PRELIMINARY SITE-SPECIFIC DERIVED CONCENTRATION GUIDELINE LEVELS

FOR THE HAMMOND DEPOT HAMMOND, INDIANA

Prepared by

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TERMS, ACRONYMS, AND ABBREVIATIONS

AEC	Atomic Energy Commission
ALARA	As Low As Reasonably Achievable
ANL	Argonne National Laboratory
bgs	below ground surface
cm	centimeters
DCGL	Derived Concentration Guideline Level
$dpm/100cm^2$	disintegrations per minute per 100 square centimeters
DLA	Defense Logistics Agency
DNSC	Defense National Stockpile Center
DSR	dose-to-source ratio
EPA	Environmental Protection Agency
ESSAP	Environmental Survey and Site Assessment Program
FSS	final status survey
HD	Hammond Depot
HSA	Historical Site Assessment
Impacted Area	Any area that is not classified as non-impacted; areas with a possibility of containing residual radioactivity in excess of natural background or fallout levels.
m	meter
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	minimum detectable concentration
mR/h	milliroentgen per hour
μR/h	microroentgen per hour
Non-Impacted Area	Area where there is no reasonable possibility (extremely low probability) of residual contamination.
NRC	U.S. Nuclear Regulatory Commission
NTS	Nevada Test Site
NUREG	Nuclear Regulatory
ORISE	Oak Ridge Institute for Science and Education
ORNL	Oak Ridge National Laboratory
pCi/g	picocuries per gram
RESRAD	RESidual RADioactvity – a dose assessment (computer) model for deriving site-specific soil guidelines.
RESRAD-BUILD	RESidual RADioactvity BUILDing – a dose assessment (computer) model for deriving site-specific building guidelines.
SML	Source Material License
TEDE	total effective dose equivalent
ThN	thorium nitrate
U_{nat}	natural uranium
wt%	weight percent

EXECUTIVE SUMMARY

The Hammond Depot (HD) site, located in Hammond, Indiana, is terminating its source material license (SML) issued by the U.S. Nuclear Regulatory Commission (NRC). The NRC license allowed for the storage of naturally-occurring radioactive materials, including thorium and uranium.[1] As a step in the license termination process, Derived Concentration Guideline Levels (DCGLs) must be determined to provide clean-up levels that satisfy regulatory requirements. This report presents preliminary DCGLs for use during the site radiological characterization activities to be conducted in 2006.

For this analysis, the NRC regulatory endpoint for the *total effective dose equivalent*, TEDE, was set to 25 mrem (1000-year peak dose) above background in accordance with 10CFR20.1402. A thorough environmental assessment was conducted to extract information from project records and prior site environmental studies in order to establish representative exposure pathways from residual radioactivity (as defined by the average member of the critical group). Using careful engineering judgment and assessment of the literature as well as correspondence with on-site operations personnel, the computational model was parameterized with relevant site-specific terms.

The most current deterministic and probabilistic RESRAD (Version 6.3) and RESRAD-BUILD (Version 3.3) computer codes developed by the Argonne National Laboratory (ANL) were used for soil and building assessments, respectively. Model outputs were evaluated first to ensure that physical conditions and mathematical terms were consistent and second by statistical sensitivity and uncertainty analyses to ensure that important exposure pathways were not overlooked. Parameters that were identified during the engineering assessment or the mathematical model phases were reassessed and analyzed in an iterative fashion to ensure completeness of the reported results.

Using the most realistically conservative models allowed within the context of the computer models, the DCGLs computed for HD are:

1. Soil, 3.4 pCi/g (picocuries per gram) Th-232 and decay products; and 2.8 pCi/g U-238/U-235 and decay products (residential farmer scenario); and

2. Building, 400 disintegrations per minute per one hundred square centimeters (dpm/100 cm^2) Th-232 and decay products; and 800 dpm/100 cm^2 U-238/U-235 and decay products (warehouse worker scenario).

A complete description of the methodology, including an assessment of the input parameters, model inputs, and results is provided in this report. The overall approach to the DCGL determination was to adopt a reasonable, yet conservative approach to the analysis, in accordance with the guidance provided in several NUREG documents.

[1] Prior to receipt and storage at the HD, thorium nitrate was domestically processed and extracted from monazite sands from 1959 to 1964. At the time of processing, ^{232}Th decay products were removed. Since the time of processing, all decay products have grown in and are in secular equilibrium with the parent, ^{232}Th. Thus, the thorium is *effectively* non-processed, natural thorium. The uranium isotopic distribution is also equivalent to natural uranium, with a weight fraction of ^{235}U equal to 0.0071.

1.0 INTRODUCTION

The Defense National Stockpile Center (DNSC) of the Defense Logistics Agency (DLA) is in the process of closing out many of its depots across the country and seeking to terminate its U.S. Nuclear Regulatory Commission (NRC) license at those facilities. Hammond Depot (HD) is one of the facilities slated for license termination. Hammond Depot stores various stockpiled ores and metals such as chrome, ferrochrome, ferromanganese, lead, tin, among others, but no radioactive materials were stored on the outdoor pads. Some of the commodities stored at the Hammond Depot—thorium nitrate (ThN), monazite sands, columbium tantalum and sodium sulfate—are radioactive materials and are listed on the DNSC's NRC source material license STC-133 that permits the storage of uranium and thorium. The NRC license was amended in 2000 to conduct site cleanup activities, underway since 2004, with the initial activities being removal of the ThN drums, accomplished in mid-2005. The other licensed materials had not been stored since 1999.

Hammond Depot was used for storing drummed and containerized stockpiled materials. Per its NRC license, no material processing was performed. All stored radioactive materials were naturally occurring. As a result, the graded approach to site cleanup is relatively straightforward: remove the containerized source material, perform scoping surveys to identify any unknown and unanticipated areas of elevated residual radioactivity; determine concentration limits for cleanup; conduct a radiological site characterization against the concentration limits to identify areas if any, requiring remediation; and finally, conduct a final status survey. Because of the simplicity in the Hammond Depot operation, the license termination process is substantially less complicated than for sites where radioactive materials were either processed, chemically-separated, naturally enhanced, enriched, or otherwise involved in the use of special nuclear materials or fission products. For a complete environmental assessment and description of the DNSC project, as it relates to the environmental assessment of HD for handling and disposition of stored thorium nitrate (ThN), refer to "Environmental Assessment: Disposition of Thorium Nitrate" (DLA 2003).

Through the process of terminating the license, Oak Ridge National Laboratory (ORNL) directed the effort to remove and disposition all previously stored radioactive materials (Hylton 2003); the Oak Ridge Institute for Science and Education (ORISE) has performed a Historical Site Assessment (HSA) (Bauer and Vitkus 2005) and a preliminary scoping survey with associated planning documents to identify site radiological conditions and validate the results of the HSA (Vitkus 2005).

Results of the ORISE scoping surveys identified low-level concentrations of Th-232 that were approximately twice background in soil samples from the burn cage area. Extensive contamination was particularly noted on the floor of Building 200E, and isolated suspect contamination was identified in Building 100W. Two unexpected findings were noted, including contaminated pallets found in Building 100E and jars of source material found in the northwest corner storage room of Building 200E. Supporting the HSA and the scoping survey results will be a detailed ORISE characterization survey of soils and buildings planned for 2006. The DCGLs described within this report will be used for the

characterization survey and the final status survey (FSS) to declare the site as having met the requirements established for allowable residual radioactivity by the NRC (10 CFR 20.1402). Formulation of the DCGLs is an important step in the overall release of the site for unrestricted use and subsequent termination of the license.

1.1. Purpose

The purpose of the analyses presented in this report is to provide site-specific derived concentration guideline levels (DCGLs) in support of the follow-on radiological characterization and FSS to demonstrate that the site can be released for unrestricted use, and accordingly, the NRC license terminated. Specifically, when the DCGLs are applied to the final status survey and the final survey results show that the DCGLs have been satisfied, the following requirements of 10CFR20.1402 are met:

> "**Title 10 CFR 20.1402:** *Radiological criteria for unrestricted use*. A site will be considered acceptable for unrestricted use if the residual radioactivity that is distinguishable from background radiation results in a TEDE to an average member of the critical group that does not exceed 25 mrem (0.25 mSv) per year, including that from groundwater sources of drinking water, and that the residual radioactivity has been reduced to levels that are as low as reasonably achievable (ALARA). Determination of the levels which are ALARA must take into account consideration of any detriments, such as deaths from transportation accidents, expected to potentially result from decontamination and waste disposal."

In addition to 10 CFR 20 requirements, several Nuclear Regulatory (NUREG) documents, including NUREG-1757, Volume 2, Appendix I and NUREG/CR-5512, Volumes 3 and 4, were used as important guidance and reference documents in this dose assessment report and the determination of DCGLs.

1.2. Scope

A site-specific DCGL analysis for the Hammond Depot is presented, including a review of the site-specific environmental parameters that drive the analysis, the methodology used for calculating the numeric limits, and results of the sensitivity and uncertainty analysis performed to ensure that no single lumped parameter, or multiple parameters, were overlooked in the model equations as it pertains to the environmental transport of residual contaminants and the resulting dose at the receptor. The analysis applies to both soil and representative buildings. The analysis applies to the site radioactive contaminants: natural thorium and natural uranium.

1.3. Introduction to the Approach

This report is organized into six sections: 1) Introduction; 2) Methods used to determine DCGLs for natural thorium and uranium; 3) Site history and description from which model parameters were selected; 4) Determination of the DCGLs; 5) Results; and 6) Summary and Conclusions. References associated with site-specific operational and environmental factors are presented in conjunction with methodology references. In addition, appendices are provided that contain both the specifically chosen input parameters to the computer codes and the code input/output results.

Having established the regulatory-driven, 25 mrem limit (TEDE) as the allowable endpoint, DCGLs were determined to correspond to that value of activity concentration, pCi/g in soil or dpm/100cm^2 for a building surface, that would predict a 1000-y peak annual dose to the average member of the critical group, for both natural thorium and uranium.

A key component in the analysis is the parameterization of the model equations. The DCGL determination for both soil and structures was aided by reviews of site records and available references, and information gathered during the conduct of a HSA by ORISE that included interviews with facility staff and the follow-on conduct of an ORISE scoping survey in 2005. A thorough environmental engineering assessment was conducted to carefully review and determine an appropriate input for each parameter into the computer codes.

The resident farmer scenario was selected as the conceptual site model for its conservatism in this dose assessment. While the site is located in an industrial area and may remain that way following license termination (leaving the use of the site for farming purposes unrealistic), uncertainty in this conclusion especially as it regards use of the site hundreds of the years in the future, resulted in the selection of the resident farmer scenario rather than industrial or recreational alternatives. The resident farmer and his family are assumed to move onto the site after release for unrestricted use, build a house, grow crops, and raise livestock for consumption. The resident farmer family constitutes the critical population group and a reasonable (credible) scenario.

The most current deterministic and probabilistic RESRAD (Version 6.3) and RESRAD-BUILD (Version 3.3) computer codes developed by the Argonne National Laboratory (ANL) were used for soil and building assessments, respectively. For soils, all pathways, with the exception of the radon pathway, were utilized to add conservatism to the dose assessment. Both deterministic and probabilistic evaluations were performed. Contamination was assumed to be limited to the top 15 centimeters (cm) of soil based on an evaluation of the site history, including anticipated mobility of thorium in the environment and ORISE preliminary (scoping) radiological survey results. For purposes of the dose assessment, principal radionuclides and decay products were mathematically treated assuming secular equilibrium. Site-specific parameters, when available, were utilized as input to both computer codes; NRC (NUREGs) and RESRAD and RESRAD-BUILD default values were otherwise used with preference given to NRC values.

Unit (normalized) concentrations of one pCi/g for each of the site's radionuclides of concern were used for the RESRAD evaluations. This approach provided dose-to-source ratios (DSRs), i.e., dose per unit activity (mrem/y per pCi/g) factors, calculated for exposed individuals over a 1000 year time period. The DSRs represent maximum doses—a conservative approach since peak doses for specific radionuclides often occur at different times. The DSRs were divided into the primary dose limit, resulting in a DCGL for that radionuclide in units of pCi/g.

Other measures of conservatism in the DCGL determination for soil included using the groundwater pathway as an "active" pathway, taking no credit for the potential of diluting any contaminated soils with a clean soil cover during remedial activities, and selecting the mass balance model for the placement of a hypothetical well in the contaminated zone. No evidence of radiological groundwater contamination has been identified to date. Of particular note, groundwater has not been used by the city of Hammond for drinking water purposes since 1920 (Bauer and Vitkus 2005). Therefore, it can be contended that keeping the drinking water pathway "active" is overly conservative, resulting in lower DCGLs (especially for uranium) and an unrealistic result. Nonetheless, for the purpose of providing preliminary DCGLs, the drinking water pathway was not suppressed in this evaluation. Consideration should be given to modifying this approach as warranted for future site remediation activities.

One exception to the conservative approach, which nonetheless validated the external radiation pathway as the predominant pathway of interest for thorium radionuclides, was the impact of the external gamma shielding factor and associated outdoor/indoor fractions on the results. While NRC (NUREG) values were incorporated as inputs to the code for the external radiation assessment (resulting in a reasonable, but non-conservative outcome), it was noted that even the use of default RESRAD inputs for thorium results in a significant outcome.

The RESRAD evaluation was supported by accompanying sensitivity and uncertainty analyses which examined the model input parameters in comparison to the intake assumptions for the receptor. The results validated that external dose from gamma radiation is the predominant contributor to the dose received at this site due to the presence of natural thorium. The water dependent pathway for uranium was also identified as an important pathway which reduced the magnitude of the resulting uranium DCGL value. However, the subsurface soil layer composition onsite is primarily comprised of high pH industrial slag overlying the fine sand and silt aquifer (Bayless 1998) and the trace quantities of uranium relative to thorium at the site minimize the effect of the water pathway in a practical sense. All other pathways and radionuclide contributors are considerably less significant.

The RESRAD-BUILD assessment utilized the "Warehouse Worker" scenario. While this may not appear "equivalent" to the soil scenario, this method enabled a similar, more conservative approach to the determination of thorium and uranium DCGLs. Conservative factors introduced into the RESRAD-BUILD evaluation included the modeling of rooms with physical dimensions much smaller than the actual size of the existing onsite warehouse (to reduce the effect of dilution as it pertains to resuspension)

and using the default (low) RESRAD-BUILD value for building ventilation. Unit dose factors, in mrem/y per pCi/m^2, were determined for the RESRAD-BUILD evaluation. To determine the preliminary thorium and uranium DCGLs, unit dose factors were divided into the primary dose limit and then converted into typical field units of dpm/100cm^2.

The final set of DCGLs was determined using an iterative process. Model-driven, site-specific parameterization was performed. Analyses were run and engineering judgment was used to evaluate the application of the model against selected parameters. Deterministic sensitivity analyses were performed to ensure that no single parameter (or group of five parameters) would have a significant impact on the results. Probabilistic uncertainty analyses were performed as a last step to ensure that no obvious errors were made on model inputs. And finally, DCGL results were discussed with the measurement team to ensure that no particularly extensive measures would need to be taken in order to develop an acceptable radiological measurement and characterization plan, for which the selected "conservative" model parameters would need to be more accurately defined.

2.0 METHODS

One critical element in the decommissioning process that leads to the successful termination of the NRC license is the development of site-specific DCGLs. Within the context of NUREG-1757, the licensee demonstrates compliance with the release criterion through a three-step process:

1) Translating the cleanup criterion (e.g. 25 mrem/y, 10 CFR20.1402) into DCGLs with units of pCi/g in soil or dpm/100 cm^2 on building surfaces;

2) Measuring the levels of residual contamination on the site; and

3) Determining that the data obtained from the measurement sampling effort ensures that the release criterion is met.

This process is presented in the MARSSIM manual, and depicted in Figure 1 below. *This report conveys the result of the DCGL modeling effort conducted as part of Step 1, the "translate" process.*

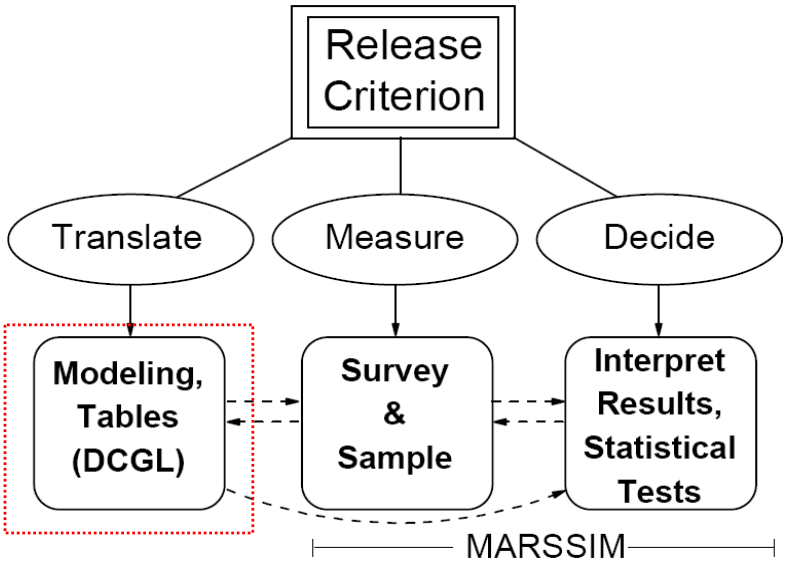

Figure 1 – Illustration of the MARSSIM Process for Site Decommissioning and License Termination.

Providing site-specific DCGLs upon which to release the site is a three step, iterative process. First a thorough environmental engineering assessment is made of the site to identify relevant parameters and parameter values for the computational analysis. Second, results of the engineering analysis and evaluation of site environmental parameters are input into a computational model that provides a deterministic result for the receptor dose (average member of the critical group) as a function of time. Third, a sensitivity/uncertainty analysis is performed to evaluate the results of the model equations and the sensitivity of specific environmental parameters for the site to ensure the most realistic and scientifically plausible parameter values were used. The iterative process ensures that the results presented from the computer model reflect actual environmental conditions of the site as much as practicable and more importantly, assure decision makers that no single lumped parameter that is of interest in the model is overlooked in the description and physical transport of the material.

2.1 Environmental Engineering Assessment for Model Parameterization

One of the key objectives in this report is to describe the specific process that was performed to provide a realistically conservative and credible assessment of the DCGL determination. As noted in Section 2.0, that process begins with an "environmental engineering assessment" involving a thorough and careful evaluation of existing environmental conditions, anticipated or realistic future use of the site, and how the actual site conditions were evaluated to provide the resultant inputs to the RESRAD codes used within the framework of the computational model. The computational model approach is described in Section 2.2.

Due to the nature of licensed activities at the site which only authorized storage and packaging of various ores and commodities, such as ThN in drums, and the results of the ORISE HSA and scoping surveys, soil contamination, if present, is believed to be restricted to soil depths of well less than one meter (likely in the 0.15 meter range) based on preliminary field assessments by ORISE (Vitkus December 2005) . No evidence of radiological groundwater contamination has been identified to date. Further validation of these conclusions will be provided during the 2006 ORISE characterization survey.

The resident farmer scenario was selected as the conceptual site model due to its inherent conservatism. While the site is located in an industrial area and may remain that way following license termination (leaving the use of the site for farming purposes unrealistic), uncertainty in this conclusion especially as it regards use of the site hundreds of the years in the future, resulted in the selection of the resident farmer scenario rather than industrial or recreational alternatives. The resident farmer and his family are assumed to move onto the site after release for unrestricted use, build a house, grow crops, and raise livestock for consumption. The resident farmer family constitutes the critical population group and a credible upper-bound scenario.

The conclusion of the engineering assessment resulted in a series of input parameters to the RESRAD codes for soil and buildings. The RESRAD input parameters with

corresponding information in the input/output files for the thorium and uranium DCGL determinations are captured in Appendices A and B. Appendix A provides a parameter-by-parameter assessment, including a complete rationale for parameter value assessment and selection. The review of the available literature, discussions with personnel familiar with the site, and prior field activities resulted in the use of several, but overall limited, site-specific parameters. While site-specific parameters are preferred for enhanced site-specific models, the RESRAD manual notes that it is not feasible to completely characterize transport and exposure processes to achieve improved modeling. In addition, the HD cannot be considered a complex site based on historical site activities and NRC's designation of decommissioning groups in NUREG-1757, Vol. 1 (Smith et al. 2003). Therefore, in many cases, the use of default parameters was considered acceptable, considering many of the parameters evaluated during the DCGL determination (through the use of sensitivity analyses) did not significantly impact the results. The exposure pathway of most significance for the predominant thorium radionuclides was external gamma radiation.

Many of the factors specified particularly in the RESRAD code can require the use of either intensive field or empirical determinations to establish site-specific inputs. The nature of site operations at the HD has not warranted the determination of many of these parameters to date, especially for those related to groundwater contamination and dietary/non-dietary inputs. In these cases, either NUREG or RESRAD defaults were considered adequate. This approach has been validated in part through a comparison of a RESRAD evaluation for thorium (the predominant element) using only default values and separate evaluations where sensitivity and uncertainty analyses were conducted using default parameters in place of other values. The resultant DCGLs were typically unaffected. One exception to this which validated the external radiation pathway as the predominant pathway of interest for thorium radionuclides was the impact of the external gamma shielding factor and associated outdoor/indoor fractions on the results. While NRC (NUREG) values were incorporated as inputs to the code for the external radiation assessment (resulting in a reasonable, but non-conservative outcome), it was noted that even the use of default RESRAD inputs for thorium results in a significant outcome.

Further discussion of the parameters used in the dose modeling effort and the justification for them is provided in Section 4. This includes several parameters considered to have special relevance to this effort. Of these, special attention is paid to the impact of soil types and hydraulic conductivity parameters on the selection of distribution (partition) coefficients (K_d) for this site. The results of this evaluation determined that the K_d selections for thorium for different soil types did not influence the results of the RESRAD output on the proposed DCGL.

Input parameters for the RESRAD-BUILD thorium and uranium dose assessments and corresponding input/output files are cited in Appendices C and D.

2.2 Computational Modeling

A conceptual site model was developed to correspond to available computer codes for performing dose assessments. RESRAD for Windows, Version 6.3, was used to evaluate the environmental transport mechanisms and resulting dose to receptor calculations from residual contaminated soil (Yu 2005). RESRAD-BUILD for Windows, Version 3.3, was used to evaluate the corresponding transport mechanisms and dose to receptor calculations from residual contamination on building surfaces (Yu 2005). For this analysis, the radiological source term was established on the basis of historical sample analyses of the stockpiled material and the waste stream certification submittals to the Nevada Test Site low-level waste facility (Hylton 2003 and Terry 2003). The contaminant source term was normalized per unit activity concentration for soil (pCi/g) and surface activity per unit area (dpm/100cm^2) for building surfaces to calculate the resulting dose to a receptor over a thousand year period. Parameterization of the model was evaluated through the engineering assessment described in Section 2.1. Models were tested and parameters were evaluated by both deterministic sensitivity analysis and probabilistic uncertainty analysis.

The approach for deterministic and probabilistic analysis followed the guidelines described in NUREG/CR-6676 and is depicted in Figure 2 taken from the NUREG. Several documents were also followed for the computational assessment: NUREG-1757 Appendix I, NUREG-1757 Supplement 1 (draft), NUREG/CR-6697, and NUREG/CR-5512, Volume 2, Volume 3 (a draft that supersedes Volume 1), and Volume 4.

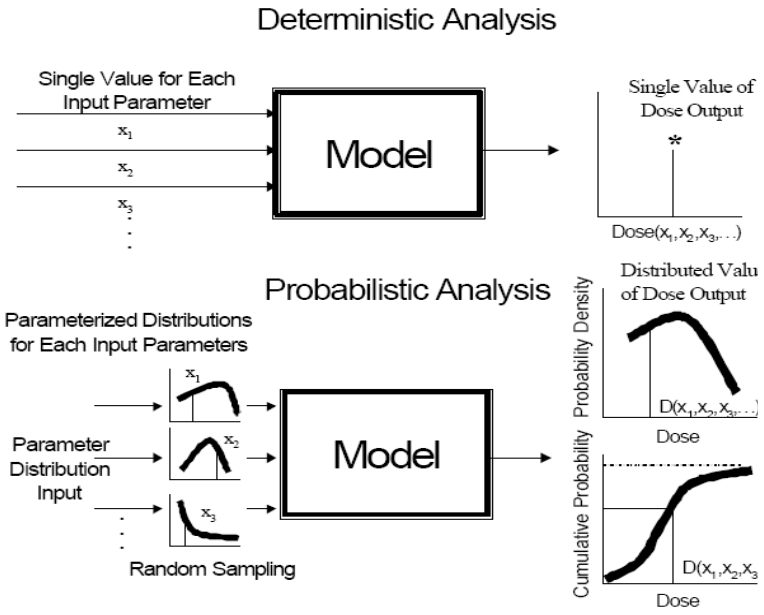

Figure 2 – Concepts of Deterministic and Probabilistic Analysis (from NUREG/CR-6676, May 2000)

3.0 SITE HISTORY AND DESCRIPTION

This section provides an overview of the Hammond Depot and all relevant site conditions that influence the analysis for the residual contamination values to ensure the requirements of 10CFR20.1402 are met. More information may be found in the ORISE HSA (Bauer and Vitkus 2005), and in the site-specific references listed in Section 7.0, particularly Parsons 1999; and "Environmental Assessment: Disposition of Thorium Nitrate" (2003).

3.1 Location

As shown in Figure 3, the Hammond Depot site is located just inside the Indiana state border with Illinois, about 490 feet east of the Indiana-Illinois state line. The site address is Hammond Depot, 3200 S. Sheffield Avenue, Hammond, IN 46327-1002.

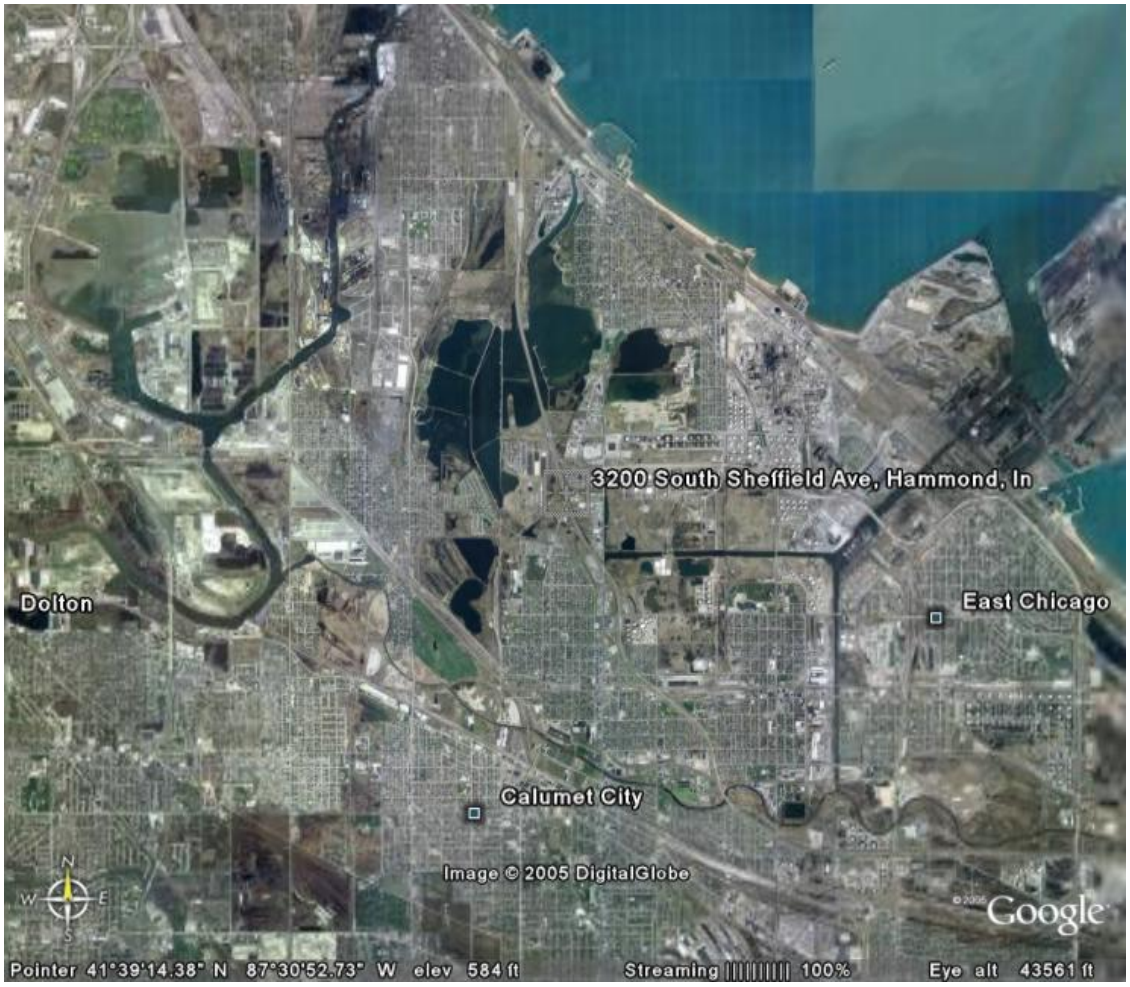

Figure 3 – Aerial View of Hammond Depot showing proximity to East Chicago, Calumet City, Lake Michigan, Lake George and Wolf Lake. (ref: GoogleEarth©)

The geographic coordinates of the Hammond Depot are latitude N413936 and longitude W873140 on the 7.5-minute quadrangle U.S. Geological Survey topographical map (Parsons 1999). Figure 4 is a detailed aerial view of the site, showing the following:

Figure 4 – Hammond Depot Aerial View. The DNSC Hammond Depot site boundary is highlighted. (ref: GoogleEarth©)

- The property is bounded by the Indiana Harbor Belt railway on the east and southeast, the Wolf Lake Industrial Center access road on the east, the Wolf Lake industrial/commercial complex on the north, Wolf Lake on the northern one-third of the western property boundary, and a drainage ditch on the west and southwest property boundary. Security of the facility is maintained by a chain-link fence with barbed wire on top.

- The land area of the entire Hammond Depot site as it is defined today is approximately 57.3 acres (Vitkus 2005) (Bauer and Vitkus 2005). For the purposes of the upcoming ORISE characterization survey in 2006 and the "contaminated zone" input parameter to the RESRAD code, the default area of 10,000 m^2 for an individual survey unit was used. It is anticipated that the upcoming ORISE characterization survey will establish several Class 3 areas (per MARSSIM) equivalent to or greater than this area whereas Class 1 areas

will comprise significantly less land area. Therefore the size of the environmental areas for which this assessment applies has not been determined at this time. The building footprint area is estimated to be about 14,100 m^2.

- The Hammond Depot is connected to the municipal sanitary sewer. However, the site previously operated a septic system north of the storage warehouses. Storm water is discharged off-site through two outfalls to Wolf Lake via drainage ditches (Parsons 1999, "*FINAL Preliminary Assessment Hammond Depot*").

3.2 Radioactive Materials Stored at HD

Over the course of more than 40 years, HD stockpiled materials of national interest, some of which contained naturally-occurring radionuclides. Radioactivity levels in the bulk thorium nitrate, predominantly ^{232}Th, were about 52,000 pCi/g averaged over the entire lot. "The entire stockpile was processed from monazite sands which are minerals made of phosphates of rare-earths and thorium. The ore contained typically 50-80 weight percent (wt%) rare earths and 4-8 wt% natural thorium, with the predominant radioisotope, ^{232}Th….furthermore, U_{nat} is found as a contaminant in monazite sands in association with the thorium." (Hermes May 2004).

From the analysis of waste stream radionuclides in the stockpiled ThN (Hylton 2003 and Terry 2003), it has been confirmed that the material is naturally radioactive and that the proportions of thorium and uranium radionuclides are in fact natural and not enriched or enhanced. While residual radioactivity present at HD is most likely from ThN, both monazite and sodium sulfate are also potential sources of both thorium and uranium contamination. The radioisotopic content is:

- Natural thorium: ^{232}Th and its decay products in secular equilibrium. Note that the ThN was processed and extracted from monazite sand in 1961. By calculation, it can be seen that since processing, all decay products have grown in to the material and are now in secular equilibrium. (Hermes 2005) The degree to which the decay products are in equilibrium is just over 99%. RESRAD and RESRAD-BUILD activity concentrations were run with unit activity values representing the equilibrium condition. DCGL values were then calculated per unit activity of the parent radioisotope, ^{232}Th.

- Natural uranium: ^{238}U and ^{235}U and associated decay products in secular equilibrium. The weight fraction of ^{235}U in natural uranium is 0.711 wt%. The associated radioactivity fraction of ^{235}U to ^{238}U is 0.047 (Abelquist and Vitkus 1997). RESRAD and RESRAD-BUILD activity concentrations were run with proportioned unit activity values representing the equilibrium condition of the decay products as well as the 0.047 activity fraction of ^{235}U to ^{238}U. DCGL values were calculated per unit activity of total uranium.

The thorium-232 and uranium-238/235 decay chains are presented in Figures 5-7, respectively.

