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Implementation and Validation of a DOE Standardized Screening Method for Evaluating Radiation Impacts to Biota at Long-Term Stewardship Sites

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Environmental Sciences Division

IMPLEMENTATION AND VALIDATION OF A DOE STANDARDIZED SCREENING METHOD FOR EVALUATING RADIATION IMPACTS TO BIOTA AT LONG-TERM STEWARDSHIP SITES

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ABSTRACT

Radiological contamination remaining at Department of Energy (DOE) waste sites after remediation may have the potential to pose risks to humans and the environment. Long-term stewardship programs at these sites must be responsive to increasing stakeholder concerns and regulatory requirements for protection of the environment (biota and ecosystems) from the effects of ionizing radiation during the pre-closure phase and during post-closure monitoring. This study is a pilot implementation and validation of the DOE Technical Standard, "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota" (the Graded Approach), and its companion software for application in long-term stewardship efforts at DOE sites.

Radionuclide concentrations in soil, water, and small mammals were evaluated using the general and two site-specific screening protocols described in the Graded Approach. Two separate waste sites (i.e., a positive control site and a negative control site) and a set of background concentrations were evaluated. Results of a previous study suggest that radionuclides were likely to pose a significant risk to the white-footed deer mouse at the positive control site, the Test Reactor Area (TRA) radioactive leaching ponds at the DOE Idaho National Engineering and Environmental Laboratory (INEEL). A baseline ecological risk assessment (BERA) indicated that radionuclides did not appear to pose an unacceptable risk to the white-footed mice at the negative control site, Bear Creek Valley on the DOE Oak Ridge Reservation in Tennessee. The background screening criteria from that BERA were also evaluated in this study.

The primary conclusion of this study is that the Graded Approach correctly classified the selected control and background sites with respect to the potential for adverse effects of ionizing radiation on terrestrial animals. This was true for all three screening protocols. That is, the positive control site failed the general and two site-specific screenings, the negative control site passed the general and two site-specific screenings, and the background screening criteria passed the general screening. Furthermore, the screening results were generally conservative relative to the baseline studies, but not so conservative as to produce false positive results for the negative control and background sites. This is consistent with the intended design and usage of the screening protocols in the Graded Approach. Therefore, this first validation study suggests that, at least within the limits of the tested exposure scenarios, the Graded Approach can be used to screen out radiological sites that are unlikely to pose a significant risk to terrestrial animals.

1. INTRODUCTION

The Department of Energy's (DOE) Environmental Management Program (EM) has determined that long-term stewardship (i.e., activities to protect human health and the environment from contamination that may remain at DOE sites following site cleanup) will be required for over 100 of the 144 waste sites, including the Oak Ridge Reservation, currently under DOE control (NRC 2000). Radiological contamination remaining at many of these sites may pose risks to humans and the environment. Long-term stewardship programs at these sites must be responsive to increasing stakeholder concerns and regulatory requirements for protection of the environment (biota and ecosystems) from the effects of ionizing radiation. This includes conducting pre-closure assessments and post-closure monitoring to estimate potential impacts associated with remaining radiological contamination.

DOE Order 450.1, "Environmental Protection Programs," was approved on January 15, 2003 and provides for the implementation of cost-effective stewardship practices that are protective of natural resources impacted by DOE operations (DOE 2003). This order is supported by DOE Order 5400.5, "Radiation Protection of the Public and the Environment (DOE 1993)," which specifies a dose limit that DOE and its contractors must meet to protect aquatic biota from the effects of ionizing radiation. In addition, dose limits below which deleterious effects have not been observed in populations of aquatic and terrestrial organisms, as recommended by the National Council on Radiation Protection and Measurements (NCRP) and the International Atomic Energy Agency (IAEA), are considered by DOE to be relevant and appropriate to the protection of all aquatic and terrestrial biota at DOE sites. DOE requires that compliance with these dose limits be reported and be made publicly available in the Annual Site Environmental Report for each site (DOE 2000). Also, ecological risk assessments at contaminated DOE sites being considered for remediation require an assessment of all stressors, including radiation (EPA 1998).

Meeting these objectives and requirements for protecting ecological receptors from the effects of ionizing radiation presents significant challenges. Conducting ecological risk assessments and environmental monitoring programs can be costly and time consuming. There are relatively few tools available for estimating radiation effects on biota and some of them require substantial effort and technical expertise to ensure that they are used correctly, especially for evaluating potential effects to terrestrial biota. Given these challenges, DOE could benefit from having technically sound tools to screen out sites that are unlikely to pose significant risks to ecological receptors.

1.1 THE GRADED APPROACH

Nationally and internationally, no standardized methods have been adopted for evaluating doses and demonstrating protection of plants and animals from the effects of radiation. In this regard, DOE's Office of Environmental Policy and Guidance, Air, Water and Radiation Division, working through the Department's Biota Dose Assessment Committee (BDAC), has developed standardized screening methods and guidance within a graded approach for evaluating radiation doses to biota. The approach is shown in Figure 1.1 and documented in the DOE Technical Standard, "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota" (DOE 2002), referred to

here after as the Graded Approach. This technical standard provides first-of- a-kind standardized "Biota Concentration Guides (BCGs)" for DOE-wide application. The formulas, values, and radioecology concepts used in the Graded Approach were recently published in a series of peer-reviewed papers in the *Journal of Environmental Radiation* (Higley et al. 2003; Higley et al. 2003; Higley et al. 2003; Jones et al. 2003).

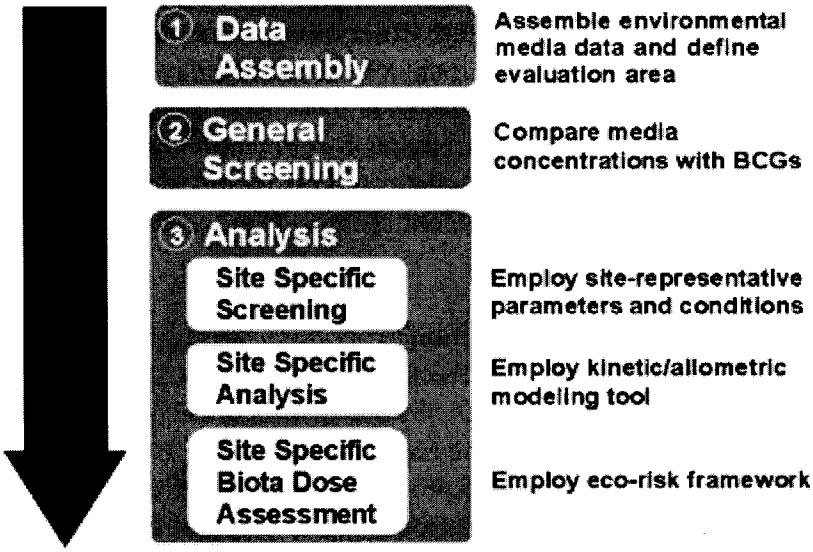

Figure 1.1 Overview of the DOE Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota.

The Graded Approach includes a general screening process in which radionuclide concentrations in environmental media are compared to a set of BCGs derived by DOE. Each radionuclide-specific BCG represents the highest radionuclide concentration in soil, sediment and water that would not result in unacceptable risks to biota (i.e., biota dose limits would not be exceeded). A site-specific screening phase and site-specific analysis phase are also included. The methodology is intended for demonstrating compliance with dose limits for biota and conducting ecological screening assessments of radiological impact at contaminated sites.

1.2 OBJECTIVES

The purpose of this study was to conduct a pilot implementation and validation of the DOE Technical Standard (DOE 2002) and its companion software, the "RAD-BCG Calculator," for application in long term stewardship efforts at DOE sites. The strategic goal of the project is to test the method's utility as an acceptable, cost-effective and easy-to-use tool that can be used for evaluating radiation doses to biota as part of routine long-term surveillance and monitoring activities for long-term stewardship sites. This goal is supported by three primary objectives: 1) validation of the Graded Approach with data from sites at which radiological risks to terrestrial biota are "known," 2) evaluation of the effect of adjusting the ambient media concentrations on the results of the Graded Approach, and 3) evaluation of the effect of site-specific uptake factors on the results of the Graded Approach. A second strategic goal is communication of the project objectives, methods, and findings to potential users and other interested parties. This second goal is primarily achieved via

publication of this report. Also, an initial presentation was given to the Oak Ridge Site Specific Advisory Board and additional opportunities will be sought to publicize this study.

2. APPROACH AND METHODS

The Graded Approach was used to test the standardized screening process and application of the Biota Concentration Guides in the evaluation of one negative and one positive control site located within the DOE Complex. This project consisted of three major tasks, which are described in detail below:

1) Selection of appropriate sites for evaluation,
2) Analysis of the existing data for each site using the Graded Approach, and
3) Comparison of the Graded Approach-based results with the findings of previous assessments.

2.1 SELECTION OF NEGATIVE AND POSITIVE CONTROL SITES

The first task was a review of existing assessments of contaminated waste sites and selection of the most appropriate sites for testing the Graded Approach. This review included evaluating key elements of Remedial Investigation (RI) reports and project records (i.e., data summaries and ecological risk assessments) and consulting with relevant project personnel. Preferred sites were those that had:

- been identified as a high priority in the congressional stewardship report (DOE 2001);
- been the subject of a formal base line ecological risk assessment (BERA);
- measurable radiological contamination; and
- preexisting biological data available.

The goal was to identify two separate waste sites (i.e., a positive control site and a negative control site) and a background location. The positive control would be one at which radiological contamination was detected in the ambient media and biota and for which the BERA indicated that radionuclides were likely to pose a significant risk to ecological receptors. The negative control site would have measurable radiological contamination in the environment and biota, but the BERA concluded that radionuclides did not appear to pose an unacceptable risk to the biological receptors. The background site would have no known sources of radiological contamination, except for naturally-occurring radionuclides in the environment and fallout from above-ground nuclear tests.

An appropriate negative control site, Bear Creek Valley (BCV), and background site were identified on the DOE Oak Ridge Reservation (ORR) in Tennessee. However, there were no waste sites on the ORR that were suitable for use as a positive control site for this study. That is, radionuclides were not determined to pose a significant ecological risk in any of the formal BERAs performed for radiologically contaminated waste sites on the ORR.

Unfortunately, a complete BERA was not available for the ORR waste site which had the highest environmental concentrations of radionuclides, the Intermediate Holding Pond (IHP). An adequate amount of soil data was available for the IHP, but co-located biota samples had not been collected or analyzed for radionuclides. The current project included a contingency for collecting biological samples if sufficient data were not included in an otherwise suitable assessment. However, accelerated cleanup of the IHP began prior to the biological sampling season included in the period of performance for this project.

The search for an appropriate positive control site was expanded to include other major DOE facilities at which radiological data for biota were most likely to have been collected. Technical points of contact at other major facilities were identified by working with the BDAC. The following list of the DOE facilities were contacted in this effort:

- Argonne National Laboratory
- Brookhaven National Laboratory
- Fernald Environmental Management Project
- Hanford/Pacific Northwest Laboratory
- Idaho National Engineering and Environmental Laboratory
- Los Alamos National Laboratory
- Nevada Test Site
- Savannah River Site
- Sandia National Laboratory

At least one person familiar with the investigations of the radiological waste sites at each location was contacted. Each point of contact was given a list of the aforementioned requirements for a positive control site and asked to identify candidate sites at their facility.

As with the ORR, no positive control sites were identified at which a suitable BERA had been performed. At most sites, screening was conducted with only media radionuclide concentrations. Very few sites had biological data with associated media radionuclide concentrations. Apparently, sites at which radionuclide concentrations might have been high enough to pose a significant ecological risk had already been remediated and those actions were either taken before formal BERAs were required or were based on potential human health risks.

Therefore, the selection of a positive control site was based on 1) the availability of environmental and biological data for radionuclides and 2) results of radioecology studies, which were scientifically rigorous but not part of a formal BERA process. Using these revised criteria, the Test Reactor Area (TRA) radioactive leaching ponds at the DOE Idaho National Engineering and Environmental Laboratory (INEEL) was selected for the positive control site.

Background concentrations of radionuclides in environmental media and biota were also sought for this study. The BERA for BCV included terrestrial biota samples collected at three sites previously sampled as part of the Oak Ridge Background Soil Characterization Project (DOE 1993). These data sets were used in the current study to evaluate whether or not the Graded Approach can correctly classify background concentrations as not likely to constitute an unacceptable ecological risk.

2.2 SITE DESCRIPTIONS

2.2.1 Positive Control

The TRA includes three liquid radioactive waste ponds constructed between 1957 and 1964 (Figure 2.1). Wastewater was discharged into Ponds 1 and 2, which were connected such that they constituted a single body of water (Kuzo et al. 1983). Wastewater then flowed through an overflow Parshall flume to Pond 3. The Pond 3 basin is 76 x 122 x 2 m and was filled to capacity in 1970 and subsequently drained by percolation through the soil. The water level in Pond 3 fluctuated between 1970 and 1976, but never again approached capacity. Percolation following high-water events led to deposition of radionuclides on the sediment/soil surface. The result was an irregular distribution of radioactive contamination in the pond basin and surrounding banks (Halford and Markham 1978).

The previously submerged soil/sediments in Pond 3 were the subject of a 1976 study (Halford and Markham 1978), which was used as the basis for the current project. The basin and banks consisted of gravelly alluvium. The area near the surface water was dominated by sedge, thistle, and wild lettuce, whereas the rest of the basin and the banks were sparsely vegetated by cheatgrass, wild barley, and rabbit brush (Halford and Markham 1978). These habitats were consistent with those found elsewhere in the cool sagebrush desert of the Snake River Plain.

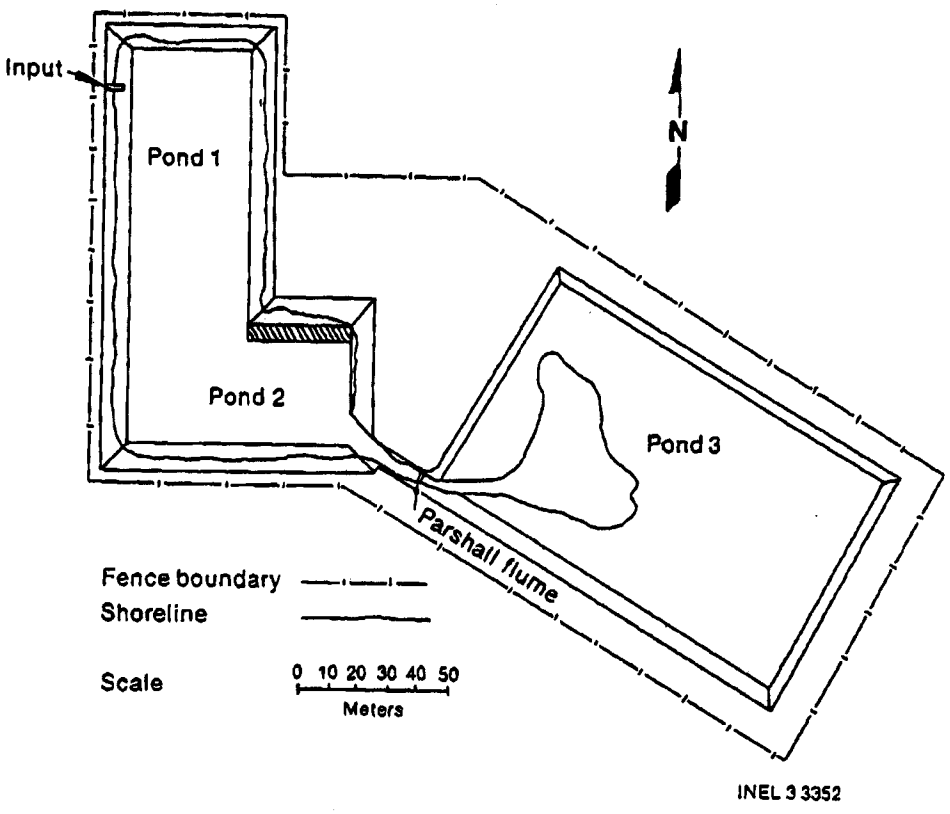

Figure 2.1 TRA Ponds at Idaho National Engineering and Environmental Laboratory.
Source: Kuzo (1983).

