT ZONE (years) 1.7241E-04
 FRACTION DECAYED DURING UNSAT TRANSPORT 6.2568E-05

PEAK CONCENTRATION CANNOT BE FOUND WITH PEAK FINDER ROUTINE:
 USE CONCENTRATION VS TIME MODE TO DETERMINE PEAK
 NO SOIL CONCENTRATION LIMITS CALCULATED SINCE THE
 AVERAGE INTEGRATED CONCENTRATION IS ZERO

TIME OF RUN 10:39:56.8
 DATE OF RUN 11/05/96
 >>> TITLE OF PROJECT:
 Th-230 :PAPA REV 2 CLASS AB WASTE

GAUSSIAN QUADRATURE SOLUTION
 MODEL OPTIONS
 IMODE: 1
 KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC
 IMODEL: 1 (1) SURF OR BURIED SOURCE; 2: POND SOURCE; 3: TABULATED SOURCE FUNCTION
 ITYPE: 0 (0) VERT AVG; (1) NON-VERT AVG; 2: AVG FROM 0 TO 2D
 >>> INPUT DATA

.....
 NUMBER OF RADIOACTIVE PROGENY 2
 LENGTH OF SOURCE PARALLEL TO GW FLOW m 6.13E+02
 WIDTH OF SOURCE PERPENDICULAR TO GW FLOW m 1.22E+02
 THICKNESS OF SOURCE (m) 7.60E+00
 PERCOLATION RATE darcy vel m/y 5.83E+01
 VOLUMETRIC WATER CONTENT IN SOURCE 2.79E+01
 VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.30E+01
 BULK DENSITY AT SOURCE (g/cm**3) 1.63E+00
 SORPTION COEFFICIENT AT SOURCE (ml/g) 3.30E+03
 BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.50E+00
 UNSATURATED ZONE THICKNESS (m) 1.30E+03
 SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) 0.00E+00
 OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
 INITIAL MASS OR ACTIVITY (mg or Ci) 3.98E+03
 MOLECULAR WEIGHT (g/mole) 2.30E+02
 SOLUBILITY LIMIT (mg/L) 1.00E+06

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HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 7.54E+03 1.60E+03 2.23E+01
BULK DENSITY OF AQUIFER (g/cm**3) 1.60E+00
POROSITY OF AQUIFER 4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g) 3.30E+03 3.60E+04 1.60E+04
DISPERSIVITY X DIRECTION (m) 1.00E+01
DISPERSIVITY Y DIRECTION (m) 5.00E+00
DISPERSIVITY Z DIRECTION (m) 1.00E+00
PORE VELOCITY (m/y) 6.25E-01
WELL SCREEN THICKNESS (m) 1.50E-01
DISTANCE TO RECEPTOR ALONG X AXIS (m) 4.75E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m) 5.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m) 5.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 5.30E-05 1.10E-06 6.70E-06
UNITS OF CONTAMINANT Ci
*****
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 1.93E+01
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
*****
LEACH RATE CONSTANT (1/y) 1.4453E-05
UNSATURATED PORE VELOCITY (m/y) 5.8000E-00
DECAY CONSTANT(S) (1/y) 9.1929E-05 4.3322E-04 3.1083E-02
RETARDATION FACTOR(S) (SATURATED) 1.3201E+04 1.4400E+05 6.4001E+04
RETARDATION FACTOR (UNSATURATED) 1.0000E+00
SOLUBILITY LIMITED MASS (mg) 2.9865E+18
SOLUBILITY LIMITED ACTIVITY (Ci) 6.1616E+14
TRANSIT TIME IN UNSAT ZONE (years) 1.7241E-04
FRACTION DECAYED DURING UNSAT TRANSPORT 1.5850E-08
*****
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
DECAY-INGROWTH FACTORS 7.5010E-02 9.5209E-02 9.5491E-02
COMPOSITE DOSE CONVERSION FACTOR (rem/Ci) 2.42E-06
LIMITING GROUNDWATER CONCENTRATION (Ci/L) 5.67E-14
NOTE: PROGENY CONCENTRATIONS ARE REPORTED AT THE TIME OF THE MAXIMUM PARENT CONCENTRATION
MAXIMUM GW CONCENTRATION FOR MBR #1: 4.61E-18 Ci/L CEDE = 1.78E-09 rem
MAXIMUM GW CONCENTRATION FOR MBR #2: 5.36E-19 Ci/L CEDE = 4.31E-10 rem
MAXIMUM GW CONCENTRATION FOR MBR #3: 1.21E-18 Ci/L CEDE = 5.92E-09 rem
MAXIMUM CEDE 8.13E-09 rem
PEAK TIME (y): 2.9175E+04
LIMITING SOIL CONCENTRATION (Ci/m**3): 9.644E-05
LIMITING SOIL CONCENTRATION (Ci/kg): 5.403E-08
LIMITING INVENTORY IN SOIL (Ci): 4.889E+01
LIMITING INVENTORY IN SOIL (mg): 2.370E+05
SPECIFIC ACTIVITY (Ci/g): 2.063E-01
EXECUTION TIME (seconds) 0
TIME OF RUN 10:39:56.9
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Th-232 :PAPA REV 2 CLASS AB WASTE*****
*****
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC
IMODEL: 1 (1) SURF OR BURIED SOURCE; (2) POND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE: 0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO ZD
>>> INPUT DATA
*****
NUMBER OF RADIOACTIVE PROGENY 2
LENGTH OF SOURCE PARALLEL TO GW FLOW (m) 6.10E+02
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 1.22E+02
THICKNESS OF SOURCE (m) 7.60E+00
PERCOLATION RATE (darcy vel m/y) 5.90E-01
VOLUMETRIC WATER CONTENT IN SOURCE 1.70E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
BULK DENSITY AT SOURCE (g/cm**3) 1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g) 3.30E+03
BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.60E+00
UNSATURATED ZONE THICKNESS (m) 1.00E-03
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) 3.30E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 3.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci) 3.78E-01
MOLECULAR WEIGHT (g/mole) 2.32E+02
SOLUBILITY LIMIT (mg/L) 1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 1.41E+10 5.75E+00 1.91E+00
BULK DENSITY OF AQUIFER (g/cm**3) 1.60E+00
POROSITY OF AQUIFER 4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g) 3.30E+03 3.60E+04 3.30E+03
DISPERSIVITY X DIRECTION (m) 1.00E+01
DISPERSIVITY Y DIRECTION (m) 5.00E+00
DISPERSIVITY Z DIRECTION (m) 1.00E+00
PORE VELOCITY (m/y) 6.25E-01
WELL SCREEN THICKNESS (m) 1.50E-01
DISTANCE TO RECEPTOR ALONG X AXIS (m) 4.75E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m) 5.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m) 5.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 2.30E+06 1.20E+06 7.50E+05
UNITS OF CONTAMINANT Ci
*****
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 3.46E+09
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
*****

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LIMITING SOIL CONCENTRATION (Ci/m**3): 1.369E-05
LIMITING SOIL CONCENTRATION (Ci/kg): 8.557E-09
LIMITING INVENTORY IN SOIL (Ci): 7.743E+00
LIMITING INVENTORY IN SOIL (mg): 3.515E-02
SPECIFIC ACTIVITY (Ci/g): 2.203E+01
EXECUTION TIME (seconds) 0
TIME OF RUN 10:39:57.2
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
U-233 :PAPA REV 2 CLASS AB WASTE*****
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 0) CONC VS TIME; 1) PEAK CONC AND LIMITING SOIL CONC
IMODEL: 1 1) SURF OR BURIED SOURCE; 2) POND SOURCE; 3) TABULATED SOURCE FUNCTION
ITYPE: 0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO ZD
>>> INPUT DATA
*****
NUMBER OF RADIOACTIVE PROGENY 1
LENGTH OF SOURCE PARALLEL TO GW FLOW (m) 6.10E+02
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 1.22E+02
THICKNESS OF SOURCE (m) 7.60E+00
PERCOLATION RATE (darcy vel m/y) 5.80E-01
VOLUMETRIC WATER CONTENT IN SOURCE 2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
BULK DENSITY AT SOURCE (g/cm**3) 1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g) 1.50E+03
BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.50E+00
UNSATURATED ZONE THICKNESS (m) 1.00E-03
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) 3.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci) 1.92E-01
MOLECULAR WEIGHT (g/mole) 2.33E+02
SOLUBILITY LIMIT (mg/L) 1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 1.59E+05 7.34E+03
BULK DENSITY OF AQUIFER (g/cm**3) 1.60E+00
POROSITY OF AQUIFER 4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g) 1.50E+01 3.30E+03
DISPERSIVITY X DIRECTION (m) 1.00E+01
DISPERSIVITY Y DIRECTION (m) 5.00E+00
DISPERSIVITY Z DIRECTION (m) 1.00E+00
PORE VELOCITY (m/y) 6.25E+01
WELL SCREEN THICKNESS (m) 1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS (m) 4.05E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m) 3.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m) 3.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 2.70E+05 1.00E+06
UNITS OF CONTAMINANT Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 1.99E+04
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
*****
LEACH RATE CONSTANT (1/y) 3.1795E-05
UNSATURATED PORE VELOCITY (m/y) 5.8000E+00
DECAY CONSTANT(S) (1/y) 4.3594E-06 9.4434E-05
RETARDATION FACTOR(S) (SATURATED) 6.1000E+01 1.3201E+04
RETARDATION FACTOR (UNSATURATED) 1.0000E+00
SOLUBILITY LIMITED MASS (mg) 1.3576E+18
SOLUBILITY LIMITED ACTIVITY (Ci) 1.3111E+13
TRANSIT TIME IN UNSAT ZONE (years) 1.7241E-04
FRACTION DECAYED DURING UNSAT TRANSPORT 7.5162E-10
-----
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
DECAY-INGROWTH FACTORS 9.4590E-01 9.5057E-02
COMPOSITE DOSE CONVERSION FACTOR (rem/Ci) 1.70E+05
LIMITING GROUNDWATER CONCENTRATION (Ci/L) 5.07E-13
NOTE: PROGENY CONCENTRATIONS ARE REPORTED AT THE TIME OF THE MAXIMUM PARENT CONCENTRATION
MAXIMUM GW CONCENTRATION FOR MBR #1: 3.35E-14 Ci/L CEDE = 1.74E-05 rem
MAXIMUM GW CONCENTRATION FOR MBR #2: 3.49E-17 Ci/L CEDE = 2.55E-08 rem
MAXIMUM CEDE 1.75E-05 rem
PEAK TIME (y): 3.433825E+02
LIMITING SOIL CONCENTRATION (Ci/m**3) 1.944E-06
LIMITING SOIL CONCENTRATION (Ci/kg) 1.215E-09
LIMITING INVENTORY IN SOIL (Ci) 1.099E+00
LIMITING INVENTORY IN SOIL (mg) 1.138E+05
SPECIFIC ACTIVITY (Ci/g): 9.658E-03
EXECUTION TIME (seconds) 0
TIME OF RUN 10:39:57.3
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
U-234 :PAPA REV 2 CLASS AB WASTE*****
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 0) CONC VS TIME; 1) PEAK CONC AND LIMITING SOIL CONC
IMODEL: 1 1) SURF OR BURIED SOURCE; 2) POND SOURCE; 3) TABULATED SOURCE FUNCTION
ITYPE: 0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO ZD
>>> INPUT DATA
*****
NUMBER OF RADIOACTIVE PROGENY 3

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LENGTH OF SOURCE PARALLEL TO GW FLOW (m)      6.10E+02
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m)   1.22E+02
THICKNESS OF SOURCE (m)                       7.60E+00
PERCOLATION RATE (darcy vel m/y)              5.30E-01
VOLUMETRIC WATER CONTENT IN SOURCE            2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE  1.00E-01
BULK DENSITY AT SOURCE (g/cm**3)              1.60E+00
SORPTION COEFFICIENT AT SOURCE ml/g           1.50E+03
BULK DENSITY IN UNSAT ZONE (g/cm**3)          1.50E+00
UNSATURATED ZONE THICKNESS (m)                1.00E+03
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g)      0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci)            8.27E-02
MOLECULAR WEIGHT (g/mole)                     2.34E+02
SOLUBILITY LIMIT (mg/L)                      1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y)    2.45E+05 7.54E+03 1.60E+03 2.23E+01
BULK DENSITY OF AQUIFER (g/cm**3)             1.60E+00
POROSITY OF AQUIFER                           4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g)      1.50E+01 3.30E+03 3.60E+04 1.60E+04
DISPERSIVITY X DIRECTION (m)                  1.00E-01
DISPERSIVITY Y DIRECTION (m)                  5.00E+00
DISPERSIVITY Z DIRECTION (m)                  1.00E+00
PORE VELOCITY (m/y)                          6.25E+01
WELL SCREEN THICKNESS (m)                    1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS (m)        4.05E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m)        0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m)        0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci)   2.60E-05 5.30E+05 1.10E+06 6.70E+06
UNITS OF CONTAMINANT                          Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg)  1.33E+04
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
-----
LEACH RATE CONSTANT (1/y)                    3.1795E-05
UNSATURATED PORE VELOCITY (m/y)              5.8000E+00
DECAY CONSTANT(S) (1/y)                     2.8292E-06 9.1929E-05 4.3322E-04 3.1083E-02
RETARDATION FACTOR(S) (SATURATED)            6.1000E+01 1.3201E+04 1.4400E+05 6.4001E+04
RETARDATION FACTOR (UNSATURATED)             1.0000E+00
SOLUBILITY LIMITED MASS (mg)                  1.3576E+18
SOLUBILITY LIMITED ACTIVITY (Ci)              8.4725E+12
TRANSIT TIME IN UNSAT ZONE (years)            1.7241E-04
FRACTION DECAYED DURING UNSAT TRANSPORT      4.8779E-10
-----
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
DECAY-INGROWTH FACTORS 9.9733E-01 8.3202E-02 1.5153E-02 1.4229E-02
COMPOSITE DOSE CONVERSION FACTOR (rem/Ci):    2.60E-05
LIMITING GROUNDWATER CONCENTRATION (Ci/L):    5.26E-13
NOTE: PROGENY CONCENTRATIONS ARE REPORTED AT THE TIME OF THE MAXIMUM PARENT CONCENTRATION
MAXIMUM GW CONCENTRATION FOR MBR #1: 3.32E-14 Ci/L CEDE = 7.24E-06 rem
MAXIMUM GW CONCENTRATION FOR MBR #2: 1.47E-17 Ci/L CEDE = 5.69E-09 rem
MAXIMUM GW CONCENTRATION FOR MBR #3: 2.46E-19 Ci/L CEDE = 1.97E-10 rem
MAXIMUM GW CONCENTRATION FOR MBR #4: 5.19E-19 Ci/L CEDE = 2.54E-09 rem
MAXIMUM CEDE 7.25E-06 rem
PEAK TIME (y): 9.462875E+02
LIMITING SOIL CONCENTRATION (Ci/m**3): 2.016E-06
LIMITING SOIL CONCENTRATION (Ci/kg): 1.260E-09
LIMITING INVENTORY IN SOIL (Ci): 1.140E+00
LIMITING INVENTORY IN SOIL (mg): 1.827E+05
SPECIFIC ACTIVITY (Ci/g): 6.241E-03
EXECUTION TIME (seconds) 0
TIME OF RUN 10:39:57.4
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
U-235 :PAPA REV 2 CLASS AB WASTE
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 0: CONC VS TIME; 1 PEAK CONC AND LIMITING SOIL CONC
IMODEL: 1 1) SURF OR BURIED SOURCE; 2) POND SOURCE; 3) TABULATED SOURCE FUNCTION
ITYPE: 0 0) VERT AVG; 1) NON-VERT AVG; 2) AVG FROM 0 TO 2D
>>> INPUT DATA
-----
NUMBER OF RADIOACTIVE PROGENY 2
LENGTH OF SOURCE PARALLEL TO GW FLOW (m) 6.10E+02
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 1.22E+02
THICKNESS OF SOURCE (m) 7.60E+00
PERCOLATION RATE (darcy vel m/y) 5.30E-01
VOLUMETRIC WATER CONTENT IN SOURCE 2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
BULK DENSITY AT SOURCE (g/cm**3) 1.60E+00
SORPTION COEFFICIENT AT SOURCE ml/g 1.50E+03
BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.50E+00
UNSATURATED ZONE THICKNESS (m) 1.00E+03
SORPTION COEFFICIENT IN UNSAT ZONE ml/g 0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci) 2.31E-03
MOLECULAR WEIGHT (g/mole) 2.35E+02
SOLUBILITY LIMIT (mg/L) 1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 7.04E+11 3.28E+04 2.18E+01
BULK DENSITY OF AQUIFER (g/cm**3) 1.60E+00
POROSITY OF AQUIFER 4.00E-01