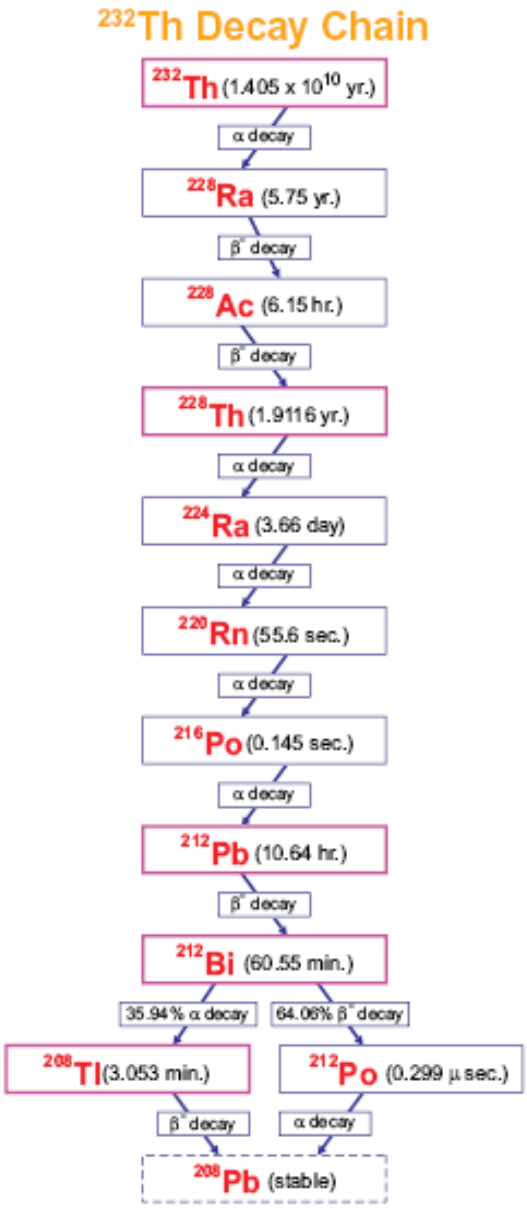

Figure 5 – Th-232 Decay Chain (from INL On-line Gamma Spectrum Catalog),
http://www.inl.gov/gammaray/catalogs/catalogs.shtml

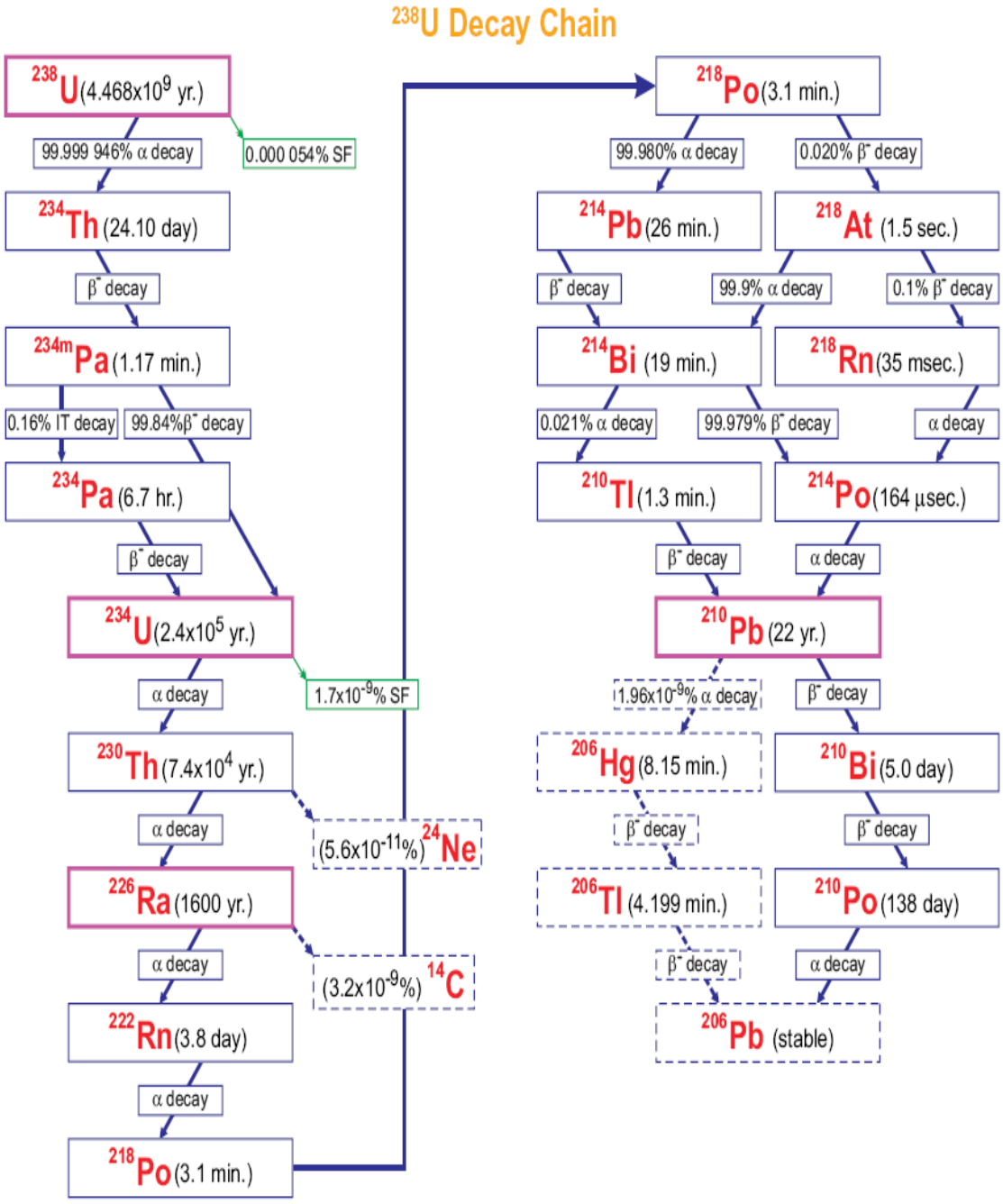

Figure 6 – U-238 Decay Chain (from INL On-line Gamma Spectrum Catalog), http://www.inl.gov/gammaray/catalogs/catalogs.shtml

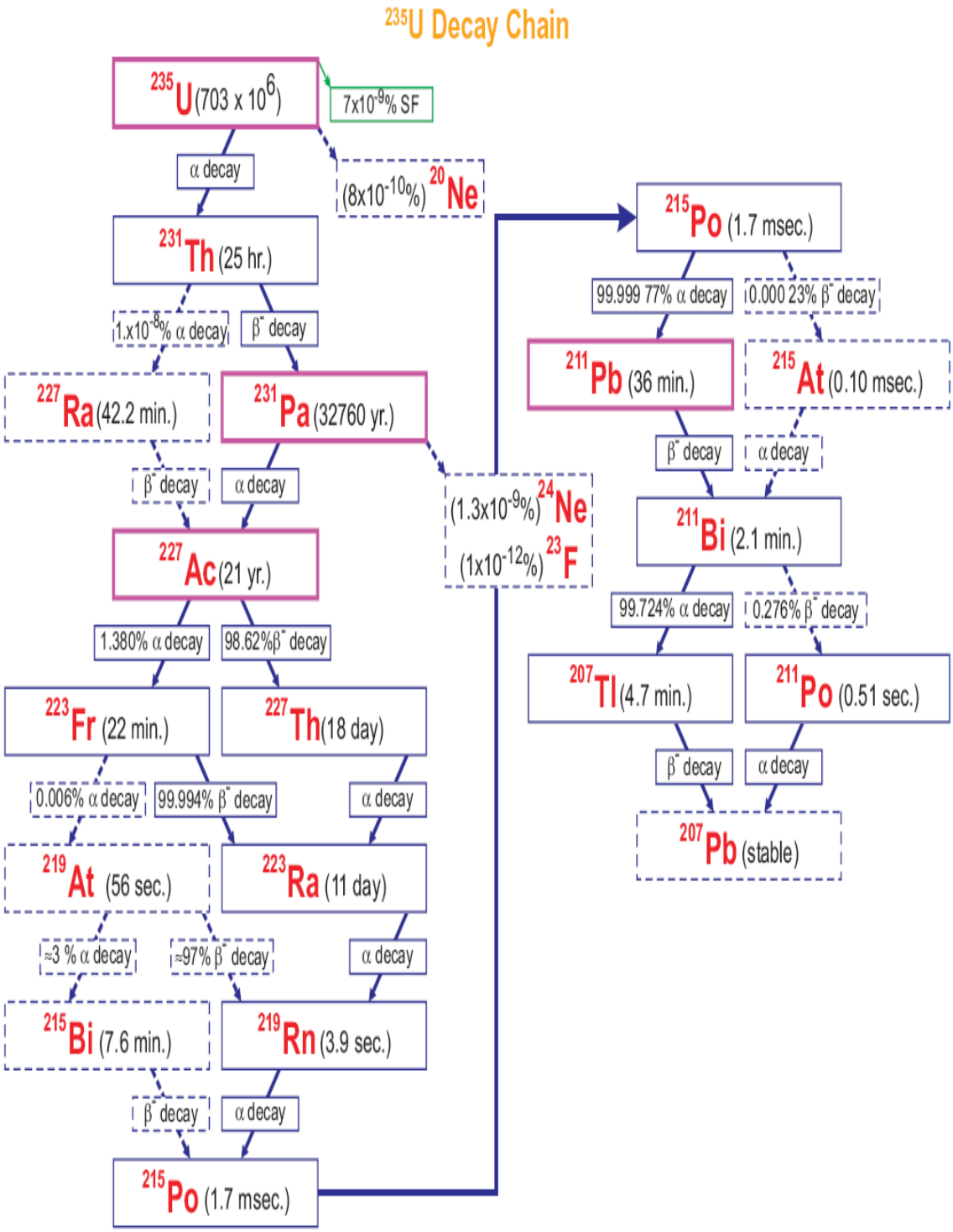

Figure 7 – U-235 Decay Chain (from INL On-line Gamma Spectrum Catalog), http://www.inl.gov/gammaray/catalogs/catalogs.shtml

Operationally, materials were usually stored in containers on site. No processing or chemical separations occurred at the Hammond Depot. Residual radioactivity present on the site, including the floor of at least one of the warehouses (200E), is from drums of ThN that had leaked. A decontamination of this warehouse to specified NRC guidelines was performed in 1979 (Bauer and Vitkus 2005).

Process knowledge and scoping survey results indicate that residual radioactivity quantities exist on the site but is primarily localized in buildings and therefore the environmental remediation scope will be relatively small. Further information on operations and/or radionuclides of interest during the packaging and transport of the materials to Nevada Test Site (NTS) is provided in the comprehensive reports by ORNL (Hermes 2004 and 2005; Hylton 2003; and Mattus 2003) listed in Section 7.0. For the source material itself and ultimately the disposition to NTS, a ^{222}Rn assessment was performed (Terry and Hermes 2003), showing a complete description of the waste stream profile and associated decay products. The result of this analysis led to the acceptable waste stream profile submittal approved by the NTS. From the waste stream profile (Terry and Hermes 2004), the source material was 99.9 wt% thorium nitrate. The remaining 0.1 wt% was a mixture of thorium hydroxide, oxide, oxalate, and nitrate.

The Hammond Depot stored approximately 950 tons of thorium nitrate crystals (hydrated form) in various configurations of roughly 2,300 drums. At the surface of a single drum, the gamma-ray exposure rate was between 20-30 mR/h. The material was characterized by ORNL in 2002. The predominant physical form of the material was a salt block monolith (Terry 2003).

The properties of the radioactive material stored at the HD are provided in Table 1 using information cited in and quoted from ORNL report ORNL-TM-2003-52 (Terry and Hermes 2003): "The domestically produced thorium nitrate was chemically processed from monazite sands mined in South Africa and is in the pentahydrate form. The ^{230}Th content of the thorium nitrate stockpile depends upon the amount of ^{238}U in the respective ore bodies."

Mine	**Mined Material**	**ThN Chemical Processing and Separation**	**ThN Form**	**Ratio of uranium concentration to average thorium concentration in each ore[2]**
South Africa	Monazite Sand	Domestic	pentahydrate	0.022

Table 1: Radioactive Material Properties

[2]The ^{230}Th content of the thorium nitrate stockpile depends upon the amount of ^{238}U in the respective ore bodies (Terry and Hermes 2003). For the purpose of the waste certification process and the analysis of residual radioactivity, the trace fraction of radioactivity from ^{230}Th is neglected.

3.3 Radioactive Material History and Contamination Potential

The ORISE HSA described the history of the Hammond Depot and locations of known contamination, areas of suspected contamination, types and concentrations of radionuclides in impacted areas, and potentially contaminated media. The HSA and implemented scoping survey approach provided an initial classification of the site areas as impacted or non-impacted using the qualitative classifications consistent with MARSSIM:

Class 1 — Buildings or land areas that have a significant potential for radioactive contamination (based on site operating history) or known contamination (based on previous radiological surveys) that exceeds the expected $DCGL_W$.

Class 2 — Areas that have, or had prior to remediation, a potential for radioactive contamination or known contamination, but are not expected to exceed the $DCGL_W$.

Class 3 — Any impacted areas that are not expected to contain residual contamination, or are expected to contain levels of residual contamination at a small fraction of the $DCGL_W$.

The HSA identified several locations germane to follow-on investigations at the site and eventual unrestricted use. First, a number of potentially Class 1 or Class 2 impact building and soil areas exist. These include areas known to be contaminated and areas that were previously contaminated and remediated or demolished (Warehouse 100W, 200E, and the former repackaging area outside the southwest corner of Warehouse 200E).

Existing roads and railroad lines and the burn cage are also considered to be potentially contaminated (Class 2) because they served as transportation routes as are areas where railroad lines have been removed.

The HSA identified remaining land areas, largely due to the inadvertent spread of contamination, as having little potential for contamination, and therefore a Class 3 designation.

No areas were identified as non-impacted, although many buildings and land areas could arguably be classified as either Class 3 or non-impacted.

Each of the areas noted above was investigated during the 2005 scoping survey and will be evaluated extensively during the ORISE 2006 characterization survey and re-classified as necessary.

3.3.1 Potential or Known Contaminated Media

The following potentially or known contaminated environmental media at the site were identified: surface soil, subsurface soil, sediment, surface water, groundwater, and buildings.

3.3.1.1 Soil

Surface soil is defined as the top layer (15 cm) of soil on the site and is used as the default thickness of the contamination zone in this report. The Hammond Depot HSA identified that radioactive material overpacking operations were conducted outside of the existing building. Surface soils may have also become contaminated via the inadvertent spread of contamination during transportation. The pallet burn cage area is also a potential source of surface soil contamination. The potential does exist for surface soil contamination to migrate deeper into the soil at the Hammond Depot. Although soils will be investigated further during site characterization, the initial scoping survey results did not identify significant soil contamination.

Subsurface soil and media are defined as any solid materials not considered to be surface soil. Surface soil sources should be evaluated based on radionuclide mobility, soil permeability, and infiltration rate to determine the potential for subsurface contamination. Some consideration for contaminants that may exist beneath parking lots, buildings, or other onsite structures may be warranted as part of the investigation.

3.3.1.2 Water

At this time, surface water is not considered to be a potentially contaminated medium.

3.3.1.3 Groundwater

No evidence of groundwater contamination has been identified and is not suspected due to a lack of a significant radioactive source term. Also, because of the low mobility of thorium in soil and the trace quantities of uranium present, the contamination of groundwater is considered an unlikely event.

3.3.1.4 Structures

Table 2 shows the buildings that were identified as having been used for the storage of radioactive material and which materials were stored.

Building	Potential Contaminants
100W (Bays 8 through 18)	Thorium nitrate, tantalum pentoxide, columbium tantalum natural minerals, columbium natural minerals, monazite sand, sodium sulfate
200E (Bays 1 through 10)	Thorium nitrate, monazite sand, sodium sulfate
100E (Bays 19 and 20)	Thorium nitrate from stored contaminated pallets

Table 2: Potential Contaminants by Building Location

Further information on the nature of these contaminants is provided in the ORISE HSA (Bauer and Vitkus 2005). The dimensions of the three warehouses are each 126 feet by 401 feet and are constructed of cinder block walls on a concrete slab floor with steel beams, columns, and roof joists. For storage purposes, the interior of each warehouse was subdivided into 20 bay areas. Warehouse 200E has been used for radioactive material storage and also has an asphalt overlayment covering an area that was previously remediated and is known to have residual contamination present. There is also a cinder block wall that divides the warehouse essentially into two halves. Warehouse 100W was used for radioactive material storage with no history of any previous remedial activities. Warehouse 100E has no history of radioactive material storage. However, contaminated pallets stored in the northern two bays were identified during the scoping survey. The immediate future use of these structures is continued Depot warehousing activities.

3.4 General Environmental and Physical Site Characteristics

The information in this section is taken primarily from the Historical Site Assessment which references the Parsons preliminary site assessment report. (Bauer and Vitkus 2005 and Parsons 1999).

3.4.1 Environmental Setting

The Hammond Depot is located in an industrial setting, with some proximal residential/commercial areas. The terrain is generally flat with general sloping towards the shore line of Lake Michigan which is located approximately three miles to the northeast of the site. Wetlands abut the property to the west as Wolf Lake. Roads and railroad spurs provide access into the site, with major state highways. Much of the land in the area, covering 20 square miles, is the result of the filling in of wetlands and low-lying areas with industrial slags from the local steel industry facilities prevalent in the area (Bayless 1998).

3.4.2 Geologic Setting

The Hammond Depot is located within the Calumet Lacustrine physiographic unit. The geology of the area is representative of glacial ice scouring the original land surfaces and later leaving glacial till deposits over the bedrock and sedimentation from Lake Chicago (ancestral Lake Michigan). The Calumet aquifer underlies the region and is consolidated within a fine sand/silt formation. The depth to the aquifer in the area is approximately 15 feet in depth (USDHHS 2004). Most of the native soils in the area are no longer identifiable due to the introduction of slag and other fill material. (Bayless 1998).

3.5 Hydrogeology, Hydrology And Water Supply

The information in this section is taken from the *Hydrology and Geochemistry of a Slag-Affected Aquifer and Chemical Characteristics of Slag-Affected Ground Water, North Western Indiana and Northeastern Illinois.* (Bayless 1998) Information directly cited from the report (with the exception of minor editorial changes) is show in quotation marks.

3.5.1 Hydrogeology

"The Calumet aquifer is comprised of those wind- and water-transported fine sand and silt. The Calumet aquifer is a surficial deposit that is 18 to 20 feet thick throughout the study area. A thin sequence of fine-grained lacustrine sediment underlies the sand; parts of the lacustrine sediment may be included in the Lake Border sequence. Thickness of the fine sand aquifer and underlying lucastine sediment averages 20 feet. A Wheeler sequence till underlies the lacustrine sediment." (Bayless 1998) The aquifer level is at approximately 580 feet above mean sea level.

The hydraulic conductivity for slag, the primary fill over the aquifer ranging in depth from 20 to 70 feet thick, is 4730 meters per year (EPA 2000). Aquifer water quality is considered non-potable due to the presence of heavy metals from the slag. Additionally, the slag chemistry has increased the pH of the water to a level in excess of 11 (USDHHS 2004 and Bayless 1998).

3.5.2 Hydrology, Precipitation, and Stream Characteristics

The Hammond Depot surface water drainage is via two outfalls that discharge runoff from the depot to Wolf Lake. The west boundary is defined by Wolf Lake, and north/south drainage ditch. Ditch locations on the north, south, and southwest boundaries, all discharge into Wolf Lake.

The climate of northwestern Indiana is considered continental with hot, humid summers and cold winters. The average annual total precipitation is 36-37 inches of precipitation, including 29 inches of snow. The average wind speed is between 8 and 12 miles per hour.

3.5.3 Water Supply

The area is serviced by a public drinking water supply drawn from Lake Michigan. There is no known use of private wells in the area. Furthermore, groundwater studies in the area have identified organic chemicals and heavy metals in the area and therefore the Calumet Aquifer is not considered a potable water supply (USDHHS 2004). The contaminant sources are the result of both the overlying slag and area industry.

4.0 DETERMINATION OF PRELIMINARY DERIVED CONCENTRATION GUIDELINE LEVELS

Methods for determining the DCGLs involved a three-step process, presented in order in this section:

1. Identifying the regulatory limit for the TEDE per year, to which an acceptable level of residual contamination corresponds;

2. Developing a site environmental model (the conceptual site model) that accounts for the physical characteristics of the site, identifies exposure pathways from the residual radioactivity, and computes the annual TEDE per unit concentration of natural thorium and natural uranium;

3. Using RESRAD Version 6.3 and RESRAD-BUILD Version 3.3 to calculate the TEDE per year per unit concentration or area, respectively, of natural thorium and natural uranium. Computational models must output the TEDE as a function of time, out to at least 1000 years, as cited by ANL for these computational models, to determine allowable soil and building surface limits that meet the requirements of 10CFR20.1402. Microsoft Excel 2003 was utilized to generate additional output results based on the dose assessment model findings.

4.1 Annual Public Dose Limit

The NRC dose limit for the public is 100 mrem TEDE in a year associated with licensed operations and exclusive of background (and other) sources (10CFR20.1301). As described in Section 1.1 of this report, per 10CFR20.1402, *Radiological Criteria for Unrestricted Use,* an average member of the critical population group may not receive a TEDE in excess of 25 mrem, including groundwater sources of drinking water. The RESRAD and RESRAD-BUILD modeling implemented for this report utilized this required input parameter for the applicable dose limit to establish the resulting DCGLs for the HD.

4.2 Conceptual Site Model

The conceptual site model has been developed on the basis of a site review and investigation, how the site is to be used once released, and a complete understanding of the most relevant exposure pathways to occupants and/or residents of the area or to receptors who ingest foodstuffs grown on-site or animals raised on site.

Figure 8, cited from the RESRAD manual (Yu 2005), provides the conceptual site model which is built on the framework of the mathematical model established within the RESRAD code, specifically:

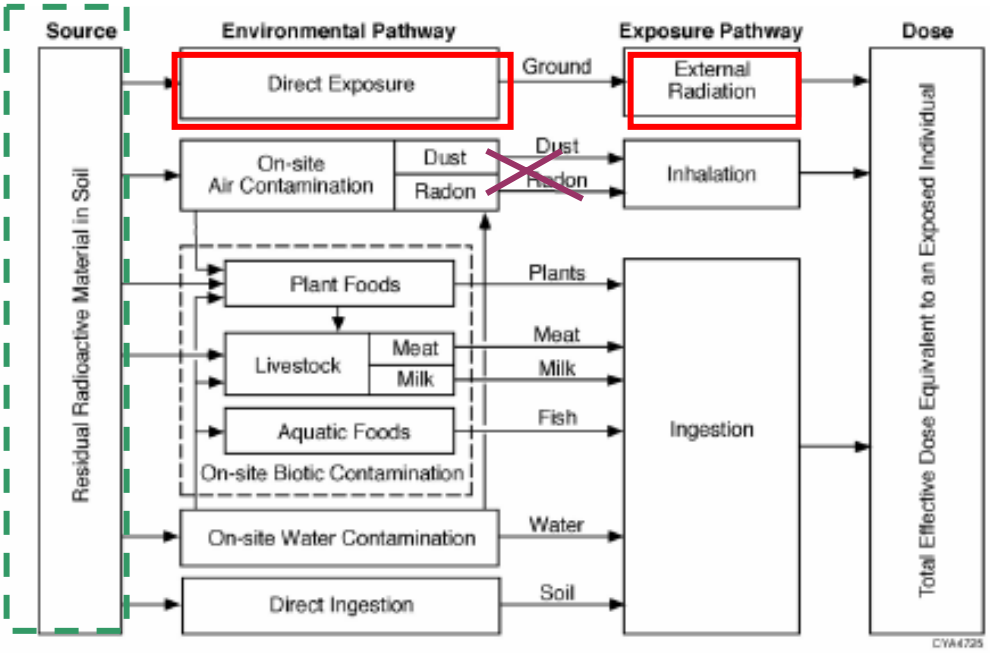

Figure 8 – Conceptual Site Model for the Hammond Depot

The conceptual site model assumes the resident farmer scenario. Realistically, the site, when released for unrestricted use, appears better suited for other purposes such as residential, recreational, or industrial uses. Under this scenario, the site could be used for building a subdivision, a baseball field, or "light industry" applications, including primarily professional office building use, small convenience shopping centers, and/or local government facilities. Farming is not a prevalent activity in the immediate vicinity of the site, and thus, is not considered the ideal exposure pathway. Nonetheless, as discussed in the RESRAD Manual, there is no certainty in the use of the site well into the future. While the presence of slag materials predominates at the HD site, making farming reasonably unlikely, the possibility remains that the site could be utilized for farming and therefore, the resident farmer scenario was utilized for the purposes of a bounding dose assessment. Accordingly, the resident farmer scenario was selected.

As shown in Figure 8, the radon pathway was "suppressed" in this assessment due to its inapplicability. In a Federal Register Notice (*Vol. 59, No. 161, Mon, Aug 22, 1994*) issued as a result of comments received from a radon workshop, the NRC noted that "radon would not be evaluated when developing release criteria due to: the ubiquitous nature of radon in the general environment, the large uncertainties in the models used to predict radon concentrations; and the inability to distinguish between naturally occurring radon and that which occurs due to licensed activities."

4.2.1 Critical Receptor/Scenario Selection

Under the selected scenario, the resident farmer and his family move onto the site after release for unrestricted use, build a house, grow crops, and raise livestock for consumption. The farmer and any associated family members and relatives living permanently on the site in the future form the critical population group. Due to their permanent status, the projected dose to these individuals will be maximized relative to temporary onsite inhabitants such as construction workers, those involved with recreational activities (e.g., baseball games), etc.

4.2.2 Exposure Pathway Selection

To be valid, the DCGL determination must take into account all significant exposure pathways impacting on the critical group. As described in the RESRAD manual (Yu 2005) these include:

- Direct exposure to external radiation from contaminated soil material;
- Internal dose from inhalation of airborne radionuclides, including radon decay products (as applicable);
- Internal dose from ingestion of:

  - plant foods grown in contaminated soil and irrigated with contaminated water;
  - meat and milk from livestock fed with contaminated fodder and water;
  - drinking water from a contaminated well or pond;
  - fish from a contaminated pond; and
  - contaminated soil

As described previously, the radon pathway was suppressed for the DCGL analysis. All other pathways were "active".

For RESRAD-BUILD, relevant pathways built into the code include:

- External exposure to penetrating radiation emitted from contamination deposited on, and affixed to, surfaces;
- External exposure to penetrating radiation emitted due to submersion in airborne particles;
- Inhalation of airborne contamination;
- Incidental ingestion of source contamination;
- Incidental ingestion of contamination that has been released, suspended, and deposited on surfaces; and
- Exposure to radon decay products

4.3 Recommended Values for RESRAD and RESRAD-BUILD Parameters

4.3.1 General Basis for the Dose Modeling Assessment

The following general assumptions formed the basis for the dose modeling assessments:

- The resident farmer scenario is applicable to soils (RESRAD); the building occupancy scenario for buildings (RESRAD-BUILD).
- The DCGLs for both soil and buildings were derived based on a review of site records and available references, information gathered during the conduct of the ORISE HSA (Bauer and Vitkus 2005), and the follow-on conduct of an ORISE scoping survey in 2005 (Vitkus 2005).
- Site-specific values, where available, were emphasized and used as input to the RESRAD and RESRAD-BUILD codes. A total of 209 inputs exist in the current RESRAD code; of these, approximately eight site-specific values (or values determined based on site-specific information) were used for modeling purposes. (Several of these values are utilized multiple times as inputs, but are counted here once.) While site specific inputs are always preferable, it is anticipated that the historical nature of site activities and the anticipated lack of subsurface contamination, especially at depths greater than 0.15 meters, will continue to preclude the need for extensive RESRAD site-specific inputs to the code.

  In lieu of site-specific values, NRC values, principally from NUREG/CR-5512, Volumes 3 and 4 (Beyeler 1999 and Haaker 1999) and NUREG/CR-6697 (Yu 2000); RESRAD default values; or information contained in the RESRAD manual were used to determine the selected inputs to the code.
- Each parameter and user input selection was evaluated individually and collectively for its appropriateness to the HD. As an example, distribution coefficients for specific elements of interest were ultimately determined based on the soil type comprising the contaminated zone. This was observed to be an urban fill, a mixture of gravel, cinders, slag, and coarse sand, resulting in the selection of a corresponding value provided in Table 32.1 of the ANL Data Collection Handbook (Yu 1993) for this type of soil matrix. This same matrix and coefficient value was used for the unsaturated and saturated zones because no representative values were available for an assumed urban fill/slag matrix below a depth of approximately 0.15 meters.
- Both deterministic and probabilistic evaluations were performed. The most recent deterministic and probabilistic versions of RESRAD (Version 6.3) and RESRAD-BUILD (Version 3.3) were used for this assessment.
- Because large buildings, i.e, warehouses, on the Hammond Depot were used to store ThN, typical "rooms" do not exist within the remaining warehouse structures for modeling purposes. However, for conservatism, rooms with small dimensional areas were modeled.

4.3.2 Specific Justification for Parameter Selection

All parameters utilized in the RESRAD evaluations for natural thorium and natural uranium are listed with justifications for their selection in Appendix A. The input/output files for the RESRAD results are provided in Appendix B. These evaluations were supported by the conduct of accompanying sensitivity and uncertainty analyses which examined the model input parameters in comparison to the intake assumptions for the receptor. Sensitivity and uncertainty analyses are further discussed in Section 5 (Results).

The following parameters taken from Appendix A were specifically selected for further discussion as a result of the environmental engineering assessment of the site (See Section 2.1). These parameters either were determined to have a specific impact on the proposed DCGLs or were *expected* to be significant and later "eliminated" following a sensitivity analysis. (Many other factors were also evaluated through a sensitivity analysis, but were determined not to be sensitive parameters and are not discussed here.).

A similar evaluation for the RESRAD-BUILD analysis was conducted to promote a conservative, but reasonable analysis, and can be found by examining the input parameters and the input/output files in Appendices C and D. The RESRAD-BUILD analysis used primarily default parameters.

4.3.2.1 Soils (RESRAD)

Pathway Selection: All pathways, including the irrigation pathway, were utilized, i.e., "active" to add conservatism to the dose assessment. The lone exception consisted of the radon pathway which was suppressed for reasons described previously.

Source term: Th-232, Th-228, and Ra-228 constituted the principal radionuclides for the thorium decay chain. U-238, U-234, Th-230, Ra-226, and Pb-210 comprised the radionuclides from the uranium-238 decay series; U-235 and its decay products (Pa-231 and Ac-227) were added at natural isotopic abundances relative to U-238 (i.e., 0.047 isotopic abundance of U-235 relative to U-238). Secular equilibrium between the parent and decay products was assumed. Uranium is present in trace quantities at the site.

Radionuclide Concentrations: Unit concentrations of one picocurie per gram (1 pCi/g) for each of the site radionuclides of concern were used. This approach provided dose-to-source ratios (DSRs), i.e., dose per unit concentration (mrem/y per pCi/g) which when divided into the primary dose limit resulted in a DCGL for that radionuclide in units of pCi/g.

Area of Contamination Zone: The contaminated zone is a belowground region in which radionuclides are present in above background concentrations. The contaminated zone was modeled (with no cover depth) under the assumption that a sandy soil matrix exists at surface (15 cm or less) depths and unlikely beyond a depth of one meter. Sandy soil was selected for modeling purposes to represent the urban fill/slag materials that exist on site. Slag materials are assumed to be present at depths beginning at well less than one

meter and continuing downward from that depth. For this reason, no other soil types or depths were assumed to be present for the unsaturated and saturated zones.

RESRAD assumes homogeneous (uniformly contaminated) contamination which is largely not the case at the site. No cover depth was also assumed.

To test the effect of changes in this parameter, a sensitivity analysis using three different input parameters (1000, 5000, and 10,000 m^2) was performed. This resulted in a determination that the use of the default RESRAD value (10,000 m^2) resulted in the highest dose to soil concentration value (mrem/y per pCi/g) and was therefore conservative.

Contaminated zone areas will be specifically delineated during the ORISE characterization survey scheduled in 2006. Class 1 (MARSSIM) areas are expected to comprise areas significantly less than the specified RESRAD default, whereas Class 3 areas are expected to consist of areas significantly greater than the RESRAD default. For purposes of the RESRAD evaluation in this report, the default value of 10,000 square meters (m^2) was used pending additional site characterization information which may result in the use of area factors and subsequent changes to the preliminary DCGLs presented in this report.

Thickness of Contaminated Zone: Contamination was assumed to be limited to the top 15 cm of soil for the majority of the site based on an evaluation of the site history (including anticipated mobility of thorium in the environment and preliminary ORISE radiological scoping survey results) and the resultant conceptual site model. Specific contamination depths will be determined during the 2006 ORISE characterization survey; surface contamination is anticipated at this time to be limited to a maximum depth of less than one meter

A sensitivity analysis was performed using depths of 0.15, 1, and 2 meters. With increasing depth, higher dose to concentration values are obtained (as expected with depth under the primary assumption of uniform contamination) and correspondingly decreasing DCGL values. Dose to concentration values remain unchanged once thicknesses within the contaminated zone of one meter or greater are reached.

Cover Depth: The cover depth corresponds to the distance to the uppermost contaminated soil sample. No cover depth was assumed overlying the contaminated area for conservative dose estimating purposes.

Soil density: Fourteen samples were collected from the site during the ORISE 2005 Phase I radiological scoping survey. The samples were brown to gray in color with a gravel matrix included in two of the collected samples. The average density of those samples (1.44 pCi/cm^3) was used based on an ORISE laboratory evaluation.

Elemental distribution (partition) coefficients (K_d): This parameter is one of the most important parameters to understand as it relates to soil migration and retardation. Site-specific values for this parameter were not determined. However, considerable efforts were devoted to the choice of appropriate and reasonable values for these coefficients (in

lieu of using the RESRAD default values) for the primary surface soil type (sand) and subsurface (slag) materials present at the site.

A sensitivity analysis conducted for another DNSC dose modeling effort with the identical radionuclides of concern (Boerner et al. 2006) determined that for *thorium* the selection of distribution coefficients (by any method) was not a sensitive influence on the DCGL determination. Therefore, the selection of these coefficients was ultimately based on knowledge of the site's hydraulic conductivity, soil types, derived "b" parameters, and "look up" values from Table 32.1 in the RESRAD Data Collection Handbook (Yu 1993).

The values provided in Table 3 were ultimately input into the RESRAD code, using the same values for all three zones based on the fact that distribution coefficients for "slag" materials which predominate at the HD site do not exist in the ANL Data Collection Handbook. In addition, these coefficients can be viewed as conservative in the sense that they represent fairly low coefficients which imply more rapid migration and correspondingly potentially higher doses.