2.2.2 Negative Control

Bear Creek Valley is mostly contained in the DOE Oak Ridge Reservation in east Tennessee (Figure 2.2). Bear Creek is approximately 12.5 km long. The headwaters are at the eastern end of the valley, which intersects the western end of the DOE Y-12 National Security Complex. Hardwood and mixed hardwood /conifer are the most abundant habitats in the watershed, followed by pine plantation and grassland habitats, with considerable riparian habitat along the length of Bear Creek (DOE 1997). Approximately 65% of the watershed is wooded, with the upper slopes being dominated by oak and oak-hickory associations and the floodplain being primarily mixed hardwoods and planted pines.

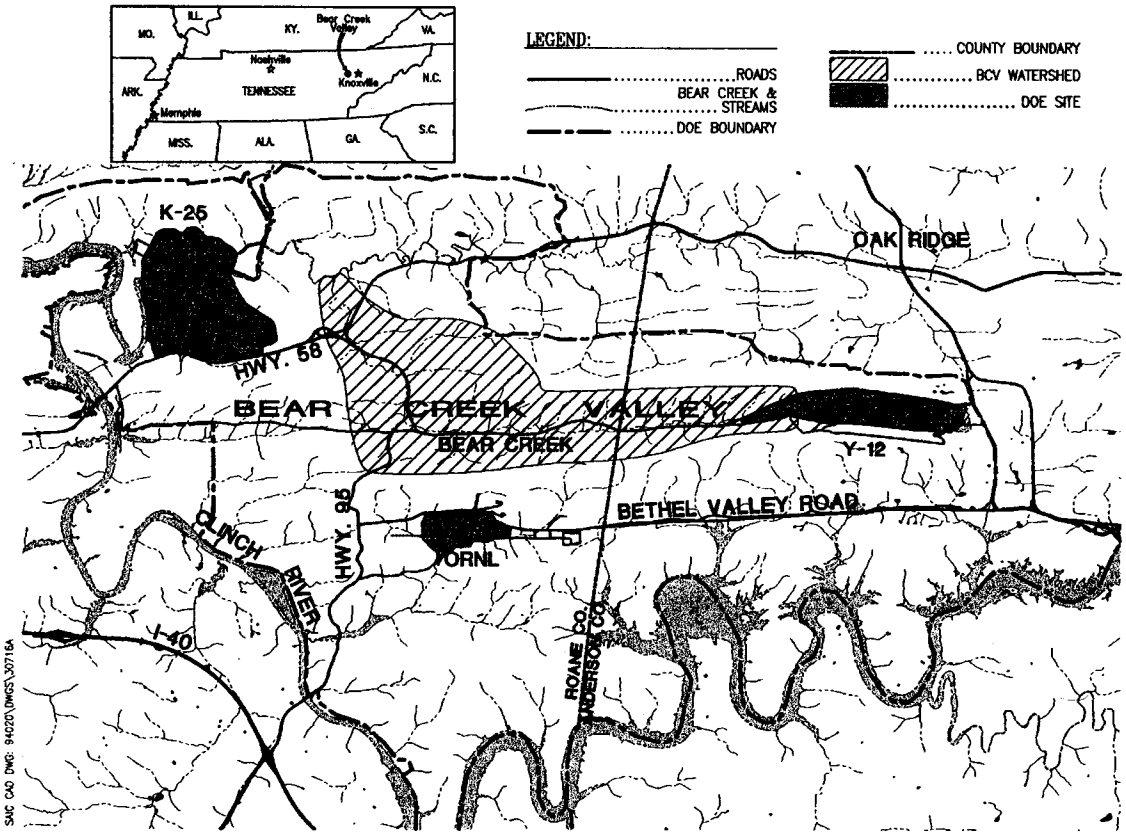

Figure 2.2 Bear Creek Valley watershed on the Oak Ridge Reservation.

There are four major waste units and two Debris Burial Areas (DBAs) in the BCV watershed. All are within the eastern (upper) 3 km of the watershed. The major waste units and the Creekside DBA are located north of Bear Creek. The Road Site DBA is just south of the creek. These areas contain various types of hazardous and radioactive wastes derived from the Y-12 Complex. The status of each major waste unit at the time of the BERA is briefly described as follows:

- The S-3 Ponds are located near the headwaters of Bear Creek. Sludges and contaminated sediments remain in place and the site is covered with a mutlilayer waste site cap and an asphalt parking lot.

- The Boneyard/Burnyard (BYBY) is approximately 0.5 km downstream from the S-3 Ponds. This waste unit includes the previously capped Hazardous Chemical Disposal Area (HCDA), from which subsurface discharges of radionuclides were detected via beta- and gamma-radiation surveys. The remainder of the BYBY was uncapped and vegetated.
- The Oil Land Farm (OLF) is adjacent to and west of the BYBY. Soils contaminated with organic chemicals, heavy metals, and uranium remain in place beneath a multilayer waste site cap.
- The Bear Creek Burial Grounds include ten distinct units and are located approximately 3 km west of the Y-12/BCV boundary. The primary purpose of the Burial Grounds was the disposal of uranium and thorium-contaminated waste.

All of the major waste units are located outside of the Bear Creek floodplain. The two DBAs were found during the Remedial Investigation and both are in the Bear Creek floodplain (DOE 1997). They are characterized by surface and shallow soil contamination with laboratory materials (e.g., glassware), hazardous chemicals, and radionuclides.

2.2.3 Background

The three background soil locations selected for biological sampling and evaluation in the BERA are on the northern slope of the BCV watershed above all known sources of contamination. They were assumed to be free of contamination from the BCV sources, because groundwater and surface water are the dominant vectors for contaminant transport. This assumption was supported by the findings of the ORR Background Soil Characterization Project (DOE 1993). All three soil locations were predominantly hardwood habitats.

2.3 SITE DATA AND PREVIOUS ASSESSMENTS

2.3.1 Positive Control Site

The following description of the data sets available for the TRA is excerpted from VanHorn et al. (1995). The contamination of environmental media near TRA has been intensively studied. Gamma-emitting and transuranic radionuclides have been detected in soils; sediment, vegetation, and water from the radioactive waste percolation pond; small mammals; coyote feces; raptors; upland game birds; waterfowl; and barn swallows. Almost all studies at the TRA have focused on the currently inactive, radioactive waste percolation ponds. The data sets used in the current study are described in Table 2.1. The soil data were decay corrected to 1976 concentrations, because they were obtained from a variety of sources spanning a number of years. The water data were not decay corrected. Rather, it was assumed that the water discharged in 1976 was essentially the same as that sampled between September 1977 and September 1978.

The mouse was selected as the receptor of concern based largely on the results of a radiation dosimetry study conducted in 1976 at the TRA site (Halford and Markham 1978). Thermoluminescent dosimeters (TLDs) were implanted in white-footed dear mice (*Peromyscus maniculatus*), least chipmunk (*Eutamias minimus*) and Ord's kangaroo rat (*Dipodomys ordii*) collected from the previously submerged portions of the Pond 3 sediment basin. The results indicated that the radiation dose rate absorbed by white-footed deer mice would have exceeded the

current threshold for potential effects on terrestrial animals (100 mRad/d or 0.001 Gy/d), which was not recommended until 1992 (IAEA 1992). The reported average internal dose rate was 160 mrem/d and the maximum dose rates observed for individuals ranged from 112 mrem/d to 510 mrem/d (Halford and Markham 1978). The TLDs were wrapped in aluminum foil. Thus, the reported dose rate units are assumed to be equivalent to mRad/d, given that the measured dose rates were almost entirely from gamma rays and X-rays which are assumed to have a radiation weighting factor of one (Kocher and Trabalka 2000).

Table 2.1 Description of data sets used in the default and site-specific screenings

Area	Medium	Description	Date	Reference
TRA	Soil	Pond 3 soil and exposed sediment, 0-2 ft. deep, 6 samples	1988	(Casey 1990)
	Water	Pond 2, unfiltered, 12 monthly samples.	1977-1978	(Millard 1986)
	Biota	Pond 3 basin, white-footed deer mouse, 13 individuals, gamma-scan of whole, unwashed organisms.	1976	(Halford and Markham 1978)
		Pond 3 basin, white-footed deer mouse and other small mammal species, 48 samples, internal (i.e., carcass without hide or internal organs) concentrations of 5 transuranics.	1981	(Halford 1987)
BCV	Soil	Floodplain transects (TS; 11), 0-4 in. deep, 2 samples each for 5 transects (including TS#6), 1 sample each for remaining transects.	1995	(DOE 1997)
		Waste sites (4), 0-12 in. or 0-2 ft. deep, 13 to 76 samples per waste site.	Pre-1995	(DOE 1997)
		Debris Burial Areas (2), 1 sample each, Road Site sample diluted 1:4 to meet radiological limits for shipping.	1995	(DOE 1997)
	Biota	Mice, white-footed and others, 3-5 per site, 5 floodplain transects and 1 waste site (BY/BY)	1995	(DOE 1997)
Background	Soil	Background screening criteria used in RI, which were derived from a reservation-wide soil study.	1995	(DOE 1997)
	Biota	Mice, white-footed and others, 3-5 at each of 3 sites.	1995	(DOE 1997)

There were also six practical considerations for selecting the mouse as the species of concern for the current study: 1) whole-body radionuclide concentrations were available, 2) co-located soil/sediment concentrations were available, 3) vertebrate animals are generally more sensitive to ionizing radiation than are plants and invertebrate animals, 4) the mouse has a reasonably small home range relative to the size of the contaminated site, 5) the mouse lives and forages in close proximity to the environmental medium of concern (i.e., soil), and 6) appropriate data are available for a similar species at the other two sites evaluated in this study.

There were also two strategic reasons for choosing the mouse for this study. First, small mammals are commonly included in ecological risk assessments for contaminated sites. Second, the Biota Concentration Guides (BCGs) for terrestrial animals in the Graded Approach are the first soil screening values of their kind. For these reasons, validation of the Graded Approach for assessing potential impacts on small mammals will be of great interest to potential users.

2.3.2 Negative Control Site

A BERA was conducted in 1996 for the BCV watershed (DOE 1997). Radionuclide concentrations were measured in groundwater, surface water, sediment, floodplain soil, waste site soil, earthworms, various types of plants, and small mammals. The biota samples were co-located with the soil samples. Assessment endpoints included adverse effects on fish, benthic invertebrates, soil invertebrates, plants, birds, small mammals, mink, fox, and deer. The data sets used in the current study are described in Table 2.1.

Radionuclides did not appear to pose significant risks to any of the assessment endpoints (DOE 1997). Therefore, BCV is an appropriate negative control site for all candidate receptors of concern. The white-footed mouse (*Peromyscus leucopus*) was selected as the receptor of concern at the negative control site based primarily on the six practical considerations described above for the positive control site. The BERA estimated the maximum dose rate from soil and food sources to white-footed mice at 18.5 mrad/d (Creekside DBA).

2.3.3 Background Site

The BERA for the BCV watershed included three uncontaminated terrestrial background locations on the ORR (DOE 1997). These sites were selected from among the population of background soil sites for the ORR (DOE 1993) because they were most geologically and ecologically similar to the contaminated sites.

Background screening criteria were calculated as part of the Remedial Investigation (DOE 1997). They represent an upper bound of the concentrations found in soils of similar geological origin at background locations on the ORR. Those criteria (i.e., a single value per radionuclide) were used in the BERA and in the current study. Concentrations in earthworms, various types of plants, and small mammals were collected in the immediate vicinity of the soil sampling locations at the three select background sites. Assessment endpoints included adverse effects on soil invertebrates, plants, birds, small mammals, mink, fox, and deer. The data sets used in the current study are described in Table 2.1.

As would be expected, background radionuclide concentrations did not appear to pose significant risks to any of the assessment endpoints (DOE 1997). The white-footed mouse was selected as the receptor of concern at the background locations for the same reasons it was selected for evaluation at the control sites.

2.4 DATA ANALYSIS

Data from the TRA, BCV, and background sites were analyzed using the RAD-BCG Calculator, an Excel spreadsheet-based program included with the Graded Approach (DOE 2002). We performed a series of screening analyses following the protocols outlined in the Graded Approach (Figure 1.1). First, a general screening assessment was performed in which upper bound estimates of ambient media concentrations were compared with default Biota Concentration Guides (BCGs).

Next, a site-specific screening was conducted in which the mean concentrations for the ambient media were compared with the default BCGs. We could not refine the evaluation area, another consideration recommended in the Graded Approach, because we were already evaluating the data at finest spatial scale possible and appropriate for white-footed mice. The next step of the site-specific screening analysis phase entails generating new BCGs based on site-specific bioaccumulation data. This step was done by calculating uptake factors for mice collected at the control sites and substituting them for the lumped parameters in the RAD-BCG Calculator. For the negative control site, the site-specific uptake factors used in the BERA were also used in this study. For the positive control site, maximum biota concentrations were divided by average media concentrations to yield conservative uptake factors. Although this method is not specifically called for in the Graded Approach, these relatively conservative uptake factors are consistent with those used in the BCV BERA.

We did not perform a Site-Specific Analysis, which is the next most realistic approach recommended in the Graded Approach. It uses the kinetic/allometric modeling tool in the RAD-BCG Calculator to generate a species-specific BCG. This step was not evaluated in the current study, because it was not expected to provide additional realism to the dose estimates. That is, the site-specific receptors (white-footed mice) were essentially the same as the default terrestrial animal (i.e., mouse) with respect to the allometric parameters included in the modeling tool (e.g., body mass).

Four notable deviations from the Graded Approach were made for the purposes of this study:

1) Remedial Investigation (RI) concentrations (i.e., the lesser of the maximum and the upper 95% confidence limit on the mean) for the ambient media were evaluated in the general screening so that results from the Graded Approach could be compared with results of the BCV BERA;
2) Radionuclides in water near the negative control site were not included in the screenings, so that results from the Graded Approach could be compared with the dose rates for soil and food reported in the BCV BERA;
3) Sites that passed the default screening were carried through to the site-specific screening; and
4) Maximum ambient media concentrations were evaluated in the site-specific screening.