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SORPTION COEFFICIENT(S) IN AQUIFER (ml/g)      1.50E+01 1.50E+01 1.50E+01
DISPERSIVITY X DIRECTION (m)                   1.00E+01
DISPERSIVITY Y DIRECTION (m)                   5.00E+00
DISPERSIVITY Z DIRECTION (m)                   1.00E+00
PORE VELOCITY (m/y)                           6.25E+01
WELL SCREEN THICKNESS (m)                     1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS            π      4.05E+02
DISTANCE TO RECEPTOR ALONG Y AXIS            π      0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS            m      0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR rem Ci     2.50E+05 1.10E+07 1.46E+07
UNITS OF CONTAMINANT                          Ci

-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg)    1.30E+09
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
-----
LEACH RATE CONSTANT (1/y)                     3.1795E-05
UNSATURATED PORE VELOCITY (m/y)               5.8000E+00
DECAY CONSTANT(S) (1/y)                       9.8458E-13 2.1133E-05 3.1840E-02
RETARDATION FACTOR(S) SATURATED               6.1000E+01 6.1000E+01 6.1000E+01
RETARDATION FACTOR (UNSATURATED)              1.0000E+00
SOLUBILITY LIMITED MASS (mg)                  1.3576E+18
SOLUBILITY LIMITED ACTIVITY (Ci)              2.9360E+06
TRANSIT TIME IN UNSAT ZONE (years)            1.7241E-04
FRACTION DECAYED DURING UNSAT TRANSPORT       2.2204E-16

-----
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
DECAY-INGROWTH FACTORS 1.0000E+00 2.0077E-02 1.9426E-02
COMPOSITE DOSE CONVERSION FACTOR (rem/Ci):    7.54E+05
LIMITING GROUNDWATER CONCENTRATION (Ci/L):    1.92E-13
NOTE: PROGENY CONCENTRATIONS ARE REPORTED AT THE TIME OF THE MAXIMUM PARENT CONCENTRATION
MAXIMUM GW CONCENTRATION FOR MBR #1: 1.30E-15 Ci/L CEDE = 2.38E-07 rem
MAXIMUM GW CONCENTRATION FOR MBR #2: 2.61E-17 Ci/L CEDE = 2.10E-07 rem
MAXIMUM GW CONCENTRATION FOR MBR #3: 2.53E-17 Ci/L CEDE = 2.70E-07 rem
MAXIMUM CEDE 7.17E-07 rem
PEAK TIME (y):                                9.597034E+02
LIMITING SOIL CONCENTRATION (Ci/m**3):        6.938E-07
LIMITING SOIL CONCENTRATION (Ci/kg):          4.336E-10
LIMITING INVENTORY IN SOIL (Ci):             3.924E-01
LIMITING INVENTORY IN SOIL (mg):             1.814E+11
SPECIFIC ACTIVITY (Ci/g): 2.163E-09
EXECUTION TIME (seconds)                      0
TIME OF RUN 10:39:57.5
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
U-238 :PAPA REV 2 CLASS AB WASTE*****
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC
IMODEL: 1 (1) SURF OR BURIED SOURCE; (2) POND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE: 0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO ZD
>>> INPUT DATA
-----
NUMBER OF RADIOACTIVE PROGENY                  4
LENGTH OF SOURCE PARALLEL TO GW FLOW (m)      6.10E+02
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m)  1.22E+02
THICKNESS OF SOURCE (m)                       7.60E+00
PERCOLATION RATE (darcy vel m/y)              5.80E-01
VOLUMETRIC WATER CONTENT IN SOURCE            2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE  1.00E-01
BULK DENSITY AT SOURCE (g/cm**3)             1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g)         1.50E+03
BULK DENSITY IN UNSAT ZONE (g/cm**3)         1.50E+00
UNSATURATED ZONE THICKNESS (m)               1.00E+03
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g)     1.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**--1) 1.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci)           2.51E-01
MOLECULAR WEIGHT (g/mole)                    2.28E+02
SOLUBILITY LIMIT (mg/L)                      1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y)  4.47E+09 2.45E+05 7.54E+03 1.60E+03 2.20E+01
BULK DENSITY OF AQUIFER (g/cm**3)            1.60E+00
POROSITY OF AQUIFER                          4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g)     1.50E+01 1.50E+01 3.30E+03 3.60E+04 1.60E+04
DISPERSIVITY X DIRECTION (m)                 1.00E+01
DISPERSIVITY Y DIRECTION (m)                 5.00E+00
DISPERSIVITY Z DIRECTION (m)                 1.00E+00
PORE VELOCITY (m/y)                         6.25E+01
WELL SCREEN THICKNESS (m)                   1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS            m      4.05E+02
DISTANCE TO RECEPTOR ALONG Y AXIS            m      0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS            m      0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR rem/Ci    2.30E+05 2.60E+05 5.30E+05 1.10E+06 6.70E+06
UNITS OF CONTAMINANT                          Ci

-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg)    7.46E+08
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
-----
LEACH RATE CONSTANT (1/y)                     3.1795E-05
UNSATURATED PORE VELOCITY (m/y)               5.8000E+00
DECAY CONSTANT(S) (1/y)                       1.5507E-10 2.9292E-06 9.1929E-05 4.3322E-04 3.1083E-02

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RETARDATION FACTOR(S) (SATURATED)      6.1000E+01 6.1000E+01 1.3201E+04 1.4400E+05 6.4001E+04
RETARDATION FACTOR (UNSATURATED)      1.0000E+00
SOLUBILITY LIMITED MASS (mg)          1.3576E+18
SOLUBILITY LIMITED ACTIVITY (Ci)      4.5657E+08
TRANSIT TIME IN UNSAT ZONE (years)    1.7241E-04
FRACTION DECAYED DURING UNSAT TRANSPORT 2.6756E-14
-----
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
DECAY-INGROWTH FACTORS 1.0000E+00 2.7115E-03 1.1622E-04 1.4666E-05 1.3335E-05
COMPOSITE DOSE CONVERSION FACTOR (rem/Ci): 2.31E-05
LIMITING GROUNDWATER CONCENTRATION (Ci/L): 5.94E-13
NOTE: PROGENY CONCENTRATIONS ARE REPORTED AT THE TIME OF THE MAXIMUM PARENT CONCENTRATION
MAXIMUM GW CONCENTRATION FOR MBR #1: 1.16E-13 Ci/L CEDE = 1.95E-05 rem
MAXIMUM GW CONCENTRATION FOR MBR #2: 3.15E-16 Ci/L CEDE = 5.98E-08 rem
MAXIMUM GW CONCENTRATION FOR MBR #3: 6.24E-20 Ci/L CEDE = 2.41E-11 rem
MAXIMUM GW CONCENTRATION FOR MBR #4: 7.22E-22 Ci/L CEDE = 5.79E-13 rem
MAXIMUM GW CONCENTRATION FOR MBR #5: 1.48E-21 Ci/L CEDE = 7.22E-12 rem
MAXIMUM CEDE 1.96E-05 rem
PEAK TIME (y): 9.597034E+02
LIMITING SOIL CONCENTRATION (Ci/m**3): 2.269E-06
LIMITING SOIL CONCENTRATION (Ci/kg): 1.418E-09
LIMITING INVENTORY IN SOIL (Ci): 1.283E-60
LIMITING INVENTORY IN SOIL (mg): 3.81E+09
SPECIFIC ACTIVITY (Ci/g): 3.363E-07
EXECUTION TIME (seconds) 0
TIME OF RUN 10:41:04.1
DATE OF RUN 11/05/96

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Numerical Recipes, Cambridge University Press.
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.....
*
*   This output was produced by the model:
*
*   GWScreen
*   Version 2.5: Menu Driven Version
*   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
*   03-96
*   Copyright 1992 Lockheed Martin Idaho
*   Technologies Corporation
*
*   .....

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>>> TITLE OF PROJECT:
Am-241 :Class C waste Re-run PAPA II LLW PAD*****

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GAUSSIAN QUADRATURE SOLUTION

MODEL OPTIONS

IMODE: 1

KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC
IMODEL: 1 (1) SURF OR BURIED SOURCE; (2) POND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE: 0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO 2D

>>> INPUT DATA

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.....
NUMBER OF RADIOACTIVE PROGENY          3
LENGTH OF SOURCE PARALLEL TO GW FLOW (m) 4.90E+01
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 2.40E+01
THICKNESS OF SOURCE (m) 3.00E+00
PERCOLATION RATE darcy vel m/y) 5.30E-01
VOLUMETRIC WATER CONTENT IN SOURCE 2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
BULK DENSITY AT SOURCE g/cm**3 1.60E+00
SORPTION COEFFICIENT AT SOURCE ml/g 5.00E+03
BULK DENSITY IN UNSAT ZONE g/cm**3 1.50E+00
UNSATURATED ZONE THICKNESS (m) 1.00E+04
SORPTION COEFFICIENT IN UNSAT ZONE ml/g 1.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE y**-1 0.00E+00
INITIAL MASS OR ACTIVITY .mg or Ci 1.50E+02
MOLECULAR WEIGHT (g/mole) 2.41E+02
SOLUBILITY LIMIT (mg/L) 1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY y 4.32E+02 2.10E+06 1.59E+05 7.34E+03
BULK DENSITY OF AQUIFER (g/cm**3) 1.60E+00
POROSITY OF AQUIFER 4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g) 5.00E+03 2.50E+01 1.50E-01 3.30E+03
DISPERSIVITY X DIRECTION (m) 1.00E+01
DISPERSIVITY Y DIRECTION (m) 5.00E+00
DISPERSIVITY Z DIRECTION (m) 1.00E+00
PORE VELOCITY (m/y) 6.25E-01
WELL SCREEN THICKNESS (m) 1.50E-01
DISTANCE TO RECEPTOR ALONG X AXIS (m) 1.25E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m) 3.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m) 1.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR rem/Ci 4.50E+06 3.90E+06 2.70E+05 3.91E+06
UNITS OF CONTAMINANT Ci

```

LIMITING SOIL CONCENTRATION CALCULATION

```

>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 4.36E+09
>>> VALUES CALCULATED IN SOURCE SUBROUTINE