Element	Contaminated Zone (Sand)	Unsaturated Zone (Sand assumed)	Saturated Zone (Sand assumed)
U	35	35	35
Th	3,200	3,200	3,200
Ra	500	500	500
Ac	450	450	450
Pa	550	550	550
Pb	270	270	270

Table 3: Selection of Partition Coefficients, K_d, by Element

While not conducted specifically for the HD site, sensitivity analyses previously conducted for the DNSC (Boerner et al. 2006) did reveal for *uranium* and its decay products, the value selected for the K_d for the contaminated, unsaturated, or saturated zones does have an impact on the DCGL determination.

Contaminated Zone Hydraulic Conductivity: A site-specific value (4730 meters/y) was used (EPA 2000). Hydraulic conductivity was a specific and important parameter identified during the environmental engineering assessment of the site (see Section 2.1), influencing the need for appropriate/reasonable choices for the soil type(s), "site-specific b parameter" and most importantly, the determination of appropriate distribution

coefficients. Each of these factors influences the others and can therefore have a potentially significant outcome on the results.

A sensitivity analysis previously performed for the DNSC for a site containing identical radionuclides of concern (Boerner et al. 2006) used the RESRAD default (10 m/y) and variable site-specific values. The results of these analyses demonstrated that differing hydraulic conductivity values had absolutely no effect on the dose to concentration values for *thorium.* While not performed for the HD site, the assumption was made in this evaluation that identical results would be obtained. Therefore, the site-specific value of 4730 meters/y was selected and used in the input to the "contaminated zone b parameter".

It has also been determined for *thorium* through prior sensitivity analyses that parameters related to hydraulic conductivity (including the distribution coefficients for this element for various soil types) were not sensitive parameters

Saturated Zone "b" parameter: As discussed above for hydraulic conductivity, the "b" parameter is influenced by site soil types and the hydraulic conductivity choice. For this evaluation, a power function fit curve was developed to estimate values for "b", given what was thought to be an appropriate site hydraulic conductivity. The power fit had a resulting correlation coefficient (R^2) of 0.82, indicating a relatively good, but not demonstrably high correlation; however, the uncertainty in the fit is believed to be significantly lower than that associated with the highly variable K_{sat} value.

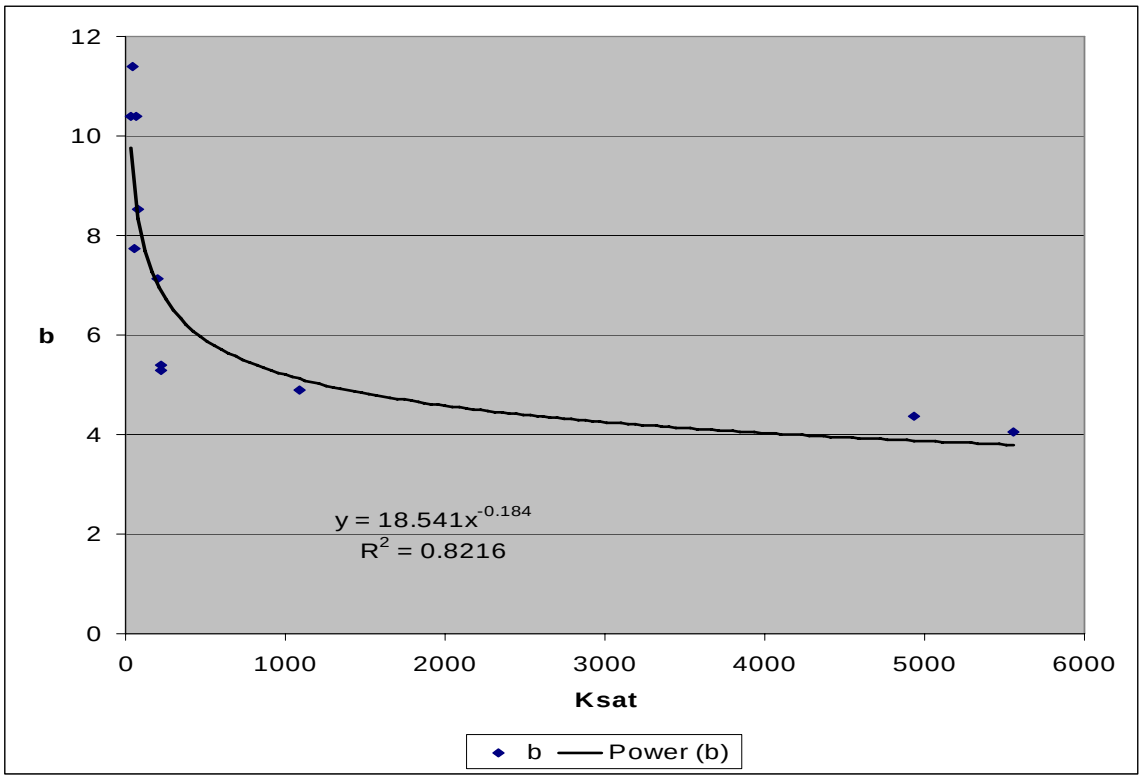

Figure 9 – Saturated Hydraulic Conductivity (K_{sat}) vs. b, Soil Exponential

Texture	K_{sat}	b
Clay	40.5	11.4
Clay Loam	77.3	8.52
Loam	219	5.39
Loamy Sand	4,930	4.38
Sand	5,550	4.05
Sandy Clay	68.4	10.4
Sandy Clay Loam	199	7.12
Sandy Loam	1,090	4.9
Silty Clay	32.6	10.4
Silty Clay Loam	53.6	7.75
Silty Loam	227	5.3

Table 4: Values for Hydraulic Conductivity and Soil Exponential Parameters for Various Soil Types (from Table E.2 RESRAD Manual Version 6, Page E-9)

The unitless value that was subsequently selected for input into the RESRAD code (i.e., 3.3) is considered appropriate for the hydraulic conductivity value selected (4730 m/y) and the primary soil type that was selected as a surrogate to urban fill/slag. The derivation of the "b" parameter is also discussed in the ANL data collection handbook (Yu 1993) and representative values provided for comparison in the RESRAD Manual (Yu 2005).

Unsaturated Zone Thickness: Sensitivity analyses have been previously evaluated for this parameter (Boerner et al. 2006) The results of this analysis indicated no corresponding change in the dose to concentration factor with thickness. Therefore, based on the lack of site-specific information and the results of the prior sensitivity analysis, the default thickness (4 meters) was selected.

Groundwater concentrations and solubility constants: The lack of site-specific groundwater and solubility data precluded the optional input of groundwater concentrations. The groundwater (dependent water) pathway for uranium—an "active" pathway in this analysis for conservative dose modeling purposes—was found to be significant upon review of the RESRAD output files, resulting in low DCGLs (~2.8 pCi/g at time "0" and 5.5 pCi/g at 270 years). However, the trace quantities believed to be present at the site (combined with the lack of anticipated groundwater contamination) will be confirmed during the 2006 ORISE characterization survey. Once confirmed, the importance of these low uranium DCGLs results will be minimized.

External gamma radiation pathway: The external gamma pathway is the predominant, most significant pathway in the DCGL determination for thorium at the HD. Appendix A cites the input values selected for shielding factors and fraction of time spent indoors/outdoors. These three values vary considerably based on the reference selected. In keeping with the primary parameter selection process cited in this report and without site-specific gamma shielding factors available, NRC values from NUREG/CR-5512, Volume 4, were selected in lieu of the RESRAD default values (Haaker 1999). Regardless of the selected input values and the reference cited—which in this case using primarily NUREG values resulted in a "non-conservative" result (a higher DCGL)—the external exposure pathway predominates for thorium.

Ingestion pathways: Based on the sensitivity analyses, the significance of the dietary and non-dietary parameters on the DCGL determination is minimal. The "driver" remains the external gamma dose contribution. Ingestion pathway values used in the evaluation were taken from both NUREG and RESRAD default values.

Radon parameters: As noted previously, this pathway was "suppressed" in the evaluation.

4.3.2.2 Buildings (RESRAD-BUILD)

The RESRAD-BUILD assessment utilized the "Warehouse Worker" scenario. The conceptual model geometry used for this evaluation is depicted in Figure 10. The conceptual model consisted of a unit room, 10m x 10m in area, with a height of 2.5 m. While this model geometry does not match the current onsite conditions, this geometric dose assessment model is representative of a conventional approach to yield a dose projection that is neither overly conservative nor unrealistically under-conservative. In keeping with this convention, the receptor is placed in the middle of the room, with equal area sources placed at the feet and on the centerline of each of the four walls. Source locations and the direction of the source were reviewed for accuracy.

The selected room size offered a conservative (smaller) volume, reducing the effect of dilution as it pertains to resuspension and was considered more likely to match a "future-sized" room in the event any onsite warehouses are renovated and reoccupied. A low (default) building ventilation rate was also used.

Unit dose factors, in mrem/y per pCi/m^2, were determined for the RESRAD-BUILD evaluation. When the dose factor was divided into the primary dose limit and converted into conventional field units, a DCGL for each radionuclide of concern (uranium and thorium) was determined in dpm/100 cm^2.

Site-specific parameters were evaluated to aid the analysis; however the use of default parameters predominated in the analysis. Results of the preliminary DCGL determination are presented in Section 5.

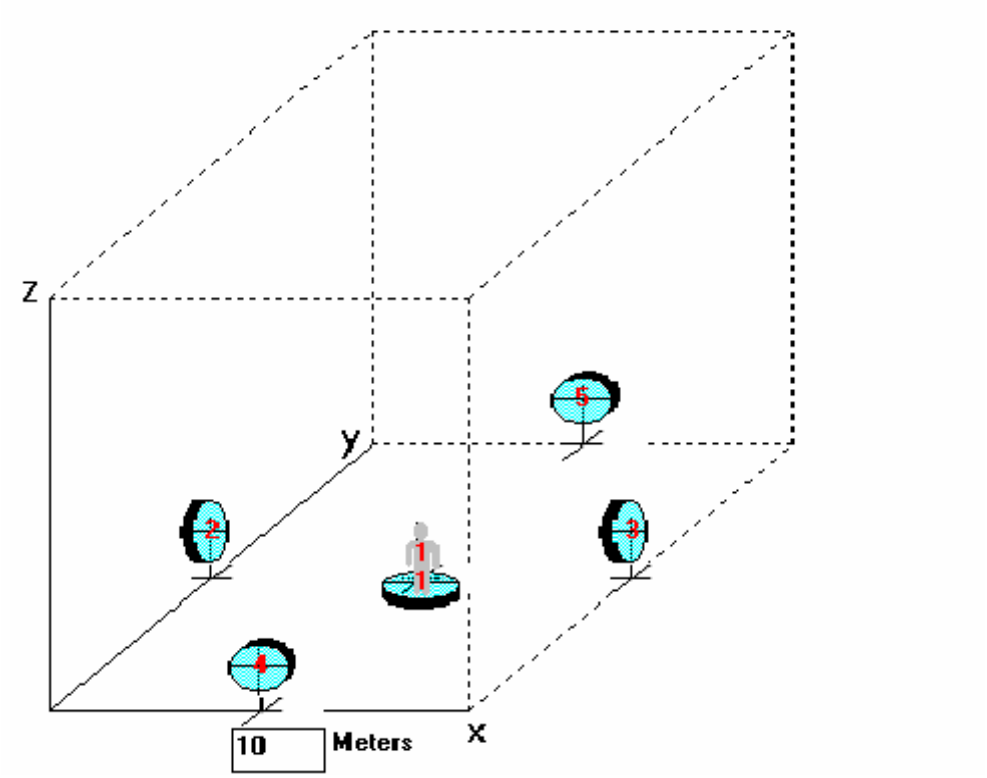

Figure 10 – Computational Model Geometry for the RESRAD-BUILD Evaluation

5.0 RESULTS

Previous sections of this report have detailed the approach and methodology for determining the preliminary DCGLs for thorium and uranium. This included a thorough environmental engineering assessment and follow-on computational modeling, understanding of the Hammond Depot site history, its radioactive material storage and potential contaminants, and associated physical, environmental, and hydrological site characteristics. The influence of several input parameters to the computational codes was also examined in detail for their relative "sensitivity", that is, their impact on the dose assessment outcome.

This section utilizes the preceding information to provide the results of the dose assessments for thorium and uranium radionuclides in both soil and buildings.

5.1 Sensitivity and Uncertainty Analysis

Sensitivity analyses are available for many, but not all, input parameters within RESRAD to assess the significance of the sensitivity of each parameter and associated uncertainty relative to the dose assessment results. Sensitivity analyses were conducted to ensure that the most important parameters for the Hammond Depot site were not overlooked by limiting the analysis solely to an environmental engineering assessment of the exposure scenarios, pathways analysis, etc.

RESRAD contains over 200 input parameters in Version 6.3. As described in Section 4, sensitivity analyses were performed for a number of site-specific and RESRAD default input parameters for both thorium and uranium. Site specific and default parameters scrutinized in this analysis included: the area of the contaminated zone, thickness of the contaminated zone, contaminated zone hydraulic conductivity, influence of the groundwater pathway, distribution coefficients, the external gamma radiation pathway (and associated indoor/outdoor fraction inputs), and ingestion pathways. Of these, the external gamma radiation pathway was definitively predominant for thorium, thereby having a significant impact on the DCGL. For uranium, the ground (direct exposure) and plant pathways were equally divided in terms of dose assessment - about 45% contribution from each. However, as stated earlier, the plant pathway was kept active for conservatism, recognizing of course that the property will likely never be used for a "resident farmer." The remaining sensitivity analyses confirmed a lack of impact on the dose modeling results.

The values used as inputs to the sensitivity analyses are provided in Appendix A and represented *conservative* and/or *representative* choices for the Hammond Depot site.

The RESRAD-BUILD assessments utilized primarily default values. As expected, the inhalation pathway was determined to be the projected highest contributor to receptor dose.

Both general and specific sources of uncertainty are inherent in a dose assessment analysis using the RESRAD computer code. General sources of uncertainty can be related to the RESRAD code itself, the scenario(s) selected, and the input parameters.

In this analysis, the external dose pathway for thorium was determined to be a sensitive and predominant dose pathway with changes in the values selected for the gamma shielding factor, indoor fraction, and outdoor fractions having a significant influence on the results. As noted previously, a comparison performed of the impact on the dose assessment results using either the RESRAD defaults or the NUREG inputs chosen for this analysis confirmed the influence of the external dose pathway.

Considerable uncertainty resides in the range of possible outcomes for a variety of input parameters available using the built-in sensitivity/uncertainty analysis tools (both deterministic and probabilistic) within the RESRAD code. These tools were utilized as practical and necessary for this evaluation, though their effectiveness in terms of capturing the results was limited in several instances.

5.2 Preliminary DCGLs

5.2.1 Radiological Parameter Inputs to the RESRAD Code

The following inputs and approach were applied to the RESRAD DCGL determination:

- Principal radionuclides and decay products are in secular equilibrium
  - Natural thorium
  - Natural uranium
- A normalized (unit) concentration of 1 pCi/g per radionuclide was applied
- Doses were calculated (by radionuclide) as a function of time, up to 1000 years.
- The peak dose over the 1000 year time period was determined (per unit activity of the parent radionuclide)
- Resulting DSRs (Dose to Source Ratios) were compared to the NRC regulatory limit, resulting in a DCGL (pCi./g), using the following equation:

$$DCGL = \left({}^{25mrem}\!\!\diagup\!\!{}_{DSR\ mrem/pCi/g} \right) \qquad (pCi/g)$$

5.2.2 RESRAD (SOIL) Results

Natural thorium

Because natural thorium (Th-232 and decay products) is the predominant onsite constituent, it was the most significant model investigated for appropriateness against the understanding of environmental transport and resulting exposure at the site. A number of deterministic sensitivity runs as well as probabilistic uncertainty analyses were conducted

to assist in the understanding of the overall environmental system and how it relates to the dose.

5.2.2.1 Dose Contribution from All Pathways: Natural Thorium

For the analysis of natural thorium, the figure below shows the time-dependent nature of the dose contribution from each of the decay products in secular equilibrium with the parent. As depicted, the maximum (summed) dose is delivered at time(t) = "0".

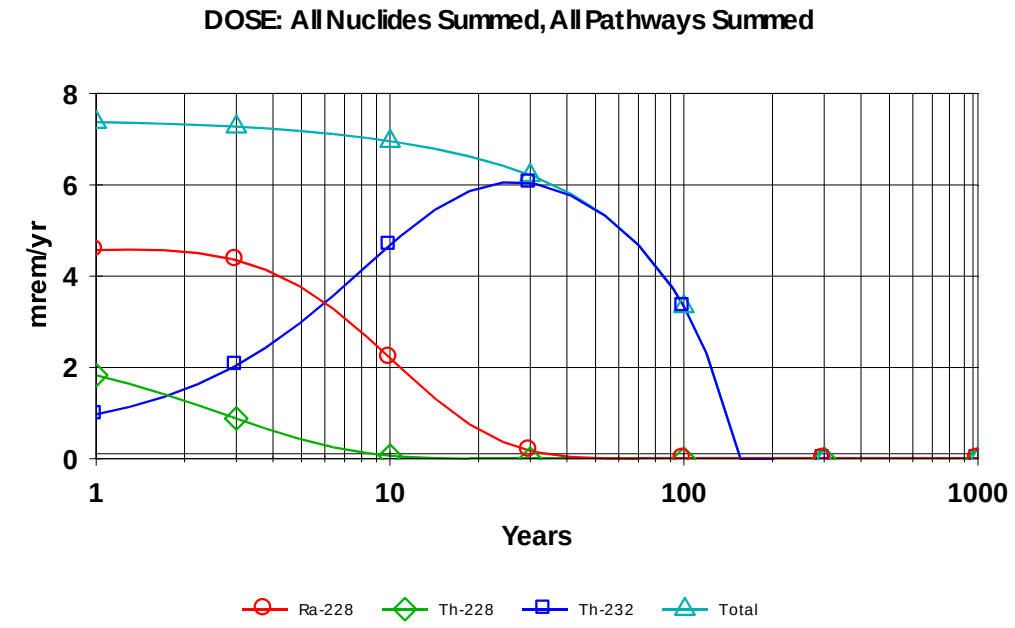

Figure 11 – Dose, All Nuclides (Thorium Chain) Summed, All Pathways Summed, (created from RESRAD v6.3 01/12/06)

5.2.2.2 Significant Pathways: Natural Thorium

The external dose pathway clearly drives the DCGL for this environmental model and therefore has the most significant impact on the potential dose to the critical group. Refer to the figure below for a depiction of this finding.

Sensitivity analyses confirmed the external pathway was clearly influenced by the selection of the:

- Gamma Shielding Factor
- Fraction spent indoors (on an annual basis)
- Fraction spent outdoors (on an annual basis)

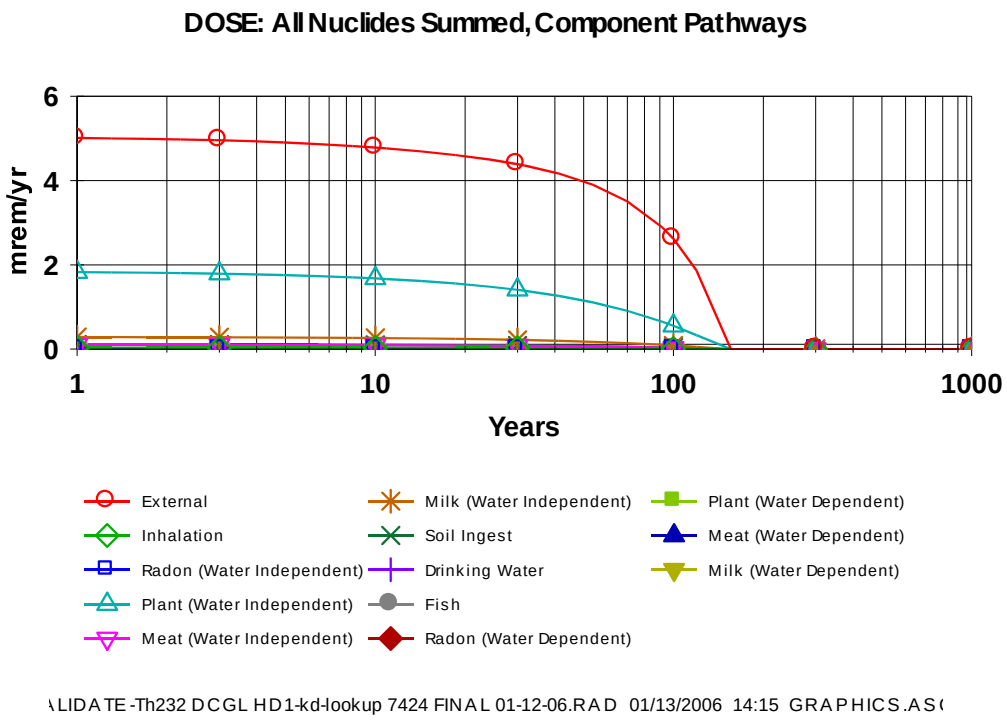

Figure 12 – Dose, All Nuclides (Thorium Chain) Summed, Component Pathways, (created from RESRAD v6.3 01/12/06)

As a result of the analyses, the following DSR for natural thorium (Th-232 and decay products) in soil was generated:

$$7.4 \text{ mrem/y per pCi/g at time} = 0$$

Dividing the DSR into the annual dose limit resulted in the following preliminary DCGL for natural thorium:

$$DCGL = 25/7.4 = 3.4 \text{ pCi/g}$$

This DCGL applies to Th-232 and *each* successive decay product under the assumption that all decay products are in secular equilibrium with the parent and possess half-lives greater than 180 days (the RESRAD recommended half-life cutoff for calculational purposes). Therefore, the 3.4 pCi/g DCGL is applicable to Th-232, Ra-228, and Th-228.

Natural uranium

The natural uranium analysis utilized the same non-elemental input parameters as were used for the thorium calculations. Elemental parameters were then changed accordingly to represent the proper parameter sets associated with U-238, U-235 and their respective decay products.

5.2.2.3 Dose Contribution from All Pathways: Natural Uranium

The time-dependent nature of the dose contribution from each of the U_{nat} decay products in assumed secular equilibrium with the parent radionuclides is shown in the figure below. At time(t) = "0", a DSR for U-238 and decay products of 8.99 mrem/y per pCi/g was generated in RESRAD—equivalent to a DCGL of 2.8 pCi/g. As for thorium, the uranium peak dose is at time-zero; however, because the site soil parameters drove the use of large Kds, the time-dependent dose function peaks again at about 250 years. Instead (and not unexpectedly), the introduction of U-235 and its short-lived Pa-231 decay product becomes the largest contributor to the dose after a period of about 250 years.

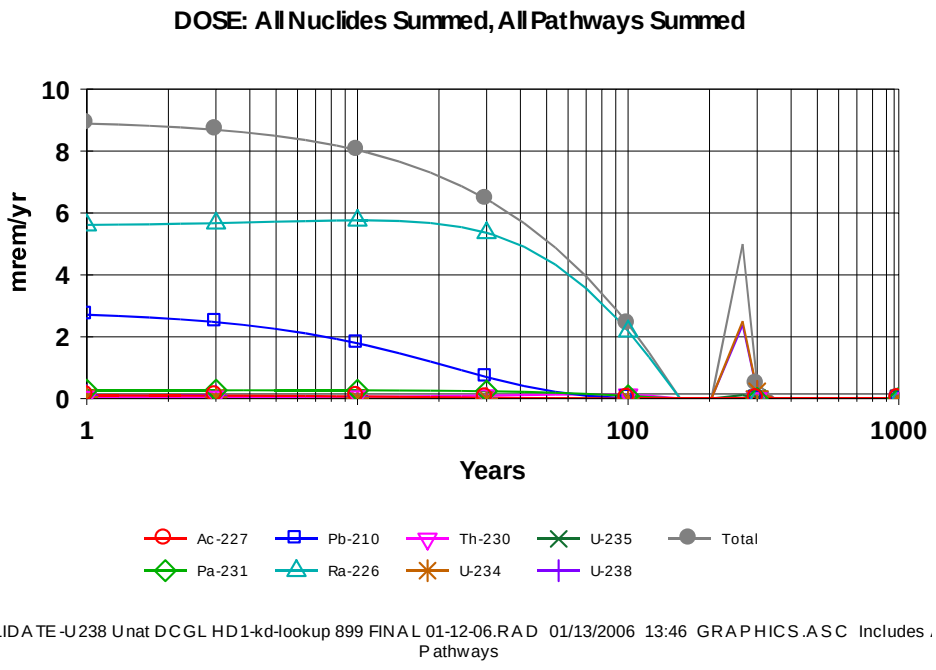

Figure 13 – Dose, All Nuclides (Uranium Chain) Summed, All Pathways Summed, (created from RESRAD v6.3 1/12/06)

5.2.2.4 Significant Pathways: Natural Uranium

Evaluating the model by pathway, the limiting pathway is shown in the graphic below to be (as expected) the drinking water pathway, not at time-zero, but at about 250 years. This systematic behavior in both the model equations and the collective understanding of contaminant transport for uranium confirms that the parameters K_d, K_{sat}, and "b" are important parameters for describing this particular site model. Prior examination of the uncertainty analysis for uranium transport and resulting pathway dose showed similar results in both relative magnitude (of the peak dose) as well as in time, though, depending on the environmental nature of the site itself, the peak dose can be retarded in time or accelerated in time depending on how the stratification between the contaminated, unsaturated, and saturated zones is described and modeled.

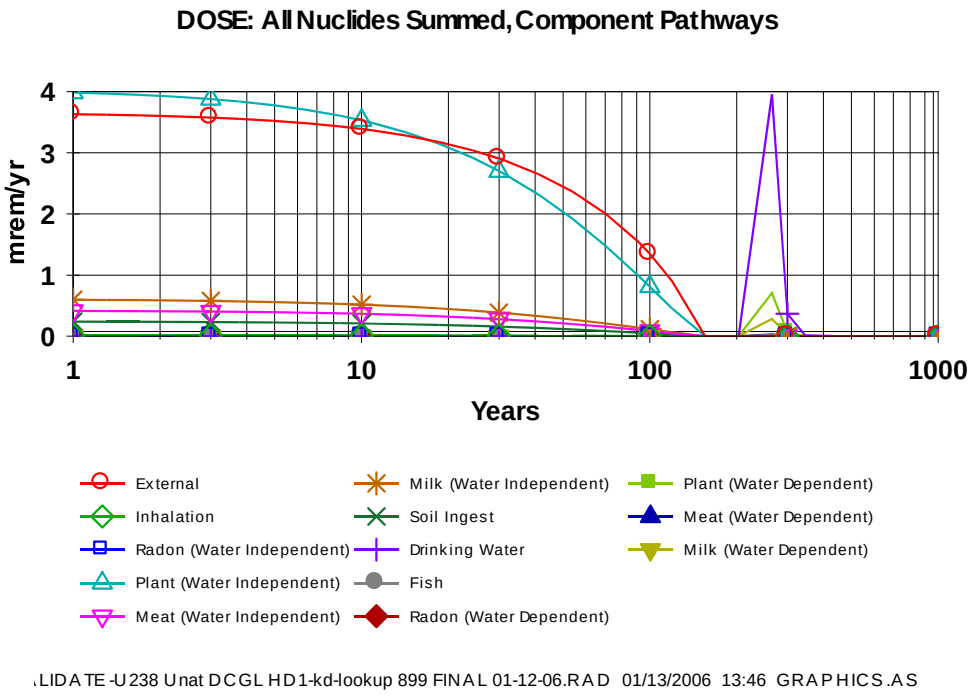

Figure 14 – Dose, All Nuclides (Uranium Chain) Summed, Component Pathways, (created from RESRAD v6.3 01/12/06)

As a result of the analyses, the following DSR for natural uranium in soil was determined (Figures 13 and 14):

$$8.99 \text{ mrem/y per pCi/g at time} = 0 \text{ years (peak dose, } t_0)$$

The corresponding DCGL, based on acceptance of the impact of the drinking water pathway on the results, is:

$$DCGL = 25/8.99 = 2.8 \text{ pCi/g}$$

This DCGL applies equally to U-238 and *each* successive decay product under the assumption that all decay products are in secular equilibrium with the U-238 parent. Additionally, this DCGL incorporates the contribution from U-235 and its decay products.

5.2.3 Summary Results - RESRAD

The results validate that external dose from gamma radiation is the predominant contributor to the dose received at this site due to the presence of thorium radionuclides. The water dependent pathway for uranium was also identified. All other pathways and radionuclide contributors are of diminished significance.

Input/output files in support of the proposed soil DCGLs are provided in Appendix B. The thorium and uranium values cited as a result of the RESRAD evaluations are preferred to the restrictive screening levels specified in NUREG-1757 Volume 1 (Smith et al. Sept 2003) of 1.1 pCi/g for Th-232 and 0.5 pCi/g for U-238, and permit the use of instrumentation with detection sensitivities adequate to satisfy these levels. However, the low preliminary uranium DCGL value, modeled on conservative assumptions, should be re-evaluated and refined based on information gained during the ORISE 2006 characterization survey. This is justified especially if the presence of uranium in trace quantities is confirmed and groundwater contamination is determined to be non-existent. In addition, specific delineation of the contamination areas during the characterization survey may result in justification for the use of "area factors" and correspondingly higher DCGLs in these smaller, localized contamination areas.

5.2.4 Radiological Parameter Inputs to the RESRAD-BUILD Code

The preliminary RESRAD-BUILD DCGLs proposed in this report are designed to aid the ORISE 2006 characterization survey but will be recalculated for completeness as necessary based on additional site information gained during the survey.

In a similar fashion to the RESRAD calculations, site parameters were selected where available and utilized in the preliminary DCGL determination for the modeled constituents present (or assumed to be present) onsite, i.e., natural thorium and natural uranium. Large warehouses remain at the HD site. However, their size (and the lack of interior rooms) aids dispersion, and therefore, was not considered a conservative choice for proper modeling. Therefore, a smaller building dimension with modeled rooms was selected.

Default parameters were primarily utilized for the RESRAD-BUILD evaluations in addition to other assigned conservative inputs. These included the use of default inhalation and ingestion rates, building air exchange, deposition velocity, and resuspension rate. One receptor was modeled with five sources for both the thorium and uranium evaluations along the "x", "y", and "z" planes available in the computer model. Even though the detectable removable activity existed at very low levels, as determined during the ORISE scoping survey (Vitkus 2005), a conservative removable fraction was utilized. Specific inputs to the RESRAD-BUILD evaluations in support of the proposed building DCGLs are provided in an input parameters table (Appendix C) and as input/output files in Appendix D.

The following additional inputs and approach were applied to the RESRAD-BUILD DCGL determination:

- Principal radionuclides and decay products are in secular equilibrium
  - Natural thorium
  - Natural uranium
- A normalized (unit) area factor of 1 pCi/m^2 per radionuclide was applied
- Doses were calculated (by radionuclide) as a function of time, up to 1000 years.
- For conservatism, the peak dose at time = "0" years was determined (per unit activity of parent radionuclide)
- Resulting dose factors were compared to the NRC regulatory limit, resulting in a DCGL (pCi/m^2), using the following equation:

$$DCGL = \left(25mrem \Big/ DSR\,(mrem/pCi/m^2) \right) \qquad (pCi/m^2)$$

- The DCGL (pCi/m^2) was then converted into conventional field survey units of dpm/100cm^2.

5.2.5 RESRAD–BUILD Results

The information provided below details the RESRAD-BUILD results for natural thorium and natural uranium.

5.2.5.1 Significant Pathways: Natural Thorium

As noted above, very little surface contamination was identified as "removable" during the ORISE scoping survey (Vitkus 2005). Nevertheless, the analysis was run with conservative default factors that would result in resuspension and inhalation. Because the objective of this analysis was the determination of preliminary site DCGLs, this conservative dose modeling approach should be refined as site characterization information becomes available.

The figure below provides a histogram plot of the significant pathways from the RESRAD-BUILD run. The inhalation pathway is clearly predominant.

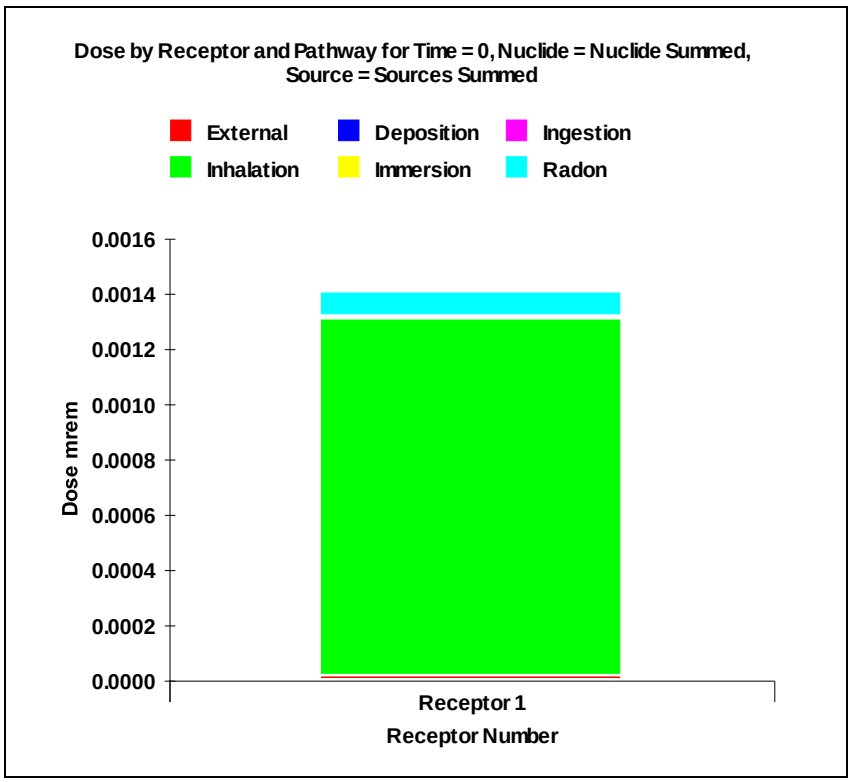

Figure 15 – Influence of natural thorium exposure pathways on receptor dose

The total dose per unit surface activity (pCi/m^2) provided in the RESRAD-BUILD output file is:

$$1.45\ E\text{-}3\ \text{mrem per year per pCi/m}^2$$

Dividing the annual dose limit by the DSR and converting into typical field units of dpm/100cm^2 resulted in the following DCGL:

$$\text{DCGL} = 25/1.45E\text{-}3 = 383\ \text{dpm/100cm}^2$$

A value of *400 dpm/100cm^2* is proposed in this report as a preliminary DCGL for demonstrating compliance with the annual dose limit. This DCGL applies equally to Th-232 and *each* successive decay product under the assumption that all decay products are in secular equilibrium with the parent. Significant Pathways: Natural Uranium

The figure below provides a histogram plot of the significant pathways for natural uranium from the RESRAD-BUILD run. Once again, the inhalation pathway is clearly predominant.