It is also worth noting that BCGs were not available for every radionuclide observed at the control sites. The BDAC Core Team members responsible for developing the method were contacted and additional BCGs were calculated. Selection of the radionuclides for which new default BCGs would be derived was based on the number of sites at which a radionuclide was detected and the relative magnitude of the measured concentrations. Table 2.2 lists the radionuclides that were measured at the control sites and the default BCGs that were available in the Graded Approach and those additional BCGs derived for the study.

The Graded Approach uses a dose rate comparison called the sum of fractions method (DOE 2002). That method is conceptually analogous to the hazard quotient (HQ) and hazard index (HI) methods used in traditional risk assessments. A partial fraction is calculated for each radionuclide by dividing the exposure concentration by the BCG for that radionuclide. A sum of fractions is calculated as the sum of the partial fractions for each radionuclide at a given location. If the sum of fractions is equal to or greater than 1.0, then the estimated dose rate is assumed to exceed the selected dose rate criterion (i.e., 0.1 Rad/d for terrestrial animals).

2.4.1 General Screening

For each radionuclide detected at the positive control site (TRA ponds), the maximum concentration in 0-2 feet of Pond 3 soils and the UCL95 concentration for the radioactive wastewater were screened against the default BCGs. The result was the partial sum of fractions based on both water and soil exposures for a terrestrial animal. The partial fractions for each radionuclide detected in the water or soil were added together to yield the overall sum of fractions for the positive control site.

For the negative control site (Bear Creek Valley), the maximum radionuclide concentrations in soil (top four inches) were compared with the default BCGs. All 11 flood plain transects, the four major waste units, and the two DBAs were evaluated. The resulting partial fractions for each radionuclide detected in soil were added together to get the overall sum of fractions for each location. In addition to the maximum soil concentrations, the upper bound concentrations used in the RI/BERA were also screened.

For the background location, there was only one value (i.e., the BCV background criterion) for each radionuclide. Those upper bound estimates of background radionuclide concentrations were compared with the default BCGs and then an overall sum of fractions was calculated.

2.4.2 Site-Specific Screening

2.4.2.1 Positive Control Site

Soil exposures were calculated using the data from the 0-2 ft samples collected in the Pond 3 basin, because average soil concentrations were not reported for shallower soil depths. Average soil and water concentrations were compared with the default BCGs. As in the general screening, partial sum of fractions for each radionuclide were added together to yield the overall sum of fractions for water and soil. Maximum soil (0-2 ft. interval) and UCL95 water concentrations were also screened against the default BCGs, making it possible to compare the sum of fractions based on upper bound concentrations with those based on mean concentrations.

Site-specific BCGs were derived for soil and water, based on the site-specific uptake factors calculated for small mammals in the Pond 3 basin (Table 2.3). Upper bound and mean concentrations in soil and water were compared with the site-specific BCGs for each radionuclide. Overall sum of fractions were then calculated for both sets of concentrations.

Table 2.2 Availability and source of default Biota Concentration Guides (BCGs)

Radionuclide	Default BCGs		Sites [a]	Availability / Source [b]
	Water (pCi/L)	Soil (pCi/g)		
Americium-241	2E5	4E3	n,p	GA
Barium-140	2E4	8E0	p	Derived
Cerium-141	2E7	8E3	p	Derived
Cerium-144	3E6	1E3	p	GA
Cesium-134	3E5	1E1	p	Derived
Cesium-137	6E5	2E1	n,p	GA
Chromium-51	1E8	5E4	p	Derived
Cobalt-58	3E6	2E3	p	Derived
Cobalt-60	1E6	7E2	p	GA
Curium-243	N/A	N/A	n	Not Available
Curium-244	2E5	4E3	n,p	Derived
Europium-152	3E6	2E3	p	Derived
Europium-154	2E6	1E3	p	GA
Eurpoium-155	3E7	2E4	p	GA
Hafnium-181	N/A	N/A	p	Not Available
Iodine-131	2E6	9E2	p	GA
Lead-212	N/A	N/A	n	Not Available
Magnesium-54	N/A	N/A	p	Not Available
Neptunium-237	N/A	N/A	n	Not Available
Potassium-40	N/A	N/A	n	Not Available
Plutonium-238	2E5	6E3	n,p	Derived [c]
Plutonium-239	2E5	6E3	n,p	GA
Ruthenium-103	N/A	N/A	p	Not Available
Scandium-46	N/A	N/A	p	Not Available
Selenium-75	9E6	5E3	p	Derived
Stronium-90	5E4	2E1	n,p	GA
Technicium-99	2E7	4E3	n	GA
Thallium-208	N/A	N/A	n	Not Available
Thorium-228	N/A	N/A	n,p	Not Available
Thorium-230	N/A	N/A	n,p	Not Available
Thorium-232	5E4	2E3	n,p	GA
Uranium-232	N/A	N/A	p	Not Available
Uranium-234	4E5	5E3	n,p	GA
Uranium-235	4E5	3E3	n,p	GA
Uranium-238	4E5	2E3	n,p	GA
Zinc-65	2E5	4E2	p	GA
Zirconium-95	2E6	1E3	p	GA

[a] Sites in the current study at which this radionuclide was detected at least once; n = negative control site, p = positive control site.

[b] GA = Graded Approach, Derived = derived for this study by the developer of the BCGs.

[c] ^{238}Pu concentrations were multiplied by 0.88 and compared with the BCGs for ^{239}Pu.

Table 2.3 Default and site-specific bioaccumulation factors

	Default		Control Sites		
			Negative	Positive	
Radionuclide	**Biota-to-Soil**	**Biota-to-Water**	**Biota-to-Soil**	**Biota-to-Water**	**Biota-to-Soil**
Americium-241	0.004	0.09	1.815		0.00278
Cerium-141	0.006	0.008		0.00394	
Cerium-144	0.006	0.008		0.00578	
Cesium-134	100	3.0			0.0243
Cesium-137	100	3.0	2.5		0.0254
Chromium-51	0.005	0.04		0.000276	
Cobalt-60	0.08	0.1			0.0269
Curium-244	0.004	0.09	2.331		0.00442
Iodine-131	3.0	1.0		0.002065	
Plutonium-238	0.003	0.09			0.00515
Plutonium-239	0.003	0.09	4.28		0.003
Selenium-75	0.0004	0.005		0.03	
Stronium-90	80	30	0		
Technetium-99	3.0	0.8	0		
Thorium-232	0.002	0.05	0.005		
Uranium-234	0.004	0.02	0.00022		
Uranium-235	0.004	0.05	0.00022		
Uranium-238	0.004	0.05	0.00022		
Zinc-65	7.0	20		0.1237	

2.4.2.2 Negative Control Site

A subset of the 17 locations evaluated in the general screening were also evaluated in the site-specific screening: one floodplain transect (TS6), three major waste units (BG, BY/BY, and OLF), and both DBAs. These sites had the best combination of the following attributes: relatively high estimated dose rates, a variety of radionuclides, and multiple soil samples. Average soil concentrations for each detected radionuclide were compared with the default BCGs. As in the general screening, partial sum of fractions for each radionuclide were added together to yield the overall sum of fractions for each location.

Site-specific soil BCGs were calculated using the soil-to-small mammal uptake factors used in the BCV BERA (Table 2.3). These soil-to-tissue uptake factors were either measured or literature-derived for selected radionuclides. The literature-derived values selected were considered to be representative for small mammals on the Oak Ridge Reservation (DOE 1997). Maximum and mean soil concentrations were compared with the site-specific BCGs for each radionuclide. Then, an overall sum of fractions was calculated for both sets of concentrations at each of the six aforementioned locations.

3. RESULTS & DISCUSSION

The screening results are presented and discussed with respect to each of the three primary objectives for this project. Those objectives are: 1) validation of the Graded Approach with data from sites at which radiological risks to terrestrial biota are "known," 2) evaluation of the impact of adjusting the ambient media concentrations on the results of the Graded Approach, and 3) evaluation of the impact of using site-specific uptake factors on the results of the Graded Approach.

Detailed screening results are presented in Appendices A through D. Appendices A and B present a complete listing of the Graded Approach results for the Negative Control Site (BCV) and Appendices C and D present a complete listing of the Graded Approach results for the Positive Control Site (TRA Pond 3). These results are in the form of RAD-BCG Calculator reports.

3.1 VALIDATION OF GRADED APPROACH RESULTS

One of the primary objectives of this study was to determine whether or not the graded approach could correctly classify a site with respect to the likelihood of adverse ecological effects due to radiological contamination. This determination was made by comparing the results from the Graded Approach with the results of an approved BERA or a scientifically rigorous study. For validation purposes, the previous assessments are considered to represent the true state of the sites being evaluated in the current study. A correct classification consists of either (1) the previous assessment indicated that the site did pose a risk to small mammals from exposure to radiation and the site failed the Graded Approach screening assessments or 2) the previous assessment indicated that the site did not pose a risk to small mammals from exposure to radiation and the site passed the Graded Approach screening assessments. Table 3.1 presents the total estimated dose rates (i.e., 0.1 times the sum of fractions) of the three Graded Approach screening protocols evaluated in this study.

Table 3.1 Estimated dose rates for three standard screening protocols from the Graded Approach

	Estimated Dose Rate (Rad/d)		
Screening Protocol [a]	**Positive Control**	**Negative Control [b]**	**Background [c]**
General			
Upper bound media concentrations & Default BCGs	134	0.073	0.0073
Site-Specific			
Average media concentrations & Default BCGs	65	0.013	N/A
Site-Specific			
Average media concentrations & Site-Specific BCGs	2.1	0.0075	N/A

[a] Upper bound media concentrations were: Positive Control = maximum for soil and UCL95 for water; Negative Control = maximum for soil; and Background = background screening criteria.
[b] The highest dose for any of the locations evaluated in each protocol is reported.
[c] The background data were not evaluated using the site-specific screening protocol because only upper bound concentrations were available.

3.1.1 Positive Control Site

The general and site-specific screenings correctly identified the Pond 3 soils and wastewater as being a potential risk to terrestrial animals. That is, the estimated dose rate to white-footed mice and other small mammals exceeded the adverse effects level of 0.1 Rad/d, as the experimental data indicated. The estimated dose rate decreased when site-specific exposure factors were included in the screening protocol. This trend is consistent with the Graded Approach objective of moving from simple but conservative exposure assumptions to more realistic exposure assumptions. In fact, the estimated dose rate based on average media concentrations and site-specific uptake factors was within approximately an order of magnitude of the 160 mRad/d dose rate measured with TLDs in white-footed deer mice at Pond 3.

3.1.2 Negative Control Site

The general and site-specific screenings correctly identified the BCV soils as being an unlikely risk to terrestrial animals. Table 3.1 presented the results for the location in BCV that had the highest estimated dose rate in each of the screening assessments. In this case, it is the general protocol that is of particular interest. Even under the most conservative exposure assumptions tested, the Graded Approach correctly estimated the dose rate at less than the 0.1 Rad/d adverse effects level. The most realistic screening protocol tested estimated the dose rate for the BY/BY at 7.5 mRad/d (See Appendix B). This is within a factor of 50 of the 0.17 mRad/d dose rate estimated for that site in the BERA.

The environmental data used in the BERA also were run through the general screening protocol of the Graded Approach. The RI soil concentrations (i.e., the lesser value of either the maximum or UCL95 soil concentrations) were compared with the default BCGs. Table 3.2 presents the dose rates estimated in the BERA and in this study. The general screening protocol overestimated the radiation dose rate for all floodplain soils and half of the waste site units and DBAs. This result is not unexpected, given the assumed conservatism of the default BCGs. The fact that dose rates for only half of the non-floodplain sites were overestimated suggests that the uptake factors used in the BERA were not always lower than the default parameters used in the Graded Approach. This observation is discussed further below.

3.1.3 Background

The general screening correctly identified the background soil as being an unlikely risk to terrestrial animals. Background exposures could not be evaluated according to the Graded Approach site-specific screening protocols, because the background criteria presented in the BERA are upper bound concentration estimates rather than mean concentrations. This situation was considered to be acceptable, given that the issue of concern is whether or not the Graded Approach would erroneously indicate that background concentrations of radionuclides pose a potential ecological risk, which it did not do. The conservatively estimated background dose rate was approximately an order of magnitude lower than the 0.1 Rad/d adverse effects level.

Table 3.2 Estimated dose rates from RI soil concentrations at the negative control site

Location	Estimated Dose Rates (mRad/day)	
	BERA [a]	Graded Approach [b]
Transect-1	2.5	11
Transect-2	0.34	2.8
Transect-3	1.4	5.0
Transect-4	1.2	5.6
Transect-5	0.54	2.8
Transect-6	3.8	11
Transect-7	0.87	7.8
Transect-8	0.55	3.8
Transect-9	0.53	3.3
Transect-10	0.77	3.2
Transect-13	0.10	4.5
Burial Ground	2.6	0.91
Bone Yard/Burn Yard	0.17	22
OLF	4.6	0.77
S3 Ponds	0.36	0.51
Creekside DBA	18.5	3.3
Road Site DBA	6.4	73.3

[a] Baseline Ecological Risk Assessment results for the white-footed mouse.
[b] Results for terrestrial animal (mouse) based on default BCGs.

3.2 EVALUATION OF SITE-SPECIFIC MODIFICATIONS

The Graded Approach recommends the use of site maximum ambient media concentrations for the general screening. If the site fails the general screening, then using average concentrations is recommended, with appropriate justification by the user. The differences in estimated terrestrial organism dose rates based on upper bound and average ambient media concentrations are evaluated below for the two control sites.

3.2.1 Positive Control Site

Upper bound and mean concentrations for water and soil at the positive control site were screened against the default BCGs. Table 3.3 presents the partial fractions for each radionuclide detected at the positive control site. The ratio of the fraction calculated from the mean concentration divided by the fraction calculated for the maximum concentration was calculated as a measure of the relative reduction in estimated radiation exposures for the two scenarios. Partial fractions calculated from average concentrations were between 27% and 94% of those calculated from upper bound concentrations. The aggregate effect of using mean concentrations was a 51% reduction in the estimated total dose rate (i.e., the ratio for the sum of fractions was 0.49). No general trends based on radionuclide source or characteristics (e.g., dominant type of emissions) could be discerned from these data.