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*****
LEACH RATE CONSTANT (1/y)                2.4166E-05
UNSATURATED PORE VELOCITY (m/y)          5.8000E+00
DECAY CONSTANT(S) (1/y)                  1.6045E-03 3.3007E-07 4.3594E-06 9.4434E-05
RETARDATION FACTOR(S) (SATURATED)        2.0001E+04 1.3100E+02 6.1000E+01 1.3201E+04
RETARDATION FACTOR (UNSATURATED)          1.0000E+00
SOLUBILITY LIMITED MASS (mg)              2.9225E+16
SOLUBILITY LIMITED ACTIVITY (Ci)          3.6948E+13
TRANSIT TIME IN UNSAT ZONE (years)        1.7241E-05
FRACTION DECAYED DURING UNSAT TRANSPORT  2.7664E-08
*****
>>> EXPOSURE DATA FOR LIMITING SOIL CONCENTRATION
*****
INTEGRATION TIME (years)                  1
BODY WEIGHT (kg)                          7.000E+01
AVERAGING TIME (days)                   3.650E+02
WATER INTAKE RATE (L/d)                  2.000E+00
EXPOSURE FREQUENCY (days/year)          3.650E+02
EXPOSURE DURATION (years)                1.000E+00
RADIOLOGICAL DOSE LIMIT (rem/y)          1.000E-04
CARCINOGENIC RISK CRITERIA                1.000E-04
HAZARD QUOTIENT                          1.000E-04
*****
>>> RESULTS OF CALCULATIONS
*****
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
DECAY-INGROWTH FACTORS 4.9857E-06 2.0524E-04 6.1625E-06 1.6675E-06
COMPOSITE DOSE CONVERSION FACTOR (rem/Ci): 3.139E+10
LIMITING GROUNDWATER CONCENTRATION (Ci/L): 4.29E-18
NOTE: PROGENY CONCENTRATIONS ARE REPORTED AT THE TIME OF THE MAXIMUM PARENT CONCENTRATION
MAXIMUM GW CONCENTRATION FOR MBR #1: 4.62E-25 Ci/L CEDE = 3.16E-15 rem
MAXIMUM GW CONCENTRATION FOR MBR #2: 7.84E-21 Ci/L CEDE = 2.23E-11 rem
MAXIMUM GW CONCENTRATION FOR MBR #3: 3.90E-22 Ci/L CEDE = 7.68E-14 rem
MAXIMUM GW CONCENTRATION FOR MBR #4: 4.87E-25 Ci/L CEDE = 1.39E-15 rem
MAXIMUM CEDE 2.24E-11 rem
PEAK TIME (y): 7.609151E-03
LIMITING SOIL CONCENTRATION (Ci/m**3): 1.399E+01
LIMITING SOIL CONCENTRATION (Ci/kg): 1.186E-02
LIMITING INVENTORY IN SOIL (Ci): 6.695E+04
LIMITING INVENTORY IN SOIL (mg): 1.948E+07
SPECIFIC ACTIVITY (Ci/g): 3.437E+00
EXECUTION TIME (seconds) 0
TIME OF RUN 10:41:04.2
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Am-243 :Class C waste Re-run PAPA II LLW PAC*****
*****
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC
IMODEL: (1) SURF OR BURIED SOURCE; 2, PCND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE: 0 (0) VERT AVG; (1) NON-VERT AVG; 2) AVG FROM 0 TO 2D
>>> INPUT DATA
*****
NUMBER OF RADIOACTIVE PROGENY 4
LENGTH OF SOURCE PARALLEL TO GW FLOW (m) 4.90E+01
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 2.40E+01
THICKNESS OF SOURCE (m) 3.00E+00
PERCOLATION RATE (darcy vel m/y) 5.80E-01
VOLUMETRIC WATER CONTENT IN SOURCE 2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
BULK DENSITY AT SOURCE (g/cm**3) 1.60E+00
SORPTION COEFFICIENT AT SOURCE ml/g 5.00E+03
BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.50E+00
UNSATURATED ZONE THICKNESS (m) 1.00E-04
SORPTION COEFFICIENT IN UNSAT ZONE ml/g 5.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE y**--1 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci) 1.43E-05
MOLECULAR WEIGHT g/mole 2.43E+02
SOLUBILITY LIMIT mg/L 1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY y 7.08E-03 2.41E-04 7.04E-08 3.28E-04 2.19E-01
BULK DENSITY OF AQUIFER g/cm**3 1.60E+00
POROSITY OF AQUIFER 4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER ml/g 5.00E+03 1.20E+03 1.50E+01 1.50E+01 1.50E-01
DISPERSIVITY X DIRECTION (m) 1.00E-01
DISPERSIVITY Y DIRECTION (m) 5.00E+00
DISPERSIVITY Z DIRECTION (m) 1.00E+00
PORE VELOCITY (m/y) 6.25E+01
WELL SCREEN THICKNESS (m) 1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS (m) 1.25E-02
DISTANCE TO RECEPTOR ALONG Y AXIS (m) 0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m) 0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 4.50E+06 4.30E+06 2.51E+05 1.10E+07 1.46E-07
UNITS OF CONTAMINANT Ci
*****
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 7.17E-02
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
*****
LEACH RATE CONSTANT (1/y) 2.4166E-05
UNSATURATED PORE VELOCITY (m/y) 5.8000E+00
DECAY CONSTANT(S) (1/y) 9.3922E-05 2.8761E-05 9.8458E-10 2.1133E-05 3.1796E-02

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RETARDATION FACTOR(S) (SATURATED)      2.0001E+04 4.8019E+03 6.1000E+01 6.1000E+01 6.1000E+01
RETARDATION FACTOR (UNSATURATED)        1.0000E+00
SOLUBILITY LIMITED MASS (mg)             2.8225E+16
SOLUBILITY LIMITED ACTIVITY (Ci)         5.6312E+12
TRANSIT TIME IN UNSAT ZONE (years)       1.7241E-05
FRACTION DECAYED DURING UNSAT TRANSPORT 1.6194E-09
-----
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
DECAY-INGROWTH FACTORS 5.9576E-02 1.5979E-01 4.2882E-06 1.0144E-06 1.0121E-06
COMPOSITE DOSE CONVERSION FACTOR rem/Ci: 5.27E-07
LIMITING GROUNDWATER CONCENTRATION Ci/L: 2.60E-15
NOTE: PROGENY CONCENTRATIONS ARE REPORTED AT THE TIME OF THE MAXIMUM PARENT CONCENTRATION
MAXIMUM GW CONCENTRATION FOR MBR #1: 1.29E-19 Ci/L CEDE = 4.29E-10 rem
MAXIMUM GW CONCENTRATION FOR MBR #2: 1.43E-19 Ci/L CEDE = 4.48E-09 rem
MAXIMUM GW CONCENTRATION FOR MBR #3: 3.29E-21 Ci/L CEDE = 5.65E-13 rem
MAXIMUM GW CONCENTRATION FOR MBR #4: 7.13E-22 Ci/L CEDE = 5.73E-12 rem
MAXIMUM GW CONCENTRATION FOR MBR #5: 7.12E-22 Ci/L CEDE = 7.59E-12 rem
MAXIMUM CEDE 4.91E-09 rem
PEAK TIME (y): 3.703013E+04
LIMITING SOIL CONCENTRATION (Ci/m**3): 8.247E-05
LIMITING SOIL CONCENTRATION (Ci/kg): 5.154E-08
LIMITING INVENTORY IN SOIL (Ci): 2.919E-01
LIMITING INVENTORY IN SOIL (mg): 1.458E+03
SPECIFIC ACTIVITY (Ci/g): 1.995E-01
EXECUTION TIME (seconds) 0
TIME OF RUN 10:41:04.3
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Ba-133 :Class C waste Re-run PAPA II LLW PADXXXXXXXXXXXXXXXXXXXX
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC
IMODEL: 1 (1) SURF OR BURIED SOURCE; (2) POND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE: 0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 1 TO 20
>>> INPUT DATA
-----
NUMBER OF RADIOACTIVE PROGENY 0
LENGTH OF SOURCE PARALLEL TO GW FLOW (m) 4.90E+01
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 2.40E+01
THICKNESS OF SOURCE (m) 3.00E+00
PERCOLATION RATE (darcy vel m/y) 5.80E-01
VOLUMETRIC WATER CONTENT IN SOURCE 2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
BULK DENSITY AT SOURCE (g/cm**3) 1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g) 1.00E+01
BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.50E+00
UNSATURATED ZONE THICKNESS (m) 1.00E-04
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) 0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci) 1.00E-04
MOLECULAR WEIGHT (g/mole) 1.33E+02
SOLUBILITY LIMIT (mg/L) 1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 1.35E+01
BULK DENSITY OF AQUIFER (g/cm**3) 1.50E+00
POROSITY OF AQUIFER 4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g) 0.00E+00
DISPERSIVITY X DIRECTION (m) 1.00E+01
DISPERSIVITY Y DIRECTION (m) 5.00E+00
DISPERSIVITY Z DIRECTION (m) 1.00E+00
PORE VELOCITY (m/y) 6.25E-01
WELL SCREEN THICKNESS (m) 1.50E-01
DISTANCE TO RECEPTOR ALONG X AXIS (m) 1.25E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m) 2.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m) 2.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR rem/Ci: 3.25E-03
UNITS OF CONTAMINANT Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 5.92E+14
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
-----
LEACH RATE CONSTANT (1/y) 1.1976E-02
UNSATURATED PORE VELOCITY (m/y) 5.8000E+00
DECAY CONSTANT(S) (1/y) 6.5763E-02
RETARDATION FACTOR(S) (SATURATED) 1.0000E+00
RETARDATION FACTOR (UNSATURATED) 1.0000E+00
SOLUBILITY LIMITED MASS (mg) 5.7432E+13
SOLUBILITY LIMITED ACTIVITY (Ci) 1.4659E+13
TRANSIT TIME IN UNSAT ZONE (years) 1.7241E-05
FRACTION DECAYED DURING UNSAT TRANSPORT 1.3339E-06
-----
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
COMPOSITE DOSE CONVERSION FACTOR rem/Ci: 3.23E-03
LIMITING GROUNDWATER CONCENTRATION Ci/L: 4.28E-11
MAXIMUM GW CONCENTRATION FOR MBR #1: 2.50E-14 Ci/L CEDE = 5.83E-08 rem
MAXIMUM CEDE 5.83E-08 rem
PEAK TIME (y): 3.809784E+00
LIMITING SOIL CONCENTRATION (Ci/m**3): 4.861E-05
LIMITING SOIL CONCENTRATION (Ci/kg): 3.038E-08
LIMITING INVENTORY IN SOIL (Ci): 1.715E-01
LIMITING INVENTORY IN SOIL (mg): 6.719E-01

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SPECIFIC ACTIVITY (Ci/g): 2.552E+02
 EXECUTION TIME (seconds) 0
 TIME OF RUN 10:41:04.4
 DATE OF RUN 11/05/96
 >>> TITLE OF PROJECT:
 C-14 :Class C waste Re-run PAPA II LLW PA*****

 GAUSSIAN QUADRATURE SOLUTION
 MODEL OPTIONS
 IMODE: 1
 KFLAG: 1 0 CONC VS TIME; 1) PEAK CONC AND LIMITING SOIL CONC
 IMODEL: 1 1) SURF OR BURIED SOURCE; 2) POND SOURCE; 3) TABULATED SOURCE FUNCTION
 ITYPE: 0 0) VERT AVG; 1) NON-VERT AVG; 2) AVG FROM 0 TO ZD
 >>> INPUT DATA

NUMBER OF RADIOACTIVE PROGENY 0
 LENGTH OF SOURCE PARALLEL TO GW FLOW (m) 4.90E+01
 WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 2.40E+01
 THICKNESS OF SOURCE (m) 3.00E+00
 PERCOLATION RATE (darcy vel m/y) 5.80E-01
 VOLUMETRIC WATER CONTENT IN SOURCE 2.79E-01
 VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
 BULK DENSITY AT SOURCE (g/cm**3) 1.60E+00
 SORPTION COEFFICIENT AT SOURCE (ml/g) 1.00E+02
 BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.50E+00
 UNSATURATED ZONE THICKNESS (m) 1.00E+04
 SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) 0.90E+00
 OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
 INITIAL MASS OR ACTIVITY (mg or Ci) 9.84E+01
 MOLECULAR WEIGHT (g/mole) 1.40E+01
 SOLUBILITY LIMIT (mg/L) 1.00E+06
 HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 5.70E+03
 BULK DENSITY OF AQUIFER (g/cm**3) 1.60E+00
 POROSITY OF AQUIFER 4.00E-01
 SORPTION COEFFICIENT (S) IN AQUIFER (ml/g) 2.00E+01
 DISPERSIVITY X DIRECTION (m) 1.00E+01
 DISPERSIVITY Y DIRECTION (m) 5.00E+00
 DISPERSIVITY Z DIRECTION (m) 1.00E+00
 PORE VELOCITY (m/y) 0.25E+01
 WELL SCREEN THICKNESS (m) 1.50E+01
 DISTANCE TO RECEPTOR ALONG X AXIS (m) 1.25E+02
 DISTANCE TO RECEPTOR ALONG Y AXIS (m) 0.00E+00
 DISTANCE TO RECEPTOR ALONG Z AXIS (m) 0.00E+00
 RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 2.10E+03
 UNITS OF CONTAMINANT Ci

 LIMITING SOIL CONCENTRATION CALCULATION
 >>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 1.97E+04
 >>> VALUES CALCULATED IN SOURCE SUBROUTINE

LEACH RATE CONSTANT (1/y) 1.2062E-03
 UNSATURATED PORE VELOCITY (m/y) 5.8000E+00
 DECAY CONSTANT(S) (1/y) 1.2160E-04
 RETARDATION FACTOR(S) (SATURATED) 8.1000E-01
 RETARDATION FACTOR (UNSATURATED) 1.0000E+00
 SOLUBILITY LIMITED MASS (mg) 5.6546E+14
 SOLUBILITY LIMITED ACTIVITY (Ci) 2.5353E+12
 TRANSIT TIME IN UNSAT ZONE (years) 1.7241E-05
 FRACTION DECAYED DURING UNSAT TRANSPORT 2.0966E-09

 COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
 COMPOSITE DOSE CONVERSION FACTOR (rem/Ci) 2.10E+03
 LIMITING GROUNDWATER CONCENTRATION (Ci/L) 6.52E-11
 MAXIMUM GW CONCENTRATION FOR MBR #1: 2.09E-09 Ci/L CEDE = 3.66E-03 rem
 MAXIMUM CEDE 3.66E-03 rem
 PEAK TIME (y) 2.981538E+02
 LIMITING SOIL CONCENTRATION (Ci m**3) 0.847E-04
 LIMITING SOIL CONCENTRATION (Ci kg) 4.279E-07
 LIMITING INVENTORY IN SOIL (Ci) 2.45E+00
 LIMITING INVENTORY IN SOIL (mg) 5.387E+02
 SPECIFIC ACTIVITY (Ci/g) 4.484E+00
 EXECUTION TIME (seconds) 0
 TIME OF RUN 10:41:04.4
 DATE OF RUN 11/05/96
 >>> TITLE OF PROJECT:
 Cd-109 :Class C waste Re-run PAPA II LLW PA*****

 GAUSSIAN QUADRATURE SOLUTION
 MODEL OPTIONS
 IMODE: 1
 KFLAG: 1 0) CONC VS TIME; 1) PEAK CONC AND LIMITING SOIL CONC
 IMODEL: 1 1) SURF OR BURIED SOURCE; 2) POND SOURCE; 3) TABULATED SOURCE FUNCTION
 ITYPE: 0 0) VERT AVG; 1) NON-VERT AVG; 2) AVG FROM 0 TO ZD
 >>> INPUT DATA

NUMBER OF RADIOACTIVE PROGENY 0
 LENGTH OF SOURCE PARALLEL TO GW FLOW (m) 4.90E+01
 WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 2.40E+01
 THICKNESS OF SOURCE (m) 3.00E+00
 PERCOLATION RATE (darcy vel m/y) 5.80E-01
 VOLUMETRIC WATER CONTENT IN SOURCE 2.79E-01
 VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
 BULK DENSITY AT SOURCE (g/cm**3) 1.60E+00