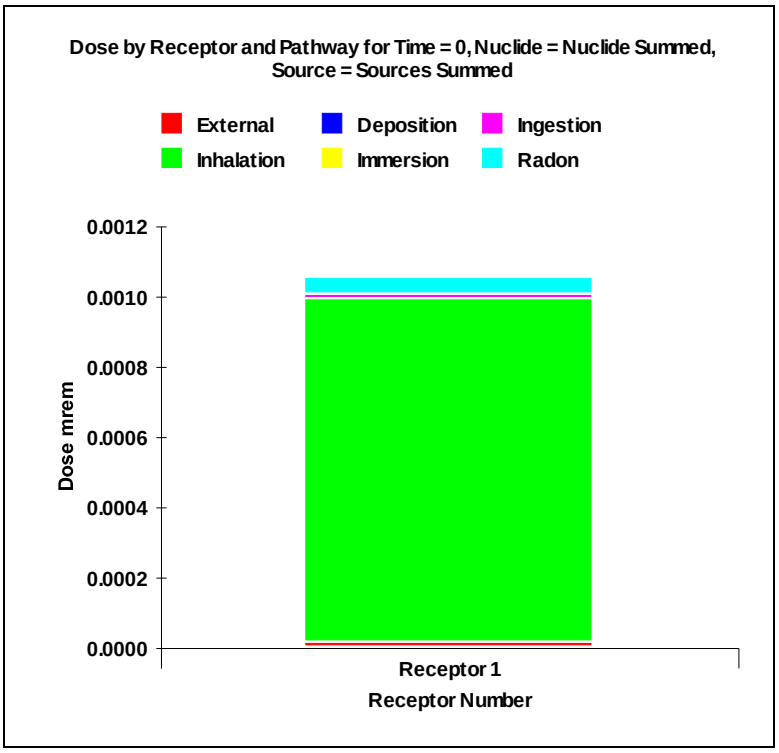

Figure 16 – Influence of natural uranium exposure pathways on receptor dose

The results of the model parameters for natural uranium provided the following total dose per unit surface activity:

$$7.29\ \text{E-4 mrem per year per pCi/m}^2$$

Dividing the annual dose limit by the DSR and converting into typical field units of dpm/100cm^2 resulted in the following DCGL:

$$\text{DCGL} = 25/7.29\text{E-4} = 761\ \text{dpm/100cm}^2$$

A value of *800 dpm/100cm^2* is proposed in this report as a preliminary building DCGL for demonstrating compliance with the annual dose limit. This DCGL applies equally to U-238 and *each* successive decay product under the assumption that all decay products are in secular equilibrium with the U-238 parent. Additionally, this DCGL incorporates the contribution from U-235 and its decay products.

5.3 Quality Assurance of RESRAD and RESRAD-BUILD

The computational tools that were used in this analysis were downloaded from the ANL website. Benchmark tests were conducted within the MS Windows-XP system to ensure that the code was installed and executing properly (the procedure for this may be found in the RESRAD manual).

6.0 SUMMARY and CONCLUSIONS

The Hammond Depot (HD) site, located in Hammond, Indiana, is terminating its source material license (SML) issued by the U.S. Nuclear Regulatory Commission (NRC). In support of that activity, the development of derived concentration guideline levels (DCGLs) through conservative dose modeling evaluations was presented in this report. DCGLs represent radionuclide-specific concentrations that correspond to the established release criteria and were developed for soil and buildings.

The HD has been used by the Defense National Stockpile Center (DNSC) since the latter 1950's for storing drummed and containerized materials. No material processing was ever authorized. Thorium nitrate is the predominant constituent at the site with uranium (U-238, U-235 and their respective decay products) present in trace quantities. Primary thorium radionuclides of interest in this report were thorium-232 (Th-232) and thorium-228 (Th-228).

Adherence to the NRC's primary dose limit of 25 mrem TEDE (in any one year in excess of natural background) and ALARA philosophy cited in 10 CFR 20.1402 is necessary to satisfy the requirements for unrestricted site use. The 25 mrem limit was accordingly used in the derivation of the DCGLs.

The site-specific DCGLs for thorium and uranium in soil and structures were supported through several means, including review of site records and available references, information gathered during the conduct of a HSA and an initial scoping survey conducted by ORISE in 2005, an extensive environmental engineering analysis of the site, which identified relevant site-specific environmental parameters for the computational model equations, and executing the most current deterministic and probabilistic versions of the RESRAD (Version 6.3) and RESRAD-BUILD (Version 3.3) computer models.

Several conservative and reasonable factors were utilized in this dose modeling assessment. These included: 1) Selection of the resident farmer scenario as the conceptual site model and the critical population group. Use of the site for farming purposes in the near future or hundreds of the years in the future may be unlikely due to its location in an industrial area and the preponderance of slag on the site, but remains a credible option; 2) Maintaining all pathways, including the groundwater pathway, as active pathways with the exception of the radon pathway; 3) Taking no credit for the potential of diluting any contaminated soils with a clean soil cover during remedial activities; and 4) Selection of the mass-balance approach for onsite well placement in the contaminated zone. Many other input parameters to the dose modeling code were used with justification for the use of all input parameters provided.

Unit concentrations of one pCi/g for each of the site's radionuclides of concern were used for the RESRAD evaluations. This approach provided dose-to-source ratios (DSRs) in units of mrem/y per pCi/g, calculated for exposed individuals over a 1000 year time period. The DSRs represented maximum doses—a conservative approach since peak

doses for specific radionuclides often occur at different times. A DCGL (pCi/g) for each radionuclide of interest was determined by dividing the DSR into the primary dose limit.

The results validated that external dose from gamma radiation is the predominant contributor to the dose received at this site due to the presence of natural thorium. Because the groundwater pathway was not suppressed as a conservative measure, the water dependent pathway for uranium was also identified as an important pathway which reduced the magnitude of the resulting uranium DCGL value. All other pathways and radionuclide contributors were of considerably less significance.

The RESRAD-BUILD assessment utilized the "Warehouse Worker" scenario. Conservative factors introduced into the RESRAD-BUILD evaluation included taking an existing onsite warehouse and dividing it into a smaller room (to reduce the effect of dilution as it pertains to resuspension) and applying a low building ventilation rate. Unit dose factors, in mrem/y per pCi/m^2, were determined for the RESRAD-BUILD evaluation. When divided into the primary dose limit and converted into conventional field units, a DCGL for each radionuclide of concern was determined in $dpm/100\ cm^2$.

As a result of the RESRAD and RESRAD-BUILD analyses, proposed site-specific soil and building DCGL's for total natural thorium and total natural uranium are provided in the table below:

Primary Radionuclide	**Soil DCGL (pCi/g) (From RESRAD)**	**Building DCGL ($dpm/100cm^2$) (From RESRAD-BUILD)**
Th-232 (and decay products)	3.4	400
U-238 (and decay products)	2.8	800

Table 5: Summary of Soil and Building DCGLs for Natural Thorium and Natural Uranium

These DCGLs represent the amount of soil contamination or building surface activity above background that would result in a total effective dose equivalent of 25 mrem to a member of the critical group. The proposed DCGLs are applicable to each of the individual decay products associated with natural thorium and uranium. For example, the DCGL for natural thorium of 3.4 pCi/g applies to not only Th-232, but to Ra-228 and Th-228 in the Th-232 decay chain as well. In like manner, the DCGL of 2.8 pCi/g for natural uranium applies to U-238 and to each of its decay products and incorporates the contribution from U-235 and its decay products based on the associated radioactivity fraction of ^{235}U to ^{238}U. The proposed DCGLs for soil and buildings will be utilized in support of a detailed characterization of the HD planned for calendar year 2006.

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APPENDIX A:

DEFENSE NATIONAL STOCKPILE CENTER
CURTIS BAY DEPOT DOSE MODELING
RECOMMENDED VALUES FOR RESRAD (v 6.3) INPUT PARAMETERS

DEFENSE NATIONAL STOCKPILE CENTER
HAMMOND DEPOT DOSE MODELING
DEFAULT AND RECOMMENDED VALUES FOR RESRAD (V6.3) INPUT PARAMETERS

RESRAD VERSION 6.3					Recommendations	
Parameter Description	**Parameter Identifier**	**Default Value**	**User Input Value** (values different from default are shown in **bold**)	**Units**	**Justification**	**Reference(s)**
CONTAMINATED ZONE PARAMETERS						
Area of contaminated zone	AREA	10,000	10,000	m^2	For purposes of the RESRAD evaluation, the default value is currently being used until further delineation of contamination zone areas through field characterization surveys occurs. To test the effect of changes in this parameter, a sensitivity analysis using three different input parameters (1000, 5000, and 10,000 m^2) were input into the code. This resulted in a determination that the use of the default RESRAD value results in the highest dose to soil concentration value (mrem/y per pCi/g) and is therefore conservative. Contaminated zone areas will be specifically delineated during the ORISE characterization survey scheduled in 2006. Class 1 (MARSSIM) areas are expected in general to comprise areas significantly less than the specified RESRAD default due to the historical nature of site activities.	ANL 1993 (Section 30) Internal ORISE communication (December 2005)
Thickness of contaminated zone	THICK0	2	**0.15**	m	A *surface* soil thickness was utilized based on the conceptual site model. The ORISE Radiological Scoping Survey results (December 2005) identified very low levels of residual contamination in surface soil samples from the burn cage area with a recommendation that subsurface investigations be performed due to the fact that there is a potential for contamination in this area below 15 to 30 cm. With this exception, contamination appears limited to surface (15 cm) soil. Specific delineation of the areas and depth of contamination will be determined during the 2006 characterization survey. A sensitivity analysis performed using depths of 0.15 and 1 meters resulted in increasing dose to concentration values (as expected with depth under the primary assumption of uniform contamination) and correspondingly decreasing DCGL values.	ANL 1993 (Section 39) ORISE 2005 (Scoping Survey)

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RESRAD VERSION 6.3					Recommendations	
Parameter Description	**Parameter Identifier**	**Default Value**	**User Input Value** (values different from default are shown in **bold**)	**Units**	**Justification**	**Reference(s)**
Length parallel to aquifer flow	LCZPAQ	100	100	m	By definition, calculated as the square root of the contaminated zone area.	ANL 1993 (Section 16)
Times for calculations	TI	1, 3, 10, 30, 100, 300, 1000	1, 3, 10, 30, 100, 300, 1000	yr	From RESRAD model defaults for "calculation times".	ANL 2001
COVER AND CONTAMINATED ZONE HYDROLOGICAL DATA						
Cover depth	COVERO	0	0	m	As a conservative approach for the dose modeling effort, no cover depth was assumed.	ANL 1993 (Section 31)
Density of cover material	DENSCV	1.5	**Not assigned**	g/cm^3	Lack of a soil cover precludes a value being assigned in RESRAD for this parameter.	ANL 1993 (Section 2)
Cover erosion rate	VCV	0.001	**Not assigned**	m/yr	Lack of a soil cover precludes a value being assigned in RESRAD for this parameter.	ANL 1993 (Section 14)
Density of contaminated zone	DENSCZ	1.5	**1.44**	g/cm^3	Fourteen (14) surface soil samples were collected from the site during the ORISE 2005 radiological scoping survey. These consisted of gray to brown soils with some gravel. The average density of those samples is reported based on an ORISE laboratory evaluation.	ORISE 2005 (Scoping Survey and laboratory determination)
Contaminated zone erosion rate	VCZ	0.001	0.001	m/yr	Sufficient site specific data was not available to estimate the erosion rate through empirical models such as the Universal Soil Loss Equation (USLE). Therefore, the RESRAD default value was used.	ANL 1993 (Section 14)

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RESRAD VERSION 6.3					**Recommendations**	
Parameter Description	**Parameter Identifier**	**Default Value**	**User Input Value** (values different from default are shown in **bold**)	**Units**	**Justification**	**Reference(s)**
Contaminated zone total porosity	TPCZ	0.4	0.4	unitless	While initial soil samples have been collected from the ORISE scoping survey to assist with a determination of the total volume, the estimate of pore volume is much more difficult. Therefore, the RESRAD default value was used as an estimate of the total porosity. Note: Porosity is often inferred not directly determined due to difficulty with direct measurements.	ANL 1993 (Section 3) ORISE 2005 (scoping survey) Personal communication with USDA, Maryland (May 2005)
Contaminated zone field capacity	FCCZ	0.2	0.2	unitless	No site-specific data was available. Therefore, the RESRAD default value was used.	ANL 2001
Contaminated zone hydraulic conductivity	HCCZ	10	**4730**	m/yr	A sensitivity analysis was performed using the RESRAD default and a site specific value identified in the literature (4730 m/yr). The results of the analyses demonstrated that differing hydraulic conductivity values had absolutely no effect on the dose to concentration values for the Hammond site. Therefore, the site specific value was selected and used in the input to the "contaminated zone b parameter". ANL discusses the wide ranging values that exist for this parameter.	EPA 2000 ANL 1993 (Section 5)
Contaminated zone b parameter	BCZ	5..3	**3.3**	unitless	This parameter is influenced by site soil types and the hydraulic conductivity choice. For this evaluation, a power fit curve of "conductivity versus zone b parameter" was performed with a resulting correlation coefficient of 0.82. The derivation of this parameter is also discussed in the ANL data collection handbook and representative values provided for comparison in the RESRAD Manual. The value is appropriate for the hydraulic conductivity value selected and the primary site-specific soil types.	ANL 1993 (Section 13) ANL 2001

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RESRAD VERSION 6.3					Recommendations	
Parameter Description	**Parameter Identifier**	**Default Value**	**User Input Value** (values different from default are shown in **bold**)	**Units**	**Justification**	**Reference(s)**
Humidity in air	HUMID	8	**Not assigned**	g/m^3	Humidity input is only required in RESRAD when tritium is a radionuclide of interest.	ANL 2001
Evapotranspiration coefficient	EVAPTR	0.5	0.5	unitless	No site-specific data was available to evaluate this parameter. Therefore, the RESRAD default value was used.	ANL 1993 (Section 12)
Wind speed	WIND	2	**4.5**	m/sec	Per city-data.com, the wind speed data for Hammond, Indiana are as follows: Average 10 mph 4.5 m/s Max 12 mph 5.4 m/s	ANL 1993 (Section 21)
Precipitation	PRECIP	1	**0.95**	m/yr	Site-specific calculated value was based on reported 37" annual average rainfall for the site.	Parsons Engineering Science (2001) ORISE 2005 (HSA Report) ANL 1993 (Section 9)
Irrigation	RI	0.2	0.2	m/yr	The default value was selected based on the absence of site-specific information.	ANL 1993 (Section 11)
Irrigation mode	IDITCH	Overhead	Overhead	unitless	The "Overhead" and "Ditch" designations are independent of the depth of the contaminated zone and have no significant impact on the RESRAD evaluation. The default designation was selected.	ANL 2001
Runoff coefficient	RUNOFF	0.2	0.2	unitless	The default value was selected based on the applicability of some ANL Data Collection Handbook descriptors to Hammond Depot site terrain features (e.g., flat/rolling land and surface soil type). The site is not considered an "agricultural" environment, however.	ANL 1993 (Section 10, Table 10.1)

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RESRAD VERSION 6.3					Recommendations	
Parameter Description	**Parameter Identifier**	**Default Value**	**User Input Value** (values different from default are shown in **bold**)	**Units**	**Justification**	**Reference(s)**
Watershed area for nearby stream or pond	WAREA	1.00E+06	1.00E+06	m^2	The RESRAD default value is being used for the initial dose modeling assessment. If required by the NRC, site specific data, such as from hydrological and morphological maps can be utilized.	ANL 1993 (Section 17)
Accuracy for water/soil computations	EPS	0.001	0.001	unitless	No site-specific or NRC value was available; therefore, the RESRAD default value was assigned.	ANL 2001
SATURATED ZONE HYDROLOGICAL DATA						
Density of saturated zone	DENSAQ	1.5	**1.44**	g/cm^3	An ORISE laboratory evaluation of soil density using collected soil samples from the ORISE scoping survey was used for the density evaluation. The user input is equivalent to the value selected for the contamination zone density.	ORISE 2005 (scoping survey and lab evaluation)
Saturated zone total porosity	TPSZ	0.4	0.4	unitless	The RESRAD default value was used due to the lack of specific site-related information. The value is equivalent to the contaminated zone total porosity input. Note: Porosity is often inferred and not directly determined due to difficulty with direct measurements.	ANL 1993 (Section 3) Personal communication with USDA, Maryland, 2005
Saturated zone effective porosity	EPSZ	0.2	0.2	unitless	No site-specific data was available. Default RESRAD value was used.	ANL 1993 (Section 4)
Saturated zone field capacity	FCSZ	0.2	0.2	unitless	No site-specific data was available. Therefore, the RESRAD default value was used.	ANL 2001
Saturated zone hydraulic conductivity	HCSZ	100	**4730**	m/yr	A site-specific value was utilized. The user input is equivalent to the value selected for the contaminated zone hydraulic conductivity. See "contaminated zone hydraulic conductivity" for further justification of selected value.	EPA 2000 ANL 1993 (Section 5)

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RESRAD VERSION 6.3					Recommendations	
Parameter Description	**Parameter Identifier**	**Default Value**	**User Input Value** (values different from default are shown in **bold**)	**Units**	**Justification**	**Reference(s)**
Saturated zone hydraulic gradient	HGWT	0.02	0.02	unitless	The default value was selected. The ORISE HSA indicates groundwater has not been used by the city of Hammond since 1920 because water supplies are available from Lake Michigan. Groundwater contamination is not considered a significant exposure pathway, though this pathway is "active" in the code for conservatism.	ORISE 2005 (HSA Report) ANL 1993 (Section 15)
Saturated zone b parameter	BSZ	5.3	**3.3**	unitless	The value is appropriate for the hydraulic conductivity value selected and the primary site-specific soil type. See additional discussion under "Contaminated zone b parameter".	ANL 1993 (Section 13)
Water table drop rate	VWT	0.001	0.001	m/yr	The default value was selected based on the assumption of a stationary level of the water table averaged over a long term period. The identical value is used for the erosion rate	ANL 1993 (Section 18)
Well pump intake depth (meters below water table)	DWIBWT	10	10	m	No site-specific data was available. Therefore, the RESRAD default value was used. Note: A site-specific input value would require screened depth of a well (e.g., private wells) within the saturated zone of the aquifer.	ANL 1993 (Section 19)
Model for Water Transport Parameters [Nondispersion (ND) or Mass-Balance (MB)]	MODEL	ND	**MB**	unitless	Per NRC guidance, the mass- balance (MB) model is an acceptable approach and provides a potentially more conservative dose estimate relative to the non-dispersion (ND) model. Accordingly, it is being utilized rather than the default RESRAD model. The MB model assumes a well is located at the center of the site rather than on the down gradient side of the site boundary. In addition, all radionuclides released from the contaminated zone are withdrawn through the well.	NUREG-1757, Vol. 2, App. I., page I-40 NUREG/CR-5512 (Vol. 4, p.3-18)
Well pumping rate	UW	250	250	m^3/yr	Site-specific values have not been generated for any onsite wells. Therefore, the RESRAD default value was used.	ANL 2001
UNCONTAMINATED UNSATURATED ZONE PARAMETERS						

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RESRAD VERSION 6.3					Recommendations	
Parameter Description	**Parameter Identifier**	**Default Value**	**User Input Value** (values different from default are shown in **bold**)	**Units**	**Justification**	**Reference(s)**
Number of unsaturated zone strata	NS	1	1	unitless	No site-specific value was available. A default dilution factor was assumed. Both NRC and ANL use the same default value.	ANL 1993 (Section 25) NUREG/CR-5512 (Vol. 4, p. 3-19)
Unsaturated zone thickness	H(1)	4	**4.572**	m	Site-specific data selected from the literature	USGS 1998
Unsaturated zone soil density	DENSUZ(1)	1.5	**1.44**	g/cm^3	An ORISE laboratory evaluation of soil density using collected soil samples from the ORISE scoping survey was used for the density evaluation. The user input is equivalent to the value selected for the contamination zone and saturated zone densities.	ORISE 2005 (scoping survey and lab evaluation) ANL 1993 (Section 2)
Unsaturated zone total porosity	TPUZ(1)	0.4	0.4	unitless	The RESRAD default value was used due to the lack of specific site-related information. The value is equivalent to the contaminated zone and saturated zone total porosity inputs.	ANL 1993 (Section 3)
Unsaturated zone effective porosity	EPUZ(1)	0.2	0.2	unitless	No site-specific data was available. Therefore, the RESRAD default value was used.	ANL 1993 (Section 4)
Unsaturated zone field capacity	FCUZ(1)	0.2	0.2	unitless	No site-specific data was available. Therefore, the RESRAD default value was used.	ANL 2001
Unsaturated zone hydraulic conductivity	HCUZ(1)	10	**4730**	m/yr	A site-specific value was utilized. See "contaminated zone hydraulic conductivity" for further justification of the selected value. The user input is equivalent to the values selected for the contaminated zone and saturated zone hydraulic conductivities.	EPA 2000 ANL 1993 (Section 5)

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RESRAD VERSION 6.3					Recommendations	
Parameter Description	**Parameter Identifier**	**Default Value**	**User Input Value** (values different from default are shown in **bold**)	**Units**	**Justification**	**Reference(s)**
Unsaturated zone b Parameter	BUZ(1)	5.3	**3.3**	unitless	The value is appropriate for the hydraulic conductivity value selected and the primary site-specific soil types. See additional discussion under "Contaminated zone b parameter".	ANL 1993 (Section 13)
ELEMENTAL DISTRIBUTION (PARTITION) COEFFICIENTS AND LEACH RATES: THORIUM						
Contaminated Zone	DCNUCC(3)	60,000	**3200**	cm^3/g	Sandy soil resides in the surface layer soil (the contaminated zone). For this soil type, the user input K_d value from Table 32.1 of the ANL Data Collection Handbook was selected. Sensitivity analyses, however, indicate that for thorium, the value selected for the K_d in the contaminated zone has no impact on the DCGL determination.	ANL 1993 (Section 32 and Table 32.1)
Unsaturated Zone	DCNUCU(3,1)	60,000	**3200**	cm^3/g	In the absence of site-specific information and values for "slag" materials in the ANL Data Collection Handbook, the value used for the contaminated zone was selected. For thorium, the value selected for the K_d for the unsaturated zone has no impact on the DCGL determination.	ANL 1993 (Section 32 and Table 32.1)
Saturated Zone	DCNUCS(3)	60,000	**3,200**	cm^3/g	In the absence of site-specific information and values for "slag" materials in the ANL Data Collection Handbook, the value used for the contaminated zone was selected. Sensitivity analyses, however, indicate that for thorium, the value selected for the K_d for the saturated zone has no impact on the DCGL determination.	ANL 1993 (Section 32 and Table 32.1)
Leach Rate	ALEACH(3)	0	0	y^{-1}	An optional parameter in RESRAD. No site-specific value was available to measure the magnitude of radionuclides leaching from the contaminated zone. The default value was selected for calculational purposes.	ANL 2001
Solubility Constant	SOLUBK(3)	0	0	unitless	An optional parameter in RESRAD. No site-specific value was available.	ANL 2001
ELEMENTAL DISTRIBUTION (PARTITION) COEFFICIENTS AND LEACH RATES: URANIUM						

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RESRAD VERSION 6.3					Recommendations	
Parameter Description	**Parameter Identifier**	**Default Value**	**User Input Value** (values different from default are shown in **bold**)	**Units**	**Justification**	**Reference(s)**
Contaminated Zone	DCNUCC(5)	50	**35**	cm^3/g	Sandy soil resides in the surface layer soil (the contaminated zone). For this soil type, the user input K_d value from Table 32.1 of the ANL Data Collection Handbook was selected. Sensitivity analyses indicate that for uranium and its progeny, the value selected for the K_d in the contaminated zone has an impact on the DCGL determination.	ANL 1993 (Section 32 and Table 32.1)
Unsaturated Zone	DCNUCU(5,1)	50	**35**	cm^3/g	In the absence of site specific information and values for "slag" materials in the ANL Data Collection Handbook, the user input K_d value from Table 32.1 of the ANL Data Collection Handbook for sandy soil was selected. Sensitivity analyses indicate that for uranium and its progeny, the value selected for the K_d for the unsaturated zone has an impact on the DCGL determination.	ANL 1993 (Section 32 and Table 32.1)
Saturated Zone	DCNUCS(5)	50	**35**	cm^3/g	In the absence of site-specific information and values for "slag" materials in the ANL Data Collection Handbook, the user input K_d value from Table 32.1 of the ANL Data Collection Handbook for sandy soil was selected. Sensitivity analyses indicate that for uranium and its progeny, the value selected for the K_d for the saturated zone has an impact on the DCGL determination.	ANL 1993 (Section 32 and Table 32.1)
Leach Rate	ALEACH(5)	0	0	y^{-1}	An optional parameter in RESRAD. No site-specific value was available to measure the magnitude of radionuclides leaching from the contaminated zone. The default value was selected for calculational purposes.	ANL 2001
Solubility Constant	SOLUBK(5)	0	0	unitless	An optional parameter in RESRAD. No site-specific value was available.	ANL 2001
ELEMENTAL DISTRIBUTION (PARTITION) COEFFICIENTS AND LEACH RATES: RADIUM						

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RESRAD VERSION 6.3					Recommendations	
Parameter Description	**Parameter Identifier**	**Default Value**	**User Input Value** (values different from default are shown in **bold**)	**Units**	**Justification**	**Reference(s)**
Contaminated Zone	DCNUCC(2)	70	**500**	cm^3/g	Sandy soil resides in the surface layer soil (the contaminated zone). For this soil type, the user input K_d value from Table 32.1 of the ANL Data Collection Handbook was selected. Radium appears in the RESRAD code as one of the daughter elements of uranium. However, it has no relevance to the DCGL determination as the DCGL is driven by the uranium (U-238) parent.	ANL 1993 (Section 32 and Table 32.1)
Unsaturated Zone	DCNUCU(2,1)	70	**500**	cm^3/g	In the absence of site-specific information and values for "slag" materials in the ANL Data Collection Handbook, the value used for the contaminated zone was selected.	ANL 1993 (Section 32 and Table 32.1)
Saturated Zone	DCNUCS(2)	70	**500**	cm^3/g	In the absence of site-specific information and values for "slag" materials in the ANL Data Collection Handbook, the value used for the contaminated zone was selected.	ANL 1993 (Section 32 and Table 32.1)
Leach Rate	ALEACH(2)	0	0	y^{-1}	An optional parameter in RESRAD. No site-specific value was available to measure the magnitude of radionuclides leaching from the contaminated zone. The default value was selected for calculational purposes.	ANL 2001
Solubility Constant	SOLUBK(2)	0	0	unitless	An optional parameter in RESRAD. No site-specific value was available.	ANL 2001
OCCUPANCY, INHALATION AND EXTERNAL GAMMA DATA						
Inhalation rate	INHALR	8,400	8,400	m^3/h	Significant uncertainty exists in the literature for this value. The values discussed and cited in NUREG-5512, Volume 3 overlap with the RESRAD default value. Therefore, the RESRAD value was selected which is slightly below the annual (and conventionally cited) "light" breathing rate for males of 1.2 m^3/h (10,512 m^3/y from ICRP Report 23. was selected.	NUREG/CR-5512 (Vol. 3, p.6-50) ANL 1993 (Section 43) ICRP Report 23
Mass loading for inhalation	MLINH	0.0001	0.0001	g/m^3	Empirical data was not generated for this parameter. Therefore, the RESRAD default parameter was used.	ANL 1993 (Section 35)

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Parameter Description	**Parameter Identifier**	**Default Value**	**User Input Value** (values different from default are shown in **bold**)	**Units**	**Justification**	**Reference(s)**
Exposure duration	ED	30	30	yr	The RESRAD default was used because DCGL calculations are not influenced by the exposure duration.	ANL 2001
Inhalation Shielding factor	SHF3	0.4	0.4	unitless	No site-specific or NRC value was available; therefore, the RESRAD default value was assigned.	ANL 1993 (Section 36)
External gamma shielding factor	SHF1	0.7	**0.55**	unitless	A site-specific determination of this parameter, based on the effect of representative onsite building construction on external gamma attenuation inside a building, has not been performed. ORISE can determine this value for a representative onsite building (if required) during the 2006 characterization survey by comparing exposure rates taken from inside and outside the building. This parameter does affect the dose to concentration value in a non-conservative manner (as determined through a sensitivity analysis) resulting in an increase in the value of the DCGL. The specific user input value cited in the referenced NRC NUREG was used for the purpose of the RESRAD assessment. The literature cites a variety of values for this parameter.	NUREG/CR-5512 (Vol. 4, p. 3-34, Table 14) ANL 1993 (Section 48)
Indoor Time Fraction (on site)	FIND	0.5	0.5	unitless	The RESRAD default value was used for the purpose of the DCGL determination. The literature cites a variety of values for this parameter.	ANL 1993 (Section 28)
Outdoor Time Fraction (on site)	FOTD	0.25	**0.1181**	unitless	The user input value cited in the NRC referenced NUREGs was used for the purpose of the RESRAD assessment. This parameter does affect the dose to concentration value in a non-conservative manner (as determined through a sensitivity analysis) resulting in an increase in the value of the DCGL. The literature cites a variety of values for this parameter.	NUREG/CR-5512 (Vol. 4, p. A-5, Table A.2) ANL 1993 (Section 29)

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Parameter Description	**Parameter Identifier**	**Default Value**	**User Input Value** (values different from default are shown in **bold**)	**Units**	**Justification**	**Reference(s)**
Shape of the contaminated zone (Circular or Non-circular)	FS	Circular	Circular	unitless	A specific determination of the area and shape of any contaminated zones will be determined during the ORISE 2006 characterization survey. Therefore, the default designation was selected for the purposes of the current RESRAD dose modeling assessment.	ANL 1993 (Section 50)
INGESTION PATHWAY (DIETARY DATA)						
Fruits, vegetables, and grain consumption	DIET(1)	160	160	kg/yr	No site-specific value was available. The default RESRAD value is more conservative than the NRC value of 112 kg/yr.	ANL 1993 (Section 42) NUREG/CR-5512 (Vol. 4, p. 3-6)
Leafy vegetable consumption	DIET(2)	14	**21.4**	kg/yr	No site-specific value was available. The NRC value was used instead for added conservatism in the dose estimate.	ANL 1993 (Section 44) NUREG/CR-5512 (Vol. 4, p. 3-6)
Milk consumption	DIET(3)	92	**233**	L/yr	No site-specific value was available. The NRC value was used instead for added conservatism in the dose estimate.	ANL 1993 (Section 47) NUREG/CR-5512 (Vol. 4, p. 3-6)
Meat and poultry consumption	DIET(4)	63	**65.1**	kg/yr	No site-specific value was available. The NRC value was used instead for added conservatism in the dose estimate.	ANL 1993 (Section 46) NUREG/CR-5512 (Vol. 4, p. 3-6)

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RESRAD VERSION 6.3					**Recommendations**	
Parameter Description	**Parameter Identifier**	**Default Value**	**User Input Value** (values different from default are shown in **bold**)	**Units**	**Justification**	**Reference(s)**
Fish consumption	DIET(5)	5.4	**20.6**	kg/yr	No site-specific value was available. The NRC value was used instead for added conservatism in the dose estimate.	ANL 1993 (Section 41) NUREG/CR-5512 (Vol. 4, p. 3-6)
Other seafood consumption	DIET(6)	0.9	0.9	kg/yr	No site-specific or NRC value was available; therefore, the default value was assigned.	ANL 1993 (Section 41)
Soil ingestion	SOIL	36.5	36.5	g/yr	The default RESRAD value results in a more conservative dose estimate than the NRC value of 18.3 g/yr and is also in agreement with the EPA value for this parameter.	ANL 1993 (Section 38) NUREG/CR-5512 (Vol. 4, p. 3-7)
Drinking water intake	DW1	510	510	L/yr	The default RESRAD value is more conservative than the NRC value of 478.5 L/yr. For comparison, "reference man" (ICRP 23) has an assigned intake of 2L/d or 730 L/y.	ANL 1993 (Section 52) NUREG/CR-5512 (Vol. 4, p. 3-7)
Contaminated fraction of drinking water	FDW	1	1	unitless	No site-specific value was available; therefore, the maximum NRC value was assigned to this parameter.	NUREG/CR-5512 (Vol. 4, p. 3-7) ANL 2001
Contaminated fraction of household water	FHHW	1	**Not assigned**	unitless	The radon pathway is not applicable; hence no value is assigned in RESRAD for this parameter.	ANL 2001
Contaminated fraction of livestock water	FLW	1	1	unitless	No site-specific value was available; therefore, the maximum NRC value was assigned to this parameter.	NUREG/CR-5512 (Vol. 4, p. 3-7)