Table 3.3 Partial fractions based on upper bound and mean exposure concentrations at the positive control site

Radionuclide	Partial Fractions		Ratio [b]
	Upper Bound Water and Soil Concentrations [a]	Mean Water and Soil Concentrations	
Americum-241	1.23E-3	7.98E-4	0.65
Cerium-141	7.42E-4	6.01E-4	0.81
Cerium-144	2.13E-3	1.58E-3	0.74
Cesium-134	4.46E+2	1.20E+2	0.27
Cesium-137	8.64E+2	5.12E+2	0.59
Chromium-51	2.92E-2	2.52E-2	0.86
Cobalt-58	4.01E-4	3.62E-4	0.90
Cobalt-60	2.58E+1	1.66E+1	0.65
Curium-244	1.16E-3	7.02E-4	0.61
Europium-152	1.52E-2	9.05E-3	0.60
Europium-154	5.03E-2	2.80E-2	0.56
Europium-155	2.47E-3	1.66E-3	0.67
Iodine-131	1.05E-2	9.84E-3	0.93
Plutonium-238	1.81E-3	9.08E-4	0.50
Plutonium-239	1.87E-3	1.09E-3	0.58
Selenium-75	4.96E-5	4.54E-5	0.92
Strontium-90	4.43E-2	2.68E-2	0.61
Thorium-232	9.56E-4	8.88E-4	0.93
Uranium-234	6.94E-4	4.48E-4	0.65
Uranium-238	7.99E-4	7.50E-4	0.94
Zinc-65	3.75E-3	3.40E-3	0.91
Zirconium-95	4.71E-4	4.34E-4	0.92
Sum	**1.34E3**	**6.49E2**	**0.49**

[a] Upper bound concentrations: soil = maximum, water = upper 95 percent confidence limit on the mean (UCL95).
[b] Ratio = (fraction for mean concentration / fraction for upper bound concentration).

3.2.2 Negative Control Site

Mean soil concentrations could be calculated for 9 of the 17 BCV locations. Only one sample was collected at the remaining 8 sites, including the two highly contaminated DBAs. Table 3.4 summarizes the estimated dose rates based on maximum and mean soil concentration data and default uptake factors. The ratio of dose rates for mean concentrations divided by the dose rate for maximum concentrations was calculated as a measure of the relative reduction in estimated radiation exposures for the two scenarios (Table 3.4). Dose rates estimated for mean soil concentrations were between 12% and 92% of those based on maximum concentrations. Using the mean typically reduced the estimated dose rate by approximately 40% (i.e., the median ratio was 0.61).

The Burial Ground and the Bone Yard/Burn Yard sites resulted in the greatest difference in doses between maximum and mean soil concentrations. However, no single radionuclide was found to be the primary contributor to these differences at both sites. For the Burial Ground, Tc^{99} and U^{234} exhibited the greater differences, but at the Burn Yard/Bone Yard, Sr^{90} and U^{235} exhibited the greatest differences in dose rates. Difference in sample size is one possible explanation for the large reduction in estimated dose rates at the major waste units relative to those at the floodplain soil sites.

That is, 13 to 76 soil samples were collected at the major waste units, whereas only one or two samples were collected at the floodplain sites (Table 2.1). One would expect higher concentrations of radionuclides near the source areas (waste units) than in the Bear Creek floodplain. The proximity to source, coupled with a more intensive sampling regime, would be expected to increase the likelihood of finding a "hot spot" near a major waste unit.

Table 3.4 Estimated dose rates calculated using maximum and mean soil concentrations and default BCGs

Site	Dose Rate (mRad/d)		Ratio of Dose Rates [b]
	Maximum Soil Concentrations	Mean Soil Concentrations [a]	
Transect-1	11	6.7	0.61
Transect-2	2.8	N/A	
Transect-3	4.99	4.6	0.92
Transect-4	5.6	4.2	0.75
Transect-5	2.8	N/A	
Transect-6	11	7.5	0.68
Transect-7	7.8	5.9	0.76
Transect-8	3.8	N/A	
Transect-9	3.3	N/A	
Transect-10	3.1	N/A	
Transect-13	4.5	N/A	
Burial Ground	5.5	0.66	0.12
Bone Yard/Burn Yard	71	13.3	0.19
OLF	1.98	0.44	0.22
S3 Ponds	1.6	0.35	0.22
Creek side DBA	3.4	N/A	
Road Site DBA (undiluted)	74	N/A	

[a] Mean concentrations were not available at locations for which only one sample was collected.
[b] Ratio = (dose rate from mean concentrations / dose rate from maximum concentrations).

3.3 EVALUATION OF BIOACCUMULATION ASSUMPTIONS

If the site fails both the general screening and the site-specific screening using average media concentrations, then the user may choose to adjust the default bioaccumulation factor (lumped parameter) as the next step in the Graded Approach (Figure 1.1). Changing this parameter in the RAD-BCG Calculator will yield a site-specific BCG. Typically, the user would review the screening results to determine which radionuclides are the primary contributors to the estimated dose rates. They can then focus their resources on identifying bioaccumulation uptake factors for those radionuclides. In this project, bioaccumulation factors were adjusted with available data (as discussed in Section 2), regardless of contribution to dose. The purpose of this diagnostic testing was to evaluate the effect of using site-specific bioaccumulation data on the estimated dose rates and BCGs values. Table 2.3 summarizes the bioaccumulation factors used to adjust the BCGs for both the negative and positive control sites.

3.3.1 Positive Control Site

For the positive control site, available soil and water sample data collected from the TRA ponds were used to compare dose rates estimated with both default and site-specific bioaccumulation

uptake factors. Table 3.5 presents the estimated dose rates based on default and site-specific BCGs and the upper bound media concentrations. Also shown is the ratio of those dose rates for each radionuclide (i.e., site-specific BCG-based dose rate divided by the default BCG-based dose rate). This ratio is a measure of the relative reduction in estimated radiation exposures resulting from the use of site-specific bioaccumulations data. As shown in Table 3.5, the greatest differences in dose rate between the default and site-specific screenings were for Cs^{134} (0.01), Cs^{137} (0.01), Zn^{65} (0.03), and I^{131} (0.27). The dose rates calculated using site-specific BCGs were lower for all of these isotopes (i.e., ratios < 1.00). The opposite was true for three other radionuclides: Se^{75} (1.04), Cm^{244} (1.10), and Pu^{238} (1.70). However, the aggregate effect of using site-specific uptake data was a 97% reduction in the estimated total dose rate to terrestrial animals or nearly twice that associated with changing from upper bound to mean media concentrations (i.e., 51%).

Table 3.6 shows differences in the default and site-specific BCGs for water and soil at the positive control site. In a few cases, changing the bioaccumulation factors changed the BCGs. For example, site-specific water BCGs for I^{131} and Zn^{65} were approximately 4 to 30 times higher than the default water BCGs, and the site-specific soil BCGs for Cs^{134} and Cs^{137} were approximately 108 to 116 times higher than the default soil BCGs. In one case, Pu^{238}, the site-specific BCG was about 41% lower than the default BCG. However, in a number of cases the BCGs did not change appreciably, even though the bioaccumulation factor had been modified. For example, the water uptake factor had been modified but there was no appreciable change in the water BCG for Ce^{141}, Ce^{144}, Cr^{51}, and Se^{75}. In soil, the site-specific uptake factor did not appreciably affect the soil BCG for Co^{60}, Cm^{244}, and Pu^{239}.

3.3.2 Negative Control Site

For the negative control site, six locations were selected to compare doses estimated using both default and site-specific bioaccumulation uptake factors. Those locations were: Floodplain Transect 6, the Bear Creek Burial Grounds, the Bone Yard/Burn Yard, the OLF, the Creekside DBA, and Road Site DBA.

Table 3.5 Comparison of dose rates from upper bound soil and water concentrations at the positive control site based on default and site-specific BCGs

Radionuclide	Total Dose Rate (Rad/d)		Ratio [a]
	Default BCGs	Site-Specific BCGs	
Americum-241	1.23E-4	9E-5	0.73
Cerium-141	7.42E-5	7.36E-5	0.99
Cerium-144	2.14E-4	2.13E-4	1.00
Cesium-134	4.46E+1	4.12E-1	0.01
Cesium-137	8.64E+1	7.49E-1	0.01
Chromium-51	2.92E-3	2.71E-3	0.93
Cobalt-58	4.01E-5	4.01E-5	1.00
Cobalt-60	2.58E+0	2.45E+0	0.95
Curium-244	1.16E-4	1.28E-4	1.10
Europium-152	1.52E-3	1.52E-3	1.00
Europium-154	5.03E-3	5.03E-3	1.00
Europium-155	2.47E-4	2.47E-4	1.00
Iodine-131	1.05E-3	2.8E-4	0.27
Plutonium-238	1.81E-4	3.5E-4	1.93
Plutonium-239	1.87E-4	1.86E-4	0.99
Selenium-75	4.96E-6	5.18E-6	1.04
Strontium-90	4.43E-3	4.43E-3	1.00
Thorium-232	9.56E-5	9.56E-5	1.00
Uranium-234	6.94E-5	6.94E-5	1.00
Uranium-238	7.99E-5	7.99E-5	1.00
Zinc-65	3.75E-4	1.23E-5	0.03
Zirconium-95	4.71E-5	4.71E-5	1.00
Total	**134**	**3.63**	**0.03**

[a] Ratio = (dose rate based on site-specific BCGs / dose rate based on default BCGs).

Table 3.6 Comparison of default and site-specific BCGs for the positive control site

Radionuclides	Water (pCi/L)			Soil (pCi/g)		
	Default BCG	Site-Specific BCG	Ratio	Default BCG	Site-Specific BCG	Ratio [a]
Americum-241	2.01E5	2.01E5	1.00	3.88E3	5.32E3	1.37
Cerium-141	1.56E7	1.58E7	1.01	7.88E3	7.88E3	1.00
Cerium-144	2.85E6	2.87E6	1.01	1.44E3	1.44E3	1.00
Cesium-134	2.99E5	2.99E5	1.00	1.03E1	1.11E3	108
Cesium-137	5.98E5	5.98E5	1.00	2.08E1	2.39E3	116
Chromium-51	9.93E7	1.07E8	1.08	5.32E4	5.32E4	1.00
Cobalt-58	3.10E6	3.10E6	1.00	1.79E3	1.79E3	1.00
Cobalt-60	1.19E6	1.19E6	1.00	7.02E2	7.38E2	1.05
Curium-244	1.92E5	1.92E5	1.00	4.06E3	3.68E3	0.91
Europium-152	2.56E6	2.56E6	1.00	1.52E3	1.52E3	1.00
Europium-154	2.17E6	2.17E6	1.00	1.27E3	1.27E3	1.00
Europium-155	2.71E7	2.71E7	1.00	1.58E4	1.58E4	1.00
Iodine-131	1.87E6	7.01E6	3.74	8.54E2	8.54E2	1.00
Plutonium-238	2.00E5	2.00E5	1.00	6.11E3	3.59E3	0.59
Plutonium-239	2.00E5	2.00E5	1.00	6.11E3	6.14E3	1.00
Selenium-75	9.48E6	9.07E6	0.96	4.78E3	4.78E3	1.00
Strontium-90	5.44E4	5.44E4	1.00	2.25E1	2.25E1	1.00
Thorium-232	5.36E4	5.36E4	1.00	1.51E3	1.51E3	1.00
Uranium-234	4.04E5	4.04E5	1.00	5.13E3	5.13E3	1.00
Uranium-238	4.06E5	4.06E5	1.00	1.58E3	1.58E3	1.00
Zinc-65	1.73E5	5.27E6	30.4	4.13E2	4.13E2	1.00
Zirconium-95	2.21E6	2.21E6	1.00	1.17E3	1.17E3	1.00

[a] Ratio = (site-specific BCGs / default BCGs).

Table 3.7 presents the estimated dose rates based on the screening of maximum soil concentrations against default and site-specific BCGs for each radionuclide and location. The ratio of total dose rate based on site-specific BCGs divided by the total dose rate based on default BCGs was calculated for each location. This ratio is a measure of the relative reduction in estimated radiation exposures resulting from the use of site-specific bioaccumulation data. Dose rates calculated using site-specific BCGs were lower for five of the six locations tested, ranging from 29 to 75% of the default dose rates. However, the estimated site-specific dose rate for the Creekside DBA was approximately five times higher than the default dose rate.

The default and site-specific BCGs for each radionuclide were compared to further investigate the observed increase in estimated dose rate when site-specific data were used (Table 3.8). The ratio presented in Table 3.8 is a measure of the relative reduction in the BCG value resulting from the use of site-specific bioaccumulations data. Therefore, ratios less than 1.0 indicate that dose rates calculated using site-specific BCGs will be higher than those calculated using default bioaccumulation data. It can be seen from these data that the dose rates for plutonium, americium, and thorium will be higher when calculated using the site-specific BCGs than when using the default

Table 3.7 Dose rates from maximum soil concentrations at the negative control site based on default and site-specific BCGs

Location	Radionuclide	Dose Rate (Rad/d)		Ratio [a]
		Default BCGs	Site-Specific BCGs	
Transect-6	Am-241	4.12E-06	1.66E-03	
	Cs-137	6.41E-03	1.98E-04	
	Tc-99	7.67E-05	1.50E-05	
	Th-232	1.27E-04	3.94E-04	
	U-234	5.92E-04	5.31E-05	
	U-235	6.77E-05	3.70E-05	
	U-238	3.85E-03	2.89E-03	
	Total	**1.11E-02**	**5.25E-03**	**0.47**
BG	Co-60	1.71E-04	1.71E-04	
	Tc-99	2.91E-03	5.67E-04	
	Th-232	7.30E-05	2.27E-04	
	U-234	1.13E-04	1.02E-05	
	U-235	1.41E-06	7.71E-07	
	U-238	2.28E-03	1.72E-03	
	Total	**5.55E-03**	**2.69E-03**	**0.48**
BY/BY	Sr-90	8.45E-03	1.10E-04	
	Tc-99	1.72E-03	3.36E-04	
	Th-232	1.26E-04	3.92E-04	
	U-234	5.07E-03	4.55E-04	
	U-235	6.00E-04	3.28E-04	
	U-238	5.58E-02	4.19E-02	
	Total	**7.17E-02**	**4.36E-02**	**0.61**
OLF	Co-60	2.42E-04	2.42E-04	
	Th-232	4.78E-05	1.48E-04	
	U-234	2.73E-04	2.45E-05	
	U-235	2.47E-05	1.35E-05	
	U-238	1.39E-03	1.05E-03	
	Total	**1.98E-03**	**1.48E-03**	**0.75**
Creekside DBA	Am-241	3.87E-06	1.55E-03	
	Cs-137	1.01E-03	3.13E-05	
	Pu-238	7.34E-06	1.03E-02	
	Pu-239	1.64E-06	2.29E-03	
	Tc-99	7.67E-05	1.50E-05	
	Th-232	1.00E-04	3.11E-04	
	U-234	5.44E-04	4.88E-05	
	U-235	5.12E-05	2.80E-05	
	U-238	1.57E-03	1.18E-03	
	Total	**3.37E-03**	**1.58E-02**	**4.69**
Road Site DBA (undiluted)	Cs-137	2.29E-02	7.10E-04	
	Pu-239	3.27E-06	4.59E-03	
	Tc-99	1.68E-03	3.27E-04	
	Th-232	1.78E-04	5.52E-04	
	U-234	3.21E-02	2.88E-03	
	U-235	2.55E-04	1.40E-04	
	U-238	1.62E-02	1.22E-02	
	Total	**7.33E-02**	**2.13E-02**	**0.29**

[a] Ratio = (dose rate based on site-specific BCGs / dose rate based on default BCGs).