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SORPTION COEFFICIENT AT SOURCE (ml/g)          1.00E+02
BULK DENSITY IN UNSAT ZONE (g/cm**3)          1.50E+00
UNSATURATED ZONE THICKNESS (m)                1.00E+04
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g)      0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci)           7.63E+04
MOLECULAR WEIGHT (g/mole)                     1.00E+02
SOLUBILITY LIMIT (mg/L)                       1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y)    1.27E+00
BULK DENSITY OF AQUIFER (g/cm**3)             1.65E+00
POROSITY OF AQUIFER                           4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g)      4.00E-01
DISPERSIVITY X DIRECTION (m)                  1.00E+01
DISPERSIVITY Y DIRECTION (m)                  5.00E+00
DISPERSIVITY Z DIRECTION (m)                  1.00E+00
PORE VELOCITY (m/y)                           6.25E+01
WELL SCREEN THICKNESS (m)                     1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS (m)        1.25E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m)        0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m)        0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci)   1.20E-04
UNITS OF CONTAMINANT                           Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg)    2.94E-04
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
-----
LEACH RATE CONSTANT (1/y)                     1.2062E-03
UNSATURATED PORE VELOCITY (m/y)               5.8000E+00
DECAY CONSTANT(S) (1/y)                      5.4751E-01
RETARDATION FACTOR(S) (SATURATED)             1.6100E+02
RETARDATION FACTOR (UNSATURATED)             1.0000E+00
SOLUBILITY LIMITED MASS (mg)                  5.6546E+14
SOLUBILITY LIMITED ACTIVITY (Ci)              1.4661E+15
TRANSIT TIME IN UNSAT ZONE (years)            1.7241E-05
FRACTION DECAYED DURING UNSAT TRANSPORT       9.4398E-06
-----
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
COMPOSITE DOSE CONVERSION FACTOR (rem/Ci):    1.20E-04
LIMITING GROUNDWATER CONCENTRATION (Ci/L):    1.14E-11
MAXIMUM GW CONCENTRATION FOR MBR #1: 3.16E-31 Ci/L CEDE = 2.77E-24 rem
MAXIMUM CEDE 2.77E-24 rem
PEAK TIME (y):                               3.619974E+01
LIMITING SOIL CONCENTRATION (Ci/m**3):        7.817E+12
LIMITING SOIL CONCENTRATION (Ci/kg):          4.886E+09
LIMITING INVENTORY IN SOIL (Ci):              2.758E+16
LIMITING INVENTORY IN SOIL (mg):              1.064E+16
SPECIFIC ACTIVITY (Ci/g):                    2.593E+03
NOTE: THE LIMITING SOIL CONCENTRATION OF 4.886E+06 Ci/kg
      EXCEEDS THE SPECIFIC ACTIVITY OF THE NUCLIDE.
WARNING !!! THE LIMITING SOIL MASS OF 1.064E+16 mg
      EXCEEDS THE SOLUBILITY LIMITED SOURCE MASS OF 5.655E+14 mg
EXECUTION TIME (seconds)                      0
TIME OF RUN 10:41:04.7
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Cm-243 :Class C waste Re-run PAPA II LLW PAC
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC
IMODEL: 1 (1) SURF OR BURIED SOURCE; 2) PCND SOURCE; 3) TABULATED SOURCE FUNCTION
ITYPE: 0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO 10
>>> INPUT DATA
-----
NUMBER OF RADIOACTIVE PROGENY                  4
LENGTH OF SOURCE PARALLEL TO GW FLOW (m)      4.00E+01
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m)  2.40E+01
THICKNESS OF SOURCE (m)                       0.00E+00
PERCOLATION RATE (darcy vel m/y)              5.90E-01
VOLUMETRIC WATER CONTENT IN SOURCE            2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE  1.00E-01
BULK DENSITY AT SOURCE (g/cm**3)              1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g)          1.00E+02
BULK DENSITY IN UNSAT ZONE (g/cm**3)          1.50E+00
UNSATURATED ZONE THICKNESS (m)                1.00E+04
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g)      0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci)           5.74E+03
MOLECULAR WEIGHT (g/mole)                     2.43E+02
SOLUBILITY LIMIT (mg/L)                       1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y)    2.85E+01 2.41E+04 7.04E+11 3.28E+04 2.18E+01
BULK DENSITY OF AQUIFER (g/cm**3)             1.60E+00
POROSITY OF AQUIFER                           4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g)      1.80E+04 1.20E+03 1.50E+01 1.50E+01 1.50E+01
DISPERSIVITY X DIRECTION (m)                  1.00E+01
DISPERSIVITY Y DIRECTION (m)                  5.00E+00
DISPERSIVITY Z DIRECTION (m)                  1.00E+00
PORE VELOCITY (m/y)                           6.25E+01
WELL SCREEN THICKNESS (m)                     1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS (m)        1.25E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m)        0.00E+00

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DISTANCE TO RECEPTOR ALONG Z AXIS      (m)      0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 1.10E+05 4.30E+06 2.50E+05 1.10E+07 1.46E+07
UNITS OF CONTAMINANT                      Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 1.11E-01
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
-----
LEACH RATE CONSTANT (1/y)                1.20E-03
UNSATURATED PORE VELOCITY (m/y)          5.8000E+00
DECAY CONSTANT(S) (1/y)                  2.4321E-02 2.8761E-05 9.8458E-13 2.1133E-05 3.1840E-02
RETARDATION FACTOR(S) (SATURATED)        7.2001E+04 4.8010E+03 6.1000E+01 6.1000E-01 6.1000E+01
RETARDATION FACTOR (UNSATURATED)         1.0000E+00
SOLUBILITY LIMITED MASS (mg)              5.6546E+14
SOLUBILITY LIMITED ACTIVITY (Ci)          4.5811E+13
TRANSIT TIME IN UNSAT ZONE (years)        1.7241E-05
FRACTION DECAYED DURING UNSAT TRANSPORT  4.1932E-07
-----
PEAK CONCENTRATION CANNOT BE FOUND WITH PEAK FINDER ROUTINE:
USE CONCENTRATION VS TIME MODE TO DETERMINE PEAK
NO SOIL CONCENTRATION LIMITS CALCULATED SINCE THE
AVERAGE INTEGRATED CONCENTRATION IS ZERO
TIME OF RUN 10:41:04.7
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Cm-244 :Class C waste Re-run PAPA II LLW PA#####
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC
IMODEL: 1 (1) SURF OR BURIED SOURCE; (2) POND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE: 0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO ZD
>>> INPUT DATA
-----
NUMBER OF RADIOACTIVE PROGENY              5
LENGTH OF SOURCE PARALLEL TO GW FLOW (m)  4.90E+01
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 2.40E+01
THICKNESS OF SOURCE (m)                   3.30E+00
PERCOLATION RATE (darcy vel m/y)          5.80E-01
VOLUMETRIC WATER CONTENT IN SOURCE        2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
BULK DENSITY AT SOURCE (g/cm**3)          1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g)      1.00E+02
BULK DENSITY IN UNSAT ZONE (g/cm**3)      1.50E+00
UNSATURATED ZONE THICKNESS (m)            1.00E-04
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g)  0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**--1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci)        1.36E-02
MOLECULAR WEIGHT (g/mole)                 2.44E+02
SOLUBILITY LIMIT (mg/L)                   1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 1.81E+01 6.56E+03 2.43E+07 1.41E+10 5.75E+00 1.91E+00
BULK DENSITY OF AQUIFER (g/cm**3)         1.60E+00
POROSITY OF AQUIFER                       4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g)  1.80E+04 1.20E+03 1.50E+01 3.30E+03 3.60E+04 3.30E+03
DISPERSIVITY X DIRECTION (m)              1.30E+01
DISPERSIVITY Y DIRECTION (m)              5.00E+00
DISPERSIVITY Z DIRECTION (m)              1.00E+00
PORE VELOCITY (m/y)                       6.25E+01
WELL SCREEN THICKNESS (m)                 1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS (m)    1.25E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m)    0.30E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m)    0.30E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem Ci) 2.30E+06 2.29E+06 2.50E+05 2.80E+06 1.20E+06 7.50E+05
UNITS OF CONTAMINANT                      Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 2.30E-01
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
-----
LEACH RATE CONSTANT (1/y)                1.20E-03
UNSATURATED PORE VELOCITY (m/y)          5.8000E+00
DECAY CONSTANT(S) (1/y)                  1.8295E-02 1.2566E-04 2.8525E-08 4.9159E-11 1.2755E-01 3.6297E-01
RETARDATION FACTOR(S) (SATURATED)        7.2001E+04 4.8010E+03 6.1000E+01 1.3201E-04 1.4400E+05 1.3201E+04
RETARDATION FACTOR (UNSATURATED)         1.0000E+00
SOLUBILITY LIMITED MASS (mg)              5.6546E+14
SOLUBILITY LIMITED ACTIVITY (Ci)          4.5811E+13
TRANSIT TIME IN UNSAT ZONE (years)        1.7241E-05
FRACTION DECAYED DURING UNSAT TRANSPORT  6.6027E-07
-----
PEAK CONCENTRATION CANNOT BE FOUND WITH PEAK FINDER ROUTINE:
USE CONCENTRATION VS TIME MODE TO DETERMINE PEAK
NO SOIL CONCENTRATION LIMITS CALCULATED SINCE THE
AVERAGE INTEGRATED CONCENTRATION IS ZERO
TIME OF RUN 10:41:04.8
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Co-60 :Class C waste Re-run PAPA II LLW PA#####
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC

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IMODEL:1 (1) SURF OR BURIED SOURCE; (2) POND SOURCE; 3: TABULATED SOURCE FUNCTION
ITYPE:0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO 2D
>>> INPUT DATA
.....
NUMBER OF RADIOACTIVE PROGENY          )
LENGTH OF SOURCE PARALLEL TO GW FLOW (m)  4.40E+01
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW m  2.40E+01
THICKNESS OF SOURCE (m)  1.00E+00
PERCOLATION RATE (darcy vel m/y)  5.80E+01
VOLUMETRIC WATER CONTENT IN SOURCE  2.70E+01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE  1.00E+01
BULK DENSITY AT SOURCE (g/cm**3)  1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g)  2.00E+01
BULK DENSITY IN UNSAT ZONE (g/cm**3)  1.50E+00
UNSATURATED ZONE THICKNESS (m)  1.00E+04
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g)  3.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1)  3.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci)  7.75E+05
MOLECULAR WEIGHT (g/mole)  6.00E+01
SOLUBILITY LIMIT (mg/L)  1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY y,  5.75E+00
BULK DENSITY OF AQUIFER (g/cm**3)  1.60E+00
POROSITY OF AQUIFER  4.00E+01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g)  1.30E+03
DISPERSIVITY X DIRECTION (m)  1.00E+01
DISPERSIVITY Y DIRECTION (m)  5.00E+00
DISPERSIVITY Z DIRECTION (m)  1.00E+00
PORE VELOCITY (m/y)  6.25E+01
WELL SCREEN THICKNESS (m)  1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS (m)  1.25E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m)  0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m)  3.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci)  2.60E+04
UNITS OF CONTAMINANT  Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg)  7.47E+05
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
.....
LEACH RATE CONSTANT (1/y)  1.2062E-03
UNSATURATED PORE VELOCITY (m/y)  5.8000E+00
DECAY CONSTANT(S) (1/y)  1.2055E-01
RETARDATION FACTOR(S) (SATURATED)  5.2010E+03
RETARDATION FACTOR (UNSATURATED)  1.0000E+00
SOLUBILITY LIMITED MASS (mg)  5.6546E+14
SOLUBILITY LIMITED ACTIVITY (Ci)  5.8643E+14
TRANSIT TIME IN UNSAT ZONE (years)  1.7241E-05
FRACTION DECAYED DURING UNSAT TRANSPORT  2.0784E-06
-----
PEAK CONCENTRATION CANNOT BE FOUND WITH PEAK FINDER ROUTINE:
USE CONCENTRATION VS TIME MODE TO DETERMINE PEAK
NO SOIL CONCENTRATION LIMITS CALCULATED SINCE THE
AVERAGE INTEGRATED CONCENTRATION IS ZERO
TIME OF RUN 10:41:04.8
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Cs-134 :Class C waste Re-run PAPA 1: LLW PACXXXXXXXXXXXX
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC
IMODEL:1 (1) SURF OR BURIED SOURCE; (2) POND SOURCE; 3: TABULATED SOURCE FUNCTION
ITYPE:0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO 2D
>>> INPUT DATA
.....
NUMBER OF RADIOACTIVE PROGENY          )
LENGTH OF SOURCE PARALLEL TO GW FLOW m,  4.40E+01
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW m,  2.40E+01
THICKNESS OF SOURCE (m)  1.00E+00
PERCOLATION RATE (darcy vel m/y)  5.80E+01
VOLUMETRIC WATER CONTENT IN SOURCE  2.70E+01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE  1.00E+01
BULK DENSITY AT SOURCE (g/cm**3)  1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g)  2.00E+01
BULK DENSITY IN UNSAT ZONE (g/cm**3)  1.50E+00
UNSATURATED ZONE THICKNESS (m)  1.00E+04
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g)  3.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1)  3.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci)  5.75E+01
MOLECULAR WEIGHT (g/mole)  1.34E+02
SOLUBILITY LIMIT (mg/L)  1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY y,  2.06E+00
BULK DENSITY OF AQUIFER (g/cm**3)  1.60E+00
POROSITY OF AQUIFER  4.00E+01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g)  4.60E+03
DISPERSIVITY X DIRECTION (m)  1.00E+01
DISPERSIVITY Y DIRECTION (m)  5.00E+00
DISPERSIVITY Z DIRECTION (m)  1.00E+00
PORE VELOCITY (m/y)  6.25E+01
WELL SCREEN THICKNESS (m)  1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS (m)  1.25E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m)  0.00E+00