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RESRAD VERSION 6.3					Recommendations	
Parameter Description	**Parameter Identifier**	**Default Value**	**User Input Value** (values different from default are shown in **bold**)	**Units**	**Justification**	**Reference(s)**
Contaminated fraction of irrigation water	FIRW	1	1	unitless	No site-specific value was available; therefore, the maximum NRC value was assigned to this parameter.	NUREG/CR-5512 (Vol. 4, p. 3-7)
Contaminated fraction of aquatic food	FR9	0.5	**1**	unitless	No site-specific value was available; therefore, the maximum NRC value was assigned to this parameter.	NUREG/CR-5512 (Vol. 4, p. 3-7)
Contaminated fraction of plant food	FPLANT	-1	**1**	unitless	No site-specific value was available; therefore, the maximum NRC value was assigned to this parameter.	NUREG/CR-5512 (Vol. 4, p. 3-7)
Contaminated fraction of meat	FMEAT	-1	**1**	unitless	No site-specific value was available; therefore, the maximum NRC value was assigned to this parameter.	NUREG/CR-5512 (Vol. 4, p. 3-7)
Contaminated fraction of milk	FMILK	-1	**1**	unitless	No site-specific value was available; therefore, the maximum NRC value was assigned to this parameter.	NUREG/CR-5512 (Vol. 4, p. 3-7)
INGESTION PATHWAY (NONDIETARY DATA)						
Livestock fodder intake for meat	LP15	68	68	kg/day	No site-specific value was available. NUREG/CR-6697 provides a range of values (13.4 to 53.6 kg/day); however, a specific justification for selecting a particular value within the range provided could not be identified. Therefore, the default value was selected.	NUREG/CR-6697, Table 3-1, p. 157)
Livestock fodder intake for milk	LP16	55	55	kg/day	No site-specific value was available. NUREG/CR-6697 provides a range of values (31.6 to 126 kg/day); however, a specific justification for selecting a particular value within the range provided could not be identified. Therefore, the default value was selected.	NUREG/CR-6697, Table 3-1, p. 158)

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RESRAD VERSION 6.3					**Recommendations**	
Parameter Description	**Parameter Identifier**	**Default Value**	**User Input Value** (values different from default are shown in **bold**)	**Units**	**Justification**	**Reference(s)**
Livestock water intake for meat	LW15	50	50	L/day	No site-specific value was available. NUREG/CR-6697 provides a range of values (25 to 100 L/day). The "base" or middle value (50 L/day) is in agreement with the RESRAD default value and was selected.	NUREG/CR-6697, Table 3-1, p. 158) ANL 1993 (Section 45)
Livestock water intake for milk	LW16	160	160	L/day	No site-specific value was available. NUREG/CR-6697 provides a range of values (30 to 120 L/day); however, a specific justification for selecting a particular value within the range provided could not be identified. Therefore, the default value was selected.	NUREG/CR-6697, Table 3-1, p. 158) ANL 1993 (Section 45)
Livestock intake of soil	LS1	0.5	0.5	kg/day	No site-specific value was identified; NUREG/CR-6697 provides a range of values (0.25 to 1.0 kg/day). The "base" or middle value (50 L/day) is in agreement with the RESRAD default value and was selected.	NUREG/CR-6697, Table 3-1, p. 158)
Mass loading for foliar deposition	MLFD	0.0001	0.0001	g/m^3	No site-specific value was identified; NUREG/CR-6697 provides a range of values (1E-7 to 7E-4 g/m^3); however, a specific justification for selecting a particular value within the range provided could not be identified. Therefore, the RESRAD default value was assigned.	NUREG/CR-6697, Table 3-1, p. 158)
Depth of soil mixing layer	DM	0.15	0.15	m	No site-specific value was identified; NUREG/CR-6697 provides a range of values (0.075 to 0.3 m). The "base" or middle value (0.15 m) is in agreement with the RESRAD default value and was selected.	NUREG/CR-6697, Table 3-1, p. 158) ANL 1993 (Section 35)

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RESRAD VERSION 6.3					Recommendations	
Parameter Description	**Parameter Identifier**	**Default Value**	**User Input Value** (values different from default are shown in **bold**)	**Units**	**Justification**	**Reference(s)**
Depth of roots	DROOT	0.9	0.9	m	No site-specific value was identified; NUREG/CR-6697 provides a range of values (0.3 to 3 m). The "base" or middle value (0.9 m) is in agreement with the RESRAD default value and was selected.	NUREG/CR-6697, Table 3-1, p. 159) ANL 1993 (Section 37)
Groundwater Fractional Usage: Drinking water	FGWDW	1	1	unitless	No site-specific value was identified; The RESRAD and NRC parameter values are identical and were selected.	NUREG/CR-5512 (Vol. 4, p. 3-7)
Groundwater Fractional Usage: Household water	FGWHH	1	**Not assigned**	unitless	The radon pathway is "suppressed" and therefore not applicable; hence no value was assigned for this parameter.	NRC Federal Register Notice (2004)
Groundwater Fractional Usage: Livestock water	FGWLW	1	1	unitless	No site-specific value was identified. The RESRAD and NRC parameter values are identical and were selected.	NUREG/CR-5512 (Vol. 4, p. 3-7)
Groundwater Fractional Usage: Irrigation water	FGWIR	1	1	unitless	No site-specific value was identified. The RESRAD and NRC parameter values are identical and were selected.	NUREG/CR-5512 (Vol. 4, p. 3-7)
PLANT TRANSFER FACTORS						
Wet weight crop yield: non-leafy vegetables	YV(1)	0.7	0.7	kg/m^2	No site-specific value was identified; NUREG/CR-6697 provides a range of values (0.31 to 3 kg/m^2); however, a specific justification for selecting a particular value within the range provided could not be identified. Therefore, the RESRAD default value was assigned.	NUREG/CR-6697, Table 3-1, p. 159)
Wet weight crop yield: leafy vegetables	YV(2)	1.5	1.5	kg/m^2	No site-specific value was identified; NUREG/CR-6697 provides a range of values (2.7 to 3 kg/m^2); however, a specific justification for selecting a particular value within the range provided could not be identified. Therefore, the RESRAD default value was assigned.	NUREG/CR-6697, Table 3-1, p. 159)

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RESRAD VERSION 6.3					Recommendations	
Parameter Description	**Parameter Identifier**	**Default Value**	**User Input Value** (values different from default are shown in **bold**)	**Units**	**Justification**	**Reference(s)**
Wet weight crop yield: fodder	YV(3)	1.1	1.1	kg/m^2	No site-specific value was identified; NUREG/CR-6697 provides a range of values (1.259 to 2.36 kg/m^2); however, a specific justification for selecting a particular value within the range provided could not be identified. Therefore, the RESRAD default value was assigned.	NUREG/CR-6697, Table 3-1, p. 159)
Length of growing season: non-leafy vegetables	TE(1)	0.17	0.17	years	No site-specific value was identified; NUREG/CR-6697 provides a range of values (0.085 to 0.4932 years); however, a specific justification for selecting a particular value within the range provided could not be identified. Therefore, the RESRAD default value was assigned.	NUREG/CR-6697, Table 3-1, p. 159)
Length of growing season: leafy vegetables	TE(2)	0.25	0.25	years	No site-specific value was identified; NUREG/CR-6697 provides a range of values (0.062 to 0.246 years); however, a specific justification for selecting a particular value within the range provided could not be identified. Therefore, the RESRAD default value was assigned.	NUREG/CR-6697, (Table 3-1, p. 159)
Length of growing season: fodder	TE(3)	0.08	0.08	years	No site-specific value was identified; NUREG/CR-6697 provides a range of values (0.04 to 0.16 years). The "base" or middle value (0.082 m) is in agreement with the RESRAD default value and was selected.	NUREG/CR-6697, (Table 3-1, p. 160)
Translocation factor: non-leafy vegetables	TIV(1)	0.1	0.1	unitless	No site-specific value was identified; NUREG/CR-6697 provides a range of values (0.06 to 0.2). The "base" or middle value (0.1) is in agreement with the RESRAD default value and was selected.	NUREG/CR-6697, (Table 3-1, p. 160)
Translocation factor: leafy vegetables	TIV(2)	1	1	unitless	No site-specific value was identified; NUREG/CR-6697 provides a range of values (0.5 to 1). The "base" or middle value (1) and maximum values are in agreement with the RESRAD default value and was selected.	NUREG/CR-6697, (Table 3-1, p. 160)
Translocation factor: fodder	TIV(3)	1	1	unitless	No site-specific value was identified; NUREG/CR-6697 provides a range of values (0.5 to 1). The "base" or middle value (1) and maximum values are in agreement with the RESRAD default value and was selected.	NUREG/CR-6697, (Table 3-1, p. 160)

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RESRAD VERSION 6.3					**Recommendations**	
Parameter Description	**Parameter Identifier**	**Default Value**	**User Input Value** (values different from default are shown in **bold**)	**Units**	**Justification**	**Reference(s)**
Weathering removal constant for vegetation	WLAM	20	20	y^{-1}	No site-specific value was identified; NUREG/CR-6697 provides a range of values (10 to 40). The "base" or middle value (20) is in agreement with the RESRAD default value and was selected.	NUREG/CR-6697, (Table 3-1, p. 160)
Wet foliar interception fraction: non-leafy vegetables	RWET(1)	0.25	0.25	unitless	No site-specific value was identified; NUREG/CR-6697 provides a range of values (0.1 to 0.6); however, a specific justification for selecting a particular value within the range provided could not be identified. Therefore, the RESRAD default value was assigned.	NUREG/CR-6697, (Table 3-1, p. 160)
Wet foliar interception fraction: leafy vegetables	RWET(2)	0.25	0.25	unitless	No site-specific value was identified; NUREG/CR-6697 provides a range of values (0.1 to 0.6); however, a specific justification for selecting a particular value within the range provided could not be identified. Therefore, the RESRAD default value was assigned.	NUREG/CR-6697, (Table 3-1, p. 161)
Wet foliar interception fraction: fodder	RWET(3)	0.25	0.25	unitless	No site-specific value was identified; NUREG/CR-6697 provides a range of values (0.1 to 0.6); however, a specific justification for selecting a particular value within the range provided could not be identified. Therefore, the RESRAD default value was assigned.	NUREG/CR-6697, (Table 3-1, p. 161)
Dry foliar interception fraction: non-leafy vegetables	RDRY(1)	0.25	0.25	unitless	No site-specific value was identified; NUREG/CR-6697 provides a range of values; however, a specific justification for selecting a particular value within the range provided could not be identified. Therefore, the RESRAD default value was assigned.	NUREG/CR-6697, (Table 3-1, p. 160)
Dry foliar interception fraction: leafy vegetables	RDRY(2)	0.25	0.25	unitless	No site-specific value was identified; NUREG/CR-6697 provides a range of values; however, a specific justification for selecting a particular value within the range provided could not be identified. Therefore, the RESRAD default value was assigned.	NUREG/CR-6697, (Table 3-1, p. 160)

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RESRAD VERSION 6.3					Recommendations	
Parameter Description	**Parameter Identifier**	**Default Value**	**User Input Value** (values different from default are shown in **bold**)	**Units**	**Justification**	**Reference(s)**
Dry foliar interception fraction: fodder	RDRY(3)	0.25	0.25	unitless	No site-specific value was identified; NUREG/CR-6697 provides a range of values; however, a specific justification for selecting a particular value within the range provided could not be identified. Therefore, the RESRAD default value was assigned.	NUREG/CR-6697, (Table 3-1, p. 160)
STORAGE TIMES BEFORE USE DATA						
Fruits, non-leafy vegetables, and grain	STOR_T(1)	14	14	days	The NRC and RESRAD default parameters are identical. Therefore, this value was assigned.	ANL 2001 NUREG/CR-5512 (Vol. 4, p.3-7)
Leafy vegetables	STOR_T(2)	1	1	days	The NRC and RESRAD default parameters are identical. Therefore, this value was assigned.	NUREG/CR-5512 (Vol. 4, p. 3-7)
Milk	STOR_T(3)	1	1	days	The NRC and RESRAD default parameters are identical. Therefore, this value was assigned.	NUREG/CR-5512 (Vol. 4, p. 3-7)
Meat	STOR_T(4)	20	20	days	The NRC and RESRAD default parameters are identical. Therefore, this value was assigned.	NUREG/CR-5512 (Vol. 4, p.3-8)
Fish	STOR_T(5)	7	7	days	The NRC and RESRAD default parameters are identical. Therefore, this value was assigned.	ANL 2001 NUREG/CR-5512 (Vol. 4, p.3-8)
Crustacea and mollusks	STOR_T(6)	7	7	days	The NRC and RESRAD default parameters are identical. Therefore, this value was assigned.	ANL 2001 NUREG/CR-5512 (Vol. 4, p.3-8)

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RESRAD VERSION 6.3					Recommendations	
Parameter Description	**Parameter Identifier**	**Default Value**	**User Input Value** (values different from default are shown in **bold**)	**Units**	**Justification**	**Reference(s)**
Well water	STOR_T(7)	1	1	days	The NRC and RESRAD default parameters are identical. Therefore, this value was assigned.	ANL 2001 NUREG/CR-5512 (Vol. 4, p.3-8)
Surface water	STOR_T(8)	1	1	days	The NRC and RESRAD default parameters are identical. Therefore, this value was assigned.	ANL 2001 NUREG/CR-5512 (Vol. 4, p.3-8)
Livestock fodder	STOR_T(9)	45	45	days	The NRC and RESRAD default parameters are identical. Therefore, this value was assigned.	ANL 2001 NUREG/CR-5512 (Vol. 4, p.3-8)
RADON DATA						
Thickness of building foundation	FLOOR1	0.15	**Not assigned**	m	This parameter is not applicable because the radon pathway was not selected.	ANL 1993 (Section 26)
Bulk density of building foundation	DENSFL	2.4	**Not assigned**	g/cm^3	This parameter is not applicable because the radon pathway was not selected.	ANL 1993 (Section 2)
Total porosity of the cover material	TPCV	0.4	**Not assigned**	unitless	This parameter is not applicable because the radon pathway was not selected.	ANL 1993 (Section 3)
Building foundation total porosity	TPFL	0.1	**Not assigned**	unitless	This parameter is not applicable because the radon pathway was not selected.	ANL 1993 (Section 3)
Volumetric water content of the cover material	PH20CV	0.05	**Not assigned**	unitless	This parameter is not applicable because the radon pathway was not selected.	ANL 1993 (Section 6)
Volumetric water content of the building foundation	PH20FL	0.03	**Not assigned**	unitless	This parameter is not applicable because the radon pathway was not selected.	ANL 1993 (Section 6)

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RESRAD VERSION 6.3					Recommendations	
Parameter Description	**Parameter Identifier**	**Default Value**	**User Input Value** (values different from default are shown in **bold**)	**Units**	**Justification**	**Reference(s)**
Diffusion coefficient for radon gas: cover zone soil material	DIFCV	2.00E-06	**Not assigned**	m^2/sec	This parameter is not applicable because the radon pathway was not selected.	ANL 1993 (Section 7)
Diffusion coefficient for radon gas: building foundation material	DIFFL	3.00E-07	**Not assigned**	m^2/sec	This parameter is not applicable because the radon pathway was not selected.	ANL 1993 (Section 7)
Diffusion coefficient for radon gas: contaminated zone soil	DIFCZ	2.00E-06	**Not assigned**	m^2/sec	This parameter is not applicable because the radon pathway was not selected.	ANL 1993 (Section 7)
Radon vertical dimension of mixing	HMIX	2	**Not assigned**	m	This parameter is not applicable because the radon pathway was not selected.	ANL 1993 (Section 20)
Average building air exchange rate	REXG	0.5	**Not assigned**	1/hour (hr^{-1})	This parameter is not applicable because the radon pathway was not selected.	ANL 1993 (Section 22)
Height of the building (room)	HRM	2.5	**Not assigned**	m	This parameter is not applicable because the radon pathway was not selected.	ANL 1993 (Section 23)
Building interior area factor	FAI	0	**Not assigned**	unitless	This parameter is not applicable because the radon pathway was not selected.	ANL 1993 (Section 23)
Building depth below ground surface	DMFL	-1	**Not assigned**	m	This parameter is not applicable because the radon pathway was not selected.	ANL 1993 (Section 24)
Emanating power of Rn-222 gas in contamination zone (radon emanation coefficient)	EMANA(1)	0.25	**Not assigned**	unitless	This parameter is not applicable because the radon pathway was not selected.	ANL 1993 (Section 8)
Emanating power of Rn-220 gas in contamination zone (radon emanation coefficient)	EMANA(2)	0.15	**Not assigned**	unitless	This parameter is not applicable because the radon pathway was not selected.	ANL 1993 (Section 8)
PATHWAY SELECTIONS						

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RESRAD VERSION 6.3					Recommendations	
Parameter Description	**Parameter Identifier**	**Default Value**	**User Input Value** (values different from default are shown in **bold**)	**Units**	**Justification**	**Reference(s)**
External gamma	NA	active	active	unitless	NA	NA
Inhalation (without radon)	NA	active	active	unitless	NA	NA
Plant ingestion	NA	active	active	unitless	NA	NA
Meat ingestion	NA	active	active	unitless	NA	NA
Milk ingestion	NA	active	active	unitless	NA	NA
Aquatic foods	NA	active	active	unitless	NA	NA
Drinking water	NA	active	active	unitless	NA	NA
Soil ingestion	NA	active	active	unitless	NA	NA
Radon	NA	active	**inactive (suppressed)**	unitless	This pathway was suppressed because the radon pathway is not applicable to this assessment.	Federal Register, 1994, p. 43210

Selected references and other notes and identifiers in this table:

ORISE, Final Report–*Radiological Scoping Survey of the Hammond Depot, Hammond, Indiana*, Oak Ridge Institute for Science and Education, December 2005.

ANL, *Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil*, Environmental Assessment and Information Sciences Division, Argonne National Laboratory, April 1993.

Parsons Engineering Science, Inc., *FINAL Focused Site Investigation Report, Hammond Depot, Hammond, Indiana, report prepared for the* U.S. Army Corps of Engineers, February 2001

ORISE, *Final Report – Historical Site Assessment of the Hammond Depot, Hammond, Indiana,* Oak Ridge Institute for Science and Education, September 2005.

ANL, *User's Manual for RESRAD, Version 6.0,* Environmental Assessment and Information Sciences Division, Argonne National Laboratory, July 2001

NRC, Federal Register, *Comments from Workshops;Radon,*Vol. 59, No. 161, Monday, August 22, 1994, p. 43210

NA = "Not applicable"

ORISE
01/13/2006

APPENDIX B.1:

RESRAD INPUT/OUTPUT FILE FOR THORIUM

Summary : Th-232 DCGL for Hammond Depot (Chapman)
File : VALIDATE-Th232 DCGL HD1-kd-lookup 7424 FINAL 01-12-06.RAD

Table of Contents

Part I: Mixture Sums and Single Radionuclide Guidelines

Dose Conversion Factor (and Related) Parameter Summary
File: FGR 13 MORBIDITY

Menu	Parameter	Current Value	Base Case*	Parameter Name
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Ra-228+D	5.078E-03	4.770E-03	DCF2(1)
B-1	Th-228+D	3.454E-01	3.420E-01	DCF2(2)
B-1	Th-232	1.640E+00	1.640E+00	DCF2(3)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Ra-228+D	1.442E-03	1.440E-03	DCF3(1)
D-1	Th-228+D	8.086E-04	3.960E-04	DCF3(2)
D-1	Th-232	2.730E-03	2.730E-03	DCF3(3)
D-34	Food transfer factors:			
D-34	Ra-228+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(1,1)
D-34	Ra-228+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(1,2)
D-34	Ra-228+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF(1,3)
D-34				
D-34	Th-228+D , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(2,1)
D-34	Th-228+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(2,2)
D-34	Th-228+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(2,3)
D-34				
D-34	Th-232 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(3,1)
D-34	Th-232 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(3,2)
D-34	Th-232 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(3,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Ra-228+D , fish	5.000E+01	5.000E+01	BIOFAC(1,1)
D-5	Ra-228+D , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC(1,2)
D-5				
D-5	Th-228+D , fish	1.000E+02	1.000E+02	BIOFAC(2,1)
D-5	Th-228+D , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC(2,2)
D-5				
D-5	Th-232 , fish	1.000E+02	1.000E+02	BIOFAC(3,1)
D-5	Th-232 , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC(3,2)

*Base Case means Default.Lib w/o Associate Nuclide contributions.

Site-Specific Parameter Summary

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	1.000E+04	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	1.500E-01	2.000E+00	---	THICK0
R011	Length parallel to aquifer flow (m)	1.000E+02	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	2.500E+01	3.000E+01	---	BRDL
R011	Time since placement of material (yr)	0.000E+00	0.000E+00	---	TI
R011	Times for calculations (yr)	1.000E+00	1.000E+00	---	T(2)
R011	Times for calculations (yr)	3.000E+00	3.000E+00	---	T(3)
R011	Times for calculations (yr)	1.000E+01	1.000E+01	---	T(4)
R011	Times for calculations (yr)	3.000E+01	3.000E+01	---	T(5)
R011	Times for calculations (yr)	1.000E+02	1.000E+02	---	T(6)
R011	Times for calculations (yr)	3.000E+02	3.000E+02	---	T(7)
R011	Times for calculations (yr)	1.000E+03	1.000E+03	---	T(8)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(9)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): Ra-228	1.000E+00	0.000E+00	---	S1(1)
R012	Initial principal radionuclide (pCi/g): Th-228	1.000E+00	0.000E+00	---	S1(2)
R012	Initial principal radionuclide (pCi/g): Th-232	1.000E+00	0.000E+00	---	S1(3)
R012	Concentration in groundwater (pCi/L): Ra-228	not used	0.000E+00	---	W1(1)
R012	Concentration in groundwater (pCi/L): Th-228	not used	0.000E+00	---	W1(2)
R012	Concentration in groundwater (pCi/L): Th-232	not used	0.000E+00	---	W1(3)
R013	Cover depth (m)	0.000E+00	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	not used	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	not used	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.440E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	4.000E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity	2.000E-01	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	4.730E+03	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	3.300E+00	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	4.500E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	5.000E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	9.500E-01	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	2.000E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	2.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	1.000E+06	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	1.000E-03	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)	1.440E+00	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	4.000E-01	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	2.000E-01	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	2.000E-01	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	4.730E+03	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	2.000E-02	2.000E-02	---	HGWT
R014	Saturated zone b parameter	3.300E+00	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	1.000E-03	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	1.000E+01	1.000E+01	---	DWIBWT

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	MB	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	2.500E+02	2.500E+02	---	UW
R015	Number of unsaturated zone strata	1	1	---	NS
R015	Unsat. zone 1, thickness (m)	4.572E+00	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	1.440E+00	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	4.000E-01	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	2.000E-01	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	2.000E-01	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	3.300E+00	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	4.730E+03	1.000E+01	---	HCUZ(1)
R016	Distribution coefficients for Ra-228				
R016	Contaminated zone (cm**3/g)	5.000E+02	7.000E+01	---	DCNUCC(1)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+02	7.000E+01	---	DCNUCU(1,1)
R016	Saturated zone (cm**3/g)	5.000E+02	7.000E+01	---	DCNUCS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	4.443E-03	ALEACH(1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)
R016	Distribution coefficients for Th-228				
R016	Contaminated zone (cm**3/g)	3.200E+03	6.000E+04	---	DCNUCC(2)
R016	Unsaturated zone 1 (cm**3/g)	3.200E+03	6.000E+04	---	DCNUCU(2,1)
R016	Saturated zone (cm**3/g)	3.200E+03	6.000E+04	---	DCNUCS(2)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	6.944E-04	ALEACH(2)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(2)
R016	Distribution coefficients for Th-232				
R016	Contaminated zone (cm**3/g)	3.200E+03	6.000E+04	---	DCNUCC(3)
R016	Unsaturated zone 1 (cm**3/g)	3.200E+03	6.000E+04	---	DCNUCU(3,1)
R016	Saturated zone (cm**3/g)	3.200E+03	6.000E+04	---	DCNUCS(3)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	6.944E-04	ALEACH(3)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(3)
R017	Inhalation rate (m**3/yr)	8.400E+03	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	1.000E-04	1.000E-04	---	MLINH
R017	Exposure duration	3.000E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	4.000E-01	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	5.500E-01	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	5.000E-01	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	1.181E-01	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	1.000E+00	1.000E+00	>0 shows circular AREA.	FS

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE(1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE(2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE(3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE(4)
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE(5)
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE(6)
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE(7)
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE(8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE(9)
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA(1)
R017	Ring 2	not used	2.732E-01	---	FRACA(2)
R017	Ring 3	not used	0.000E+00	---	FRACA(3)
R017	Ring 4	not used	0.000E+00	---	FRACA(4)
R017	Ring 5	not used	0.000E+00	---	FRACA(5)
R017	Ring 6	not used	0.000E+00	---	FRACA(6)
R017	Ring 7	not used	0.000E+00	---	FRACA(7)
R017	Ring 8	not used	0.000E+00	---	FRACA(8)
R017	Ring 9	not used	0.000E+00	---	FRACA(9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)
R018	Fruits, vegetables and grain consumption (kg/yr)	1.600E+02	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	2.140E+01	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	2.330E+02	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	6.510E+01	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	2.060E+01	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	9.000E-01	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	3.650E+01	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	5.100E+02	5.100E+02	---	DWI
R018	Contamination fraction of drinking water	1.000E+00	1.000E+00	---	FDW
R018	Contamination fraction of household water	not used	1.000E+00	---	FHHW
R018	Contamination fraction of livestock water	1.000E+00	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	1.000E+00	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	1.000E+00	5.000E-01	---	FR9
R018	Contamination fraction of plant food	1.000E+00	-1	---	FPLANT
R018	Contamination fraction of meat	1.000E+00	-1	---	FMEAT
R018	Contamination fraction of milk	1.000E+00	-1	---	FMILK
R019	Livestock fodder intake for meat (kg/day)	6.800E+01	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	5.500E+01	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	5.000E+01	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	1.600E+02	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	5.000E-01	5.000E-01	---	LSI

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R019	Mass loading for foliar deposition (g/m**3)	1.000E-04	1.000E-04	---	MLFD
R019	Depth of soil mixing layer (m)	1.500E-01	1.500E-01	---	DM
R019	Depth of roots (m)	9.000E-01	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	1.000E+00	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	1.000E+00	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	1.000E+00	1.000E+00	---	FGWIR
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)	7.000E-01	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy (kg/m**2)	1.500E+00	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	1.100E+00	1.100E+00	---	YV(3)
R19B	Growing Season for Non-Leafy (years)	1.700E-01	1.700E-01	---	TE(1)
R19B	Growing Season for Leafy (years)	2.500E-01	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	8.000E-02	8.000E-02	---	TE(3)
R19B	Translocation Factor for Non-Leafy	1.000E-01	1.000E-01	---	TIV(1)
R19B	Translocation Factor for Leafy	1.000E+00	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	1.000E+00	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	2.000E+01	2.000E+01	---	WLAM
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C14	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
C14	DCF correction factor for gaseous forms of C14	not used	0.000E+00	---	CO2F
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)
TITL	Number of graphical time points	32	---	---	NPTS
TITL	Maximum number of integration points for dose	17	---	---	LYMAX
TITL	Maximum number of integration points for risk	257	---	---	KYMAX

Summary of Pathway Selections

Pathway	User Selection
1 -- external gamma	active
2 -- inhalation (w/o radon)	active
3 -- plant ingestion	active
4 -- meat ingestion	active
5 -- milk ingestion	active
6 -- aquatic foods	active
7 -- drinking water	active
8 -- soil ingestion	active
9 -- radon	suppressed
Find peak pathway doses	active

Summary : Th-232 DCGL for Hammond Depot (Chapman)
File : VALIDATE-Th232 DCGL HD1-kd-lookup **7424** FINAL 01-12-06.RAD

Contaminated Zone Dimensions		Initial Soil Concentrations, pCi/g	
Area:	10000.00 square meters	Ra-228	1.000E+00
Thickness:	0.15 meters	Th-228	1.000E+00
Cover Depth:	0.00 meters	Th-232	1.000E+00

Total Dose TDOSE(t), mrem/yr
Basic Radiation Dose Limit = 2.500E+01 mrem/yr
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
TDOSE(t):	7.424E+00	7.374E+00	7.275E+00	6.957E+00	6.213E+00	3.338E+00	0.000E+00	0.000E+00
M(t):	2.970E-01	2.950E-01	2.910E-01	2.783E-01	2.485E-01	1.335E-01	0.000E+00	0.000E+00

Maximum TDOSE(t): 7.424E+00 mrem/yr at t = 0.000E+00 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years
Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-228	2.307E+00	0.3107	1.140E-03	0.0002	0.000E+00	0.0000	1.648E+00	0.2220	8.520E-02	0.0115	2.733E-01	0.0368	3.329E-02	0.0045
Th-228	2.596E+00	0.3497	5.688E-03	0.0008	0.000E+00	0.0000	2.051E-02	0.0028	2.251E-03	0.0003	4.011E-04	0.0001	1.525E-02	0.0021
Th-232	1.326E-01	0.0179	3.224E-02	0.0043	0.000E+00	0.0000	1.778E-01	0.0240	1.329E-02	0.0018	1.681E-02	0.0023	6.335E-02	0.0085
Total	5.035E+00	0.6783	3.907E-02	0.0053	0.000E+00	0.0000	1.846E+00	0.2487	1.007E-01	0.0136	2.905E-01	0.0391	1.119E-01	0.0151

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years
Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.348E+00	0.5856
Th-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.640E+00	0.3556
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.362E-01	0.0588
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.424E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years
Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-228	2.768E+00	0.3754	2.607E-03	0.0004	0.000E+00	0.0000	1.452E+00	0.1969	7.547E-02	0.0102	2.397E-01	0.0325	3.349E-02	0.0045
Th-228	1.801E+00	0.2442	3.930E-03	0.0005	0.000E+00	0.0000	1.417E-02	0.0019	1.556E-03	0.0002	2.771E-04	0.0000	1.054E-02	0.0014
Th-232	4.412E-01	0.0598	3.224E-02	0.0044	0.000E+00	0.0000	3.615E-01	0.0490	2.267E-02	0.0031	4.718E-02	0.0064	6.691E-02	0.0091
Total	5.010E+00	0.6794	3.877E-02	0.0053	0.000E+00	0.0000	1.828E+00	0.2478	9.970E-02	0.0135	2.872E-01	0.0389	1.109E-01	0.0150

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years
Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.571E+00	0.6199
Th-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.832E+00	0.2484
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.717E-01	0.1318
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.374E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years
Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-228	2.950E+00	0.4056	3.744E-03	0.0005	0.000E+00	0.0000	1.122E+00	0.1542	5.868E-02	0.0081	1.843E-01	0.0253	3.040E-02	0.0042
Th-228	8.669E-01	0.1192	1.876E-03	0.0003	0.000E+00	0.0000	6.765E-03	0.0009	7.426E-04	0.0001	1.323E-04	0.0000	5.029E-03	0.0007
Th-232	1.140E+00	0.1567	3.255E-02	0.0045	0.000E+00	0.0000	6.624E-01	0.0911	3.830E-02	0.0053	9.690E-02	0.0133	7.363E-02	0.0101
*******	*********	******	*********	******	*********	******	*********	******	*********	******	*********	******	*********	******
Total	4.957E+00	0.6815	3.817E-02	0.0052	0.000E+00	0.0000	1.791E+00	0.2462	9.772E-02	0.0134	2.813E-01	0.0387	1.091E-01	0.0150

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years
Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.349E+00	0.5979
Th-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.815E-01	0.1212
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.044E+00	0.2810
*******	*********	******	*********	******	*********	******	*********	******	*********	******	*********	******	*********	******
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.275E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years
Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-228	1.646E+00	0.2366	2.406E-03	0.0003	0.000E+00	0.0000	4.486E-01	0.0645	2.366E-02	0.0034	7.322E-02	0.0105	1.453E-02	0.0021
Th-228	6.700E-02	0.0096	1.407E-04	0.0000	0.000E+00	0.0000	5.075E-04	0.0001	5.571E-05	0.0000	9.922E-06	0.0000	3.773E-04	0.0001
Th-232	3.071E+00	0.4415	3.354E-02	0.0048	0.000E+00	0.0000	1.229E+00	0.1767	6.791E-02	0.0098	1.903E-01	0.0274	8.787E-02	0.0126
*******	*********	******	*********	******	*********	******	*********	******	*********	******	*********	******	*********	******
Total	4.784E+00	0.6877	3.609E-02	0.0052	0.000E+00	0.0000	1.678E+00	0.2413	9.162E-02	0.0132	2.635E-01	0.0379	1.028E-01	0.0148

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years
Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.208E+00	0.3174
Th-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.809E-02	0.0098
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.680E+00	0.6728
*******	*********	******	*********	******	*********	******	*********	******	*********	******	*********	******	*********	******
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.957E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years
Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-228	1.347E-01	0.0217	1.841E-04	0.0000	0.000E+00	0.0000	3.161E-02	0.0051	1.670E-03	0.0003	5.151E-03	0.0008	1.062E-03	0.0002
Th-228	4.413E-05	0.0000	8.474E-08	0.0000	0.000E+00	0.0000	3.056E-07	0.0000	3.355E-08	0.0000	5.975E-09	0.0000	2.272E-07	0.0000
Th-232	4.256E+00	0.6850	3.025E-02	0.0049	0.000E+00	0.0000	1.376E+00	0.2215	7.519E-02	0.0121	2.158E-01	0.0347	8.542E-02	0.0137
Total	4.390E+00	0.7067	3.043E-02	0.0049	0.000E+00	0.0000	1.408E+00	0.2266	7.686E-02	0.0124	2.209E-01	0.0356	8.648E-02	0.0139

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years
Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.744E-01	0.0281
Th-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.478E-05	0.0000
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.038E+00	0.9719
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.213E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years
Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-228	1.336E-05	0.0000	1.210E-08	0.0000	0.000E+00	0.0000	2.077E-06	0.0000	1.098E-07	0.0000	3.386E-07	0.0000	6.979E-08	0.0000
Th-228	2.524E-16	0.0000	3.234E-19	0.0000	0.000E+00	0.0000	1.167E-18	0.0000	1.281E-19	0.0000	2.280E-20	0.0000	8.671E-19	0.0000
Th-232	2.619E+00	0.7846	1.200E-02	0.0036	0.000E+00	0.0000	5.552E-01	0.1663	3.034E-02	0.0091	8.717E-02	0.0261	3.411E-02	0.0102
*******	*********	******	*********	******	*********	******	*********	******	*********	******	*********	******	*********	******
Total	2.619E+00	0.7846	1.200E-02	0.0036	0.000E+00	0.0000	5.552E-01	0.1663	3.034E-02	0.0091	8.717E-02	0.0261	3.411E-02	0.0102

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years
Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.597E-05	0.0000
Th-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.549E-16	0.0000
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.338E+00	1.0000
*******	*********	******	*********	******	*********	******	*********	******	*********	******	*********	******	*********	******
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.338E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years
Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
*******	*********	******	*********	******	*********	******	*********	******	*********	******	*********	******	*********	******
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years
Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
*******	*********	******	*********	******	*********	******	*********	******	*********	******	*********	******	*********	******
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years
Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
*******	*********	******	*********	******	*********	******	*********	******	*********	******	*********	******	*********	******
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years
Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ra-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-228	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-232	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
*******	*********	******	*********	******	*********	******	*********	******	*********	******	*********	******	*********	******
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

*Sum of all water independent and dependent pathways.