BCGs. Isotopes of all three of these elements were found at the Creekside DBA. Table 3.7 also indicates that each of these isotopes was a major contributor to the estimated dose rate at that site.

It was thought that the conservative assumptions used to select the default lumped parameters (DOE 2002) would almost always result in default BCGs that were lower (i.e., more conservative) than the site-specific BCGs. The comparatively high site-specific uptake factors could: 1) be an artifact of the sampling and analysis methods or the statistical assumption used in the BERA or 2) they could reflect a real difference in contaminant uptake in BCV relative to that reported in the literature. However, the available data do not provide any clear evidence as to why the site-specific bioaccumulation factors would be higher than the default uptake (lumped) parameters.

Table 3.8 Comparison of default and site-specific BCGs for the negative control site

Radionuclide	Default BCG	Site-Specific BCG	Ratio [a]
Amercium-241	3879.41	9.65	0.0025
Cesium-137	20.76	670.43	32
Strontium-90	22.48	1728.95	77
Technecium-99	4472.08	22918.60	5.1
Plutonium-238	6114.89	4.36	0.00071
Plutonium-239	6114.89	4.36	0.00071
Thorium-232	1506.25	485.07	0.32
Uranium-234	5128.76	57136.20	11
Uranium-235	2834.74	5187.70	1.8
Uranium-238	1577.79	2098.11	1.3

[a] Ratio = (site-specific BCGs / default BCGs).

4. SUMMARY & CONCLUSIONS

The Graded Approach was used to test the standardized screening process and application of the Biota Concentration Guides in the evaluation of potential impacts on terrestrial animals at one negative and one positive control site located within the DOE Complex. In summary, the Graded Approach correctly classified the selected control and background sites under all three screening protocols. The positive control site failed the general and two site-specific screenings, the negative control site passed the general and two site-specific screenings, and the background screening criteria passed the general screening. The primary conclusion of this study is that the Graded Approach correctly classified the selected control and background sites under all three screening protocols.

The effect of using site-specific exposure parameters was also evaluated. The first site-specific modification tested was the change from upper bound media concentrations to average media concentrations, which is the recommended method for evaluating the potential for effects on a representative individual, rather than on the maximally exposed individual (DOE 2002). This modification consistently resulted in reduced sum of fractions (i.e., lower estimated dose rates) for all sites and locations. However, this did not alter the ability of the Graded Approach to correctly indicate that radionuclides at the positive control site were expected to pose a risk to terrestrial biota. Indeed, the estimated total absorbed dose rate based on average media concentrations better approximated the measured dose rate for white-footed deer mice at the positive control site (Halford and Markham 1978) than that based on the upper bound concentrations.

The second site-specific modification tested was the change from default bioaccumulation factors to site-specific bioaccumulation factors. The use of site-specific BCGs had mixed effects on the estimated dose rates. Relative to the default BCGs, some site-specific BCGs increased (i.e., estimated dose rates decreased), some decreased, and some remained unchanged. It's worth noting that the diagnostic testing of the site-specific uptake factors was based on upper bound media concentrations rather than average media concentrations. This method would not be used in an actual site-specific screening. Rather, the same media concentrations were used in both diagnostic tests to help facilitate comparison of the two site-specific modifications (i.e., changing the media concentrations and changing the uptake factors).

Results of the comparison of the two diagnostic tests were somewhat mixed. For the positive control site, changing the uptake factors had a far greater effect on the dose rate estimates (97% reduction) than did changing the media concentrations (51% reduction). This result was also true for the major waste units at the negative control site. At these sites, changing the media concentrations approximately doubled the reduction in estimated dose rates relative to that observed when the uptake factors were changed. This effect was not observed for the floodplain location at the negative control site. Changing the uptake factor decreased the estimated dose rate at this location by 51%, whereas changing the media concentration reduced the estimated dose rate at that location by 32%. It is not clear why the results for the floodplain site would be different from those for the waste units and the positive control site. Possibly the relatively small number of samples collected at the floodplain site increased the variability of the results. Overall, adjustment of the bioaccumulation factors had the greatest impact on the estimated dose rates, but use of site-specific uptake factors did

not always reduce the estimated dose rates, whereas switching from the upper bound to average media concentrations did reduce estimated dose rates under all scenarios.

The primary conclusion of this study is that the Graded Approach correctly classified the selected control and background sites with respect to the potential for adverse effects of ionizing radiation on terrestrial animals. This was true for all three screening protocols. Furthermore, the screening results were generally conservative relative to the baseline studies, but not so conservative as to produce false positive results for the negative control and background sites. This finding is consistent with the intended design and use of the screening protocols in the Graded Approach. Therefore, this first validation study suggests that, at least within the limits of the tested exposure scenarios, the Graded Approach can be used to screen out radiological sites that are unlikely to pose a significant risk to terrestrial animals.

The primary implication of these findings for the long term stewardship program and other environmental protection programs is that quantitative screening evaluations can be performed quickly and efficiently. The first two screening analyses (i.e., General Screening and Site-Specific Screening with mean concentrations) do not require additional data beyond that which is commonly collected for environmental assessments (i.e., contaminant concentrations in ambient media). This fact is especially important for assessments of risks to terrestrial animals, because relevant biological samples are not typically collected in support of other assessment objectives, such as estimating dietary pathways for humans. In addition, the ability to efficiently conduct screening evaluations for radiation doses to terrestrial animals means that additional can be directed at the sites, pathways, and isotopes of greatest concern. Moreover, reducing the amount of sampling at radiologically contaminated sites helps ensure the health and safety of field samplers and laboratory technicians.

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APPENDIX A

BEAR CREEK VALLEY
GRADED APPROACH OUTPUT (DEFAULT PARAMETERS)

Terrestrial Organism Dose Estimates Using Maximum Soil Concentrations

Notes: **Radionuclide Concentrations in 0-4 inch soil depths**
Default Parameters

Recommended Terrestrial Organisms Dose Rate: 0.1 rad/day
Rad Dose Rate= Site Data (pCi/g) * 0.1 Rad day-1/Soil Limit (pCi/g)

Site Description: **TS1 - Max Conc.**
Terrestrial System Data Entry/BCG Worksheet
Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Am-241	3879.41282	0.08	2.06E-05	2.06E-05		2.06E-06
Cs-137	20.7572282	1.17	0.056366	0.056366		0.005637
Pu-238	6114.88861	0.0264	4.30E-06	4.32E-06		4.32E-07
Pu-239	6114.88861	0.03	4.91E-06	4.91E-06		4.91E-07
Tc-99	4472.07805	10.81	0.002417	0.002417		0.000242
Th-232	1506.24722	1.17	0.000777	0.000777		7.77E-05
U-234	5128.75947	44.13	0.008604	0.008604		0.00086
U-235	2834.74249	2.66	0.000938	0.000938		9.38E-05
U-238	1577.78939	67	0.042464	0.042464		0.004246
			0.111593	0.111593	**Total Dose:**	**0.01116**

You have passed the terrestrial site screen

Site Description: **TS2 - Max Conc**
Terrestrial System Data Entry/BCG Worksheet
Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Am-241	3879.41282	0.06	1.55E-05	1.55E-05		1.55E-06
Cs-137	20.7572282	0.44	0.021197	0.021197		0.00212
Tc-99	4472.07805	8.38	0.001874	0.001874		0.000187
Th-232	1506.24722	0.83	0.000551	0.000551		5.51E-05
U-234	5128.75947	4.07	0.000794	0.000794		7.94E-05
U-235	2834.74249	0.25	8.82E-05	8.82E-05		8.82E-06
U-238	1577.78939	5.45	0.003454	0.003454		0.000345
			0.027974	0.027974	**Total Dose:**	**0.002797**

You have passed the terrestrial site screen

Site Description: **TS3 - Max Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Am-241	3879.41282	0.13	3.35E-05	3.35E-05		3.35E-06
Cs-137	20.7572282	0.35	0.016862	0.016862		0.001686
Tc-99	4472.07805	11.98	0.002679	0.002679		0.000268
Th-232	1506.24722	1.02	0.000677	0.000677		6.77E-05
U-234	5128.75947	20.94	0.004083	0.004083		0.000408
U-235	2834.74249	1.62	0.000571	0.000571		5.71E-05
U-238	1577.78939	39.55	0.025067	0.025067		0.002507
			0.049972	0.049972	**Total Dose:**	**0.004997**

You have passed the terrestrial site screen

Site Description: **TS4 - Max Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions	Dose Rate (Rad/day)	
Cs-137	20.7572282	0.23	0.01108	0.01108		0.001108
Cm-244	4000.00000	0.14000	0.00003	0.00003		3.5E-06
Tc-99	4472.07805	4.55	0.001017	0.001017		0.000102
Th-232	1506.24722	0.63	0.000418	0.000418		4.18E-05
U-234	5128.75947	14.71	0.002868	0.002868		0.000287
U-235	2834.74249	1.21	0.000427	0.000427		4.27E-05
U-238	1577.78939	63.41	0.040189	0.040189		0.004019
			0.056	0.056		**0.005604**

You have passed the terrestrial site screen

Site Description: **TS5 - Max Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Cs-137	20.7572282	0.55	0.026497	0.026497		0.00265
Pu-239	6114.88861	0.02	3.27E-06	3.27E-06		3.27E-07
Th-232	1506.24722	1.11	0.000737	0.000737		7.37E-05
U-234	5128.75947	1.33	0.000259	0.000259		2.59E-05
U-235	2834.74249	0.03	1.06E-05	1.06E-05		1.06E-06
U-238	1577.78939	1.38	0.000875	0.000875		8.75E-05
			0.028382	0.028382	**Total Dose:**	**0.002838**

You have passed the terrestrial site screen

Site Description: **TS6 - Max Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Am-241	3879.41	0.16	4.12E-05	4.12E-05		4.12E-06
Cs-137	20.76	1.33	0.064074	0.064074		0.006407
Tc-99	4472.08	3.43	0.000767	0.000767		7.67E-05
Th-232	1506.25	1.91	0.001268	0.001268		0.000127
U-234	5128.76	30.36	0.00592	0.00592		0.000592
U-235	2834.74	1.92	0.000677	0.000677		6.77E-05
U-238	1577.79	60.72	0.038484	0.038484		0.003848
			0.111231	0.111231	**Total Dose:**	**0.011123**

You have passed the terrestrial site screen

Site Description: **TS7 - Max Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Am-241	3879.41	0.08	2.06E-05	2.06E-05		2.06E-06
Cs-137	20.76	0.76	0.036614	0.036614		0.003661
Pu-239	6114.89	0.02	3.27E-06	3.27E-06		3.27E-07
Tc-99	4472.08	2.47	0.000552	0.000552		5.52E-05
Th-232	1506.25	0.95	0.000631	0.000631		6.31E-05
U-234	5128.76	29.49	0.00575	0.00575		0.000575
U-235	2834.74	2.08	0.000734	0.000734		7.34E-05
U-238	1577.79	52.66	0.033376	0.033376		0.003338
			0.07768	0.07768	**Total Dose:**	**0.007768**

You have passed the terrestrial site screen

Site Description: **TS8 - Max Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Cs-137	20.7572282	0.68	0.03276	0.03276		0.003276
Pu-239	6114.88861	0.02	3.27E-06	3.27E-06		3.27E-07
Th-232	1506.24722	1.04	0.00069	0.00069		6.9E-05
U-234	5128.75947	4.29	0.000836	0.000836		8.36E-05
U-235	2834.74249	0.33	0.000116	0.000116		1.16E-05
U-238	1577.78939	6.17	0.003911	0.003911		0.000391
			0.038317	0.038317	**Total Dose:**	**0.003832**

You have passed the terrestrial site screen

Site Description: **TS9 – Max Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Cs-137	20.7572282	0.62	0.029869	0.029869		0.002987
Cm-244	4.00E+03	0.17	4.20E-05	4.19E-05		4.25E-06
Pu-239	6114.88861	0.02	3.27E-06	3.27E-06		3.27E-07
Th-232	1506.24722	0.87	0.000578	0.000578		5.78E-05
U-234	5128.75947	1.83	0.000357	0.000357		3.57E-05
U-235	2834.74249	0.1	3.53E-05	3.53E-05		3.53E-06
U-238	1577.78939	2.69	0.001705	0.001705		0.00017
			0.032547	0.032547	**Total Dose:**	**0.003259**

You have passed the terrestrial site screen

Site Description: **TS10 - Max Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Cs-137	20.7572282	0.44	0.021197	0.021197		0.00212
Pu-239	6114.88861	0.03	4.91E-06	4.91E-06		4.91E-07
Th-232	1506.24722	0.79	0.000524	0.000524		5.24E-05
U-234	5128.75947	7.24	0.001412	0.001412		0.000141
U-235	2834.74249	0.39	0.000138	0.000138		1.38E-05
U-238	1577.78939	13.14	0.008328	0.008328		0.000833
			0.031604	0.031604	**Total Dose:**	**0.00316**

You have passed the terrestrial site screen

Site Description: **TS13 - Max Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Cs-137	20.7572282	0.87	0.041913	0.041913		0.004191
Th-232	1506.24722	0.99	0.000657	0.000657		6.57E-05
U-234	5128.75947	2.14	0.000417	0.000417		4.17E-05
U-235	2834.74249	0.07	2.47E-05	2.47E-05		2.47E-06
U-238	1577.78939	2.58	0.001635	0.001635		0.000164
			0.044648	0.044648	**Total Dose:**	**0.004465**

You have passed the terrestrial site screen

Site Description: **Burial Ground- Max Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Co-60	701.51	1.2	0.001711	0.001711		0.000171
Tc-99	4472.08	130	0.029069	0.029069		0.002907
Th-232	1506.25	1.1	0.00073	0.00073		7.3E-05
U-234	5128.76	5.8	0.001131	0.001131		0.000113
U-235	2834.74	0.04	1.41E-05	1.41E-05		1.41E-06
U-238	1577.79	36	0.022817	0.022817		0.002282
			0.055472	0.055472	**Total Dose:**	**0.005547**

You have passed the terrestrial site screen

Site Description: **BY/BY Max Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Sr-90	22.48	1.9	0.084506	0.084506		0.008451
Tc-99	4472.08	77	0.017218	0.017218		0.001722
Th-232	1506.25	1.9	0.001261	0.001261		0.000126
U-234	5128.76	260	0.050695	0.050695		0.005069
U-235	2834.74	17	0.005997	0.005997		0.0006
U-238	1577.79	880	0.557742	0.557742		0.055774
			0.717419	0.717419	**Total Dose:**	**0.071742**

You have passed the terrestrial site screen

Site Description: **OLF - Max Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Co-60	701.51249	1.7	0.002423	0.002423		0.000242
Th-232	1506.24722	0.72	0.000478	0.000478		4.78E-05
U-234	5128.75947	14	0.00273	0.00273		0.000273
U-235	2834.74249	0.7	0.000247	0.000247		2.47E-05
U-238	1577.78939	22	0.013944	0.013944		0.001394
			0.019822	0.019822	**Total Dose:**	**0.001982**