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DISTANCE TO RECEPTOR ALONG Z AXIS      (m)      0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 7.40E+04
UNITS OF CONTAMINANT                      Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 4.44E+01
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
-----
LEACH RATE CONSTANT (1/y)                5.9894E-03
UNSATURATED PORE VELOCITY (m/y)          5.8000E+00
DECAY CONSTANT(S) (1/y)                  3.3615E-01
RETARDATION FACTOR(S) (SATURATED)        1.8401E+04
RETARDATION FACTOR (UNSATURATED)         1.0000E+00
SOLUBILITY LIMITED MASS (mg)              1.1388E+14
SOLUBILITY LIMITED ACTIVITY (Ci)          1.4746E+14
TRANSIT TIME IN UNSAT ZONE (years)        1.7241E-05
FRACTION DECAYED DURING UNSAT TRANSPORT  5.7957E-06
-----
PEAK CONCENTRATION CANNOT BE FOUND WITH PEAK FINDER ROUTINE:
USE CONCENTRATION VS TIME MODE TO DETERMINE PEAK
NO SOIL CONCENTRATION LIMITS CALCULATED SINCE THE
AVERAGE INTEGRATED CONCENTRATION IS ZERO
TIME OF RUN 10:41:04.9
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Cs-137 :Class C waste Re-run PAPA II LLW PACXXXXXXXXXXXX
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0)CONC VS TIME; (1)PEAK CONC AND LIMITING SOIL CONC
IMODEL:1 (1) SURF OR BURIED SOURCE; (2)POND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE:0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO 2D
>>> INPUT DATA
-----
NUMBER OF RADIOACTIVE PROGENY              0
LENGTH OF SOURCE PARALLEL TO GW FLOW (m)   4.90E+01
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 2.40E+01
THICKNESS OF SOURCE (m)                    3.00E+00
PERCOLATION RATE (darcy vel m/y)           5.83E-01
VOLUMETRIC WATER CONTENT IN SOURCE         2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
BULK DENSITY AT SOURCE (g/cm**3)           1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g)       2.00E+01
BULK DENSITY IN UNSAT ZONE (g/cm**3)       1.50E+00
UNSATURATED ZONE THICKNESS (m)              1.00E-04
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g)   0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci)         4.23E+02
MOLECULAR WEIGHT (g/mole)                  1.37E+02
SOLUBILITY LIMIT (mg/L)                    1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 3.00E+01
BULK DENSITY OF AQUIFER (g/cm**3)           1.60E+00
POROSITY OF AQUIFER                        4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g)   4.60E+03
DISPERSIVITY X DIRECTION (m)                1.00E+01
DISPERSIVITY Y DIRECTION (m)                5.00E+00
DISPERSIVITY Z DIRECTION (m)                1.00E+00
PORE VELOCITY (m/y)                         6.25E+01
WELL SCREEN THICKNESS (m)                   1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS (m)     1.25E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m)     0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m)     0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 5.00E+04
UNITS OF CONTAMINANT                      Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 4.35E+03
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
-----
LEACH RATE CONSTANT (1/y)                5.9894E-03
UNSATURATED PORE VELOCITY (m/y)          5.8000E+00
DECAY CONSTANT(S) (1/y)                  3.3105E-02
RETARDATION FACTOR(S) (SATURATED)        1.8401E+04
RETARDATION FACTOR (UNSATURATED)         1.0000E+00
SOLUBILITY LIMITED MASS (mg)              1.1388E+14
SOLUBILITY LIMITED ACTIVITY (Ci)          9.9137E+12
TRANSIT TIME IN UNSAT ZONE (years)        1.7241E-05
FRACTION DECAYED DURING UNSAT TRANSPORT  3.9836E-07
-----
PEAK CONCENTRATION CANNOT BE FOUND WITH PEAK FINDER ROUTINE:
USE CONCENTRATION VS TIME MODE TO DETERMINE PEAK
NO SOIL CONCENTRATION LIMITS CALCULATED SINCE THE
AVERAGE INTEGRATED CONCENTRATION IS ZERO
TIME OF RUN 10:41:04.9
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Fe-55 :Class C waste Re-run PAPA II LLW PACXXXXXXXXXXXX
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0)CONC VS TIME; (1)PEAK CONC AND LIMITING SOIL CONC

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IMODEL:1 (1) SURF OR BURIED SOURCE; (2) POND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE:0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO 3D
>>> INPUT DATA
.....
NUMBER OF RADIOACTIVE PROGENY                0
LENGTH OF SOURCE PARALLEL TO GW FLOW m)      4.90E+01
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW m   2.40E+01
THICKNESS OF SOURCE m                         3.00E+00
PERCOLATION RATE (darcy vel m/y)             5.80E+01
VOLUMETRIC WATER CONTENT IN SOURCE            2.70E+01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE  1.00E+01
BULK DENSITY AT SOURCE (g/cm**3)             1.60E+00
SORPTION COEFFICIENT AT SOURCE ml/g)          0.00E+00
BULK DENSITY IN UNSAT ZONE g/cm**3)          1.50E+00
UNSATURATED ZONE THICKNESS m)                 1.00E+04
SORPTION COEFFICIENT IN UNSAT ZONE ml/g)      0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**+1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci)           1.00E+06
MOLECULAR WEIGHT (g/mole)                    5.50E+01
SOLUBILITY LIMIT (mg/L)                      1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y)   2.70E+00
BULK DENSITY OF AQUIFER (g/cm**3)            1.60E+00
POROSITY OF AQUIFER                          4.00E+01
SORPTION COEFFICIENT(S) IN AQUIFER ml/g)      0.00E+00
DISPERSIVITY X DIRECTION (m)                 1.00E+01
DISPERSIVITY Y DIRECTION (m)                 5.00E+00
DISPERSIVITY Z DIRECTION (m)                 1.00E+00
PORE VELOCITY (m/y)                          6.25E+01
WELL SCREEN THICKNESS m)                     1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS m)        1.25E+02
DISTANCE TO RECEPTOR ALONG Y AXIS m)        0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS m)        0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci)  5.90E+01
UNITS OF CONTAMINANT                          Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg)  4.32E+05
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
.....
LEACH RATE CONSTANT (1/y)                    1.2062E-03
UNSATURATED PORE VELOCITY (m/y)              5.8000E+00
DECAY CONSTANT(S) (1/y)                      2.5390E-01
RETARDATION FACTOR(S) (SATURATED)            3.2010E+03
RETARDATION FACTOR (UNSATURATED)            1.0000E+00
SOLUBILITY LIMITED MASS (mg)                  5.6546E+14
SOLUBILITY LIMITED ACTIVITY (Ci)              1.3474E+15
TRANSIT TIME IN UNSAT ZONE (years)            1.7241E-05
FRACTION DECAYED DURING UNSAT TRANSPORT      4.3776E-06
-----
PEAK CONCENTRATION CANNOT BE FOUND WITH PEAK FINDER ROUTINE:
USE CONCENTRATION VS TIME MODE TO DETERMINE PEAK
NO SOIL CONCENTRATION LIMITS CALCULATED SINCE THE
AVERAGE INTEGRATED CONCENTRATION IS ZERO
TIME OF RUN 10:41:05.0
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
H-3 :Class C waste Re-run PAPA 11 LLW PA*****
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC
IMODEL:1 (1) SURF OR BURIED SOURCE; (2) POND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE:0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO 3D
>>> INPUT DATA
.....
NUMBER OF RADIOACTIVE PROGENY                0
LENGTH OF SOURCE PARALLEL TO GW FLOW m)      4.90E+01
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW m   2.40E+01
THICKNESS OF SOURCE m                         3.00E+00
PERCOLATION RATE (darcy vel m/y)             5.80E+01
VOLUMETRIC WATER CONTENT IN SOURCE            2.70E+01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE  1.00E+01
BULK DENSITY AT SOURCE (g/cm**3)             1.60E+00
SORPTION COEFFICIENT AT SOURCE ml/g)          0.00E+00
BULK DENSITY IN UNSAT ZONE g/cm**3)          1.50E+00
UNSATURATED ZONE THICKNESS m)                 1.00E+04
SORPTION COEFFICIENT IN UNSAT ZONE ml/g)      0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**+1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci)           3.77E+03
MOLECULAR WEIGHT (g/mole)                    3.00E+00
SOLUBILITY LIMIT (mg/L)                      1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y)   1.00E+01
BULK DENSITY OF AQUIFER (g/cm**3)            1.60E+00
POROSITY OF AQUIFER                          4.00E+01
SORPTION COEFFICIENT(S) IN AQUIFER ml/g)      0.00E+00
DISPERSIVITY X DIRECTION (m)                 1.00E+01
DISPERSIVITY Y DIRECTION (m)                 5.00E+00
DISPERSIVITY Z DIRECTION (m)                 1.00E+00
PORE VELOCITY (m/y)                          6.25E+01
WELL SCREEN THICKNESS m)                     1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS m)        1.25E+02
DISTANCE TO RECEPTOR ALONG Y AXIS m)        0.00E+00

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DISTANCE TO RECEPTOR ALONG Z AXIS      'm)    0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci)  6.30E+01
UNITS OF CONTAMINANT                      Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg)  3.89E+02
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
-----
LEACH RATE CONSTANT (1/y)                6.9295E-01
UNSATURATED PORE VELOCITY m/y)           5.8300E-00
DECAY CONSTANT(S) (1/y)                  5.6353E-02
RETARDATION FACTOR(S) (SATURATED)        1.3000E+00
RETARDATION FACTOR (UNSATURATED)         1.3000E+00
SOLUBILITY LIMITED MASS (mg)              3.9431E+11
SOLUBILITY LIMITED ACTIVITY Ci            3.5441E+12
TRANSIT TIME IN UNSAT ZONE (years)        1.7241E-05
FRACTION DECAYED DURING UNSAT TRANSPORT  9.7161E-07
-----
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
COMPOSITE DOSE CONVERSION FACTOR (rem/Ci):  6.30E+01
LIMITING GROUNDWATER CONCENTRATION (Ci/L):  2.17E-09
MAXIMUM GW CONCENTRATION FOR MBR #1:  2.93E-05 Ci/L CEDE =  1.30E+00 rem
MAXIMUM CEDE 1.30E+00 rem
PEAK TIME (y):                           2.557892E+00
LIMITING SOIL CONCENTRATION Ci/m**3):    8.213E-05
LIMITING SOIL CONCENTRATION (Ci/kg):      5.133E-08
LIMITING INVENTORY IN SOIL (Ci):          2.897E-01
LIMITING INVENTORY IN SOIL (mg):          2.988E-02
SPECIFIC ACTIVITY (Ci/g):                 9.696E+03
EXECUTION TIME (seconds)                   3
TIME OF RUN 10:41:05.1
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
1-129 :Class C waste Re-run PAPA II LLW PA*****
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC
IMODEL: 1 (1) SURF OR BURIED SOURCE; (2) POND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE: 0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO ZD
>>> INPUT DATA
-----
NUMBER OF RADIOACTIVE PROGENY              0
LENGTH OF SOURCE PARALLEL TO GW FLOW (m)   4.90E+01
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 2.40E+01
THICKNESS OF SOURCE (m)                   3.30E+00
PERCOLATION RATE (darcy vel m/y)           5.30E-01
VOLUMETRIC WATER CONTENT IN SOURCE         2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.30E-01
BULK DENSITY AT SOURCE (g/cm**3)           1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g)       5.00E+00
BULK DENSITY IN UNSAT ZONE (g/cm**3)       1.50E+00
UNSATURATED ZONE THICKNESS (m)              1.00E-04
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g)   0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (1/y) 0.30E+00
INITIAL MASS OR ACTIVITY (mg or Ci)         8.65E-04
MOLECULAR WEIGHT (g/mole)                  1.29E+02
SOLUBILITY LIMIT (mg/L)                    1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 1.57E+07
BULK DENSITY OF AQUIFER (g/cm**3)          1.60E+00
POROSITY OF AQUIFER                        4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g)   5.00E+00
DISPERSIVITY X DIRECTION (m)               1.00E+01
DISPERSIVITY Y DIRECTION (m)               5.00E+00
DISPERSIVITY Z DIRECTION (m)               1.00E+00
PORE VELOCITY m/y                          4.5E+01
WELL SCREEN THICKNESS (m)                  1.50E-01
DISTANCE TO RECEPTOR ALONG X AXIS        m 1.00E+02
DISTANCE TO RECEPTOR ALONG Y AXIS        m 1.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS        m 1.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR rem Ci 2.30E+05
UNITS OF CONTAMINANT                       Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg)  4.90E+03
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
-----
LEACH RATE CONSTANT (1/y)                2.3352E-02
UNSATURATED PORE VELOCITY m/y)           5.8000E-00
DECAY CONSTANT(S) (1/y)                  4.4150E-08
RETARDATION FACTOR(S) (SATURATED)        2.1000E+01
RETARDATION FACTOR (UNSATURATED)         1.3000E+00
SOLUBILITY LIMITED MASS (mg)              2.9208E+13
SOLUBILITY LIMITED ACTIVITY Ci            5.1606E+06
TRANSIT TIME IN UNSAT ZONE (years)        1.7241E-05
FRACTION DECAYED DURING UNSAT TRANSPORT  7.6117E-13
-----
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
COMPOSITE DOSE CONVERSION FACTOR (rem/Ci):  2.90E+05
LIMITING GROUNDWATER CONCENTRATION (Ci/L):  4.89E-13
MAXIMUM GW CONCENTRATION FOR MBR #1:  2.98E-13 Ci/L CEDE =  6.08E-05 rem
MAXIMUM CEDE 6.08E-05 rem

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PEAK TIME (y): 5.907546E+01
LIMITING SOIL CONCENTRATION (Ci/m**3): 4.031E-07
LIMITING SOIL CONCENTRATION (Ci/kg): 2.519E-10
LIMITING INVENTORY IN SOIL (Ci): 1.422E-03
LIMITING INVENTORY IN SOIL (mg): 3.049E+03
SPECIFIC ACTIVITY (Ci/g): 1.167E-04
EXECUTION TIME (seconds): 0
TIME OF RUN 10:41:05.2
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Nb-94 :Class C waste Re-run PAPA II LLW PAD*****
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC
IMODEL: 1 (1) SURF OR BURIED SOURCE; (2) POND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE: 0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO 2D
>>> INPUT DATA
*****
NUMBER OF RADIOACTIVE PROGENY 0
LENGTH OF SOURCE PARALLEL TO GW FLOW (m) 4.90E+01
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 2.40E+01
THICKNESS OF SOURCE (m) 3.00E+00
PERCOLATION RATE (darcy vel m/y) 5.80E-01
VOLUMETRIC WATER CONTENT IN SOURCE 2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
BULK DENSITY AT SOURCE (g/cm**3) 1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g) 1.00E+03
BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.50E+00
UNSATURATED ZONE THICKNESS (m) 1.00E-04
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) 0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci) 1.58E+00
MOLECULAR WEIGHT (g/mole) 9.40E-01
SOLUBILITY LIMIT (mg/L) 1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 2.00E+04
BULK DENSITY OF AQUIFER (g/cm**3) 1.60E+00
POROSITY OF AQUIFER 4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g) 5.50E+02
DISPERSIVITY X DIRECTION (m) 1.00E+01
DISPERSIVITY Y DIRECTION (m) 5.00E+00
DISPERSIVITY Z DIRECTION (m) 1.00E+00
PORE VELOCITY (m/y) 6.25E+01
WELL SCREEN THICKNESS (m) 1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS (m) 1.25E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m) 0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m) 0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 5.10E+03
UNITS OF CONTAMINANT Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 8.31E+03
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
*****
LEACH RATE CONSTANT (1/y) 1.2081E-04
UNSATURATED PORE VELOCITY (m/y) 5.8000E+00
DECAY CONSTANT(S) (1/y) 3.4657E-05
RETARDATION FACTOR(S) (SATURATED) 2.2010E+03
RETARDATION FACTOR (UNSATURATED) 1.0000E+00
SOLUBILITY LIMITED MASS (mg) 5.6458E+15
SOLUBILITY LIMITED ACTIVITY (Ci) 1.0745E+12
TRANSIT TIME IN UNSAT ZONE (years) 1.7241E-05
FRACTION DECAYED DURING UNSAT TRANSPORT 5.9754E-10
-----
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
COMPOSITE DOSE CONVERSION FACTOR (rem/Di): 5.10E+03
LIMITING GROUNDWATER CONCENTRATION (Ci/Li): 2.69E-11
MAXIMUM GW CONCENTRATION FOR MBR #1: 2.79E-10 Di Li DECE = 1.04E-05 rem
MAXIMUM CEDE 1.04E-05 rem
PEAK TIME (y): 5.907546E+01
LIMITING SOIL CONCENTRATION (Ci/m**3): 4.031E-07
LIMITING SOIL CONCENTRATION (Ci/kg): 2.519E-10
LIMITING INVENTORY IN SOIL (Ci): 1.422E-03
LIMITING INVENTORY IN SOIL (mg): 3.049E+03
SPECIFIC ACTIVITY (Ci/g): 1.167E-04
EXECUTION TIME (seconds): 0
TIME OF RUN 10:41:05.2
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Ni-59 :Class C waste Re-run PAPA II LLW PAD*****
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC
IMODEL: 1 (1) SURF OR BURIED SOURCE; (2) POND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE: 0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO 2D
>>> INPUT DATA
*****
NUMBER OF RADIOACTIVE PROGENY 0
LENGTH OF SOURCE PARALLEL TO GW FLOW (m) 4.90E+01
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 2.40E+01