Dose/Source Ratios Summed Over All Pathways
Parent and Progeny Principal Radionuclide Contributions Indicated

Parent (i)	Product (j)	Thread Fraction	DSR(j,t) At Time in Years (mrem/yr)/(pCi/g) 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Ra-228+D	Ra-228+D	1.000E+00	3.852E+00	3.384E+00	2.611E+00	1.053E+00	7.776E-02	6.506E-06	0.000E+00	0.000E+00
Ra-228+D	Th-228+D	1.000E+00	4.961E-01	1.188E+00	1.738E+00	1.155E+00	9.660E-02	9.466E-06	0.000E+00	0.000E+00
Ra-228+D	ΣDSR(j)		4.348E+00	4.571E+00	4.349E+00	2.208E+00	1.744E-01	1.597E-05	0.000E+00	0.000E+00
Th-228+D	Th-228+D	1.000E+00	2.640E+00	1.832E+00	8.815E-01	6.809E-02	4.478E-05	2.549E-16	0.000E+00	0.000E+00
Th-232	Th-232	1.000E+00	1.870E-01	1.856E-01	1.828E-01	1.733E-01	1.464E-01	5.786E-02	0.000E+00	0.000E+00
Th-232	Ra-228+D	1.000E+00	2.282E-01	6.599E-01	1.368E+00	2.733E+00	3.255E+00	1.675E+00	0.000E+00	0.000E+00
Th-232	Th-228+D	1.000E+00	2.098E-02	1.262E-01	4.933E-01	1.774E+00	2.636E+00	1.605E+00	0.000E+00	0.000E+00
Th-232	ΣDSR(j)		4.362E-01	9.717E-01	2.044E+00	4.680E+00	6.038E+00	3.338E+00	0.000E+00	0.000E+00

The DSR includes contributions from associated (half-life ó 180 days) daughters.

Single Radionuclide Soil Guidelines G(i,t) in pCi/g
Basic Radiation Dose Limit = 2.500E+01 mrem/yr

Nuclide (i)	t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Ra-228	5.750E+00	5.469E+00	5.748E+00	1.132E+01	1.434E+02	1.565E+06	*2.726E+14	*2.726E+14
Th-228	9.470E+00	1.365E+01	2.836E+01	3.671E+02	5.582E+05	*8.195E+14	*8.195E+14	*8.195E+14
Th-232	5.732E+01	2.573E+01	1.223E+01	5.342E+00	4.140E+00	7.490E+00	*1.097E+05	*1.097E+05

*At specific activity limit

Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose = 0.000E+00 years

Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Ra-228	1.000E+00	1.317 ± 0.003	4.583E+00	5.455E+00	4.348E+00	5.750E+00
Th-228	1.000E+00	0.000E+00	2.640E+00	9.470E+00	2.640E+00	9.470E+00
Th-232	1.000E+00	26.43 ± 0.05	6.063E+00	4.123E+00	4.362E-01	5.732E+01

Individual Nuclide Dose Summed Over All Pathways
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	THF(i)	DOSE(j,t), mrem/yr t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Ra-228	Ra-228	1.000E+00	3.852E+00	3.384E+00	2.611E+00	1.053E+00	7.776E-02	6.506E-06	0.000E+00	0.000E+00
Ra-228	Th-232	1.000E+00	2.282E-01	6.599E-01	1.368E+00	2.733E+00	3.255E+00	1.675E+00	0.000E+00	0.000E+00
Ra-228	ΣDOSE(j)		4.080E+00	4.044E+00	3.979E+00	3.786E+00	3.333E+00	1.675E+00	0.000E+00	0.000E+00
Th-228	Ra-228	1.000E+00	4.961E-01	1.188E+00	1.738E+00	1.155E+00	9.660E-02	9.466E-06	0.000E+00	0.000E+00
Th-228	Th-228	1.000E+00	2.640E+00	1.832E+00	8.815E-01	6.809E-02	4.478E-05	2.549E-16	0.000E+00	0.000E+00
Th-228	Th-232	1.000E+00	2.098E-02	1.262E-01	4.933E-01	1.774E+00	2.636E+00	1.605E+00	0.000E+00	0.000E+00
Th-228	ΣDOSE(j)		3.157E+00	3.145E+00	3.113E+00	2.997E+00	2.733E+00	1.605E+00	0.000E+00	0.000E+00
Th-232	Th-232	1.000E+00	1.870E-01	1.856E-01	1.828E-01	1.733E-01	1.464E-01	5.786E-02	0.000E+00	0.000E+00

THF(i) is the thread fraction of the parent nuclide.

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	THF(i)	S(j,t), pCi/g t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Ra-228	Ra-228	1.000E+00	1.000E+00	8.825E-01	6.873E-01	2.865E-01	2.352E-02	3.730E-06	5.190E-17	0.000E+00
Ra-228	Th-232	1.000E+00	0.000E+00	1.133E-01	3.012E-01	6.852E-01	9.270E-01	9.048E-01	7.875E-01	4.843E-01
Ra-228	ΣS(j):		1.000E+00	9.958E-01	9.886E-01	9.718E-01	9.506E-01	9.048E-01	7.875E-01	4.843E-01
Th-228	Ra-228	1.000E+00	0.000E+00	2.845E-01	5.339E-01	3.958E-01	3.578E-02	5.678E-06	7.901E-17	0.000E+00
Th-228	Th-228	1.000E+00	1.000E+00	6.956E-01	3.365E-01	2.651E-02	1.864E-05	1.717E-16	0.000E+00	0.000E+00
Th-228	Th-232	1.000E+00	0.000E+00	1.861E-02	1.236E-01	5.535E-01	9.151E-01	9.048E-01	7.875E-01	4.843E-01
Th-228	ΣS(j):		1.000E+00	9.987E-01	9.941E-01	9.759E-01	9.509E-01	9.048E-01	7.875E-01	4.843E-01
Th-232	Th-232	1.000E+00	1.000E+00	9.993E-01	9.979E-01	9.931E-01	9.794E-01	9.329E-01	8.119E-01	4.994E-01

THF(i) is the thread fraction of the parent nuclide.
RESCALC.EXE execution time = 3.08 seconds

APPENDIX B.2:

RESRAD INPUT/OUTPUT FILE FOR URANIUM

Summary : U-238 DCGL for Hammond Depot (Chapman)
File : VALIDATE-U238 Unat DCGL HD1-kd-lookup 899 FINAL 01-12-06.RAD

Table of Contents

Part I: Mixture Sums and Single Radionuclide Guidelines

Dose Conversion Factor (and Related) Parameter Summary
File: FGR 13 MORBIDITY

Menu	Parameter	Current Value	Base Case*	Parameter Name
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Ac-227+D	6.724E+00	6.700E+00	DCF2(1)
B-1	Pa-231	1.280E+00	1.280E+00	DCF2(2)
B-1	Pb-210+D	2.320E-02	1.360E-02	DCF2(3)
B-1	Ra-226+D	8.594E-03	8.580E-03	DCF2(4)
B-1	Th-230	3.260E-01	3.260E-01	DCF2(5)
B-1	U-234	1.320E-01	1.320E-01	DCF2(6)
B-1	U-235+D	1.230E-01	1.230E-01	DCF2(7)
B-1	U-238	1.180E-01	1.180E-01	DCF2(8)
B-1	U-238+D	1.180E-01	1.180E-01	DCF2(9)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Ac-227+D	1.480E-02	1.410E-02	DCF3(1)
D-1	Pa-231	1.060E-02	1.060E-02	DCF3(2)
D-1	Pb-210+D	7.276E-03	5.370E-03	DCF3(3)
D-1	Ra-226+D	1.321E-03	1.320E-03	DCF3(4)
D-1	Th-230	5.480E-04	5.480E-04	DCF3(5)
D-1	U-234	2.830E-04	2.830E-04	DCF3(6)
D-1	U-235+D	2.673E-04	2.660E-04	DCF3(7)
D-1	U-238	2.550E-04	2.550E-04	DCF3(8)
D-1	U-238+D	2.687E-04	2.550E-04	DCF3(9)
D-34	Food transfer factors:			
D-34	Ac-227+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(1,1)
D-34	Ac-227+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	2.000E-05	2.000E-05	RTF(1,2)
D-34	Ac-227+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-05	2.000E-05	RTF(1,3)
D-34	Pa-231 , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(2,1)
D-34	Pa-231 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	5.000E-03	5.000E-03	RTF(2,2)
D-34	Pa-231 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(2,3)
D-34	Pb-210+D , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(3,1)
D-34	Pb-210+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-04	8.000E-04	RTF(3,2)
D-34	Pb-210+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	3.000E-04	3.000E-04	RTF(3,3)
D-34	Ra-226+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(4,1)
D-34	Ra-226+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(4,2)
D-34	Ra-226+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF(4,3)
D-34	Th-230 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(5,1)
D-34	Th-230 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(5,2)
D-34	Th-230 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(5,3)
D-34	U-234 , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(6,1)
D-34	U-234 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(6,2)
D-34	U-234 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(6,3)
D-34	U-235+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(7,1)
D-34	U-235+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(7,2)
D-34	U-235+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(7,3)

Dose Conversion Factor (and Related) Parameter Summary (continued)
File: FGR 13 MORBIDITY

Menu	Parameter	Current Value	Base Case*	Parameter Name
D-34	U-238 , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(8,1)
D-34	U-238 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(8,2)
D-34	U-238 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(8,3)
D-34				
D-34	U-238+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(9,1)
D-34	U-238+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(9,2)
D-34	U-238+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(9,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Ac-227+D , fish	1.500E+01	1.500E+01	BIOFAC(1,1)
D-5	Ac-227+D , crustacea and mollusks	1.000E+03	1.000E+03	BIOFAC(1,2)
D-5				
D-5	Pa-231 , fish	1.000E+01	1.000E+01	BIOFAC(2,1)
D-5	Pa-231 , crustacea and mollusks	1.100E+02	1.100E+02	BIOFAC(2,2)
D-5				
D-5	Pb-210+D , fish	3.000E+02	3.000E+02	BIOFAC(3,1)
D-5	Pb-210+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(3,2)
D-5				
D-5	Ra-226+D , fish	5.000E+01	5.000E+01	BIOFAC(4,1)
D-5	Ra-226+D , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC(4,2)
D-5				
D-5	Th-230 , fish	1.000E+02	1.000E+02	BIOFAC(5,1)
D-5	Th-230 , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC(5,2)
D-5				
D-5	U-234 , fish	1.000E+01	1.000E+01	BIOFAC(6,1)
D-5	U-234 , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(6,2)
D-5				
D-5	U-235+D , fish	1.000E+01	1.000E+01	BIOFAC(7,1)
D-5	U-235+D , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(7,2)
D-5				
D-5	U-238 , fish	1.000E+01	1.000E+01	BIOFAC(8,1)
D-5	U-238 , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(8,2)
D-5				
D-5	U-238+D , fish	1.000E+01	1.000E+01	BIOFAC(9,1)
D-5	U-238+D , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(9,2)

*Base Case means Default.Lib w/o Associate Nuclide contributions.

Site-Specific Parameter Summary

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	1.000E+04	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	1.500E-01	2.000E+00	---	THICK0
R011	Length parallel to aquifer flow (m)	1.000E+02	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	2.500E+01	3.000E+01	---	BRDL
R011	Time since placement of material (yr)	0.000E+00	0.000E+00	---	TI
R011	Times for calculations (yr)	1.000E+00	1.000E+00	---	T(2)
R011	Times for calculations (yr)	3.000E+00	3.000E+00	---	T(3)
R011	Times for calculations (yr)	1.000E+01	1.000E+01	---	T(4)
R011	Times for calculations (yr)	3.000E+01	3.000E+01	---	T(5)
R011	Times for calculations (yr)	1.000E+02	1.000E+02	---	T(6)
R011	Times for calculations (yr)	3.000E+02	3.000E+02	---	T(7)
R011	Times for calculations (yr)	1.000E+03	1.000E+03	---	T(8)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(9)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): Ac-227	4.700E-02	0.000E+00	---	S1(1)
R012	Initial principal radionuclide (pCi/g): Pa-231	4.700E-02	0.000E+00	---	S1(2)
R012	Initial principal radionuclide (pCi/g): Pb-210	1.000E+00	0.000E+00	---	S1(3)
R012	Initial principal radionuclide (pCi/g): Ra-226	1.000E+00	0.000E+00	---	S1(4)
R012	Initial principal radionuclide (pCi/g): Th-230	1.000E+00	0.000E+00	---	S1(5)
R012	Initial principal radionuclide (pCi/g): U-234	1.000E+00	0.000E+00	---	S1(6)
R012	Initial principal radionuclide (pCi/g): U-235	4.700E-02	0.000E+00	---	S1(7)
R012	Initial principal radionuclide (pCi/g): U-238	1.000E+00	0.000E+00	---	S1(8)
R012	Concentration in groundwater (pCi/L): Ac-227	not used	0.000E+00	---	W1(1)
R012	Concentration in groundwater (pCi/L): Pa-231	not used	0.000E+00	---	W1(2)
R012	Concentration in groundwater (pCi/L): Pb-210	not used	0.000E+00	---	W1(3)
R012	Concentration in groundwater (pCi/L): Ra-226	not used	0.000E+00	---	W1(4)
R012	Concentration in groundwater (pCi/L): Th-230	not used	0.000E+00	---	W1(5)
R012	Concentration in groundwater (pCi/L): U-234	not used	0.000E+00	---	W1(6)
R012	Concentration in groundwater (pCi/L): U-235	not used	0.000E+00	---	W1(7)
R012	Concentration in groundwater (pCi/L): U-238	not used	0.000E+00	---	W1(8)
R013	Cover depth (m)	0.000E+00	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	not used	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	not used	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.440E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	1.000E-03	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	4.000E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity	2.000E-01	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	4.730E+03	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	3.300E+00	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	4.500E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	5.000E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	9.500E-01	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	2.000E-01	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	2.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	1.000E+06	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	1.000E-03	1.000E-03	---	EPS

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R014	Density of saturated zone (g/cm**3)	1.440E+00	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	4.000E-01	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	2.000E-01	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	2.000E-01	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	4.730E+03	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	1.000E-02	2.000E-02	---	HGWT
R014	Saturated zone b parameter	3.300E+00	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	1.000E-03	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	1.000E+01	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	MB	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	2.500E+02	2.500E+02	---	UW
R015	Number of unsaturated zone strata	1	1	---	NS
R015	Unsat. zone 1, thickness (m)	4.572E+00	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	1.440E+00	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	4.000E-01	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	2.000E-01	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	2.000E-01	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	3.300E+00	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	4.730E+03	1.000E+01	---	HCUZ(1)
R016	Distribution coefficients for Ac-227				
R016	Contaminated zone (cm**3/g)	4.500E+02	2.000E+01	---	DCNUCC(1)
R016	Unsaturated zone 1 (cm**3/g)	4.500E+02	2.000E+01	---	DCNUCU(1,1)
R016	Saturated zone (cm**3/g)	4.500E+02	2.000E+01	---	DCNUCS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	4.937E-03	ALEACH(1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)
R016	Distribution coefficients for Pa-231				
R016	Contaminated zone (cm**3/g)	5.500E+02	5.000E+01	---	DCNUCC(2)
R016	Unsaturated zone 1 (cm**3/g)	5.500E+02	5.000E+01	---	DCNUCU(2,1)
R016	Saturated zone (cm**3/g)	5.500E+02	5.000E+01	---	DCNUCS(2)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	4.039E-03	ALEACH(2)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(2)
R016	Distribution coefficients for Pb-210				
R016	Contaminated zone (cm**3/g)	2.700E+02	1.000E+02	---	DCNUCC(3)
R016	Unsaturated zone 1 (cm**3/g)	2.700E+02	1.000E+02	---	DCNUCU(3,1)
R016	Saturated zone (cm**3/g)	2.700E+02	1.000E+02	---	DCNUCS(3)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	8.226E-03	ALEACH(3)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(3)
R016	Distribution coefficients for Ra-226				
R016	Contaminated zone (cm**3/g)	5.000E+02	7.000E+01	---	DCNUCC(4)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+02	7.000E+01	---	DCNUCU(4,1)
R016	Saturated zone (cm**3/g)	5.000E+02	7.000E+01	---	DCNUCS(4)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	4.443E-03	ALEACH(4)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(4)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R016	Distribution coefficients for Th-230				
R016	Contaminated zone (cm**3/g)	3.200E+03	6.000E+04	---	DCNUCC(5)
R016	Unsaturated zone 1 (cm**3/g)	3.200E+03	6.000E+04	---	DCNUCU(5,1)
R016	Saturated zone (cm**3/g)	3.200E+03	6.000E+04	---	DCNUCS(5)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	6.944E-04	ALEACH(5)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(5)
R016	Distribution coefficients for U-234				
R016	Contaminated zone (cm**3/g)	3.500E+01	5.000E+01	---	DCNUCC(6)
R016	Unsaturated zone 1 (cm**3/g)	3.500E+01	5.000E+01	---	DCNUCU(6,1)
R016	Saturated zone (cm**3/g)	3.500E+01	5.000E+01	---	DCNUCS(6)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	6.324E-02	ALEACH(6)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(6)
R016	Distribution coefficients for U-235				
R016	Contaminated zone (cm**3/g)	3.500E+01	5.000E+01	---	DCNUCC(7)
R016	Unsaturated zone 1 (cm**3/g)	3.500E+01	5.000E+01	---	DCNUCU(7,1)
R016	Saturated zone (cm**3/g)	3.500E+01	5.000E+01	---	DCNUCS(7)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	6.324E-02	ALEACH(7)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(7)
R016	Distribution coefficients for U-238				
R016	Contaminated zone (cm**3/g)	3.500E+01	5.000E+01	---	DCNUCC(8)
R016	Unsaturated zone 1 (cm**3/g)	3.500E+01	5.000E+01	---	DCNUCU(8,1)
R016	Saturated zone (cm**3/g)	3.500E+01	5.000E+01	---	DCNUCS(8)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	6.324E-02	ALEACH(8)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(8)
R017	Inhalation rate (m**3/yr)	8.400E+03	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	1.000E-04	1.000E-04	---	MLINH
R017	Exposure duration	3.000E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	4.000E-01	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	5.500E-01	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	5.000E-01	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	1.181E-01	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	1.000E+00	1.000E+00	>0 shows circular AREA.	FS
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE(1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE(2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE(3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE(4)
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE(5)
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE(6)
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE(7)
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE(8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE(9)
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA(1)
R017	Ring 2	not used	2.732E-01	---	FRACA(2)
R017	Ring 3	not used	0.000E+00	---	FRACA(3)
R017	Ring 4	not used	0.000E+00	---	FRACA(4)
R017	Ring 5	not used	0.000E+00	---	FRACA(5)
R017	Ring 6	not used	0.000E+00	---	FRACA(6)
R017	Ring 7	not used	0.000E+00	---	FRACA(7)
R017	Ring 8	not used	0.000E+00	---	FRACA(8)
R017	Ring 9	not used	0.000E+00	---	FRACA(9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)
R018	Fruits, vegetables and grain consumption (kg/yr)	1.600E+02	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	2.140E+01	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	2.330E+02	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	6.510E+01	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	2.060E+01	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	9.000E-01	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	3.650E+01	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	5.100E+02	5.100E+02	---	DWI
R018	Contamination fraction of drinking water	1.000E+00	1.000E+00	---	FDW
R018	Contamination fraction of household water	not used	1.000E+00	---	FHHW
R018	Contamination fraction of livestock water	1.000E+00	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	1.000E+00	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	1.000E+00	5.000E-01	---	FR9
R018	Contamination fraction of plant food	1.000E+00	-1	---	FPLANT
R018	Contamination fraction of meat	1.000E+00	-1	---	FMEAT
R018	Contamination fraction of milk	1.000E+00	-1	---	FMILK
R019	Livestock fodder intake for meat (kg/day)	6.800E+01	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	5.500E+01	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	5.000E+01	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	1.600E+02	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	5.000E-01	5.000E-01	---	LSI
R019	Mass loading for foliar deposition (g/m**3)	1.000E-04	1.000E-04	---	MLFD
R019	Depth of soil mixing layer (m)	1.500E-01	1.500E-01	---	DM
R019	Depth of roots (m)	9.000E-01	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	1.000E+00	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	1.000E+00	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	1.000E+00	1.000E+00	---	FGWIR
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)	7.000E-01	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy (kg/m**2)	1.500E+00	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	1.100E+00	1.100E+00	---	YV(3)
R19B	Growing Season for Non-Leafy (years)	1.700E-01	1.700E-01	---	TE(1)
R19B	Growing Season for Leafy (years)	2.500E-01	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	8.000E-02	8.000E-02	---	TE(3)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R19B	Translocation Factor for Non-Leafy	1.000E-01	1.000E-01	---	TIV(1)
R19B	Translocation Factor for Leafy	1.000E+00	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	1.000E+00	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	2.000E+01	2.000E+01	---	WLAM
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C14	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
C14	DCF correction factor for gaseous forms of C14	not used	0.000E+00	---	CO2F
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)

Site-Specific Parameter Summary (continued)

Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
TITL	Number of graphical time points	32	---	---	NPTS
TITL	Maximum number of integration points for dose	17	---	---	LYMAX
TITL	Maximum number of integration points for risk	1	---	---	KYMAX

Summary of Pathway Selections

Pathway	User Selection
1 -- external gamma	active
2 -- inhalation (w/o radon)	active
3 -- plant ingestion	active
4 -- meat ingestion	active
5 -- milk ingestion	active
6 -- aquatic foods	active
7 -- drinking water	active
8 -- soil ingestion	active
9 -- radon	suppressed
Find peak pathway doses	active

Summary : U-238 DCGL for Hammond Depot (Chapman)
File : VALIDATE-U238 Unat DCGL HD1-kd-lookup 899 FINAL 01-12-06.RAD

Contaminated Zone Dimensions		Initial Soil Concentrations, pCi/g	
Area:	10000.00 square meters	Ac-227	4.700E-02
Thickness:	0.15 meters	Pa-231	4.700E-02
Cover Depth:	0.00 meters	Pb-210	1.000E+00
		Ra-226	1.000E+00
		Th-230	1.000E+00
		U-234	1.000E+00
		U-235	4.700E-02
		U-238	1.000E+00

Total Dose TDOSE(t), mrem/yr
Basic Radiation Dose Limit = 2.500E+01 mrem/yr
Total Mixture Sum M(t) = Fraction of Basic Dose Limit Received at Time (t)

t (years):	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
TDOSE(t):	8.992E+00	8.890E+00	8.689E+00	8.032E+00	6.444E+00	2.409E+00	4.651E-01	1.154E-03
M(t):	3.597E-01	3.556E-01	3.475E-01	3.213E-01	2.578E-01	9.635E-02	1.860E-02	4.617E-05

Maximum TDOSE(t): 8.992E+00 mrem/yr at t = 0.000E+00 years

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years
Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	3.291E-02	0.0037	6.093E-03	0.0007	0.000E+00	0.0000	5.153E-02	0.0057	4.686E-04	0.0001	1.659E-03	0.0002	1.535E-02	0.0017
Pa-231	3.696E-03	0.0004	1.276E-03	0.0001	0.000E+00	0.0000	1.509E-01	0.0168	9.923E-02	0.0110	3.689E-04	0.0000	1.142E-02	0.0013
Pb-210	2.233E-03	0.0002	4.467E-04	0.0000	0.000E+00	0.0000	2.152E+00	0.2393	2.274E-01	0.0253	2.943E-01	0.0327	1.604E-01	0.0178
Ra-226	3.556E+00	0.3955	1.753E-04	0.0000	0.000E+00	0.0000	1.628E+00	0.1811	8.589E-02	0.0096	2.705E-01	0.0301	3.213E-02	0.0036
Th-230	1.225E-03	0.0001	6.399E-03	0.0007	0.000E+00	0.0000	1.690E-02	0.0019	1.834E-03	0.0002	3.769E-04	0.0000	1.232E-02	0.0014
U-234	1.477E-04	0.0000	2.512E-03	0.0003	0.000E+00	0.0000	2.073E-02	0.0023	3.209E-03	0.0004	2.000E-02	0.0022	6.167E-03	0.0007
U-235	1.261E-02	0.0014	1.100E-04	0.0000	0.000E+00	0.0000	9.219E-04	0.0001	1.434E-04	0.0000	8.878E-04	0.0001	2.739E-04	0.0000
U-238	5.008E-02	0.0056	2.246E-03	0.0002	0.000E+00	0.0000	1.968E-02	0.0022	3.047E-03	0.0003	1.899E-02	0.0021	5.855E-03	0.0007
*******	*********	******	*********	******	*********	******	*********	******	*********	******	*********	******	*********	******
Total	3.659E+00	0.4070	1.926E-02	0.0021	0.000E+00	0.0000	4.041E+00	0.4494	4.213E-01	0.0469	6.070E-01	0.0675	2.440E-01	0.0271

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 0.000E+00 years
Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.080E-01	0.0120
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.669E-01	0.0297
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.837E+00	0.3155
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.573E+00	0.6199
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.906E-02	0.0043
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.276E-02	0.0059
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.495E-02	0.0017
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.990E-02	0.0111
*******	*********	******	*********	******	*********	******	*********	******	*********	******	*********	******	*********	******
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.992E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years
Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	3.168E-02	0.0036	5.834E-03	0.0007	0.000E+00	0.0000	4.934E-02	0.0056	4.487E-04	0.0001	1.588E-03	0.0002	1.470E-02	0.0017
Pa-231	4.701E-03	0.0005	1.451E-03	0.0002	0.000E+00	0.0000	1.509E-01	0.0170	9.823E-02	0.0110	4.164E-04	0.0000	1.178E-02	0.0013
Pb-210	2.146E-03	0.0002	4.266E-04	0.0000	0.000E+00	0.0000	2.055E+00	0.2312	2.172E-01	0.0244	2.810E-01	0.0316	1.532E-01	0.0172
Ra-226	3.531E+00	0.3972	1.868E-04	0.0000	0.000E+00	0.0000	1.676E+00	0.1885	9.191E-02	0.0103	2.764E-01	0.0311	3.661E-02	0.0041
Th-230	2.755E-03	0.0003	6.352E-03	0.0007	0.000E+00	0.0000	1.748E-02	0.0020	1.858E-03	0.0002	4.913E-04	0.0001	1.225E-02	0.0014
U-234	1.386E-04	0.0000	2.342E-03	0.0003	0.000E+00	0.0000	1.934E-02	0.0022	2.994E-03	0.0003	1.865E-02	0.0021	5.750E-03	0.0006
U-235	1.183E-02	0.0013	1.026E-04	0.0000	0.000E+00	0.0000	8.630E-04	0.0001	1.358E-04	0.0000	8.279E-04	0.0001	2.556E-04	0.0000
U-238	4.693E-02	0.0053	2.094E-03	0.0002	0.000E+00	0.0000	1.836E-02	0.0021	2.843E-03	0.0003	1.770E-02	0.0020	5.460E-03	0.0006
Total	3.631E+00	0.4085	1.879E-02	0.0021	0.000E+00	0.0000	3.987E+00	0.4485	4.157E-01	0.0468	5.971E-01	0.0672	2.400E-01	0.0270

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+00 years
Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.036E-01	0.0117
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.675E-01	0.0301
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.709E+00	0.3047
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.612E+00	0.6313
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.119E-02	0.0046
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.921E-02	0.0055
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.401E-02	0.0016
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.339E-02	0.0105
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.890E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years
Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	2.935E-02	0.0034	5.347E-03	0.0006	0.000E+00	0.0000	4.522E-02	0.0052	4.113E-04	0.0000	1.456E-03	0.0002	1.347E-02	0.0016
Pa-231	6.582E-03	0.0008	1.772E-03	0.0002	0.000E+00	0.0000	1.506E-01	0.0173	9.615E-02	0.0111	5.033E-04	0.0001	1.241E-02	0.0014
Pb-210	1.982E-03	0.0002	3.890E-04	0.0000	0.000E+00	0.0000	1.874E+00	0.2157	1.981E-01	0.0228	2.563E-01	0.0295	1.397E-01	0.0161
Ra-226	3.481E+00	0.4006	2.075E-04	0.0000	0.000E+00	0.0000	1.758E+00	0.2023	1.025E-01	0.0118	2.865E-01	0.0330	4.476E-02	0.0052
Th-230	5.769E-03	0.0007	6.258E-03	0.0007	0.000E+00	0.0000	1.870E-02	0.0022	1.914E-03	0.0002	7.262E-04	0.0001	1.210E-02	0.0014
U-234	1.222E-04	0.0000	2.036E-03	0.0002	0.000E+00	0.0000	1.681E-02	0.0019	2.603E-03	0.0003	1.621E-02	0.0019	4.999E-03	0.0006
U-235	1.040E-02	0.0012	8.927E-05	0.0000	0.000E+00	0.0000	7.562E-04	0.0001	1.219E-04	0.0000	7.198E-04	0.0001	2.227E-04	0.0000
U-238	4.122E-02	0.0047	1.821E-03	0.0002	0.000E+00	0.0000	1.596E-02	0.0018	2.471E-03	0.0003	1.539E-02	0.0018	4.746E-03	0.0005
*******	*********	******	*********	******	*********	******	*********	******	*********	******	*********	******	*********	******
Total	3.576E+00	0.4116	1.792E-02	0.0021	0.000E+00	0.0000	3.880E+00	0.4466	4.043E-01	0.0465	5.778E-01	0.0665	2.324E-01	0.0268

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+00 years
Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.527E-02	0.0110
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.681E-01	0.0309
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.471E+00	0.2844
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.673E+00	0.6529
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.547E-02	0.0052
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.278E-02	0.0049
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.231E-02	0.0014
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.161E-02	0.0094
*******	*********	******	*********	******	*********	******	*********	******	*********	******	*********	******	*********	******
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.689E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years
Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	2.246E-02	0.0028	3.936E-03	0.0005	0.000E+00	0.0000	3.329E-02	0.0041	3.027E-04	0.0000	1.072E-03	0.0001	9.919E-03	0.0012
Pa-231	1.196E-02	0.0015	2.626E-03	0.0003	0.000E+00	0.0000	1.478E-01	0.0184	8.907E-02	0.0111	7.342E-04	0.0001	1.397E-02	0.0017
Pb-210	1.498E-03	0.0002	2.813E-04	0.0000	0.000E+00	0.0000	1.355E+00	0.1687	1.433E-01	0.0178	1.853E-01	0.0231	1.011E-01	0.0126
Ra-226	3.307E+00	0.4117	2.602E-04	0.0000	0.000E+00	0.0000	1.951E+00	0.2429	1.296E-01	0.0161	3.093E-01	0.0385	6.605E-02	0.0082
Th-230	1.582E-02	0.0020	5.930E-03	0.0007	0.000E+00	0.0000	2.323E-02	0.0029	2.160E-03	0.0003	1.572E-03	0.0002	1.163E-02	0.0014
U-234	7.890E-05	0.0000	1.246E-03	0.0002	0.000E+00	0.0000	1.028E-02	0.0013	1.592E-03	0.0002	9.914E-03	0.0012	3.058E-03	0.0004
U-235	6.638E-03	0.0008	5.486E-05	0.0000	0.000E+00	0.0000	4.800E-04	0.0001	8.534E-05	0.0000	4.403E-04	0.0001	1.378E-04	0.0000
U-238	2.615E-02	0.0033	1.114E-03	0.0001	0.000E+00	0.0000	9.762E-03	0.0012	1.512E-03	0.0002	9.414E-03	0.0012	2.903E-03	0.0004
Total	3.391E+00	0.4222	1.545E-02	0.0019	0.000E+00	0.0000	3.531E+00	0.4396	3.676E-01	0.0458	5.178E-01	0.0645	2.087E-01	0.0260

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+01 years
Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.098E-02	0.0088
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.661E-01	0.0331
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.787E+00	0.2225
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.763E+00	0.7175
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.035E-02	0.0075
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.617E-02	0.0033
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.836E-03	0.0010
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.085E-02	0.0063
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.032E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years
Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	1.037E-02	0.0016	1.616E-03	0.0003	0.000E+00	0.0000	1.367E-02	0.0021	1.243E-04	0.0000	4.400E-04	0.0001	4.073E-03	0.0006
Pa-231	1.994E-02	0.0031	3.527E-03	0.0005	0.000E+00	0.0000	1.290E-01	0.0200	7.047E-02	0.0109	9.754E-04	0.0002	1.470E-02	0.0023
Pb-210	6.715E-04	0.0001	1.098E-04	0.0000	0.000E+00	0.0000	5.290E-01	0.0821	5.592E-02	0.0087	7.233E-02	0.0112	3.944E-02	0.0061
Ra-226	2.826E+00	0.4385	3.004E-04	0.0000	0.000E+00	0.0000	1.989E+00	0.3087	1.508E-01	0.0234	3.050E-01	0.0473	8.660E-02	0.0134
Th-230	4.025E-02	0.0062	5.011E-03	0.0008	0.000E+00	0.0000	3.567E-02	0.0055	2.984E-03	0.0005	3.821E-03	0.0006	1.047E-02	0.0016
U-234	2.518E-05	0.0000	3.017E-04	0.0000	0.000E+00	0.0000	2.489E-03	0.0004	3.853E-04	0.0001	2.398E-03	0.0004	7.405E-04	0.0001
U-235	1.827E-03	0.0003	1.402E-05	0.0000	0.000E+00	0.0000	1.470E-04	0.0000	3.811E-05	0.0000	1.067E-04	0.0000	3.664E-05	0.0000
U-238	7.058E-03	0.0011	2.693E-04	0.0000	0.000E+00	0.0000	2.361E-03	0.0004	3.656E-04	0.0001	2.277E-03	0.0004	7.020E-04	0.0001
Total	2.906E+00	0.4509	1.115E-02	0.0017	0.000E+00	0.0000	2.702E+00	0.4193	2.810E-01	0.0436	3.874E-01	0.0601	1.568E-01	0.0243

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+01 years
Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.029E-02	0.0047
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.386E-01	0.0370
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.974E-01	0.1082
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.358E+00	0.8315
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.820E-02	0.0152
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.340E-03	0.0010
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.169E-03	0.0003
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.303E-02	0.0020
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.444E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years
Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	5.455E-04	0.0002	5.103E-05	0.0000	0.000E+00	0.0000	4.318E-04	0.0002	3.928E-06	0.0000	1.390E-05	0.0000	1.286E-04	0.0001
Pa-231	1.505E-02	0.0062	1.540E-03	0.0006	0.000E+00	0.0000	4.396E-02	0.0182	2.202E-02	0.0091	4.241E-04	0.0002	5.692E-03	0.0024
Pb-210	3.583E-05	0.0000	2.903E-06	0.0000	0.000E+00	0.0000	1.399E-02	0.0058	1.480E-03	0.0006	1.913E-03	0.0008	1.043E-03	0.0004
Ra-226	1.264E+00	0.5248	1.150E-04	0.0000	0.000E+00	0.0000	7.140E-01	0.2964	5.798E-02	0.0241	1.074E-01	0.0446	3.504E-02	0.0145
Th-230	6.870E-02	0.0285	1.980E-03	0.0008	0.000E+00	0.0000	3.769E-02	0.0156	3.058E-03	0.0013	5.080E-03	0.0021	5.247E-03	0.0022
U-234	8.763E-06	0.0000	1.775E-06	0.0000	0.000E+00	0.0000	1.699E-05	0.0000	2.287E-06	0.0000	1.249E-05	0.0000	4.377E-06	0.0000
U-235	2.092E-05	0.0000	5.952E-07	0.0000	0.000E+00	0.0000	1.606E-05	0.0000	7.936E-06	0.0000	6.731E-07	0.0000	2.144E-06	0.0000
U-238	5.726E-05	0.0000	1.334E-06	0.0000	0.000E+00	0.0000	1.170E-05	0.0000	1.812E-06	0.0000	1.127E-05	0.0000	3.476E-06	0.0000
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Total	1.349E+00	0.5598	3.693E-03	0.0015	0.000E+00	0.0000	8.101E-01	0.3363	8.455E-02	0.0351	1.148E-01	0.0477	4.716E-02	0.0196

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+02 years
Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.175E-03	0.0005
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.868E-02	0.0368
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.846E-02	0.0077
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.179E+00	0.9044
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.218E-01	0.0505
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.668E-05	0.0000
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.833E-05	0.0000
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.685E-05	0.0000
*******	*********	******	*********	******	*********	******	*********	******	*********	******	*********	******	*********	******
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.409E+00	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years
Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 3.000E+02 years
Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-234	1.845E-01	0.3966	9.419E-04	0.0020	0.000E+00	0.0000	3.287E-02	0.0707	1.402E-03	0.0030	1.318E-02	0.0283	2.328E-01	0.5006
U-235	8.492E-03	0.0183	4.635E-05	0.0001	0.000E+00	0.0000	1.513E-03	0.0033	7.811E-05	0.0002	5.862E-04	0.0013	1.072E-02	0.0230
U-238	1.755E-01	0.3773	9.012E-04	0.0019	0.000E+00	0.0000	3.127E-02	0.0672	1.335E-03	0.0029	1.254E-02	0.0270	2.215E-01	0.4763
Total	3.684E-01	0.7922	1.889E-03	0.0041	0.000E+00	0.0000	6.565E-02	0.1412	2.815E-03	0.0061	2.631E-02	0.0566	4.651E-01	1.0000

*Sum of all water independent and dependent pathways.