You have passed the terrestrial site screen

Site Description: **S3 Ponds – Max Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Pu-239	6114.88861	0.02	3.27E-06	3.27E-06		3.27E-07
Tc-99	4472.07805	6.8	0.001521	0.001521		0.000152
Th-232	1506.24722	1.5	0.000996	0.000996		9.96E-05
U-234	5128.75947	7.7	0.001501	0.001501		0.00015
U-235	2834.74249	0.54	0.00019	0.00019		1.9E-05
U-238	1577.78939	18	0.011408	0.011408		0.001141
			0.01562	0.01562	**Total Dose:**	**0.001562**

You have passed the terrestrial site screen

Site Description: **Creekside – Max Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Am-241	3879.41282	0.15	3.87E-05	3.87E-05		3.87E-06
Cs-137	20.7572282	0.21	0.010117	0.010117		0.001012
Pu-238	6114.88861	0.4488	7.30E-05	7.34E-05		7.34E-06
Pu-239	6114.88861	0.1	1.64E-05	1.64E-05		1.64E-06
Tc-99	4472.07805	3.43	0.000767	0.000767		7.67E-05
Th-232	1506.24722	1.51	0.001002	0.001002		0.0001
U-234	5128.75947	27.9	0.00544	0.00544		0.000544
U-235	2834.74249	1.45	0.000512	0.000512		5.12E-05
U-238	1577.78939	24.79	0.015712	0.015712		0.001571
			0.033605	0.033605	**Total Dose:**	**0.003368**

You have passed the terrestrial site screen

Site Description: **Road Side (diluted 1:4) - Max Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Cs-137	20.7572282	1.19	0.057329	0.057329		0.005733
Pu-239	6114.88861	0.05	8.18E-06	8.18E-06		8.18E-07
Tc-99	4472.07805	18.74	0.00419	0.00419		0.000419
Th-232	1506.24722	0.67	0.000445	0.000445		4.45E-05
U-234	5128.75947	411.39	0.080212	0.080212		0.008021
U-235	2834.74249	1.81	0.000639	0.000639		6.39E-05
U-238	1577.78939	63.75	0.040405	0.040405		0.00404
			0.183228	0.183228	**Total Dose:**	**0.018323**

You have passed the terrestrial site screen

Site Description: **Road Side (undiluted) - Max**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Cs-137	20.7572282	4.76	0.229318	0.229318		0.022932
Pu-239	6114.88861	0.2	3.27E-05	3.27E-05		3.27E-06
Tc-99	4472.07805	74.96	0.016762	0.016762		0.001676
Th-232	1506.24722	2.68	0.001779	0.001779		0.000178
U-234	5128.75947	1645.56	0.32085	0.32085		0.032085
U-235	2834.74249	7.24	0.002554	0.002554		0.000255
U-238	1577.78939	255	0.161619	0.161619		0.016162
			0.732914	0.732914	**Total Dose:**	**0.073291**

You have passed the terrestrial site screen

Terrestrial Organism Dose Estimates Using Mean Soil Concentrations

Recommended Terrestrial Organisms Dose Rate: 0.1 rad/day

Rad Dose Rate= Site Data (pCi/g) * 0.1 Rad day-1/Soil Limit (pCi/g)

Site Description: TS1 - Avg Conc.

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Am-241	3879.41282	0.04	1.03E-05	1.03E-05		1.03E-06
Cs-137	20.7572282	0.74	0.03565	0.03565		0.003565
Pu-238	6114.88861	0.0176	2.90E-06	2.88E-06		2.88E-07
Pu-239	6114.88861	0.02	3.27E-06	3.27E-06		3.27E-07
Tc-99	4472.07805	6.64	0.001485	0.001485		0.000148
Th-232	1506.24722	1	0.000664	0.000664		6.64E-05
U-234	5128.75947	29.44	0.00574	0.00574		0.000574
U-235	2834.74249	1.47	0.000519	0.000519		5.19E-05
U-238	1577.78939	35.66	0.022601	0.022601		0.00226
			0.066672	0.066672	**Total Dose:**	**0.006668**

You have passed the terrestrial site screen

Site Description: TS2 - Avg Conc

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Am-241	3879.41282	0.06	1.55E-05	1.55E-05		1.55E-06
Cs-137	20.7572282	0.44	0.021197	0.021197		0.00212
Tc-99	4472.07805	8.38	0.001874	0.001874		0.000187
Th-232	1506.24722	0.83	0.000551	0.000551		5.51E-05
U-234	5128.75947	4.07	0.000794	0.000794		7.94E-05
U-235	2834.74249	0.25	8.82E-05	8.82E-05		8.82E-06
U-238	1577.78939	5.45	0.003454	0.003454		0.000345
			0.027974	0.027974	**Total Dose:**	**0.002797**

You have passed the terrestrial site screen

Site Description: **TS3 - Avg Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Am-241	3879.41282	0.11	2.84E-05	2.84E-05		2.84E-06
Cs-137	20.7572282	0.31	0.014935	0.014935		0.001493
Tc-99	4472.07805	9.49	0.002122	0.002122		0.000212
Th-232	1506.24722	0.95	0.000631	0.000631		6.31E-05
U-234	5128.75947	20.28	0.003954	0.003954		0.000395
U-235	2834.74249	1.48	0.000522	0.000522		5.22E-05
U-238	1577.78939	38.27	0.024255	0.024255		0.002426
			0.046447	0.046447	**Total Dose:**	**0.004645**

You have passed the terrestrial site screen

Site Description: **TS4 - Avg Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Cs-137	20.7572282	0.17	0.00819	0.00819		0.000819
Cm-244	4000.00000	0.14000	0.00003	0.00003		3.5E-06
Tc-99	4472.07805	4.49	0.001004	0.001004		0.0001
Th-232	1506.24722	0.62	0.000412	0.000412		4.12E-05
U-234	5128.75947	11.86	0.002312	0.002312		0.000231
U-235	2834.74249	1.07	0.000377	0.000377		3.77E-05
U-238	1577.78939	46.85	0.029693	0.029693		0.002969
			0.041989	0.041989	**Total Dose:**	**0.004202**

You have passed the terrestrial site screen

Site Description: **TS5 - Avg Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Cs-137	20.7572282	0.55	0.026497	0.026497		0.00265
Pu-239	6114.88861	0.02	3.27E-06	3.27E-06		3.27E-07
Th-232	1506.24722	1.11	0.000737	0.000737		7.37E-05
U-234	5128.75947	1.33	0.000259	0.000259		2.59E-05
U-235	2834.74249	0.03	1.06E-05	1.06E-05		1.06E-06
U-238	1577.78939	1.38	0.000875	0.000875		8.75E-05
			0.028382	0.028382	**Total Dose:**	**0.002838**

You have passed the terrestrial site screen

Site Description: **TS6 - Avg Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Am-241	3879.41282	0.1	2.58E-05	2.58E-05		2.58E-06
Cs-137	20.7572282	0.92	0.044322	0.044322		0.004432
Tc-99	4472.07805	3.06	0.000684	0.000684		6.84E-05
Th-232	1506.24722	1.4	0.000929	0.000929		9.29E-05
U-234	5128.75947	19.55	0.003812	0.003812		0.000381
U-235	2834.74249	1.21	0.000427	0.000427		4.27E-05
U-238	1577.78939	39.03	0.024737	0.024737		0.002474
			0.074937	0.074937	**Total Dose:**	**0.007494**

You have passed the terrestrial site screen

Site Description: **TS7 - Avg Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Am-241	3879.41282	0.05	1.29E-05	1.29E-05		1.29E-06
Cs-137	20.7572282	0.7	0.033723	0.033723		0.003372
Pu-239	6114.88861	0.02	3.27E-06	3.27E-06		3.27E-07
Tc-99	4472.07805	2.51	0.000561	0.000561		5.61E-05
Th-232	1506.24722	0.95	0.000631	0.000631		6.31E-05
U-234	5128.75947	17.94	0.003498	0.003498		0.00035
U-235	2834.74249	1.21	0.000427	0.000427		4.27E-05
U-238	1577.78939	31.36	0.019876	0.019876		0.001988
			0.058732	0.058732	**Total Dose:**	**0.005873**

You have passed the terrestrial site screen

Site Description: **TS8 - Avg Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Cs-137	20.7572282	0.68	0.03276	0.03276		0.003276
Pu-239	6114.88861	0.02	3.27E-06	3.27E-06		3.27E-07
Th-232	1506.24722	1.04	0.00069	0.00069		6.9E-05
U-234	5128.75947	4.29	0.000836	0.000836		8.36E-05
U-235	2834.74249	0.33	0.000116	0.000116		1.16E-05
U-238	1577.78939	6.17	0.003911	0.003911		0.000391
			0.038317	0.038317	**Total Dose:**	**0.003832**

You have passed the terrestrial site screen

Site Description: **TS9 - Avg Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Cs-137	20.7572282	0.62	0.029869	0.029869		0.002987
Cm-244	4.00E+03	0.17	4.20E-05	4.19E-05		4.25E-06
Pu-239	6114.88861	0.02	3.27E-06	3.27E-06		3.27E-07
Th-232	1506.24722	0.87	0.000578	0.000578		5.78E-05
U-234	5128.75947	1.83	0.000357	0.000357		3.57E-05
U-235	2834.74249	0.1	3.53E-05	3.53E-05		3.53E-06
U-238	1577.78939	2.69	0.001705	0.001705		0.00017
			0.032547	0.032547	**Total Dose:**	**0.003259**

You have passed the terrestrial site screen

Site Description: **TS10 - Avg Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Cs-137	20.7572282	0.44	0.021197	0.021197		0.00212
Pu-239	6114.88861	0.03	4.91E-06	4.91E-06		4.91E-07
Th-232	1506.24722	0.79	0.000524	0.000524		5.24E-05
U-234	5128.75947	7.24	0.001412	0.001412		0.000141
U-235	2834.74249	0.39	0.000138	0.000138		1.38E-05
U-238	1577.78939	13.14	0.008328	0.008328		0.000833
			0.031604	0.031604	**Total Dose:**	**0.00316**

You have passed the terrestrial site screen

Site Description: **TS13 - Avg Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Cs-137	20.7572282	0.87	0.041913	0.041913		0.004191
Th-232	1506.24722	0.99	0.000657	0.000657		6.57E-05
U-234	5128.75947	2.14	0.000417	0.000417		4.17E-05
U-235	2834.74249	0.07	2.47E-05	2.47E-05		2.47E-06
U-238	1577.78939	2.58	0.001635	0.001635		0.000164
			0.044648	0.044648	**Total Dose:**	**0.004465**

You have passed the terrestrial site screen

Site Description: **Burial Ground- Avg Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Co-60	701.51249	1.67	0.002381	0.002381		0.000238
Tc-99	4472.07805	8.28	0.001851	0.001851		0.000185
Th-232	1506.24722	0.38	0.000252	0.000252		2.52E-05
U-234	5128.75947	0.93	0.000181	0.000181		1.81E-05
U-235	2834.74249	0.03	1.06E-05	1.06E-05		1.06E-06
U-238	1577.78939	3.03	0.00192	0.00192		0.000192
			0.006597	0.006597	**Total Dose:**	**0.00066**

You have passed the terrestrial site screen

Site Description: **BY/BY -- Avg Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Sr-90	22.4836282	0.32	0.014233	0.014233		0.001423
Tc-99	4472.07805	21.9	0.004897	0.004897		0.00049
Th-232	1506.24722	0.41	0.000272	0.000272		2.72E-05
U-234	5128.75947	95.2	0.018562	0.018562		0.001856
U-235	2834.74249	2.25	0.000794	0.000794		7.94E-05
U-238	1577.78939	149	0.094436	0.094436		0.009444
			0.133193	0.133193	**Total Dose:**	**0.013319**

You have passed the terrestrial site screen

Site Description: **OLF - Avg Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Co-60	701.51249	1.08	0.00154	0.00154		0.000154
Th-232	1506.24722	0.36	0.000239	0.000239		2.39E-05
U-234	5128.75947	2.55	0.000497	0.000497		4.97E-05
U-235	2834.74249	0.04	1.41E-05	1.41E-05		1.41E-06
U-238	1577.78939	3.35	0.002123	0.002123		0.000212
			0.004413	0.004413	**Total Dose:**	**0.000441**

You have passed the terrestrial site screen

Site Description: **S3 Ponds - Avg Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Tc-99	4472.07805	2.05	0.000458	0.000458		4.58E-05
Th-232	1506.24722	0.41	0.000272	0.000272		2.72E-05
U-234	5128.75947	1.87	0.000365	0.000365		3.65E-05
U-235	2834.74249	0.11	3.88E-05	3.88E-05		3.88E-06
U-238	1577.78939	3.74	0.00237	0.00237		0.000237
			0.003504	0.003504	**Total Dose:**	**0.00035**

You have passed the terrestrial site screen

Terrestrial Organism Dose Estimates Using RI Exposure Soil Concentrations

Recommended Terrestrial Organisms Dose Rate: 0.1 rad/day

Rad Dose Rate= Site Data (pCi/g) * 0.1 Rad day-1/Soil Limit (pCi/g)

Site Description: TS1 - RI Exp Conc.