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THICKNESS OF SOURCE (m) 3.00E+00
PERCOLATION RATE (darcy vel m/y) 5.80E-01
VOLUMETRIC WATER CONTENT IN SOURCE 2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
BULK DENSITY AT SOURCE (g/cm**3) 1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g) 1.00E+02
BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.50E+00
UNSATURATED ZONE THICKNESS (m) 1.00E-04
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) 0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci) 5.90E+02
MOLECULAR WEIGHT (g/mole) 5.90E+01
SOLUBILITY LIMIT (mg/L) 1.00E+06
HALF-LIFE (S) OF CONTAMINANT AND PROGENY (y) 7.53E+04
BULK DENSITY OF AQUIFER (g/cm**3) 1.63E+00
POROSITY OF AQUIFER 4.00E-01
SORPTION COEFFICIENT (S) IN AQUIFER (ml/g) 3.00E+02
DISPERSIVITY X DIRECTION (m) 1.00E+01
DISPERSIVITY Y DIRECTION (m) 5.00E+00
DISPERSIVITY Z DIRECTION (m) 1.00E+00
PORE VELOCITY (m/y) 6.25E+01
WELL SCREEN THICKNESS (m) 1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS (m) 1.25E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m) 0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m) 0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 3.50E+03
UNITS OF CONTAMINANT Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 7.30E+06
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
-----
LEACH RATE CONSTANT (1/y) 1.2062E-03
UNSATURATED PORE VELOCITY (m/y) 5.8000E+00
DECAY CONSTANT(S) (1/y) 9.2420E-06
RETARDATION FACTOR(S) (SATURATED) 1.2910E+03
RETARDATION FACTOR (UNSATURATED) 1.0000E+00
SOLUBILITY LIMITED MASS (mg) 5.6546E+14
SOLUBILITY LIMITED ACTIVITY (Ci) 4.5722E+10
TRANSIT TIME IN UNSAT ZONE (years) 1.7241E-05
FRACTION DECAYED DURING UNSAT TRANSPORT 1.5934E-10
-----
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
COMPOSITE DOSE CONVERSION FACTOR (rem/Ci): 3.50E+03
LIMITING GROUNDWATER CONCENTRATION (Ci/L): 3.91E-11
MAXIMUM GW CONCENTRATION FOR MBR #1: 5.61E-09 Ci/L CEDE = 1.43E-02 rem
MAXIMUM CEDE 1.43E-02 rem
PEAK TIME (y): 2.751775E+03
LIMITING SOIL CONCENTRATION (Ci/m**3): 1.167E-03
LIMITING SOIL CONCENTRATION (Ci/kg): 7.296E-07
LIMITING INVENTORY IN SOIL (Ci): 4.119E+00
LIMITING INVENTORY IN SOIL (mg): 5.094E+04
SPECIFIC ACTIVITY (Ci/g): 8.086E-02
EXECUTION TIME (seconds) 0
TIME OF RUN 10:41:05.3
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
N1-63 :Class C waste Re-run PAPA II LLW PACXXXXXXXXXXXXXXXXXXXX
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC
IMODEL: (1) SURF OR BURIED SOURCE; (2) POND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE: 0 (0) VERT AVG; (1) NON-VERT AVG; 2) AVG FROM 0 TO ZD
>>> INPUT DATA
-----
NUMBER OF RADIOACTIVE PROGENY )
LENGTH OF SOURCE PARALLEL TO GW FLOW (m) 4.90E+01
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 2.40E+01
THICKNESS OF SOURCE (m) 3.00E+00
PERCOLATION RATE (darcy vel m/y) 5.80E-01
VOLUMETRIC WATER CONTENT IN SOURCE 2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
BULK DENSITY AT SOURCE (g/cm**3) 1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g) 1.00E+02
BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.50E+00
UNSATURATED ZONE THICKNESS (m) 1.00E-04
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) 0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci) 4.38E+04
MOLECULAR WEIGHT (g/mole) 6.30E+01
SOLUBILITY LIMIT (mg/L) 1.00E+06
HALF-LIFE (S) OF CONTAMINANT AND PROGENY (y) 1.00E+02
BULK DENSITY OF AQUIFER (g/cm**3) 1.60E+00
POROSITY OF AQUIFER 4.00E-01
SORPTION COEFFICIENT (S) IN AQUIFER (ml/g) 3.00E+02
DISPERSIVITY X DIRECTION (m) 1.00E+01
DISPERSIVITY Y DIRECTION (m) 5.00E+00
DISPERSIVITY Z DIRECTION (m) 1.00E+00
PORE VELOCITY (m/y) 6.25E+01
WELL SCREEN THICKNESS (m) 1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS (m) 1.25E+02

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DISTANCE TO RECEPTOR ALONG Y AXIS      (m)      0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS      (m)      0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci)  5.40E-01
UNITS OF CONTAMINANT                      Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg)  7.71E-05
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
-----
LEACH RATE CONSTANT (1/y)                 1.2062E-03
UNSATURATED PORE VELOCITY (m/y)           5.8000E-00
DECAY CONSTANT(S) (1/y)                   6.9315E-03
RETARDATION FACTOR(S) (SATURATED)         1.2010E+03
RETARDATION FACTOR (UNSATURATED)         1.3000E+00
SOLUBILITY LIMITED MASS (mg)               5.6546E-14
SOLUBILITY LIMITED ACTIVITY (Ci)           3.2114E-13
TRANSIT TIME IN UNSAT ZONE (years)         1.7241E-05
FRACTION DECAYED DURING UNSAT TRANSPORT  1.1951E-07
-----
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
COMPOSITE DOSE CONVERSION FACTOR (rem/Ci):  5.40E-01
LIMITING GROUNDWATER CONCENTRATION (Ci/L):  2.54E-09
MAXIMUM GW CONCENTRATION FOR MBR #1: 2.43E-11 Ci/L CEDE = 9.57E-07 rem
MAXIMUM CEDE 9.57E-07 rem
PEAK TIME (y):                             9.14151E+02
LIMITING SOIL CONCENTRATION (Ci/m**3):     1.297E+03
LIMITING SOIL CONCENTRATION (Ci/kg):        8.107E-01
LIMITING INVENTORY IN SOIL (Ci):            4.576E+06
LIMITING INVENTORY IN SOIL (mg):            8.058E+07
SPECIFIC ACTIVITY (Ci/g): 5.679E+01
EXECUTION TIME (seconds)                    0
TIME OF RUN 10:41:05.4
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Np-237                                     :Class C waste Re-run PAPA II LLW PA*****
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC
MODEL: 1 (1) SURF OR BURIED SOURCE; (2) POND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE: 0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO ZD
>>> INPUT DATA
-----
NUMBER OF RADIOACTIVE PROGENY              2
LENGTH OF SOURCE PARALLEL TO GW FLOW (m)   4.90E+01
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 2.40E+01
THICKNESS OF SOURCE (m)                    3.30E-00
PERCOLATION RATE (darcy vel m/y)           5.80E-01
VOLUMETRIC WATER CONTENT IN SOURCE         2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
BULK DENSITY AT SOURCE (g/cm**3)           1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g)       5.00E+03
BULK DENSITY IN UNSAT ZONE (g/cm**3)        1.50E+00
UNSATURATED ZONE THICKNESS (m)              1.00E-04
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g)    0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci)         7.86E-05
MOLECULAR WEIGHT (g/mole)                   2.37E+02
SOLUBILITY LIMIT (mg/L)                     1.00E-06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 2.10E+06 1.59E+05 7.34E+03
BULK DENSITY OF AQUIFER (g/cm**3)           1.60E+00
POROSITY OF AQUIFER                         4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g)    2.50E-01 1.50E+01 3.30E+03
DISPERSIVITY X DIRECTION (m)                1.00E-01
DISPERSIVITY Y DIRECTION (m)                5.00E-00
DISPERSIVITY Z DIRECTION (m)                1.00E-00
PORE VELOCITY (m/y)                         6.25E+01
WELL SCREEN THICKNESS (m)                   1.50E-01
DISTANCE TO RECEPTOR ALONG X AXIS (m)      1.25E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m)      1.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m)      3.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 3.90E-06 1.70E-05 3.91E+06
UNITS OF CONTAMINANT                        Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg)  1.09E+02
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
-----
LEACH RATE CONSTANT (1/y)                 2.4166E-05
UNSATURATED PORE VELOCITY (m/y)           5.9000E+00
DECAY CONSTANT(S) (1/y)                   3.3007E-07 4.3594E-06 9.4434E-05
RETARDATION FACTOR(S) (SATURATED)         1.0100E+02 6.1000E+01 1.3201E+04
RETARDATION FACTOR (UNSATURATED)         1.3000E+00
SOLUBILITY LIMITED MASS (mg)               2.8225E+16
SOLUBILITY LIMITED ACTIVITY (Ci)           2.3291E+10
TRANSIT TIME IN UNSAT ZONE (years)         1.7241E-05
FRACTION DECAYED DURING UNSAT TRANSPORT  5.6909E-12
-----
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
DECAY-INGROWTH FACTORS 9.9979E-01 2.7156E-03 7.8482E-05
COMPOSITE DOSE CONVERSION FACTOR (rem/Ci):  3.30E-06
LIMITING GROUNDWATER CONCENTRATION (Ci/L):  3.51E-14

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NOTE: PROGENY CONCENTRATIONS ARE REPORTED AT THE TIME OF THE MAXIMUM PARENT CONCENTRATION
 MAXIMUM GW CONCENTRATION FOR MBR #1: 5.46E-17 Ci/L CEDE = 1.55E-07 rem
 MAXIMUM GW CONCENTRATION FOR MBR #2: 2.45E-19 Ci/L CEDE = 4.84E-11 rem
 MAXIMUM GW CONCENTRATION FOR MBR #3: 3.28E-23 Ci/L CEDE = 9.35E-14 rem
 MAXIMUM CEDE 1.55E-07 rem
 PEAK TIME (y): 6.238477E+02
 LIMITING SOIL CONCENTRATION (Ci/m**3): 1.434E-05
 LIMITING SOIL CONCENTRATION (Ci/kg): 8.462E-09
 LIMITING INVENTORY IN SOIL (Ci): 5.053E-02
 LIMITING INVENTORY IN SOIL (mg): 7.037E-04
 SPECIFIC ACTIVITY (Ci/g): 7.189E-04
 EXECUTION TIME (seconds) 0
 TIME OF RUN 10:41:05.5
 DATE OF RUN 11/05/96

>>> TITLE OF PROJECT:

Pb-210 :Class C waste Re-run PAPA 11 LLW PAD

GAUSSIAN QUADRATURE SOLUTION

MODEL OPTIONS

IMODE: 1

KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC

IMODEL: 1 (1) SURF OR BURIED SOURCE; (2) POND SOURCE; (3) TABULATED SOURCE FUNCTION

ITYPE: 0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO 2D

>>> INPUT DATA

.....
 NUMBER OF RADIOACTIVE PROGENY 0
 LENGTH OF SOURCE PARALLEL TO GW FLOW (m) 4.90E-01
 WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 2.40E-01
 THICKNESS OF SOURCE (m) 3.00E-00
 PERCOLATION RATE (darcy vel m/y) 5.80E-01
 VOLUMETRIC WATER CONTENT IN SOURCE 2.79E-01
 VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
 BULK DENSITY AT SOURCE (g/cm**3) 1.60E+00
 SORPTION COEFFICIENT AT SOURCE (ml/g) 0.00E+00
 BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.50E+00
 UNSATURATED ZONE THICKNESS (m) 1.00E-04
 SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) 1.00E+04
 OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
 INITIAL MASS OR ACTIVITY (mg or Ci) 2.00E-01
 MOLECULAR WEIGHT (g/mole) 2.10E+02
 SOLUBILITY LIMIT (mg/L) 1.00E+06
 HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 2.23E+01
 BULK DENSITY OF AQUIFER (g/cm**3) 1.60E+00
 POROSITY OF AQUIFER 4.00E-01
 SORPTION COEFFICIENT(S) IN AQUIFER (ml/g) 1.00E+04
 DISPERSIVITY X DIRECTION (m) 1.00E+01
 DISPERSIVITY Y DIRECTION (m) 5.00E+00
 DISPERSIVITY Z DIRECTION (m) 1.00E+00
 PORE VELOCITY (m/y) 6.25E-01
 WELL SCREEN THICKNESS (m) 1.50E-01
 DISTANCE TO RECEPTOR ALONG X AXIS (m) 1.25E+02
 DISTANCE TO RECEPTOR ALONG Y AXIS (m) 0.00E+00
 DISTANCE TO RECEPTOR ALONG Z AXIS (m) 0.00E+00
 RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 6.70E+06
 UNITS OF CONTAMINANT Ci