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years
Water Independent Pathways (Inhalation excludes radon)

Radio-	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

Total Dose Contributions TDOSE(i,p,t) for Individual Radionuclides (i) and Pathways (p)
As mrem/yr and Fraction of Total Dose At t = 1.000E+03 years
Water Dependent Pathways

Radio-	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
Nuclide	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Ac-227	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pa-231	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Th-230	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-234	4.401E-04	0.3813	4.938E-05	0.0428	0.000E+00	0.0000	7.845E-05	0.0680	7.791E-06	0.0067	1.860E-05	0.0161	5.943E-04	0.5149
U-235	3.945E-04	0.3418	6.767E-06	0.0059	0.000E+00	0.0000	7.022E-05	0.0608	1.628E-05	0.0141	6.768E-07	0.0006	4.885E-04	0.4231
U-238	5.290E-05	0.0458	6.016E-06	0.0052	0.000E+00	0.0000	9.429E-06	0.0082	9.511E-07	0.0008	2.262E-06	0.0020	7.155E-05	0.0620
Total	8.875E-04	0.7689	6.216E-05	0.0538	0.000E+00	0.0000	1.581E-04	0.1370	2.502E-05	0.0217	2.154E-05	0.0187	1.154E-03	1.0000

*Sum of all water independent and dependent pathways.

Dose/Source Ratios Summed Over All Pathways
Parent and Progeny Principal Radionuclide Contributions Indicated

Parent (i)	Product (j)	Thread Fraction	DSR(j,t) At Time in Years (mrem/yr)/(pCi/g) 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Ac-227+D	Ac-227+D	1.000E+00	2.298E+00	2.204E+00	2.027E+00	1.510E+00	6.445E-01	2.499E-02	0.000E+00	0.000E+00
Pa-231	Pa-231	1.000E+00	5.634E+00	5.575E+00	5.456E+00	5.052E+00	3.997E+00	1.258E+00	0.000E+00	0.000E+00
Pa-231	Ac-227+D	1.000E+00	4.419E-02	1.164E-01	2.476E-01	6.101E-01	1.080E+00	6.289E-01	0.000E+00	0.000E+00
Pa-231	ΣDSR(j)		5.678E+00	5.691E+00	5.703E+00	5.662E+00	5.077E+00	1.887E+00	0.000E+00	0.000E+00
Pb-210+D	Pb-210+D	1.000E+00	2.837E+00	2.709E+00	2.471E+00	1.787E+00	6.974E-01	1.846E-02	0.000E+00	0.000E+00
Ra-226+D	Ra-226+D	1.000E+00	5.522E+00	5.474E+00	5.379E+00	5.053E+00	4.182E+00	1.663E+00	0.000E+00	0.000E+00
Ra-226+D	Pb-210+D	1.000E+00	5.147E-02	1.378E-01	2.936E-01	7.098E-01	1.176E+00	5.156E-01	0.000E+00	0.000E+00
Ra-226+D	ΣDSR(j)		5.573E+00	5.612E+00	5.673E+00	5.763E+00	5.358E+00	2.179E+00	0.000E+00	0.000E+00
Th-230	Th-230	1.000E+00	3.788E-02	3.761E-02	3.705E-02	3.513E-02	2.973E-02	1.189E-02	0.000E+00	0.000E+00
Th-230	Ra-226+D	1.000E+00	1.168E-03	3.534E-03	8.182E-03	2.346E-02	5.890E-02	8.994E-02	0.000E+00	0.000E+00
Th-230	Pb-210+D	1.000E+00	7.997E-06	4.925E-05	2.355E-04	1.755E-03	9.568E-03	1.992E-02	0.000E+00	0.000E+00
Th-230	ΣDSR(j)		3.906E-02	4.119E-02	4.547E-02	6.035E-02	9.820E-02	1.218E-01	0.000E+00	0.000E+00
U-234	U-234	1.000E+00	5.276E-02	4.921E-02	4.278E-02	2.617E-02	6.331E-03	3.146E-05	2.328E-01	0.000E+00
U-234	Th-230	1.000E+00	1.758E-07	4.936E-07	1.056E-06	2.439E-06	3.645E-06	1.708E-06	1.264E-05	1.313E-05
U-234	Ra-226+D	1.000E+00	3.400E-09	2.377E-08	1.205E-07	9.067E-07	4.764E-06	1.117E-05	0.000E+00	5.360E-05
U-234	Pb-210+D	1.000E+00	1.872E-11	2.420E-10	2.454E-09	4.929E-08	6.236E-07	2.340E-06	0.000E+00	5.276E-04
U-234	ΣDSR(j)		5.276E-02	4.921E-02	4.278E-02	2.617E-02	6.340E-03	4.668E-05	2.328E-01	5.943E-04
U-235+D	U-235+D	1.000E+00	3.180E-01	2.980E-01	2.616E-01	1.658E-01	4.473E-02	3.648E-04	2.201E-01	0.000E+00
U-235+D	Pa-231	1.000E+00	5.442E-05	1.646E-04	3.609E-04	8.334E-04	1.193E-03	4.486E-04	3.895E-03	4.017E-03
U-235+D	Ac-227+D	1.000E+00	3.357E-07	1.983E-06	9.031E-06	5.908E-05	2.322E-04	2.148E-04	3.968E-03	6.376E-03
U-235+D	ΣDSR(j)		3.181E-01	2.982E-01	2.620E-01	1.667E-01	4.616E-02	1.028E-03	2.280E-01	1.039E-02
U-238	U-238	5.400E-05	2.561E-06	2.389E-06	2.077E-06	1.270E-06	3.072E-07	1.523E-09	1.134E-05	0.000E+00
U-238+D	U-238+D	9.999E-01	9.989E-02	9.339E-02	8.161E-02	5.085E-02	1.303E-02	8.684E-05	2.212E-01	0.000E+00
U-238+D	U-234	9.999E-01	7.392E-08	2.084E-07	4.237E-07	7.785E-07	5.473E-07	8.963E-09	1.984E-04	0.000E+00
U-238+D	Th-230	9.999E-01	1.700E-13	1.088E-12	5.120E-12	3.245E-11	1.104E-10	7.653E-11	3.583E-07	3.742E-07
U-238+D	Ra-226+D	9.999E-01	2.359E-15	3.520E-14	3.881E-13	8.086E-12	1.007E-10	4.219E-10	6.031E-06	6.317E-06
U-238+D	Pb-210+D	9.999E-01	1.098E-17	2.893E-16	6.171E-15	3.430E-13	1.081E-11	8.254E-11	6.194E-05	6.486E-05
U-238+D	ΣDSR(j)		9.989E-02	9.339E-02	8.161E-02	5.085E-02	1.303E-02	8.685E-05	2.215E-01	7.155E-05

The DSR includes contributions from associated (half-life ó 180 days) daughters.

Summary : U-238 DCGL for Hammond Depot (Chapman)
File : VALIDATE-U238 Unat DCGL HD1-kd-lookup 899 FINAL 01-12-06.RAD

Single Radionuclide Soil Guidelines G(i,t) in pCi/g
Basic Radiation Dose Limit = 2.500E+01 mrem/yr

Nuclide (i)	t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Ac-227	1.088E+01	1.134E+01	1.233E+01	1.655E+01	3.879E+01	1.000E+03	*7.232E+13	*7.232E+13
Pa-231	4.403E+00	4.393E+00	4.383E+00	4.415E+00	4.925E+00	1.325E+01	*4.723E+10	*4.723E+10
Pb-210	8.813E+00	9.228E+00	1.012E+01	1.399E+01	3.585E+01	1.354E+03	*7.634E+13	*7.634E+13
Ra-226	4.486E+00	4.455E+00	4.407E+00	4.338E+00	4.666E+00	1.148E+01	*9.885E+11	*9.885E+11
Th-230	6.401E+02	6.070E+02	5.498E+02	4.143E+02	2.546E+02	2.053E+02	*2.018E+10	*2.018E+10
U-234	4.738E+02	5.080E+02	5.844E+02	9.553E+02	3.943E+03	5.356E+05	1.074E+02	4.206E+04
U-235	7.860E+01	8.385E+01	9.541E+01	1.499E+02	5.416E+02	2.431E+04	1.096E+02	2.405E+03
U-238	2.503E+02	2.677E+02	3.063E+02	4.916E+02	1.918E+03	2.878E+05	1.129E+02	*3.361E+05
*******	*********	*********	*********	*********	*********	*********	*********	*********

*At specific activity limit

Summed Dose/Source Ratios DSR(i,t) in (mrem/yr)/(pCi/g)
and Single Radionuclide Soil Guidelines G(i,t) in pCi/g
at tmin = time of minimum single radionuclide soil guideline
and at tmax = time of maximum total dose = 0.000E+00 years

Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Ac-227	4.700E-02	0.000E+00	2.298E+00	1.088E+01	2.298E+00	1.088E+01
Pa-231	4.700E-02	4.141 ± 0.008	5.705E+00	4.382E+00	5.678E+00	4.403E+00
Pb-210	1.000E+00	0.000E+00	2.837E+00	8.813E+00	2.837E+00	8.813E+00
Ra-226	1.000E+00	10.43 ± 0.02	5.763E+00	4.338E+00	5.573E+00	4.486E+00
Th-230	1.000E+00	74.0 ± 0.1	1.354E-01	1.847E+02	3.906E-02	6.401E+02
U-234	1.000E+00	254.7 ± 0.5	4.932E+00	5.069E+00	5.276E-02	4.738E+02
U-235	4.700E-02	254.5 ± 0.5	4.705E+00	5.314E+00	3.181E-01	7.860E+01
U-238	1.000E+00	254.7 ± 0.5	4.699E+00	5.320E+00	9.990E-02	2.503E+02
*******	*********	**********	*********	*********	*********	*********

Summary : U-238 DCGL for Hammond Depot (Chapman)
File : VALIDATE-U238 Unat DCGL HD1-kd-lookup 899 FINAL 01-12-06.RAD

Individual Nuclide Dose Summed Over All Pathways
Parent Nuclide and Branch Fraction Indicated

Nuclide (j)	Parent (i)	THF(i)	DOSE(j,t), mrem/yr t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Ac-227	Ac-227	1.000E+00	1.080E-01	1.036E-01	9.527E-02	7.098E-02	3.029E-02	1.175E-03	0.000E+00	0.000E+00
Ac-227	Pa-231	1.000E+00	2.077E-03	5.470E-03	1.164E-02	2.867E-02	5.076E-02	2.956E-02	0.000E+00	0.000E+00
Ac-227	U-235	1.000E+00	1.578E-08	9.321E-08	4.244E-07	2.777E-06	1.091E-05	1.010E-05	1.865E-04	2.997E-04
Ac-227	ΣDOSE(j)		1.101E-01	1.091E-01	1.069E-01	9.966E-02	8.106E-02	3.074E-02	1.865E-04	2.997E-04
Pa-231	Pa-231	1.000E+00	2.648E-01	2.620E-01	2.564E-01	2.374E-01	1.878E-01	5.913E-02	0.000E+00	0.000E+00
Pa-231	U-235	1.000E+00	2.558E-06	7.738E-06	1.696E-05	3.917E-05	5.608E-05	2.108E-05	1.831E-04	1.888E-04
Pa-231	ΣDOSE(j)		2.648E-01	2.620E-01	2.564E-01	2.375E-01	1.879E-01	5.915E-02	1.831E-04	1.888E-04
Pb-210	Pb-210	1.000E+00	2.837E+00	2.709E+00	2.471E+00	1.787E+00	6.974E-01	1.846E-02	0.000E+00	0.000E+00
Pb-210	Ra-226	1.000E+00	5.147E-02	1.378E-01	2.936E-01	7.098E-01	1.176E+00	5.156E-01	0.000E+00	0.000E+00
Pb-210	Th-230	1.000E+00	7.997E-06	4.925E-05	2.355E-04	1.755E-03	9.568E-03	1.992E-02	0.000E+00	0.000E+00
Pb-210	U-234	1.000E+00	1.872E-11	2.420E-10	2.454E-09	4.929E-08	6.236E-07	2.340E-06	0.000E+00	5.276E-04
Pb-210	U-238	9.999E-01	1.098E-17	2.893E-16	6.171E-15	3.430E-13	1.081E-11	8.254E-11	6.194E-05	6.486E-05
Pb-210	ΣDOSE(j)		2.888E+00	2.847E+00	2.765E+00	2.498E+00	1.883E+00	5.540E-01	6.194E-05	5.925E-04
Ra-226	Ra-226	1.000E+00	5.522E+00	5.474E+00	5.379E+00	5.053E+00	4.182E+00	1.663E+00	0.000E+00	0.000E+00
Ra-226	Th-230	1.000E+00	1.168E-03	3.534E-03	8.182E-03	2.346E-02	5.890E-02	8.994E-02	0.000E+00	0.000E+00
Ra-226	U-234	1.000E+00	3.400E-09	2.377E-08	1.205E-07	9.067E-07	4.764E-06	1.117E-05	0.000E+00	5.360E-05
Ra-226	U-238	9.999E-01	2.359E-15	3.520E-14	3.881E-13	8.086E-12	1.007E-10	4.219E-10	6.031E-06	6.317E-06
Ra-226	ΣDOSE(j)		5.523E+00	5.478E+00	5.387E+00	5.077E+00	4.241E+00	1.753E+00	6.031E-06	5.991E-05
Th-230	Th-230	1.000E+00	3.788E-02	3.761E-02	3.705E-02	3.513E-02	2.973E-02	1.189E-02	0.000E+00	0.000E+00
Th-230	U-234	1.000E+00	1.758E-07	4.936E-07	1.056E-06	2.439E-06	3.645E-06	1.708E-06	1.264E-05	1.313E-05
Th-230	U-238	9.999E-01	1.700E-13	1.088E-12	5.120E-12	3.245E-11	1.104E-10	7.653E-11	3.583E-07	3.742E-07
Th-230	ΣDOSE(j)		3.788E-02	3.761E-02	3.705E-02	3.513E-02	2.974E-02	1.189E-02	1.300E-05	1.350E-05
U-234	U-234	1.000E+00	5.276E-02	4.921E-02	4.278E-02	2.617E-02	6.331E-03	3.146E-05	2.328E-01	0.000E+00
U-234	U-238	9.999E-01	7.392E-08	2.084E-07	4.237E-07	7.785E-07	5.473E-07	8.963E-09	1.984E-04	0.000E+00
U-234	ΣDOSE(j)		5.276E-02	4.921E-02	4.278E-02	2.617E-02	6.331E-03	3.147E-05	2.330E-01	0.000E+00
U-235	U-235	1.000E+00	1.495E-02	1.401E-02	1.230E-02	7.794E-03	2.102E-03	1.714E-05	1.035E-02	0.000E+00
U-238	U-238	5.400E-05	2.561E-06	2.389E-06	2.077E-06	1.270E-06	3.072E-07	1.523E-09	1.134E-05	0.000E+00
U-238	U-238	9.999E-01	9.989E-02	9.339E-02	8.161E-02	5.085E-02	1.303E-02	8.684E-05	2.212E-01	0.000E+00
U-238	ΣDOSE(j)		9.990E-02	9.339E-02	8.161E-02	5.085E-02	1.303E-02	8.684E-05	2.213E-01	0.000E+00

THF(i) is the thread fraction of the parent nuclide.

Summary : U-238 DCGL for Hammond Depot (Chapman)
File : VALIDATE-U238 Unat DCGL HD1-kd-lookup 899 FINAL 01-12-06.RAD

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated

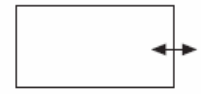
0Nuclide (j)	Parent (i)	THF(i)	S(j,t), pCi/g t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Ac-227	Ac-227	1.000E+00	4.700E-02	4.530E-02	4.209E-02	3.254E-02	1.560E-02	1.189E-03	7.606E-07	5.038E-18
Ac-227	Pa-231	1.000E+00	0.000E+00	1.466E-03	4.224E-03	1.225E-02	2.532E-02	2.932E-02	1.353E-02	7.886E-04
Ac-227	U-235	1.000E+00	0.000E+00	1.529E-08	1.285E-07	1.127E-06	5.376E-06	1.001E-05	4.836E-06	2.819E-07
Ac-227	ΣS(j):		4.700E-02	4.677E-02	4.631E-02	4.479E-02	4.092E-02	3.052E-02	1.353E-02	7.888E-04
Pa-231	Pa-231	1.000E+00	4.700E-02	4.681E-02	4.643E-02	4.513E-02	4.161E-02	3.131E-02	1.390E-02	8.103E-04
Pa-231	U-235	1.000E+00	0.000E+00	9.617E-07	2.700E-06	7.207E-06	1.236E-05	1.117E-05	4.970E-06	2.897E-07
Pa-231	ΣS(j):		4.700E-02	4.681E-02	4.643E-02	4.514E-02	4.162E-02	3.133E-02	1.391E-02	8.106E-04
Pb-210	Pb-210	1.000E+00	1.000E+00	9.615E-01	8.888E-01	6.750E-01	3.075E-01	1.963E-02	7.559E-06	8.478E-18
Pb-210	Ra-226	1.000E+00	0.000E+00	3.041E-02	8.731E-02	2.504E-01	5.023E-01	5.366E-01	2.090E-01	6.882E-03
Pb-210	Th-230	1.000E+00	0.000E+00	6.633E-06	5.795E-05	5.819E-04	3.994E-03	2.056E-02	4.598E-02	4.065E-02
Pb-210	U-234	1.000E+00	0.000E+00	1.967E-11	5.033E-10	1.552E-08	2.568E-07	2.411E-06	6.395E-06	5.844E-06
Pb-210	U-238	9.999E-01	0.000E+00	1.384E-17	1.047E-15	1.023E-13	4.385E-12	8.485E-11	2.791E-10	2.645E-10
Pb-210	ΣS(j):		1.000E+00	9.919E-01	9.761E-01	9.260E-01	8.138E-01	5.768E-01	2.550E-01	4.754E-02
Ra-226	Ra-226	1.000E+00	1.000E+00	9.951E-01	9.855E-01	9.524E-01	8.639E-01	6.141E-01	2.316E-01	7.624E-03
Ra-226	Th-230	1.000E+00	0.000E+00	4.320E-04	1.289E-03	4.213E-03	1.196E-02	3.301E-02	6.002E-02	5.059E-02
Ra-226	U-234	1.000E+00	0.000E+00	1.906E-09	1.640E-08	1.566E-07	9.589E-07	4.098E-06	8.392E-06	7.273E-06
Ra-226	U-238	9.999E-01	0.000E+00	1.783E-15	4.509E-14	1.337E-12	2.005E-11	1.545E-10	3.684E-10	3.293E-10
Ra-226	ΣS(j):		1.000E+00	9.956E-01	9.868E-01	9.566E-01	8.759E-01	6.471E-01	2.916E-01	5.822E-02
Th-230	Th-230	1.000E+00	1.000E+00	9.993E-01	9.979E-01	9.930E-01	9.791E-01	9.321E-01	8.098E-01	4.949E-01
Th-230	U-234	1.000E+00	0.000E+00	8.720E-06	2.457E-05	6.646E-05	1.193E-04	1.339E-04	1.166E-04	7.123E-05
Th-230	U-238	9.999E-01	0.000E+00	1.223E-11	1.012E-10	8.444E-10	3.574E-09	5.997E-09	5.283E-09	3.229E-09
Th-230	ΣS(j):		1.000E+00	9.993E-01	9.979E-01	9.931E-01	9.792E-01	9.322E-01	8.099E-01	4.950E-01
U-234	U-234	1.000E+00	1.000E+00	9.387E-01	8.272E-01	5.313E-01	1.500E-01	1.792E-03	5.755E-09	3.416E-28
U-234	U-238	9.999E-01	0.000E+00	2.661E-06	7.035E-06	1.506E-05	1.275E-05	5.081E-07	4.896E-12	9.697E-31
U-234	ΣS(j):		1.000E+00	9.387E-01	8.272E-01	5.313E-01	1.500E-01	1.793E-03	5.760E-09	3.426E-28
U-235	U-235	1.000E+00	4.700E-02	4.412E-02	3.888E-02	2.497E-02	7.049E-03	8.425E-05	2.707E-10	1.610E-29
U-238	U-238	5.400E-05	5.400E-05	5.069E-05	4.467E-05	2.869E-05	8.099E-06	9.680E-08	3.110E-13	1.850E-32
U-238	U-238	9.999E-01	9.999E-01	9.387E-01	8.271E-01	5.313E-01	1.500E-01	1.792E-03	5.760E-09	3.425E-28
U-238	ΣS(j):		1.000E+00	9.387E-01	8.272E-01	5.313E-01	1.500E-01	1.793E-03	5.760E-09	3.426E-28

THF(i) is the thread fraction of the parent nuclide.
RESCALC.EXE execution time = 10.14 seconds

APPENDIX C:

DEFENSE NATIONAL STOCKPILE CENTER
CURTIS BAY DEPOT DOSE MODELING
RECOMMENDED VALUES FOR RESRAD-BUILD (v 3.3) INPUT PARAMETERS

DEFENSE NATIONAL STOCKPILE CENTER
HAMMOND DEPOT DOSE MODELING
RECOMMENDED VALUES FOR RESRAD-BUILD (v3.3) INPUT PARAMETERS

RESRAD-BUILD v3.3					Recommendations	
Parameter Description	**Parameter Identifier**	**Default Value**	**User Input Value** (values different from default are shown in **bold**)	**Units**	**Justification**	**Reference(s)**
J.1 TIME PARAMETERS						
Exposure Duration *(output= "Total Time")*	TTIME	365	365	d	As stated in the manual, 365 days would typically be selected to assess an annual dose.	RESRAD-BUILD Manual v3.3 Appendix J.1.1
Indoor Fraction *(output= "Fraction Inside")*	FTIN	0.5	0.5	Unitless	A warehouse worker spending 50 hours per week in the building would yield a fraction of 50/(24*7)=0.29. To produce a more conservative case, the default of 0.5 was used.	RESRAD-BUILD Manual v3.3 App. J.1.2
Number of Times for Calculation	NTIME	1	1	Unitless	No significant time-dependent effects are relevant for these runs. As a result, no multiple runs (<10) are needed to review small time-scale effects. The default value is sufficient.	RESRAD-BUILD Manual v3.3 App. J.1.3
Time	DOSE_TIME	1	**0, 1, 1000**	Year	Three time scales were used to calculate "peak dose" in a 1000-year period.	RESRAD-BUILD Manual v3.3 App. J.1.4
Maximum Time Integration Points	POINT	17	**257**	Unitless	Mathematical convergence is reasonably achieved on Pentium-processors even at the largest allowable number of integration points.	RESRAD-BUILD Manual v3.3 App. J.1.5
J.2 BUILDING PARAMETERS						
Number of Rooms	NROOM	1	1	Unitless	The existing state of the warehouse facilities, and the intended long-term use post-closure, does not warrant any additional complicated efforts in describing air flow patterns between adjacent rooms. Therefore, a one-room model was selected "to represent complete instantaneous air mixing of the internal volume being modeled."  1-Room Warehouse	RESRAD-BUILD Manual v3.3 App. J.2.1
Deposition Velocity	UD	0.01	0.01	m/s	For this source term as understood, no compelling information existed to evaluate the deposition velocity beyond the use of default values, in other than the probabilistic analyses.	RESRAD-BUILD Manual v3.3 App. J.2.2
Resuspension Rate	DKSUS	5.0E-7	5.0E-7	s^{-1}	No site-specific data is available that would provide a ventilation rate any more accurate or	RESRAD-BUILD Manual v3.3

DEFENSE NATIONAL STOCKPILE CENTER
HAMMOND DEPOT DOSE MODELING
RECOMMENDED VALUES FOR RESRAD-BUILD (v3.3) INPUT PARAMETERS

RESRAD-BUILD v3.3					Recommendations	
Parameter Description	**Parameter Identifier**	**Default Value**	**User Input Value** (values different from default are shown in **bold**)	**Units**	**Justification**	**Reference(s)**
					more credible than the default value.	App. J.2.3
Room Height	H	2.5	2.5	m	For geometric convenience of the conceptual model, the default value was used. In addition, the default value is less than the actual height of the warehouses, which yields a more conservative DCGL. These are very large (and empty) warehouses with no interior walls and only rafters remaining to support the roof.	RESRAD-BUILD Manual v3.3 App. J.2.4
Room Area	AREA	36	**100**	m^2	Mathematical treatment and representation of the conceptual model used a simple, one room model, 10m x 10m in area. This model simplifies the overall source-term allocation and ensures a consistent conservative approach until such time that the results become unrealistically conservative.	RESRAD-BUILD Manual v3.3 App. J.2.5
Air Exchange Rate	LAMBDAT (bldg) LINPUT (room)	0.8	0.8	h^{-1}	For the one-room model, the air exchange rate for the building and that for the room are the same value, in this case, the default value for a one-room model. For these historic warehouses, the air exchange rate is probably larger, but for conservatism, the default was used	RESRAD-BUILD Manual v3.3 App. J.2.6
Flow Rate between Rooms	Q12 Q21	N/A	N/A	N/A	For a one-room model, this parameter is not applicable.	RESRAD-BUILD Manual v3.3 App. J.2.7
Outdoor Inflow and Outflow	Q10 Q01	72 72	**200**	m^3/h	For the one-room model, the rate at which the outdoor air flows into the room is equal to the rate at which the air flows from the room to the exterior. This parameter is calculated as a product of the site-specific values: (room area)*(height)*(air exchange rate)	RESRAD-BUILD Manual v3.3 App. J.2.8
J.3 RECEPTOR PARAMETERS						
Number of Receptors	ND	1	1	Unitless	One receptor was placed in the middle of the modeled room. The overall approach was to make the conceptual model simple and straightforward because of the condition of the buildings and the future anticipated use, i.e., deconstruction.	RESRAD-BUILD Manual v3.3 App. J.3.1

DEFENSE NATIONAL STOCKPILE CENTER
HAMMOND DEPOT DOSE MODELING
RECOMMENDED VALUES FOR RESRAD-BUILD (v3.3) INPUT PARAMETERS

RESRAD-BUILD v3.3					Recommendations	
Parameter Description	**Parameter Identifier**	**Default Value**	**User Input Value** (values different from default are shown in **bold**)	**Units**	**Justification**	**Reference(s)**
Receptor Room	DLVL	1	1	Unitless	The default value was selected based on a one room model.	RESRAD-BUILD Manual v3.3 App. J.3.2
Receptor Location	DX	1,1,1	**5,5,1**	Unitless	The receptor was placed in the middle of the 10m x 10m room. The z dimension is the conventional 1 meter height, dose to the receptor. *(See summary graphic below)*	RESRAD-BUILD Manual v3.3 App. J.3.3
Receptor Time Fraction	TWGHT	1	1	Unitless	The receptor is assumed to be at this position 100% of the time while in the building.	RESRAD-BUILD Manual v3.3 App. J.3.4
Receptor Breathing/Inhalation Rate	BRTRATE	18	18	Unitless	The default value was selected.	RESRAD-BUILD Manual v3.3 App. J.3.5
Indirect Ingestion Rate	INGE2	1.0E-04	1.0E-04	m^2/h	The default value was selected.	RESRAD-BUILD Manual v3.3 App. J.3.6
J.4 SOURCE PARAMETERS						
Number of Sources	NS	1	**5**	Unitless	Five sources were selected to represent an areal source on the floor and on each of four walls. The geometry approach, as selected, is conservative. If during site characterization and follow-up, it is determined that the geometry should be modified to more appropriately describe the actual facility, this model may be modified. A specific conservatism is the fact that the warehouses are large, yet, the model employed here assumes four walls. *(See summary graphic below)*	RESRAD-BUILD Manual v3.3 App. J.4.1
Source Room	SLVL	1	1	Unitless	Default value based on one room in the conceptual model. *(See summary graphic below)*	RESRAD-BUILD Manual v3.3 App. J.4.2
Source Type	STYPE	Volume	**Area**	Unitless	The thickness of the contamination is small relative to the attenuation properties of the material. *(See summary graphic below)*	RESRAD-BUILD Manual v3.3 App. J.4.3
Source Direction	SDIR		Appropriate orthogonal projection from the areal, plane source	Unitless	For example, from the x-z plane, the y coordinate projection was placed on the geometric centerline of the plane. *(See summary graphic below)*	RESRAD-BUILD Manual v3.3 App. J.4.4

DEFENSE NATIONAL STOCKPILE CENTER
HAMMOND DEPOT DOSE MODELING
RECOMMENDED VALUES FOR RESRAD-BUILD (v3.3) INPUT PARAMETERS

RESRAD-BUILD v3.3					**Recommendations**	
Parameter Description	**Parameter Identifier**	**Default Value**	**User Input Value** (values different from default are shown in **bold**)	**Units**	**Justification**	**Reference(s)**
Source Location	SX	0,0,0	**Appropriate Centerline Geometry**	Unitless	Each of the five sources represented an equivalent area of contamination on each of the four walls and floor, accordingly. *(See summary graphic below)*	RESRAD-BUILD Manual v3.3 App. J.4.5
Source Length/Area	SAREA	36	**100 (floor)** **25 (each of 4 walls)**	m^2	The floor and wall area values were based on the conceptual model where the floor area is 100 m^2 and each wall area is determined by multiplying the length of each wall by the ceiling height.	RESRAD-BUILD Manual v3.3 App. J.4.6
Air Release Fraction	AIRFR	0.1	0.1	Unitless	The default value was selected.	RESRAD-BUILD Manual v3.3 App. J.4.7
Direct Ingestion Rate	INGE1	0	0	h^{-1} (for area source)	The default value was selected.	RESRAD-BUILD Manual v3.3 App. J.4.8
Removable Fraction	RMVFR	0.5	0.5	Unitless	The default value was selected.	RESRAD-BUILD Manual v3.3 App. J.4.9
Source Lifetime	RFO	365	**1.0E+04**	days	The user input value is the "most likely" value as cited in the RESRAD-BUILD manual. The modeling effort assumed only radioactive decay and no credit for effective removal of the source with time.	RESRAD-BUILD Manual v3.3 App. J.4.10
Radon Release Fraction	RRF	0.1	0.1	Unitless	The default value was selected.	RESRAD-BUILD Manual v3.3 App. J.4.11
Radionuclide Concentration/Activity	RNUCACT	1	1	pCi/ m^2	Unit surface activity values were input for natural thorium and natural uranium. All decay products for each of the series were included if the half-life of the decay product was greater than 180 days (a recommended cutoff from RESRAD). For thorium, Th-232, Th-228, and Ra-228 were included. For natural uranium, U-238, U-234, Th-230, Ra-226, and Pb-210 each received an input of "1"; concurrently the proper atom fractions were input for U-235, Pa-231, and Ac-227 (at 0.047 pCi/m^2, the corresponding activity for natural uranium where the weight fraction of U235 is 0.7%.) Correspondingly:	RESRAD-BUILD Manual v3.3 App. J.4.12