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions	Dose Rate (Rad/day)
Am-241	3879.4128	0.08	2.06E-05	2.062E-05	2.06217E-06
Cs-137	20.757228	1.17	0.056366	0.0563659	0.005636591
Pu-238	6114.8886	0.0264	4.30E-06	4.32E-06	4.3173E-07
Pu-239	6114.8886	0.03	4.91E-06	4.906E-06	4.90606E-07
Tc-99	4472.0781	10.81	0.002417	0.0024172	0.000241722
Th-232	1506.2472	1.17	0.000777	0.0007768	7.76765E-05
U-234	5128.7595	44.13	0.008604	0.0086044	0.000860442
U-235	2834.7425	2.66	0.000938	0.0009384	9.38357E-05
U-238	1577.7894	67	0.042464	0.0424645	0.004246448
			0.111593	0.1115927	**Total Dose:** **0.011159699**

You have passed the terrestrial site screen

Site Description: TS2 - RI Exp Conc

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions	Dose Rate (Rad/day)
Am-241	3879.4128	0.06	1.55E-05	1.547E-05	1.54663E-06
Cs-137	20.757228	0.44	0.021197	0.0211974	0.002119744
Tc-99	4472.0781	8.38	0.001874	0.0018738	0.000187385
Th-232	1506.2472	0.83	0.000551	0.000551	5.51038E-05
U-234	5128.7595	4.07	0.000794	0.0007936	7.93564E-05
U-235	2834.7425	0.25	8.82E-05	8.819E-05	8.81914E-06
U-238	1577.7894	5.45	0.003454	0.0034542	0.00034542
			0.027974	0.0279737	**Total Dose:** **0.002797374**

You have passed the terrestrial site screen

Site Description: **TS3 - RI Exp Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Am-241	3879.4128	0.13	3.35E-05	3.351E-05		3.35102E-06
Cs-137	20.757228	0.35	0.016862	0.0168616		0.00168616
Tc-99	4472.0781	11.98	0.002679	0.0026788		0.000267884
Th-232	1506.2472	1.02	0.000677	0.0006772		6.7718E-05
U-234	5128.7595	20.94	0.004083	0.0040829		0.000408286
U-235	2834.7425	1.62	0.000571	0.0005715		5.7148E-05
U-238	1577.7894	39.55	0.025067	0.0250667		0.002506672
			0.049972	0.0499722	**Total Dose:**	**0.004997219**

Site Description: **TS4 - RI Exp Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Cs-137	20.757228	0.23	0.01108	0.0110805		0.001108
Cm-244	4000.00000	0.14000	0.00003	0.00003		3.500E-6
Tc-99	4472.0781	4.55	0.001017	0.0010174		0.000102
Th-232	1506.2472	0.63	0.000418	0.0004183		4.18E-05
U-234	5128.7595	14.71	0.002868	0.0028681		0.000287
U-235	2834.7425	1.21	0.000427	0.0004268		4.27E-05
U-238	1577.7894	63.41	0.040189	0.0401891		0.004019
			0.056	0.0560003	**Total Dose:**	**0.005604**

Site Description: **TS5 - RI Exp Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Cs-137	20.757228	0.55	0.026497	0.0264968		0.00264967
Pu-239	6114.8886	0.02	3.27E-06	3.271E-06		3.27071E-07
Th-232	1506.2472	1.11	0.000737	0.0007369		7.36931E-05
U-234	5128.7595	1.33	0.000259	0.0002593		2.59322E-05
U-235	2834.7425	0.03	1.06E-05	1.058E-05		1.0583E-06
U-238	1577.7894	1.38	0.000875	0.0008746		8.74641E-05
			0.028382	0.0283815	**Total Dose:**	**0.00283815**

You have passed the terrestrial site screen

Site Description: **TS6 - RI Exp Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Am-241	3879.4128	0.16	4.12E-05	4.124E-05		4.12434E-06
Cs-137	20.757228	1.33	0.064074	0.0640741		0.006407407
Tc-99	4472.0781	3.43	0.000767	0.000767		7.66981E-05
Th-232	1506.2472	1.91	0.001268	0.0012681		0.000126805
U-234	5128.7595	30.36	0.00592	0.0059196		0.000591956
U-235	2834.7425	1.92	0.000677	0.0006773		6.7731E-05
U-238	1577.7894	60.72	0.038484	0.0384842		0.003848422
			0.111231	0.1112314	**Total Dose:**	**0.011123144**

You have passed the terrestrial site screen

Site Description: **TS7 - RI Exp Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Am-241	3879.4128	0.08	2.06E-05	2.062E-05		2.06217E-06
Cs-137	20.757228	0.76	0.036614	0.0366138		0.003661375
Pu-239	6114.8886	0.02	3.27E-06	3.271E-06		3.27071E-07
Tc-99	4472.0781	2.47	0.000552	0.0005523		5.52316E-05
Th-232	1506.2472	0.95	0.000631	0.0006307		6.30707E-05
U-234	5128.7595	29.49	0.00575	0.0057499		0.00057499
U-235	2834.7425	2.08	0.000734	0.0007338		7.33753E-05
U-238	1577.7894	52.66	0.033376	0.0333758		0.00333758
			0.07768	0.0776802	**Total Dose:**	**0.00776801**

You have passed the terrestrial site screen

Site Description: **TS8 - RI Exp Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Cs-137	20.757228	0.68	0.03276	0.0327597		0.003275967
Pu-239	6114.8886	0.02	3.27E-06	3.271E-06		3.27071E-07
Th-232	1506.2472	1.04	0.00069	0.0006905		6.90458E-05
U-234	5128.7595	4.29	0.000836	0.0008365		8.3646E-05
U-235	2834.7425	0.33	0.000116	0.0001164		1.16413E-05
U-238	1577.7894	6.17	0.003911	0.0039105		0.000391053
			0.038317	0.0383168	**Total Dose:**	**0.003831681**

You have passed the terrestrial site screen

Site Description: **TS9 - RI Exp Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Cs-137	20.757228	0.62	0.029869	0.0298691		0.002986911
Cm-244	4.00E+03	0.17	4.20E-05	4.19E-05		0.00000425
Pu-239	6114.8886	0.02	3.27E-06	3.271E-06		3.27071E-07
Th-232	1506.2472	0.87	0.000578	0.0005776		5.77594E-05
U-234	5128.7595	1.83	0.000357	0.0003568		3.56811E-05
U-235	2834.7425	0.1	3.53E-05	3.528E-05		3.52766E-06
U-238	1577.7894	2.69	0.001705	0.0017049		0.000170492
			0.032547	0.032547	**Total Dose:**	**0.003258948**

You have passed the terrestrial site screen

Site Description: **TS10 - RI Exp Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Cs-137	20.757228	0.44	0.021197	0.0211974		0.002119744
Pu-239	6114.8886	0.03	4.91E-06	4.906E-06		4.90606E-07
Th-232	1506.2472	0.79	0.000524	0.0005245		5.24482E-05
U-234	5128.7595	7.24	0.001412	0.0014116		0.00014116
U-235	2834.7425	0.39	0.000138	0.0001376		1.37579E-05
U-238	1577.7894	13.14	0.008328	0.0083281		0.00083281
			0.031604	0.0316042	**Total Dose:**	**0.00316041**

You have passed the terrestrial site screen

Site Description: **TS13 - RI Exp Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Cs-137	20.757228	0.87	0.041913	0.0419131		0.004191311
Th-232	1506.2472	0.99	0.000657	0.0006573		6.57263E-05
U-234	5128.7595	2.14	0.000417	0.0004173		4.17255E-05
U-235	2834.7425	0.07	2.47E-05	2.469E-05		2.46936E-06
U-238	1577.7894	2.58	0.001635	0.0016352		0.00016352
			0.044648	0.0446475	**Total Dose:**	**0.004464752**

You have passed the terrestrial site screen

Site Description: **Burial Ground- RI Exp Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Co-60	701.51249	1.2	0.001711	0.0017106		0.000171059
Tc-99	4472.0781	15.88	0.003551	0.0035509		0.000355092
Th-232	1506.2472	0.45	0.000299	0.0002988		2.98756E-05
U-234	5128.7595	1.39	0.000271	0.000271		2.71021E-05
U-235	2834.7425	0.04	1.41E-05	1.411E-05		1.41106E-06
U-238	1577.7894	5.19	0.003289	0.0032894		0.000328941
			0.009135	0.0091348	**Total Dose:**	**0.00091348**

You have passed the terrestrial site screen

Site Description: **BY/BY Exp Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Sr-90	22.483628	0.57	0.025352	0.0253518		0.002535178
Tc-99	4472.0781	35.61	0.007963	0.0079627		0.000796274
Th-232	1506.2472	0.61	0.000405	0.000405		4.0498E-05
U-234	5128.7595	136.31	0.026578	0.0265776		0.002657758
U-235	2834.7425	3.47	0.001224	0.0012241		0.00012241
U-238	1577.7894	253.12	0.160427	0.160427		0.016042699
			0.221948	0.2219482	**Total Dose:**	**0.02219481**

You have passed the terrestrial site screen

Site Description: **OLF - Exp Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Co-60	701.51249	1.65	0.002352	0.0023521		0.000235206
Th-232	1506.2472	0.47	0.000312	0.000312		3.12034E-05
U-234	5128.7595	4.71	0.000918	0.0009184		9.18351E-05
U-235	2834.7425	0.08	2.82E-05	2.822E-05		2.82213E-06
U-238	1577.7894	6.39	0.00405	0.00405		0.000404997
			0.007661	0.0076606	**Total Dose:**	**0.000766064**

You have passed the terrestrial site screen

Site Description: **S3 Ponds - Exp Conc**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Pu-239	6114.8886	0.02	3.27E-06	3.271E-06		3.27071E-07
Tc-99	4472.0781	3	0.000671	0.0006708		6.70829E-05
Th-232	1506.2472	0.55	0.000365	0.0003651		3.65146E-05
U-234	5128.7595	2.72	0.00053	0.0005303		5.30343E-05
U-235	2834.7425	0.16	5.64E-05	5.644E-05		5.64425E-06
U-238	1577.7894	5.56	0.003524	0.0035239		0.00035239
			0.00515	0.0051499	**Total Dose:**	**0.00051499**

You have passed the terrestrial site screen

Site Description: **Background Conc - Default Parameters**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Am-241	3879.413	0.058	1.5E-05	1.5E-05		1.5E-06
Cm-244	4.00E+03	3.5	8.60E-04	8.62E-04		8.75E-05
Cs-137	20.75723	1.4	0.067446	0.067446		0.006745
Pu-238	6114.889	0.1056	1.70E-05	1.73E-05		1.73E-06
Pu-239	6114.889	0.065	1.06E-05	1.06E-05		1.06E-06
Tc-99	4472.078	4.07	0.00091	0.00091		9.1E-05
Th-232	1506.247	2.75	0.001826	0.001826		0.000183
U-234	5128.759	3.2	0.000624	0.000624		6.24E-05
U-235	2834.742	0.24	8.47E-05	8.47E-05		8.47E-06
U-238	1577.789	2.6	0.001648	0.001648		0.000165
			0.072564	0.072564	**Total Dose:**	**0.007346**

You have passed the terrestrial site screen

APPENDIX B

BEAR CREEK VALLEY
GRADED APPROACH OUTPUT (SITE SPECIFIC PARAMETERS)

Terrestrial Organism Dose Estimates Using Maximum Soil Concentrations (Site Specific Parameters)

Site Description: TS6 - Max Conc (Site Specific Parameters)

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Am-241	9.648724	0.16	0.016583	0.016583		0.001658
Cs-137	670.4347	1.33	0.001984	0.001984		0.000198
Tc-99	22918.6	3.43	0.00015	0.00015		1.5E-05
Th-232	485.0744	1.91	0.003938	0.003938		0.000394
U-234	57136.2	30.36	0.000531	0.000531		5.31E-05
U-235	5187.704	1.92	0.00037	0.00037		3.7E-05
U-238	2098.109	60.72	0.02894	0.02894		0.002894
			0.052495	0.052495	**Total Dose:**	**0.00525**

You have passed the terrestrial site screen

Site Description: Burial Ground Max Conc (Site Specific Parameters)

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Co-60	701.5125	1.2	0.001711	0.001711		0.000171
Tc-99	22918.6	130	0.005672	0.005672		0.000567
Th-232	485.0744	1.1	0.002268	0.002268		0.000227
U-234	57136.2	5.8	0.000102	0.000102		1.02E-05
U-235	5187.704	0.04	7.71E-06	7.71E-06		7.71E-07
U-238	2098.109	36	0.017158	0.017158		0.001716
			0.026918	0.026918	**Total Dose:**	**0.002692**

You have passed the terrestrial site screen

Site Description: BY/BY Max Conc (Site Specific Parameters)

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Sr-90	1728.947	1.9	0.001099	0.001099		0.00011
Tc-99	22918.6	77	0.00336	0.00336		0.000336
Th-232	485.0744	1.9	0.003917	0.003917		0.000392
U-234	57136.2	260	0.004551	0.004551		0.000455
U-235	5187.704	17	0.003277	0.003277		0.000328
U-238	2098.109	880	0.419425	0.419425		0.041943
			0.435628	0.435628	**Total Dose:**	**0.043563**

You have passed the terrestrial site screen

Site Description: OLF - Max Conc (Site Specific Parameters)

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Co-60	701.5125	1.7	0.002423	0.002423		0.000242
Th-232	485.0744	0.72	0.001484	0.001484		0.000148
U-234	57136.2	14	0.000245	0.000245		2.45E-05
U-235	5187.704	0.7	0.000135	0.000135		1.35E-05
U-238	2098.109	22	0.010486	0.010486		0.001049
			0.014773	0.014773	**Total Dose:**	**0.001477**

You have passed the terrestrial site screen

Site Description: **Creekside - Max Conc (Site Specific Parameters)**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Am-241	9.648724	0.15	0.015546	0.015546		0.001555
Cs-137	670.4347	0.21	0.000313	0.000313		3.13E-05
Pu-238	4.361865	0.4488	1.00E-01	1.03E-01		0.010289
Pu-239	4.361865	0.1	0.022926	0.022926		0.002293
Tc-99	22918.6	3.43	0.00015	0.00015		1.5E-05
Th-232	485.0744	1.51	0.003113	0.003113		0.000311
U-234	57136.2	27.9	0.000488	0.000488		4.88E-05
U-235	5187.704	1.45	0.00028	0.00028		2.8E-05
U-238	2098.109	24.79	0.011815	0.011815		0.001182
			0.054631	0.054631	**Total Dose:**	**0.015752**

You have passed the terrestrial site screen

Site Description: **Road Side (diluted 1:4) - Max Conc (Site Specific Parameters)**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Cs-137	670.4347	1.19	0.001775	0.001775		0.000177
Pu-239	4.361865	0.05	0.011463	0.011463		0.001146
Tc-99	22918.6	18.74	0.000818	0.000818		8.18E-05
Th-232	485.0744	0.67	0.001381	0.001381		0.000138
U-234	57136.2	411.39	0.0072	0.0072		0.00072
U-235	5187.704	1.81	0.000349	0.000349		3.49E-05
U-238	2098.109	63.75	0.030385	0.030385		0.003038
			0.05337	0.05337	**Total Dose:**	**0.005337**

You have passed the terrestrial site screen

Site Description: **Road Side (undiluted) - Max Conc (Site Specific Parameters)**

Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Cs-137	670.4347	4.76	0.0071	0.0071		0.00071
Pu-239	4.361865	0.2	0.045852	0.045852		0.004585
Tc-99	22918.6	74.96	0.003271	0.003271		0.000327
Th-232	485.0744	2.68	0.005525	0.005525		0.000552
U-234	57136.2	1645.56	0.028801	0.028801		0.00288
U-235	5187.704	7.24	0.001396	0.001396		0.00014
U-238	2098.109	255	0.121538	0.121538		0.012154
			0.213482	0.213482	**Total Dose:**	**0.021348**

You have passed the terrestrial site screen

Terrestrial Organism Dose Estimates Using RI Exposure Concentrations (Site Specific Parameters)

Site Description: **TS6 - RI Exp Conc (Site Specific Parameters)**
Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Am-241	9.648724	0.16	0.016583	0.016583		0.001658
Cs-137	670.4347	1.33	0.001984	0.001984		0.000198
Tc-99	22918.6	3.43	0.00015	0.00015		1.5E-05
Th-232	485.0744	1.91	0.003938	0.003938		0.000394
U-234	57136.2	30.36	0.000531	0.000531		5.31E-05
U-235	5187.704	1.92	0.00037	0.00037		3.7E-05
U-238	2098.109	60.72	0.02894	0.02894		0.002894
			0.052495	0.052495	**Total Dose:**	**0.00525**