LIMITING SOIL CONCENTRATION CALCULATION

>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 2.62E+00

>>> VALUES CALCULATED IN SOURCE SUBROUTINE

.....
 LEACH RATE CONSTANT (1/y) 6.9295E-01
 UNSATURATED PORE VELOCITY (m/y) 5.8000E+00
 DECAY CONSTANT(S) (1/y) 3.1983E-02
 RETARDATION FACTOR(S) (SATURATED) 6.4001E+04
 RETARDATION FACTOR UNSATURATED 1.4000E+05
 SOLUBILITY LIMITED MASS (mg) 9.8431E+11
 SOLUBILITY LIMITED ACTIVITY (Ci) 7.5204E+13
 TRANSIT TIME IN UNSAT ZONE (years) 4.1379E+00
 FRACTION DECAYED DURING UNSAT TRANSPORT 1.2069E-01

PEAK CONCENTRATION CANNOT BE FOUND WITH PEAK FINDER ROUTINE:

USE CONCENTRATION VS TIME MODE TO DETERMINE PEAK

NO SOIL CONCENTRATION LIMITS CALCULATED SINCE THE

AVERAGE INTEGRATED CONCENTRATION IS ZERO

TIME OF RUN 10:41:05.6

DATE OF RUN 11/05/96

>>> TITLE OF PROJECT:

Pu-238 :Class C waste Re-run PAPA 11 LLW PAD

GAUSSIAN QUADRATURE SOLUTION

MODEL OPTIONS

IMODE: 1

KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC

IMODEL: 1 (1) SURF OR BURIED SOURCE; (2) POND SOURCE; (3) TABULATED SOURCE FUNCTION

ITYPE: 0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO 2D

>>> INPUT DATA

.....
 NUMBER OF RADIOACTIVE PROGENY 4
 LENGTH OF SOURCE PARALLEL TO GW FLOW (m) 4.90E+01
 WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 2.40E+01
 THICKNESS OF SOURCE (m) 3.00E+00
 PERCOLATION RATE (darcy vel m/y) 5.80E-01
 VOLUMETRIC WATER CONTENT IN SOURCE 2.79E-01

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VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
BULK DENSITY AT SOURCE (g/cm**3) 1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g) 5.00E-03
BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.50E+00
UNSATURATED ZONE THICKNESS (m) 1.00E-04
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) 0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci) 1.01E-01
MOLECULAR WEIGHT (g/mole) 2.33E-02
SOLUBILITY LIMIT (mg/L) 1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 8.77E+01 2.45E+05 7.54E+03 1.60E+03 2.23E+01
BULK DENSITY OF AQUIFER (g/cm**3) 1.60E+00
POROSITY OF AQUIFER 4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g) 1.00E+03 1.50E+01 3.30E+03 3.60E+04 1.60E+04
DISPERSIVITY X DIRECTION (m) 1.00E+01
DISPERSIVITY Y DIRECTION (m) 5.00E+00
DISPERSIVITY Z DIRECTION (m) 1.00E+00
PORO VELOCITY (m/y) 6.25E+01
WELL SCREEN THICKNESS (m) 1.50E-01
DISTANCE TO RECEPTOR ALONG X AXIS (m) 1.25E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m) 0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m) 0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 3.80E+06 2.60E+05 5.30E+05 1.10E+06 6.70E+06
UNITS OF CONTAMINANT Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 7.06E+00
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
-----
LEACH RATE CONSTANT (1/y) 2.4166E-05
UNSATURATED PORE VELOCITY (m/y) 5.8000E+00
DECAY CONSTANT(S) (1/y) 7.9036E-03 2.8292E-06 9.1929E-05 4.3322E-04 3.1083E-02
RETARDATION FACTOR(S) (SATURATED) 4.8010E+03 6.1000E+01 1.3201E+04 1.4400E+05 6.4001E+04
RETARDATION FACTOR (UNSATURATED) 1.0000E+00
SOLUBILITY LIMITED MASS (mg) 2.8225E+16
SOLUBILITY LIMITED ACTIVITY (Ci) 4.8382E+14
TRANSIT TIME IN UNSAT ZONE (years) 1.7241E-05
FRACTION DECAYED DURING UNSAT TRANSPORT 1.3627E-07
-----
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
DECAY-INGROWTH FACTORS 1.7854E-06 3.5639E-04 4.7357E-05 1.3191E-05 1.2721E-05
COMPOSITE DOSE CONVERSION FACTOR (rem/Ci): 4.10E-09
LIMITING GROUNDWATER CONCENTRATION (Ci/L): 3.34E-17
NOTE: PROGENY CONCENTRATIONS ARE REPORTED AT THE TIME OF THE MAXIMUM PARENT CONCENTRATION
MAXIMUM GW CONCENTRATION FOR MBR #1: 9.30E-25 Ci/L CEDE = 2.58E-15 rem
MAXIMUM GW CONCENTRATION FOR MBR #2: 1.46E-20 Ci/L CEDE = 2.77E-12 rem
MAXIMUM GW CONCENTRATION FOR MBR #3: 8.97E-24 Ci/L CEDE = 3.47E-15 rem
MAXIMUM GW CONCENTRATION FOR MBR #4: 2.29E-25 Ci/L CEDE = 1.84E-16 rem
MAXIMUM GW CONCENTRATION FOR MBR #5: 4.97E-25 Ci/L CEDE = 2.43E-15 rem
MAXIMUM CEDE 2.78E-12 rem
PEAK TIME (y): 1.674663E+03
LIMITING SOIL CONCENTRATION (Ci/m**3): 1.233E-03
LIMITING SOIL CONCENTRATION (Ci/kg): 7.707E-01
LIMITING INVENTORY IN SOIL (Ci): 4.350E+06
LIMITING INVENTORY IN SOIL (mg): 2.538E+08
SPECIFIC ACTIVITY (Ci/g): 1.714E+01
EXECUTION TIME (seconds) 0
TIME OF RUN 10:41:05.7
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Pu-239 :Class C waste Re-run PAPA II LLW PACXXXXXXXXXXXXXXXXXXXX
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC
IMODEL: 1 (1) SURF OR BURIED SOURCE; 2 (2) POND SOURCE; 3 (3) TABULATED SOURCE FUNCTION
ITYPE: 0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO 20
>>> INPUT DATA
-----
NUMBER OF RADIOACTIVE PROGENY 3
LENGTH OF SOURCE PARALLEL TO GW FLOW (m) 4.90E-01
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 2.40E-01
THICKNESS OF SOURCE (m) 3.00E-03
PERCOLATION RATE (darcy vel m/y) 5.80E-01
VOLUMETRIC WATER CONTENT IN SOURCE 2.78E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
BULK DENSITY AT SOURCE (g/cm**3) 1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g) 5.00E-03
BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.50E+00
UNSATURATED ZONE THICKNESS (m) 1.00E-04
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) 0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci) 9.70E-03
MOLECULAR WEIGHT (g/mole) 2.33E+02
SOLUBILITY LIMIT (mg/L) 1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 2.41E+04 7.04E+11 3.28E+04 2.18E+01
BULK DENSITY OF AQUIFER (g/cm**3) 1.60E+00
POROSITY OF AQUIFER 4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g) 1.00E+03 1.50E+01 1.50E+01 1.50E+01
DISPERSIVITY X DIRECTION (m) 1.00E+01
DISPERSIVITY Y DIRECTION (m) 5.00E+00
DISPERSIVITY Z DIRECTION (m) 1.00E+00

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PORE VELOCITY (m/y) 6.25E+01
WELL SCREEN THICKNESS (m) 1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS (m) 1.25E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m) 3.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m) 3.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 4.30E+06 2.50E+05 1.10E+07 1.46E+07
UNITS OF CONTAMINANT Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 1.56E+02
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
-----
LEACH RATE CONSTANT (1/y) 2.4166E-05
UNSATURATED PORE VELOCITY (m/y) 5.8000E+00
DECAY CONSTANT(S) (1/y) 2.8761E-05 9.8458E-13 2.1133E-05 3.1840E-02
RETARDATION FACTOR(S) (SATURATED) 4.8010E+03 6.1000E+01 6.1000E+01 6.1000E+01
RETARDATION FACTOR (UNSATURATED) 1.0000E+00
SOLUBILITY LIMITED MASS (mg) 2.8225E+16
SOLUBILITY LIMITED ACTIVITY (Ci) 1.7533E+12
TRANSIT TIME IN UNSAT ZONE (years) 1.7241E-05
FRACTION DECAYED DURING UNSAT TRANSPORT 4.9588E-10
-----
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
DECAY-INGROWTH FACTORS 6.5616E-01 1.1771E-08 1.7570E-09 1.7504E-09
COMPOSITE DOSE CONVERSION FACTOR (rem/Ci) 4.30E+06
LIMITING GROUNDWATER CONCENTRATION (Ci/L) 3.19E-14
NOTE: PROGENY CONCENTRATIONS ARE REPORTED AT THE TIME OF THE MAXIMUM PARENT CONCENTRATION
MAXIMUM GW CONCENTRATION FOR MBR #1: 3.34E-15 Ci/L CEDE = 1.05E-05 rem
MAXIMUM GW CONCENTRATION FOR MBR #2: 4.72E-21 Ci/L CEDE = 8.62E-13 rem
MAXIMUM GW CONCENTRATION FOR MBR #3: 7.05E-22 Ci/L CEDE = 5.66E-12 rem
MAXIMUM GW CONCENTRATION FOR MBR #4: 7.02E-22 Ci/L CEDE = 7.48E-12 rem
MAXIMUM CEDE 1.05E-05 rem
PEAK TIME (y): 1.464998E+04
LIMITING SOIL CONCENTRATION (Ci/m**3): 2.620E-05
LIMITING SOIL CONCENTRATION (Ci/kg): 1.637E-08
LIMITING INVENTORY IN SOIL (Ci): 9.242E-02
LIMITING INVENTORY IN SOIL (mg): 1.488E+03
SPECIFIC ACTIVITY (Ci/g): 6.212E-02
EXECUTION TIME (seconds) )
TIME OF RUN 10:41:05.8
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Pu-241 :Class C waste Re-run PAPA II LLW PA00000000000000000000
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC
IMODEL: 1 (1) SURF OR BURIED SOURCE; (2) POND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE: 0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO ZD
>>> INPUT DATA
-----
NUMBER OF RADIOACTIVE PROGENY 4
LENGTH OF SOURCE PARALLEL TO GW FLOW (m) 4.90E+01
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 2.40E+01
THICKNESS OF SOURCE (m) 3.00E+00
PERCOLATION RATE (darcy vel m/y) 5.80E-01
VOLUMETRIC WATER CONTENT IN SOURCE 2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
BULK DENSITY AT SOURCE (g/cm**3) 1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g) 5.00E+03
BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.50E+00
UNSATURATED ZONE THICKNESS (m) 1.30E+04
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) 0.39E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE y**-1 0.00E+00
INITIAL MASS OR ACTIVITY mg or Ci 1.86E+01
MOLECULAR WEIGHT (g/mole) 2.41E+02
SOLUBILITY LIMIT (mg/L) 1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 1.44E+01 4.32E+02 2.10E+06 1.59E+05 7.34E+03
BULK DENSITY OF AQUIFER (g/cm**3) 1.60E+00
POROSITY OF AQUIFER 4.20E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g) 1.20E+03 5.00E+03 2.50E+01 1.50E+01 3.30E+03
DISPERSIVITY X DIRECTION (m) 1.00E+01
DISPERSIVITY Y DIRECTION (m) 5.00E+00
DISPERSIVITY Z DIRECTION (m) 1.00E+00
PORE VELOCITY (m/y) 6.25E+01
WELL SCREEN THICKNESS (m) 1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS (m) 1.25E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m) 3.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m) 3.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 8.20E+04 4.50E+06 3.90E+06 2.70E+05 3.91E+06
UNITS OF CONTAMINANT Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 1.80E+02
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
-----
LEACH RATE CONSTANT (1/y) 2.4166E-05
UNSATURATED PORE VELOCITY (m/y) 5.8000E+00
DECAY CONSTANT(S) (1/y) 4.8135E-02 1.6045E-03 3.3007E-07 4.3594E-06 9.4434E-05
RETARDATION FACTOR(S) (SATURATED) 4.8010E+03 2.0001E+04 1.0700E+02 6.1000E+01 1.3201E+04
RETARDATION FACTOR (UNSATURATED) 1.0000E+00
SOLUBILITY LIMITED MASS (mg) 2.8225E+16