You have passed the terrestrial site screen

Site Description: **Burial Ground - RI EXP Conc (Site Specific Parameters)**
Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Co-60	701.5125	1.2	0.001711	0.001711		0.000171
Tc-99	22918.6	15.88	0.000693	0.000693		6.93E-05
Th-232	485.0744	0.45	0.000928	0.000928		9.28E-05
U-234	57136.2	1.39	2.43E-05	2.43E-05		2.43E-06
U-235	5187.704	0.04	7.71E-06	7.71E-06		7.71E-07
U-238	2098.109	5.19	0.002474	0.002474		0.000247
			0.005837	0.005837	**Total Dose:**	**0.000584**

You have passed the terrestrial site screen

Site Description: **BY/BY - RI Exp Conc (Site Specific Parameters)**
Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Sr-90	1728.947	0.57	0.00033	0.00033		3.3E-05
Tc-99	22918.6	35.61	0.001554	0.001554		0.000155
Th-232	485.0744	0.61	0.001258	0.001258		0.000126
U-234	57136.2	136.31	0.00240	0.00239		0.000239
U-235	5187.704	3.47	0.000669	0.000669		6.69E-05
U-238	2098.109	253.12	0.120642	0.120642		0.012064
			0.126838	0.126838	**Total Dose:**	**0.012684**

You have passed the terrestrial site screen

Site Description: **OLF - RI Exp Conc (Site Specific Parameters)**
Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Co-60	701.5125	1.65	0.002352	0.002352		0.000235
Th-232	485.0744	0.47	0.000969	0.000969		9.69E-05
U-234	57136.2	4.71	8.24E-05	8.24E-05		8.24E-06
U-235	5187.704	0.08	1.54E-05	1.54E-05		1.54E-06
U-238	2098.109	6.39	0.003046	0.003046		0.000305
			0.006464	0.006464	**Total Dose:**	**0.000646**

You have passed the terrestrial site screen

Terrestrial Organism Dose Estimates Using Mean Soil Concentrations (Site Specific Parameters)

Site Description: **TS6 - Mean Conc (Site Specific Parameters)**
Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Am-241	9.648724	0.1	0.010364	0.010364		0.001036
Cs-137	670.4347	0.92	0.001372	0.001372		0.000137
Tc-99	22918.6	3.06	0.000134	0.000134		1.34E-05
Th-232	485.0744	1.4	0.002886	0.002886		0.000289
U-234	57136.2	19.5 5	0.000342	0.000342		3.42E-05
U-235	5187.704	1.21	0.000233	0.000233		2.33E-05
U-238	2098.109	39.0 3	0.018602	0.018602		0.00186
			0.033934	0.033934	**Total Dose:**	**0.003393**

You have passed the terrestrial site screen

Site Description: **Burial Ground - Mean Conc (Site Specific Parameters)**
Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Co-60	701.5125	1.67	0.002381	0.002381		0.000238
Tc-99	22918.6	8.28	0.000361	0.000361		3.61E-05
Th-232	485.0744	0.38	0.000783	0.000783		7.83E-05
U-234	57136.2	0.93	1.63E-05	1.63E-05		1.63E-06
U-235	5187.704	0.03	5.78E-06	5.78E-06		5.78E-07
U-238	2098.109	3.03	0.001444	0.001444		0.000144
			0.004991	0.004991	**Total Dose:**	**0.000499**

You have passed the terrestrial site screen

Site Description: **BY/BY - Mean Conc (Site Specific Parameters)**
Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Sr-90	1728.947	0.32	0.000185	0.000185		1.85E-05
Tc-99	22918.6	21.9	0.000956	0.000956		9.56E-05
Th-232	485.0744	0.41	0.000845	0.000845		8.45E-05
U-234	57136.2	95.2	0.001666	0.001666		0.000167
U-235	5187.704	2.25	0.000434	0.000434		4.34E-05
U-238	2098.109	149	0.071016	0.071016		0.007102
			0.075102	0.075102	**Total Dose:**	**0.00751**

You have passed the terrestrial site screen

Site Description: **OLF - Mean Conc (Site Specific Parameters)**
Terrestrial System Data Entry/BCG Worksheet

Limits in Std Units

Nuclide	Soil Limit pCi/g	Site Data	Partial Fraction	Water & Soil Sum of Fractions		Dose Rate (Rad/day)
Co-60	701.5125	1.08	0.00154	0.00154		0.000154
Th-232	485.0744	0.36	0.000742	0.000742		7.42E-05
U-234	57136.2	2.55	4.46E-05	4.46E-05		4.46E-06
U-235	5187.704	0.04	7.71E-06	7.71E-06		7.71E-07
U-238	2098.109	3.35	0.001597	0.001597		0.00016
			0.003931	0.003931	**Total Dose:**	**0.000393**

You have passed the terrestrial site screen

APPENDIX C

TRA PONDS
GRADED APPROACH OUTPUT (DEFAULT PARAMETERS)

Terrestrial Organism Dose Estimates Using Maximum Soil and UCL 95 Water Concentrations (Casey 90 Max Soil & UCL 95 water - decay corrected)

	Water, Terrestrial Systems			Soil			Water &
	Water Limit	Site Data	Partial	Limit	Site	Partial	Soil Sum
Nuclide	pCi/L	Data	Fraction	pCi/g	Data	Fraction	of Fractions
Am-241	2.00E+05			4.00E+03	4.783	1.20E-03	1.23E-03
Ce-144	3.00E+06	6.10E+03	2.10E-03	1.00E+03			2.14E-03
Cs-137	6.00E+05	2.88E+03	4.80E-03	2.00E+01	17944.25	8.60E+02	8.64E+02
Co-60	1.00E+06	6.60E+03	5.50E-03	7.00E+02	18067.19	2.60E+01	2.58E+01
Eu-154	2.00E+06			1.00E+03	64.063	5.00E-02	5.03E-02
Eu-155	3.00E+07			2.00E+04	39.143	2.50E-03	2.47E-03
I-131	2.00E+06	1.96E+04	1.00E-02	9.00E+02			1.05E-02
Pu-238	2.00E+05			6.00E+03	11.067	1.80E-03	1.81E-03
Pu-239	2.00E+05			6.00E+03	11.408	1.90E-03	1.87E-03
Sr-90	5.00E+04			2.00E+01	0.997	4.40E-02	4.43E-02
Th-232	5.00E+04			2.00E+03	1.44	9.60E-04	9.56E-04
U-234	4.00E+05			5.00E+03	3.56	6.90E-04	6.94E-04
U-238	4.00E+05			2.00E+03	1.26	8.00E-04	7.99E-04
Zn-65	2.00E+05	6.50E+02	3.70E-03	4.00E+02			3.75E-03
Zr-95	2.00E+06	1.04E+03	4.70E-04	1.00E+03			4.71E-04
Cr-51	1.00E+08	2.90E+06	2.90E-02	5.00E+04			2.92E-02
Ce-141	2.00E+07	1.16E+04	7.40E-04	8.00E+03			7.42E-04
Cs-134	3.00E+05	9.20E+02	3.10E-03	1.00E+01	4582.01	4.50E+02	4.46E+02
Se-75	9.00E+06	4.70E+02	5.00E-05	5.00E+03			4.96E-05
Cm-244	2.00E+05			4.00E+03	4.719	1.20E-03	1.16E-03
Co-58	3.00E+06	1.24E+03	4.00E-04	2.00E+03			4.01E-04
Eu-152	3.00E+06			2.00E+03	23.14	1.50E-02	1.52E-02
			6.06E-02			1.34E+03	1.34E+03

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Terrestrial Organism Dose Estimates Using Average Soil and Water Concentrations

Site Description: **Casey 90 Avg Soil & Water - decay corrected**

	Water, Terrestrial Systems			Soil			Water &
	Water Limit	Site Data	Partial	Limit	Site	Partial	Soil Sum
Nuclide	pCi/L	Data	Fraction	pCi/g	Data	Fraction	of Fractions
Am-241	2.00E+05			4.00E+03	3.095	8.00E-04	7.98E-04
Ce-144	3.00E+06	4.50E+03	1.60E-03	1.00E+03			1.58E-03
Cs-137	6.00E+05	2.78E+03	4.60E-03	2.00E+01	10621.41	5.10E+02	5.12E+02
Co-60	1.00E+06	6.20E+03	5.20E-03	7.00E+02	11647.61	1.70E+01	1.66E+01
Eu-154	2.00E+06			1.00E+03	35.613	2.80E-02	2.80E-02
Eu-155	3.00E+07			2.00E+04	26.269	1.70E-03	1.66E-03
I-131	2.00E+06	1.84E+04	9.80E-03	9.00E+02			9.84E-03
Pu-238	2.00E+05			6.00E+03	5.555	9.10E-04	9.08E-04
Pu-239	2.00E+05			6.00E+03	6.695	1.10E-03	1.09E-03
Sr-90	5.00E+04			2.00E+01	0.602	2.70E-02	2.68E-02
Th-232	5.00E+04			2.00E+03	1.337	8.90E-04	8.88E-04
U-234	4.00E+05			5.00E+03	2.3	4.50E-04	4.48E-04
U-238	4.00E+05			2.00E+03	1.183	7.50E-04	7.50E-04
Zn-65	2.00E+05	5.90E+02	3.40E-03	4.00E+02			3.40E-03
Zr-95	2.00E+06	9.60E+02	4.30E-04	1.00E+03			4.34E-04
Cr-51	1.00E+08	2.50E+06	2.50E-02	5.00E+04			2.52E-02
Ce-141	2.00E+07	9.40E+03	6.00E-04	8.00E+03			6.01E-04
Cs-134	3.00E+05	8.60E+02	2.90E-03	1.00E+01	1236.164	1.20E+02	1.20E+02
Se-75	9.00E+06	4.30E+02	4.50E-05	5.00E+03			4.54E-05
Cm-244	2.00E+05			4.00E+03	2.85	7.00E-04	7.02E-04
Co-58	3.00E+06	1.12E+03	3.60E-04	2.00E+03			3.62E-04
Eu-152	3.00E+06			2.00E+03	13.779	9.10E-03	9.05E-03
			5.41E-02			6.47E+02	6.49E+02

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APPENDIX D

TRA PONDS
GRADED APPROACH OUTPUT (SITE-SPECIFIC PARAMETERS)

Terrestrial Organism Estimates Using Maximum Soil and UCL95 Water Concentrations
(Site Specific Parameters)

	Water, Terrestrial Systems			Soil			Water &
Nuclide	Water Limit pCi/L	Site Data Data	Partial Fraction	Limit pCi/g	Site Data	Partial Fraction	Soil Sum of Fractions
Am-241	2.00E+05			5.00E+03	4.783	9.00E-04	9.00E-04
Ce-144	3.00E+06	6.10E+03	2.10E-03	1.00E+03			2.13E-03
Cs-137	6.00E+05	2.88E+03	4.80E-03	2.00E+03	17944.251	7.50E+00	7.49E+00
Co-60	1.00E+06	6.60E+03	5.50E-03	7.00E+02	18067.188	2.40E+01	2.45E+01
Eu-154	2.00E+06			1.00E+03	64.063	5.00E-02	5.03E-02
Eu-155	3.00E+07			2.00E+04	39.143	2.50E-03	2.47E-03
I-131	7.00E+06	1.96E+04	2.80E-03	9.00E+02			2.80E-03
Pu-238	2.00E+05			4.00E+03	11.067	3.10E-03	3.08E-03
Pu-239	2.00E+05			6.00E+03	11.408	1.90E-03	1.86E-03
Sr-90	5.00E+04			2.00E+01	0.997	4.40E-02	4.43E-02
Th-232	5.00E+04			2.00E+03	1.44	9.60E-04	9.56E-04
U-234	4.00E+05			5.00E+03	3.56	6.90E-04	6.94E-04
U-238	4.00E+05			2.00E+03	1.26	8.00E-04	7.99E-04
Zn-65	5.00E+06	6.50E+02	1.20E-04	4.00E+02			1.23E-04
Zr-95	2.00E+06	1.04E+03	4.70E-04	1.00E+03			4.71E-04
Cr-51	1.00E+08	2.90E+06	2.70E-02	5.00E+04			2.71E-02
Ce-141	2.00E+07	1.16E+04	7.40E-04	8.00E+03			7.36E-04
Cs-134	3.00E+05	9.20E+02	3.10E-03	1.00E+03	4582.01	4.10E+00	4.12E+00
Se-75	9.00E+06	4.70E+02	5.20E-05	5.00E+03			5.18E-05
Cm-244	2.00E+05			4.00E+03	4.719	1.30E-03	1.28E-03
Co-58	3.00E+06	1.24E+03	4.00E-04	2.00E+03			4.01E-04
Eu-152	3.00E+06			2.00E+03	23.14	1.50E-02	1.52E-02
			4.72E-02			3.60E+01	3.62E+01

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Terrestrial Organism Dose Estimates Using Average Soil and Water Concentrations (Site Specific)

	Water, Terrestrial Systems			Soil			Water &
	Water Limit	Site Data	Partial	Limit	Site	Partial	Soil Sum
Nuclide	pCi/L	Data	Fraction	pCi/g	Data	Fraction	of Fractions
Am-241	2.00E+05			5.00E+03	3.095	5.80E-04	5.82E-04
Ce-144	3.00E+06	4.50E+03	1.60E-03	1.00E+03			1.57E-03
Cs-137	6.00E+05	2.78E+03	4.60E-03	2.00E+03	10621.41	4.40E+00	4.43E+00
Co-60	1.00E+06	6.20E+03	5.20E-03	7.00E+02	11647.61	1.60E+01	1.58E+01
Eu-154	2.00E+06			1.00E+03	35.613	2.80E-02	2.80E-02
Eu-155	3.00E+07			2.00E+04	26.269	1.70E-03	1.66E-03
I-131	7.00E+06	1.84E+04	2.60E-03	9.00E+02			2.62E-03
Pu-238	2.00E+05			4.00E+03	5.555	1.50E-03	1.55E-03
Pu-239	2.00E+05			6.00E+03	6.695	1.10E-03	1.09E-03
Sr-90	5.00E+04			2.00E+01	0.602	2.70E-02	2.68E-02
Th-232	5.00E+04			2.00E+03	1.337	8.90E-04	8.88E-04
U-234	4.00E+05			5.00E+03	2.3	4.50E-04	4.48E-04
U-238	4.00E+05			2.00E+03	1.183	7.50E-04	7.50E-04
Zn-65	5.00E+06	5.90E+02	1.10E-04	4.00E+02			1.12E-04
Zr-95	2.00E+06	9.60E+02	4.30E-04	1.00E+03			4.34E-04
Cr-51	1.00E+08	2.50E+06	2.30E-02	5.00E+04			2.33E-02
Ce-141	2.00E+07	9.40E+03	6.00E-04	8.00E+03			5.96E-04
Cs-134	3.00E+05	8.60E+02	2.90E-03	1.00E+03	1236.164	1.10E+00	1.11E+00
Se-75	9.00E+06	4.30E+02	4.70E-05	5.00E+03			4.74E-05
Cm-244	2.00E+05			4.00E+03	2.85	7.70E-04	7.74E-04
Co-58	3.00E+06	1.12E+03	3.60E-04	2.00E+03			3.62E-04
Eu-152	3.00E+06			2.00E+03	13.779	9.10E-03	9.05E-03
			4.18E-02			2.10E+01	2.14E+01
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