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SOLUBILITY LIMITED ACTIVITY (Ci)      2.9099E+15
TRANSIT TIME IN UNSAT ZONE (years)    1.7241E-05
FRACTION DECAYED DURING UNSAT TRANSPORT 8.2992E-07
-----
PEAK CONCENTRATION CANNOT BE FOUND WITH PEAK FINDER ROUTINE:
USE CONCENTRATION VS TIME MODE TO DETERMINE PEAK
NO SOIL CONCENTRATION LIMITS CALCULATED SINCE THE
AVERAGE INTEGRATED CONCENTRATION IS ZERO
TIME OF RUN 10:41:05.9
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Pu-242                               :Class C waste Re-run PAPA II LLW PA0000000000000000
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0) CONC VS TIME; (1) PEAK CONC AND LIMITING SOIL CONC
IMODEL: 1 (1) SURF OR BURIED SOURCE; (2) POND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE: 0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO 20
>>> INPUT DATA
-----
NUMBER OF RADIOACTIVE PROGENY          5
LENGTH OF SOURCE PARALLEL TO GW FLOW (m) 4.90E+01
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) 2.40E+01
THICKNESS OF SOURCE (m) 3.00E+00
PERCOLATION RATE (darcy vel m/y) 5.80E-01
VOLUMETRIC WATER CONTENT IN SOURCE 2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE 1.00E-01
BULK DENSITY AT SOURCE (g/cm**3) 1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g) 5.00E+03
BULK DENSITY IN UNSAT ZONE (g/cm**3) 1.50E+00
UNSATURATED ZONE THICKNESS (m) 1.00E-04
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) 0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci) 7.93E-08
MOLECULAR WEIGHT (g/mole) 2.42E-02
SOLUBILITY LIMIT (mg/L) 1.70E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) 8.30E+07 4.47E+09 2.45E+05 7.54E+03 1.60E+03 2.23E+01
BULK DENSITY OF AQUIFER (g/cm**3) 1.60E+00
POROSITY OF AQUIFER 4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g) 1.20E+03 1.50E+01 1.50E+01 3.30E+03 3.60E+04 1.60E+04
DISPERSIVITY X DIRECTION (m) 1.00E-01
DISPERSIVITY Y DIRECTION (m) 5.00E+00
DISPERSIVITY Z DIRECTION (m) 1.00E+00
PORE VELOCITY (m/y) 6.25E-01
WELL SCREEN THICKNESS (m) 1.53E+01
DISTANCE TO RECEPTOR ALONG X AXIS (m) 1.25E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m) 0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m) 0.30E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci) 4.10E+06 2.30E+05 2.60E+05 5.30E+05 1.10E+06 6.70E+06
UNITS OF CONTAMINANT Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 4.45E+00
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
-----
LEACH RATE CONSTANT (1/y) 2.4166E-05
UNSATURATED PORE VELOCITY (m/y) 5.8000E+00
DECAY CONSTANT(S) (1/y) 8.3512E-09 1.5507E-10 2.8292E-06 9.1929E-05 4.3322E-04 3.1083E-02
RETARDATION FACTOR(S) (SATURATED) 4.8010E+03 6.1000E+01 6.1000E+01 1.3201E+04 1.4400E+05 6.4301E+04
RETARDATION FACTOR (UNSATURATED) 1.0000E+00
SOLUBILITY LIMITED MASS (mg) 2.8225E+16
SOLUBILITY LIMITED ACTIVITY (Ci) 5.3277E+08
TRANSIT TIME IN UNSAT ZONE (years) 1.7241E-05
FRACTION DECAYED DURING UNSAT TRANSPORT 1.4400E-13
-----
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
DECAY-INGROWTH FACTORS 9.9985E-01 2.7179E-06 6.0295E-08 2.4964E-08 1.7893E-08 1.7795E-08
COMPOSITE DOSE CONVERSION FACTOR (rem/Ci): 4.13E+06
LIMITING GROUNDWATER CONCENTRATION (Ci/L): 3.34E-14
NOTE: PROGENY CONCENTRATIONS ARE REPORTED AT THE TIME OF THE MAXIMUM PARENT CONCENTRATION
MAXIMUM GW CONCENTRATION FOR MBR #1: 4.32E-20 Ci/L CEDE = 1.29E-10 rem
MAXIMUM GW CONCENTRATION FOR MBR #2: 9.24E-24 Ci/L CEDE = 1.55E-15 rem
MAXIMUM GW CONCENTRATION FOR MBR #3: 2.25E-25 Ci/L CEDE = 4.28E-17 rem
MAXIMUM GW CONCENTRATION FOR MBR #4: 3.92E-28 Ci/L CEDE = 1.52E-19 rem
MAXIMUM GW CONCENTRATION FOR MBR #5: 2.58E-29 Ci/L CEDE = 2.07E-20 rem
MAXIMUM GW CONCENTRATION FOR MBR #6: 5.77E-29 Ci/L CEDE = 2.82E-19 rem
MAXIMUM CEDE 1.29E-10 rem
PEAK TIME (y): 1.752881E+04
LIMITING SOIL CONCENTRATION (Ci/m**3): 1.739E-05
LIMITING SOIL CONCENTRATION (Ci/kg): 1.087E-08
LIMITING INVENTORY IN SOIL (Ci): 6.136E-02
LIMITING INVENTORY IN SOIL (mg): 3.444E+06
SPECIFIC ACTIVITY (Ci/g): 1.781E-05
EXECUTION TIME (seconds) 3
TIME OF RUN 10:41:06.0
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Sb-125                               :Class C waste Re-run PAPA II LLW PA0000000000000000
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GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1

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KFLAG: 1 (0)CONC VS TIME; (1)PEAK CONC AND LIMITING SOIL CONC
IMODEL:1 (1) SURF OR BURIED SOURCE; (2)POND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE:0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO ZD
>>> INPUT DATA
.....
NUMBER OF RADIOACTIVE PROGENY                0
LENGTH OF SOURCE PARALLEL TO GW FLOW (m)      4.90E+01
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m)   2.40E+01
THICKNESS OF SOURCE (m)                       3.00E+00
PERCOLATION RATE (darcy vel m/y)              5.30E-01
VOLUMETRIC WATER CONTENT IN SOURCE            2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE  1.00E-01
BULK DENSITY AT SOURCE (g/cm**3)             1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g)         3.00E+00
BULK DENSITY IN UNSAT ZONE (g/cm**3)         1.50E+00
UNSATURATED ZONE THICKNESS (m)               1.00E-04
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g)     0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci)           3.55E+02
MOLECULAR WEIGHT (g/mole)                    1.25E+02
SOLUBILITY LIMIT (mg/L)                      1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y)   2.73E+00
BULK DENSITY OF AQUIFER (g/cm**3)            1.60E+00
POROSITY OF AQUIFER                          4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g)     1.50E+02
DISPERSIVITY X DIRECTION (m)                 1.00E+01
DISPERSIVITY Y DIRECTION (m)                 5.00E+00
DISPERSIVITY Z DIRECTION (m)                 1.00E+00
PORE VELOCITY (m/y)                          6.25E+01
WELL SCREEN THICKNESS (m)                    1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS (m)       1.25E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m)       0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m)       0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci)  2.60E+03
UNITS OF CONTAMINANT                          Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg)  3.39E+02
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
.....
LEACH RATE CONSTANT (1/y)                    6.9295E-01
UNSATURATED PORE VELOCITY (m/y)              5.8000E+00
DECAY CONSTANT(S) (1/y)                     2.5390E-01
RETARDATION FACTOR(S) (SATURATED)            6.9100E+02
RETARDATION FACTOR (UNSATURATED)             1.0000E+00
SOLUBILITY LIMITED MASS (mg)                 9.8431E+11
SOLUBILITY LIMITED ACTIVITY (Ci)             1.0320E-12
TRANSIT TIME IN UNSAT ZONE (years)           1.7241E-05
FRACTION DECAYED DURING UNSAT TRANSPORT      4.3776E-06
-----
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
COMPOSITE DOSE CONVERSION FACTOR (rem/Ci):    2.60E+03
LIMITING GROUNDWATER CONCENTRATION (Ci/L):    5.27E-11
MAXIMUM GW CONCENTRATION FOR MBR #1: 9.22E-29 Ci/L CEDE = 1.75E-22 rem
MAXIMUM CEDE 1.75E-22 rem
PEAK TIME (y):                               9.891810E+01
LIMITING SOIL CONCENTRATION (Ci/m**3):        5.754E+16
LIMITING SOIL CONCENTRATION (Ci/kg):          3.596E+13
LIMITING INVENTORY IN SOIL (Ci):              2.030E+20
LIMITING INVENTORY IN SOIL (mg):              1.936E+20
SPECIFIC ACTIVITY (Ci/g):                     1.048E+03
NOTE: THE LIMITING SOIL CONCENTRATION OF 3.596E+10 Ci/g
      EXCEEDS THE SPECIFIC ACTIVITY OF THE NUCLIDE.
WARNING  THE LIMITING SOIL MASS OF 1.936E+20 mg
      EXCEEDS THE SOLUBILITY LIMITED SOURCE MASS OF 9.843E+11 mg
EXECUTION TIME seconds,  )
TIME OF RUN 10:41:06.3
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Sr-90                                     :Class C waste Re-run PAPA II LLW PA
-----
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0)CONC VS TIME; (1)PEAK CONC AND LIMITING SOIL CONC
IMODEL:1 (1) SURF OR BURIED SOURCE; (2)POND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE:0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO ZD
>>> INPUT DATA
.....
NUMBER OF RADIOACTIVE PROGENY                0
LENGTH OF SOURCE PARALLEL TO GW FLOW (m)      4.90E+01
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m)   2.40E+01
THICKNESS OF SOURCE (m)                       3.00E+00
PERCOLATION RATE (darcy vel m/y)              5.30E-01
VOLUMETRIC WATER CONTENT IN SOURCE            2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE  1.00E-01
BULK DENSITY AT SOURCE (g/cm**3)             1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g)         3.00E+00
BULK DENSITY IN UNSAT ZONE (g/cm**3)         1.50E+00
UNSATURATED ZONE THICKNESS (m)               1.00E-04
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g)     0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) 0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci)           1.30E+00

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MOLECULAR WEIGHT (g/mole)          9.00E+01
SOLUBILITY LIMIT (mg/L)            1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y)  2.91E+01
BULK DENSITY OF AQUIFER (g/cm**3)  1.60E+00
POROSITY OF AQUIFER                4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g)  2.00E+01
DISPERSIVITY X DIRECTION (m)       1.00E-01
DISPERSIVITY Y DIRECTION (m)       5.00E+00
DISPERSIVITY Z DIRECTION (m)       1.00E+00
PORE VELOCITY (m/y)                6.25E+01
WELL SCREEN THICKNESS (m)          1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS (m)  1.25E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m)  0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m)  0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci)  1.30E+05
UNITS OF CONTAMINANT                Ci
-----
LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg)  9.52E+00
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
-----
LEACH RATE CONSTANT (1/y)          3.8065E-02
UNSATURATED PORE VELOCITY (m/y)    5.8000E+00
DECAY CONSTANT(S) (1/y)           2.3803E-02
RETARDATION FACTOR(S) (SATURATED)  8.1000E+01
RETARDATION FACTOR (UNSATURATED)   1.0000E+00
SOLUBILITY LIMITED MASS (mg)        1.7919E+13
SOLUBILITY LIMITED ACTIVITY (Ci)    2.4463E+12
TRANSIT TIME IN UNSAT ZONE (years)  1.7241E-05
FRACTION DECAYED DURING UNSAT TRANSPORT  4.1040E-07
-----
COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION
COMPOSITE DOSE CONVERSION FACTOR (rem/Ci):  1.30E+05
LIMITING GROUNDWATER CONCENTRATION (Ci/L):  1.05E-12
MAXIMUM GW CONCENTRATION FOR MBR #1:  9.73E-12 Ci/L CEDE =  9.24E-04 rem
MAXIMUM CEDE  9.24E-04 rem
PEAK TIME (y):                     1.086491E+02
LIMITING SOIL CONCENTRATION (Ci/m**3):  3.986E-05
LIMITING SOIL CONCENTRATION (Ci/kg):    2.491E-08
LIMITING INVENTORY IN SOIL (Ci):        1.406E-01
LIMITING INVENTORY IN SOIL (mg):        1.030E+00
SPECIFIC ACTIVITY (Ci/g):  1.365E+02
EXECUTION TIME (seconds)              0
TIME OF RUN 10:41:06.4
DATE OF RUN 11/05/96
>>> TITLE OF PROJECT:
Tc-99                               :Class C waste Re-run PAPA 1: LLW PA*****
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GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 1
KFLAG: 1 (0)CONC VS TIME; (1)PEAK CONC AND LIMITING SOIL CONC
IMODEL:1 (1) SURF OR BURIED SOURCE; (2)POND SOURCE; (3) TABULATED SOURCE FUNCTION
ITYPE:0 (0) VERT AVG; (1) NON-VERT AVG; (2) AVG FROM 0 TO ZD
>>> INPUT DATA
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NUMBER OF RADIOACTIVE PROGENY          0
LENGTH OF SOURCE PARALLEL TO GW FLOW (m)  4.90E+01
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m)  2.40E+01
THICKNESS OF SOURCE (m)                3.00E+00
PERCOLATION RATE (darcy vel m/y)        5.80E-01
VOLUMETRIC WATER CONTENT IN SOURCE      2.79E-01
VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE  1.00E-01
BULK DENSITY AT SOURCE (g/cm**3)        1.60E+00
SORPTION COEFFICIENT AT SOURCE (ml/g)    1.00E+00
BULK DENSITY IN UNSAT ZONE (g/cm**3)    1.50E+00
UNSATURATED ZONE THICKNESS (m)          1.00E+04
SORPTION COEFFICIENT IN UNSAT ZONE (ml/g)  0.00E+00
OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1)  0.00E+00
INITIAL MASS OR ACTIVITY (mg or Ci)      5.61E+03
MOLECULAR WEIGHT (g/mole)               9.90E+01
SOLUBILITY LIMIT (mg/L)                 1.00E+06
HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y)  2.13E+05
BULK DENSITY OF AQUIFER (g/cm**3)       1.60E+00
POROSITY OF AQUIFER                     4.00E-01
SORPTION COEFFICIENT(S) IN AQUIFER (ml/g)  1.00E+01
DISPERSIVITY X DIRECTION (m)            1.00E-01
DISPERSIVITY Y DIRECTION (m)            5.00E+00
DISPERSIVITY Z DIRECTION (m)            1.00E+00
PORE VELOCITY (m/y)                    6.25E+01
WELL SCREEN THICKNESS (m)               1.50E+01
DISTANCE TO RECEPTOR ALONG X AXIS (m)  1.25E+02
DISTANCE TO RECEPTOR ALONG Y AXIS (m)  0.00E+00
DISTANCE TO RECEPTOR ALONG Z AXIS (m)  0.00E+00
RADIOLOGICAL DOSE CONVERSION FACTOR (rem/Ci)  1.30E+03
UNITS OF CONTAMINANT                    Ci
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LIMITING SOIL CONCENTRATION CALCULATION
>>> INITIAL ACTIVITY CONVERTED TO MASS (mg)  3.31E+02
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
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LEACH RATE CONSTANT (1/y)              1.0289E-01
UNSATURATED PORE VELOCITY (m/y)        5.8000E+00

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DECAY CONSTANT(S) (1/y)	3.2542E-06
RETARDATION FACTOR(S) (SATURATED)	1.1000E+00
RETARDATION FACTOR (UNSATURATED)	1.1000E+00
SOLUBILITY LIMITED MASS (mg)	6.6291E+12
SOLUBILITY LIMITED ACTIVITY (Ci)	1.1248E+08
TRANSIT TIME IN UNSAT ZONE (years)	1.7241E-05
FRACTION DECAYED DURING UNSAT TRANSPORT	5.6107E-11

COMMITTED EFFECTIVE DOSE EQUIVALENT CALCULATION	
COMPOSITE DOSE CONVERSION FACTOR (rem/Ci):	1.30E+03
LIMITING GROUNDWATER CONCENTRATION (Ci/L):	1.05E-10
MAXIMUM GW CONCENTRATION FOR MBR #1:	1.25E-11 Ci/L CEDE = 1.18E-05 rem
MAXIMUM CEDE	1.18E-05 rem
PEAK TIME (y):	4.908766E+00
LIMITING SOIL CONCENTRATION (Ci m**3):	1.345E-05
LIMITING SOIL CONCENTRATION (Ci/kg):	8.404E-09
LIMITING INVENTORY IN SOIL (Ci):	4.744E-02
LIMITING INVENTORY IN SOIL (mg):	2.796E+03
SPECIFIC ACTIVITY (Ci/g):	1.697E-02
EXECUTION TIME (seconds)	0