DEFENSE NATIONAL STOCKPILE CENTER
HAMMOND DEPOT DOSE MODELING
RECOMMENDED VALUES FOR RESRAD-BUILD (v3.3) INPUT PARAMETERS

RESRAD-BUILD v3.3					Recommendations	
Parameter Description	**Parameter Identifier**	**Default Value**	**User Input Value** (values different from default are shown in **bold**)	**Units**	**Justification**	**Reference(s)**
					Nuclide [pCi/m2] Th-232 1.000E+00 Th-228 1.000E+00 Ra-228 1.000E+00 U-238 1.000E+00 U-235 4.700E-02 U-234 1.000E+00 Pa-231 4.700E-02 Th-230 1.000E+00 Ac-227 4.700E-02 Ra-226 1.000E+00 Pb-210 1.000E+00	
Number of Regions in Volume Source	NREGI0	N/A	N/A	Unitless	This parameter applies to volume sources, not to area sources as described.	RESRAD-BUILD Manual v3.3 App. J.4.13
Contaminated Region	FCONT0	N/A	N/A	Unitless	This parameter applies to volume sources, not to area sources as described.	RESRAD-BUILD Manual v3.3 App. J.4.14
Source Region Thickness	THICK0	N/A	N/A	Unitless	This parameter applies to volume sources, not to area sources as described.	RESRAD-BUILD Manual v3.3 App. J.4.15
Source Density	DENSI0	N/A	N/A	Unitless	This parameter applies to volume sources, not to area sources as described.	RESRAD-BUILD Manual v3.3 App. J.4.16
Source Erosion Rate	EROS0	N/A	N/A	Unitless	This parameter applies to volume sources, not to area sources as described.	RESRAD-BUILD Manual v3.3 App. J.4.17
Source Porosity	POROS0	N/A	N/A	Unitless	This parameter applies to volume sources, not to area sources as described.	RESRAD-BUILD Manual v3.3 App. J.4.18
Radon Effective Diffusion Coefficient	EFDIF0	2E-06	N/A	Unitless	This input parameter could not be located in the RESRAD-BUILD code, v3.3.	RESRAD-BUILD Manual v3.3 App. J.4.19
Radon Emanation Fraction	EMANA0	0.2	**0.1**	Unitless	A lower radon emanation fraction was selected for modeling purposes; however, this parameter was irrelevant to the modeling	RESRAD-BUILD Manual v3.3 App. J.4.20

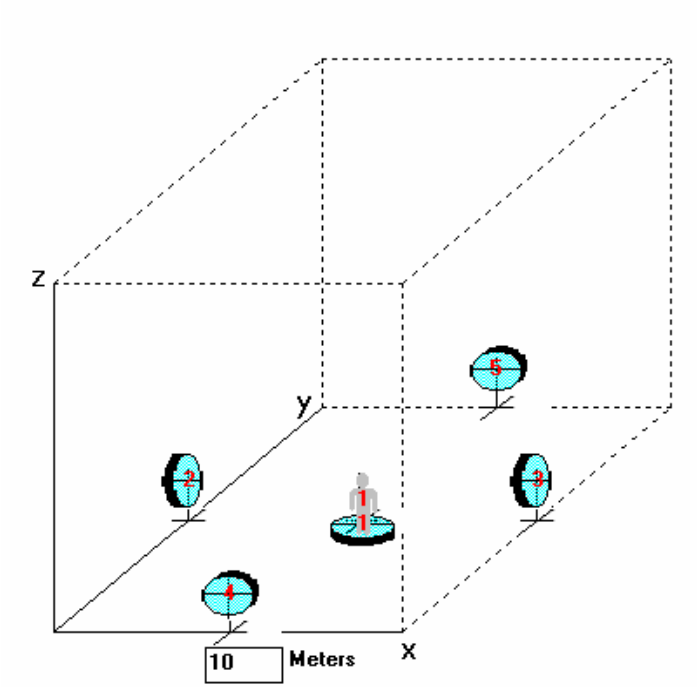
DEFENSE NATIONAL STOCKPILE CENTER
HAMMOND DEPOT DOSE MODELING
RECOMMENDED VALUES FOR RESRAD-BUILD (v3.3) INPUT PARAMETERS

RESRAD-BUILD v3.3					Recommendations	
Parameter Description	**Parameter Identifier**	**Default Value**	**User Input Value** (values different from default are shown in **bold)**	**Units**	**Justification**	**Reference(s)**
					evaluation results.	
Source Material	MTLS	Concrete	Concrete	Unitless	This parameter applies to volume sources, not to area sources as described.	RESRAD-BUILD Manual v3.3 App. J.4.21
J.5 SHIELDING PARAMETERS						
Shielding Thickness	DSTH	0	0	cm	The default value was selected. The evaluation assumed only surface contamination was present.	RESRAD-BUILD Manual v3.3 App. J.5.1
Shielding Density	DSDEN	2.4	2.4	g/cm^3	The default value was selected based on the existence of a concrete surface.	RESRAD-BUILD Manual v3.3 App. J.5.2
Shielding Material	MTLC	Concrete	Concrete	unitless	The default value was selected based on the known existence of a concrete surface.	RESRAD-BUILD Manual v3.3 App. J.5.3
J.6 TRITIUM MODEL PARAMETERS – NOT APPLICABLE TO THE SITE						

Geometrical Summary of the Conceptual Model
(as described in the table above)

For the one-room model, five sources are present with corresponding input parameters, and the receptor placed at the coordinates 5,5,1 (m)

Source	X	Y	Z	Direction
1	5	5	0	Z
2	0	5	1.25	X
3	10	5	1.25	X
4	5	0	1.25	Y
5	5	10	1.25	Y



The geometric representation is shown in the illustration below. Though conservative, it sets a lower bound on the DCGL.

APPENDIX D.1:

RESRAD-BUILD INPUT/OUTPUT FILE FOR THORIUM

 Title : TH-232 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD Th232chain-2006-01-11.bld

RESRAD-BUILD Table of Contents

==========
==========
=== ===
=== RESRAD-BUILD Input Parameters ===
=== ===
==========
==========

Number of Sources : 5
Number of Receptors: 1
Total Time : 3.650000E+02 days
Fraction Inside : 5.000000E-01

========== Receptor Information ==========

Receptor	Room	x [m]	y [m]	z [m]	FracTime	Inhalation [m3/day]	Ingestion(Dust) [m2/hr]
1	1	5.000	5.000	1.000	1.000	1.80E+01	1.00E-04

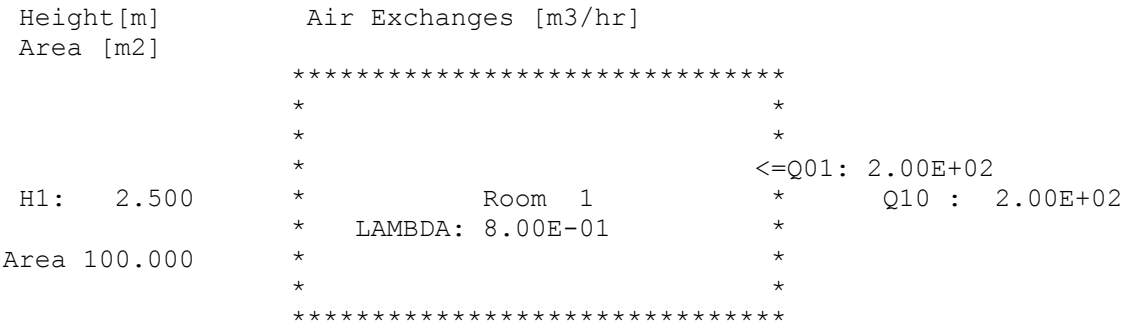
=== Receptor-Source Shielding Relationship ===

Receptor	Source	Density [g/cm3]	Thickness [cm]	Material
1	1	2.40E+00	0.00E+00	Concrete
1	2	2.40E+00	0.00E+00	Concrete
1	3	2.40E+00	0.00E+00	Concrete
1	4	2.40E+00	0.00E+00	Concrete
1	5	2.40E+00	0.00E+00	Concrete

 Title : TH-232 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD Th232chain-2006-01-11.bld

======== Building Information ========

Building Air Exchange Rate: 8.00E-01 1/hr



Deposition velocity: 1.00E-02 [m/s]   Resuspension Rate: 5.00E-07 [1/s]

======== Source Information ========

Source: 1
Location:: Room : 1 x: 5.00 y: 5.00 z: 0.00[m]
Geometry:: Type: Area Area:1.00E+02 [m2] Direction: z
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 5.000E-01
Time to Remove: 1.000E+04 [day]

Radon Release Fraction: 1.000E-01

Contamination::

Nuclide	Concentration	Dose Conversion Factor (Library: FGR 13 Morbidity		
	[pCi/m2]	Ingestion [mrem/pCi]	Inhalation [mrem/pCi]	Submersion [mrem/yr/ (pCi/m3)]
TH-232	1.000E+00	2.730E-03	1.640E+00	1.018E-06
TH-228	1.000E+00	8.086E-04	3.454E-01	9.378E-03
RA-228	1.000E+00	1.442E-03	5.078E-03	5.583E-03

Source: 2
Location:: Room : 1 x: 0.00 y: 5.00 z: 1.25[m]
Geometry:: Type: Area Area:2.50E+01 [m2] Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 5.000E-01
Time to Remove: 1.000E+04 [day]

Radon Release Fraction: 1.000E-01

Contamination::

Nuclide	Concentration	Dose Conversion Factor (Library: FGR 13 Morbidity		
	[pCi/m2]	Ingestion [mrem/pCi]	Inhalation [mrem/pCi]	Submersion [mrem/yr/ (pCi/m3)]
TH-232	1.000E+00	2.730E-03	1.640E+00	1.018E-06
TH-228	1.000E+00	8.086E-04	3.454E-01	9.378E-03
RA-228	1.000E+00	1.442E-03	5.078E-03	5.583E-03

Source: 3
Location:: Room : 1 x: 10.00 y: 5.00 z: 1.25[m]
Geometry:: Type: Area Area:2.50E+01 [m2] Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 5.000E-01
Time to Remove: 1.000E+04 [day]

Radon Release Fraction: 1.000E-01

Contamination::

Nuclide	Concentration	Dose Conversion Factor (Library: FGR 13 Morbidity		
	[pCi/m2]	Ingestion [mrem/pCi]	Inhalation [mrem/pCi]	Submersion [mrem/yr/ (pCi/m3)]
TH-232	1.000E+00	2.730E-03	1.640E+00	1.018E-06
TH-228	1.000E+00	8.086E-04	3.454E-01	9.378E-03
RA-228	1.000E+00	1.442E-03	5.078E-03	5.583E-03

Source: 4
Location:: Room : 1 x: 5.00 y: 0.00 z: 1.25[m]
Geometry:: Type: Area Area:2.50E+01 [m2] Direction: y
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 5.000E-01
Time to Remove: 1.000E+04 [day]

Radon Release Fraction: 1.000E-01

Contamination::

Nuclide	Concentration	Dose Conversion Factor (Library: FGR 13 Morbidity		
	[pCi/m2]	Ingestion [mrem/pCi]	Inhalation [mrem/pCi]	Submersion [mrem/yr/ (pCi/m3)]
TH-232	1.000E+00	2.730E-03	1.640E+00	1.018E-06
TH-228	1.000E+00	8.086E-04	3.454E-01	9.378E-03
RA-228	1.000E+00	1.442E-03	5.078E-03	5.583E-03

 Title : TH-232 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD Th232chain-2006-01-11.bld

 Source: 5
        Location:: Room : 1 x: 5.00 y: 10.00 z: 1.25[m]
        Geometry:: Type: Area   Area:2.50E+01 [m2] Direction: y
        Pathway ::
             Direct Ingestion Rate: 0.000E+00 [1/hr]
             Fraction released to air: 1.000E-01
             Removable fraction: 5.000E-01
             Time to Remove: 1.000E+04 [day]

             Radon Release Fraction: 1.000E-01

   Contamination::

Nuclide	Concentration	Dose Conversion Factor (Library: FGR 13 Morbidity		
	[pCi/m2]	Ingestion [mrem/pCi]	Inhalation [mrem/pCi]	Submersion [mrem/yr/ (pCi/m3)]
TH-232	1.000E+00	2.730E-03	1.640E+00	1.018E-06
TH-228	1.000E+00	8.086E-04	3.454E-01	9.378E-03
RA-228	1.000E+00	1.442E-03	5.078E-03	5.583E-03

 Title : TH-232 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD Th232chain-2006-01-11.bld
 Evaluation Time: 0.00000000E+00 years

```
            ================================================
            ================================================
            ===       Assessment for Time:  1              ===
            ===             Time =0.00E+00 yr              ===
            ================================================
            ================================================


            ========  Source Information  ========


 Source:  1
        Location::  Room :  1  x:   5.00 y:   5.00  z:   0.00 [m]
        Geometry::  Type: Area        Area:1.00E+02 [m2]  Direction: z
        Pathway ::
             Direct Ingestion Rate:    0.000E+00 [1/hr]
             Fraction released to air: 1.000E-01
             Removable fraction:       5.000E-01
             Time to Remove:           1.000E+04 [day]



         Contamination::     Nuclide    Concentration
                                          [pCi/m2]
                             TH-232      1.000E+00
                             TH-228      1.000E+00
                             RA-228      1.000E+00

 Source:  2
        Location::  Room :  1  x:   0.00 y:   5.00  z:   1.25 [m]
        Geometry::  Type: Area        Area:2.50E+01 [m2]  Direction: x
        Pathway ::
             Direct Ingestion Rate:    0.000E+00 [1/hr]
             Fraction released to air: 1.000E-01
             Removable fraction:       5.000E-01
             Time to Remove:           1.000E+04 [day]



         Contamination::     Nuclide    Concentration
                                          [pCi/m2]
                             TH-232      1.000E+00
                             TH-228      1.000E+00
                             RA-228      1.000E+00
```

 Title : TH-232 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD Th232chain-2006-01-11.bld
 Evaluation Time: 0.00000000E+00 years

 Source: 3
        Location:: Room : 1 x: 10.00 y: 5.00 z: 1.25 [m]
        Geometry:: Type: Area   Area:2.50E+01 [m2] Direction: x
        Pathway ::
             Direct Ingestion Rate: 0.000E+00 [1/hr]
             Fraction released to air: 1.000E-01
             Removable fraction: 5.000E-01
             Time to Remove: 1.000E+04 [day]

         Contamination::   Nuclide   Concentration
                                          [pCi/m2]
                             TH-232   1.000E+00
                             TH-228   1.000E+00
                             RA-228   1.000E+00

 Source: 4
        Location:: Room : 1 x: 5.00 y: 0.00 z: 1.25 [m]
        Geometry:: Type: Area   Area:2.50E+01 [m2] Direction: y
        Pathway ::
             Direct Ingestion Rate: 0.000E+00 [1/hr]
             Fraction released to air: 1.000E-01
             Removable fraction: 5.000E-01
             Time to Remove: 1.000E+04 [day]

         Contamination::   Nuclide   Concentration
                                          [pCi/m2]
                             TH-232   1.000E+00
                             TH-228   1.000E+00
                             RA-228   1.000E+00

 Title : TH-232 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD Th232chain-2006-01-11.bld
 Evaluation Time: 0.00000000E+00 years

 Source: 5
        Location:: Room : 1 x: 5.00 y: 10.00 z: 1.25 [m]
        Geometry:: Type: Area   Area:2.50E+01 [m2] Direction: y
        Pathway ::
             Direct Ingestion Rate: 0.000E+00 [1/hr]
             Fraction released to air: 1.000E-01
             Removable fraction: 5.000E-01
             Time to Remove: 1.000E+04 [day]

          Contamination::   Nuclide   Concentration
                                           [pCi/m2]
                              TH-232   1.000E+00
                              TH-228   1.000E+00
                              RA-228   1.000E+00

 Title : TH-232 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD Th232chain-2006-01-11.bld
 Evaluation Time: 0.00000000E+00 years

RESRAD-BUILDDose Tables

Source Contributions to Receptor Doses

[mrem]

	Source 1	Source 2	Source 3	Source 4	Source 5	Total
Receptor 1	7.41E-04	1.78E-04	1.78E-04	1.78E-04	1.78E-04	1.45E-03
Total	7.41E-04	1.78E-04	1.78E-04	1.78E-04	1.78E-04	1.45E-03

 Title : TH-232 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD Th232chain-2006-01-11.bld
 Evaluation Time: 0.00000000E+00 years

Pathway Detail of Doses
=======================
[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	4.43E-05	7.16E-08	6.04E-10	6.47E-04	4.52E-05	4.15E-06
Total	4.43E-05	7.16E-08	6.04E-10	6.47E-04	4.52E-05	4.15E-06

Source: 2

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	3.49E-06	1.79E-08	1.51E-10	1.62E-04	1.13E-05	1.04E-06
Total	3.49E-06	1.79E-08	1.51E-10	1.62E-04	1.13E-05	1.04E-06

Source: 3

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	3.49E-06	1.79E-08	1.51E-10	1.62E-04	1.13E-05	1.04E-06
Total	3.49E-06	1.79E-08	1.51E-10	1.62E-04	1.13E-05	1.04E-06

Source: 4

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	3.49E-06	1.79E-08	1.51E-10	1.62E-04	1.13E-05	1.04E-06
Total	3.49E-06	1.79E-08	1.51E-10	1.62E-04	1.13E-05	1.04E-06

Source: 5

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	3.49E-06	1.79E-08	1.51E-10	1.62E-04	1.13E-05	1.04E-06
Total	3.49E-06	1.79E-08	1.51E-10	1.62E-04	1.13E-05	1.04E-06

 Title : TH-232 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD Th232chain-2006-01-11.bld
 Evaluation Time: 0.00000000E+00 years

Nuclide Detail of Doses
=======================
[mrem]

Source: 1

Nuclide	Receptor 1	Total
TH-232		
TH-232	5.64E-04	5.64E-04
TH-228	1.01E-06	1.01E-06
RA-228	1.19E-06	1.19E-06
TH-228		
TH-228	1.31E-04	1.31E-04
RA-228		
TH-228	2.41E-05	2.41E-05
RA-228	1.94E-05	1.94E-05

Source: 2

Nuclide	Receptor 1	Total
TH-232		
TH-232	1.41E-04	1.41E-04
TH-228	2.23E-07	2.23E-07
RA-228	1.21E-07	1.21E-07
TH-228		
TH-228	2.90E-05	2.90E-05
RA-228		
TH-228	5.33E-06	5.33E-06
RA-228	1.97E-06	1.97E-06

Source: 3

Nuclide	Receptor 1	Total
TH-232		
TH-232	1.41E-04	1.41E-04
TH-228	2.23E-07	2.23E-07
RA-228	1.21E-07	1.21E-07
TH-228		

TH-228	2.90E-05	2.90E-05
RA-228		
TH-228	5.33E-06	5.33E-06
RA-228	1.97E-06	1.97E-06

Source: 4

Nuclide	Receptor 1	Total
TH-232		
TH-232	1.41E-04	1.41E-04
TH-228	2.23E-07	2.23E-07
RA-228	1.21E-07	1.21E-07
TH-228		
TH-228	2.90E-05	2.90E-05
RA-228		
TH-228	5.33E-06	5.33E-06
RA-228	1.97E-06	1.97E-06

Source: 5

Nuclide	Receptor 1	Total
TH-232		
TH-232	1.41E-04	1.41E-04
TH-228	2.23E-07	2.23E-07
RA-228	1.21E-07	1.21E-07
TH-228		
TH-228	2.90E-05	2.90E-05
RA-228		
TH-228	5.33E-06	5.33E-06
RA-228	1.97E-06	1.97E-06

 Title : TH-232 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD Th232chain-2006-01-11.bld
 Evaluation Time: 1.00000000 years

```
            ================================================
            ================================================
            ===       Assessment for Time:  2              ===
            ===             Time =1.00E+00 yr              ===
            ================================================
            ================================================


            ========  Source Information  ========


 Source:  1
        Location::  Room :  1  x:   5.00 y:   5.00  z:   0.00 [m]
        Geometry::  Type: Area        Area:1.00E+02 [m2]  Direction: z
        Pathway ::
             Direct Ingestion Rate:    0.000E+00 [1/hr]
             Fraction released to air: 1.000E-01
             Removable fraction:       4.907E-01
             Time to Remove:           1.000E+04 [day]



         Contamination::     Nuclide    Concentration
                                          [pCi/m2]
                             TH-232      9.817E-01
                             TH-228      9.817E-01
                             RA-228      9.817E-01

 Source:  2
        Location::  Room :  1  x:   0.00 y:   5.00  z:   1.25 [m]
        Geometry::  Type: Area        Area:2.50E+01 [m2]  Direction: x
        Pathway ::
             Direct Ingestion Rate:    0.000E+00 [1/hr]
             Fraction released to air: 1.000E-01
             Removable fraction:       4.907E-01
             Time to Remove:           1.000E+04 [day]



         Contamination::     Nuclide    Concentration
                                          [pCi/m2]
                             TH-232      9.817E-01
                             TH-228      9.817E-01
                             RA-228      9.817E-01
```

 Title : TH-232 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD Th232chain-2006-01-11.bld
 Evaluation Time: 1.00000000 years

 Source: 3
        Location:: Room : 1 x: 10.00 y: 5.00 z: 1.25 [m]
        Geometry:: Type: Area   Area:2.50E+01 [m2] Direction: x
        Pathway ::
             Direct Ingestion Rate: 0.000E+00 [1/hr]
             Fraction released to air: 1.000E-01
             Removable fraction: 4.907E-01
             Time to Remove: 1.000E+04 [day]

         Contamination::   Nuclide   Concentration
                                          [pCi/m2]
                             TH-232   9.817E-01
                             TH-228   9.817E-01
                             RA-228   9.817E-01

 Source: 4
        Location:: Room : 1 x: 5.00 y: 0.00 z: 1.25 [m]
        Geometry:: Type: Area   Area:2.50E+01 [m2] Direction: y
        Pathway ::
             Direct Ingestion Rate: 0.000E+00 [1/hr]
             Fraction released to air: 1.000E-01
             Removable fraction: 4.907E-01
             Time to Remove: 1.000E+04 [day]

         Contamination::   Nuclide   Concentration
                                          [pCi/m2]
                             TH-232   9.817E-01
                             TH-228   9.817E-01
                             RA-228   9.817E-01

 Title : TH-232 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD Th232chain-2006-01-11.bld
 Evaluation Time: 1.00000000 years

 Source: 5
        Location:: Room : 1 x: 5.00 y: 10.00 z: 1.25 [m]
        Geometry:: Type: Area   Area:2.50E+01 [m2] Direction: y
        Pathway ::
             Direct Ingestion Rate: 0.000E+00 [1/hr]
             Fraction released to air: 1.000E-01
             Removable fraction: 4.907E-01
             Time to Remove: 1.000E+04 [day]

         Contamination::   Nuclide   Concentration
                                          [pCi/m2]
                             TH-232   9.817E-01
                             TH-228   9.817E-01
                             RA-228   9.817E-01

 Title : TH-232 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD Th232chain-2006-01-11.bld
 Evaluation Time: 1.00000000 years

RESRAD-BUILDDose Tables

Source Contributions to Receptor Doses

[mrem]

	Source 1	Source 2	Source 3	Source 4	Source 5	Total
Receptor 1	7.39E-04	1.77E-04	1.77E-04	1.77E-04	1.77E-04	1.45E-03
Total	7.39E-04	1.77E-04	1.77E-04	1.77E-04	1.77E-04	1.45E-03

Title : TH-232 DCGL for HD (Chapman)
Input File : C:\Program Files\RESRAD_Family\BUILD\HD Th232chain-2006-01-11.bld
Evaluation Time: 1.00000000 years

Pathway Detail of Doses
[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	4.35E-05	7.16E-08	6.04E-10	6.47E-04	4.44E-05	4.15E-06
Total	4.35E-05	7.16E-08	6.04E-10	6.47E-04	4.44E-05	4.15E-06

Source: 2

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	3.43E-06	1.79E-08	1.51E-10	1.62E-04	1.11E-05	1.04E-06
Total	3.43E-06	1.79E-08	1.51E-10	1.62E-04	1.11E-05	1.04E-06

Source: 3

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	3.43E-06	1.79E-08	1.51E-10	1.62E-04	1.11E-05	1.04E-06
Total	3.43E-06	1.79E-08	1.51E-10	1.62E-04	1.11E-05	1.04E-06

Source: 4

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	3.43E-06	1.79E-08	1.51E-10	1.62E-04	1.11E-05	1.04E-06
Total	3.43E-06	1.79E-08	1.51E-10	1.62E-04	1.11E-05	1.04E-06

Source: 5

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	3.43E-06	1.79E-08	1.51E-10	1.62E-04	1.11E-05	1.04E-06
Total	3.43E-06	1.79E-08	1.51E-10	1.62E-04	1.11E-05	1.04E-06

 Title : TH-232 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD Th232chain-2006-01-11.bld
 Evaluation Time: 1.00000000 years

Nuclide Detail of Doses
=======================
[mrem]

Source: 1

Nuclide	Receptor 1	Total
TH-232		
TH-232	5.64E-04	5.64E-04
TH-228	6.14E-06	6.14E-06
RA-228	3.35E-06	3.35E-06
TH-228		
TH-228	9.05E-05	9.05E-05
RA-228		
TH-228	5.83E-05	5.83E-05
RA-228	1.70E-05	1.70E-05

Source: 2

Nuclide	Receptor 1	Total
TH-232		
TH-232	1.41E-04	1.41E-04
TH-228	1.36E-06	1.36E-06
RA-228	3.40E-07	3.40E-07
TH-228		
TH-228	2.00E-05	2.00E-05
RA-228		
TH-228	1.29E-05	1.29E-05
RA-228	1.72E-06	1.72E-06

Source: 3

Nuclide	Receptor 1	Total
TH-232		
TH-232	1.41E-04	1.41E-04
TH-228	1.36E-06	1.36E-06
RA-228	3.40E-07	3.40E-07
TH-228		

TH-228	2.00E-05	2.00E-05
RA-228		
TH-228	1.29E-05	1.29E-05
RA-228	1.72E-06	1.72E-06

Source: 4

Nuclide	Receptor 1	Total
TH-232		
TH-232	1.41E-04	1.41E-04
TH-228	1.36E-06	1.36E-06
RA-228	3.40E-07	3.40E-07
TH-228		
TH-228	2.00E-05	2.00E-05
RA-228		
TH-228	1.29E-05	1.29E-05
RA-228	1.72E-06	1.72E-06

Source: 5

Nuclide	Receptor 1	Total
TH-232		
TH-232	1.41E-04	1.41E-04
TH-228	1.36E-06	1.36E-06
RA-228	3.40E-07	3.40E-07
TH-228		
TH-228	2.00E-05	2.00E-05
RA-228		
TH-228	1.29E-05	1.29E-05
RA-228	1.72E-06	1.72E-06

 Title : TH-232 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD Th232chain-2006-01-11.bld
 Evaluation Time: 1000.00000 years

```
            ================================================
            ================================================
            ===       Assessment for Time:  3              ===
            ===             Time =1.00E+03 yr              ===
            ================================================
            ================================================
```

 ======== Source Information ========

 Source: 1
        Location:: Room : 1 x: 5.00 y: 5.00 z: 0.00 [m]
        Geometry:: Type: Area   Area:1.00E+02 [m2] Direction: z
        Pathway ::
             Direct Ingestion Rate: 0.000E+00 [1/hr]
             Fraction released to air: 1.000E-01
             Removable fraction: 0.000E+00
             Time to Remove: 1.000E+04 [day]

Contamination::	Nuclide	Concentration [pCi/m2]
	TH-232	5.000E-01
	TH-228	5.000E-01
	RA-228	5.000E-01

 Source: 2
        Location:: Room : 1 x: 0.00 y: 5.00 z: 1.25 [m]
        Geometry:: Type: Area   Area:2.50E+01 [m2] Direction: x
        Pathway ::
             Direct Ingestion Rate: 0.000E+00 [1/hr]
             Fraction released to air: 1.000E-01
             Removable fraction: 0.000E+00
             Time to Remove: 1.000E+04 [day]

Contamination::	Nuclide	Concentration [pCi/m2]
	TH-232	5.000E-01
	TH-228	5.000E-01
	RA-228	5.000E-01

 Title : TH-232 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD Th232chain-2006-01-11.bld
 Evaluation Time: 1000.00000 years

 Source: 3
        Location:: Room : 1 x: 10.00 y: 5.00 z: 1.25 [m]
        Geometry:: Type: Area   Area:2.50E+01 [m2] Direction: x
        Pathway ::
             Direct Ingestion Rate: 0.000E+00 [1/hr]
             Fraction released to air: 1.000E-01
             Removable fraction: 0.000E+00
             Time to Remove: 1.000E+04 [day]

         Contamination::   Nuclide   Concentration
                                          [pCi/m2]
                             TH-232   5.000E-01
                             TH-228   5.000E-01
                             RA-228   5.000E-01

 Source: 4
        Location:: Room : 1 x: 5.00 y: 0.00 z: 1.25 [m]
        Geometry:: Type: Area   Area:2.50E+01 [m2] Direction: y
        Pathway ::
             Direct Ingestion Rate: 0.000E+00 [1/hr]
             Fraction released to air: 1.000E-01
             Removable fraction: 0.000E+00
             Time to Remove: 1.000E+04 [day]

         Contamination::   Nuclide   Concentration
                                          [pCi/m2]
                             TH-232   5.000E-01
                             TH-228   5.000E-01
                             RA-228   5.000E-01

 Title : TH-232 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD Th232chain-2006-01-11.bld
 Evaluation Time: 1000.00000 years

 Source: 5
        Location:: Room : 1 x: 5.00 y: 10.00 z: 1.25 [m]
        Geometry:: Type: Area   Area:2.50E+01 [m2] Direction: y
        Pathway ::
             Direct Ingestion Rate: 0.000E+00 [1/hr]
             Fraction released to air: 1.000E-01
             Removable fraction: 0.000E+00
             Time to Remove: 1.000E+04 [day]

          Contamination::   Nuclide   Concentration
                                           [pCi/m2]
                              TH-232   5.000E-01
                              TH-228   5.000E-01
                              RA-228   5.000E-01

 Title : TH-232 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD Th232chain-2006-01-11.bld
 Evaluation Time: 1000.00000 years

RESRAD-BUILDDose Tables

Source Contributions to Receptor Doses

[mrem]

	Source 1	Source 2	Source 3	Source 4	Source 5	Total
Receptor 1	4.52E-05	7.46E-06	7.46E-06	7.46E-06	7.46E-06	7.50E-05
Total	4.52E-05	7.46E-06	7.46E-06	7.46E-06	7.46E-06	7.50E-05

Title : TH-232 DCGL for HD (Chapman)
Input File : C:\Program Files\RESRAD_Family\BUILD\HD Th232chain-2006-01-11.bld
Evaluation Time: 1000.00000 years

Pathway Detail of Doses
[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.24E-05	0.00E+00	0.00E+00	0.00E+00	2.28E-05	0.00E+00
Total	2.24E-05	0.00E+00	0.00E+00	0.00E+00	2.28E-05	0.00E+00

Source: 2

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	1.76E-06	0.00E+00	0.00E+00	0.00E+00	5.70E-06	0.00E+00
Total	1.76E-06	0.00E+00	0.00E+00	0.00E+00	5.70E-06	0.00E+00

Source: 3

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	1.76E-06	0.00E+00	0.00E+00	0.00E+00	5.70E-06	0.00E+00
Total	1.76E-06	0.00E+00	0.00E+00	0.00E+00	5.70E-06	0.00E+00

Source: 4

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	1.76E-06	0.00E+00	0.00E+00	0.00E+00	5.70E-06	0.00E+00
Total	1.76E-06	0.00E+00	0.00E+00	0.00E+00	5.70E-06	0.00E+00

Source: 5

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	1.76E-06	0.00E+00	0.00E+00	0.00E+00	5.70E-06	0.00E+00
Total	1.76E-06	0.00E+00	0.00E+00	0.00E+00	5.70E-06	0.00E+00

 Title : TH-232 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD Th232chain-2006-01-11.bld
 Evaluation Time: 1000.00000 years

Nuclide Detail of Doses
=======================
[mrem]

Source: 1

Nuclide	Receptor 1	Total
TH-232		
TH-232	1.12E-08	1.12E-08
TH-228	3.61E-05	3.61E-05
RA-228	9.05E-06	9.05E-06

Source: 2

Nuclide	Receptor 1	Total
TH-232		
TH-232	6.03E-10	6.03E-10
TH-228	6.75E-06	6.75E-06
RA-228	7.12E-07	7.12E-07

Source: 3

Nuclide	Receptor 1	Total
TH-232		
TH-232	6.03E-10	6.03E-10
TH-228	6.75E-06	6.75E-06
RA-228	7.12E-07	7.12E-07

Source: 4

Nuclide	Receptor 1	Total
TH-232		

 Title : TH-232 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD Th232chain-2006-01-11.bld
 Evaluation Time: 1000.00000 years

TH-232	6.03E-10	6.03E-10
TH-228	6.75E-06	6.75E-06
RA-228	7.12E-07	7.12E-07

Source: 5

Nuclide	Receptor 1	Total
TH-232		
TH-232	6.03E-10	6.03E-10
TH-228	6.75E-06	6.75E-06
RA-228	7.12E-07	7.12E-07

Title : TH-232 DCGL for HD (Chapman)
Input File : C:\Program Files\RESRAD_Family\BUILD\HD Th232chain-2006-01-11.bld
Full Summary

RESRAD-BUILD Dose (Time) Tables

Receptor Dose Received for the Exposure Duration

(mrem)

	Evaluation Time [yr]		
	0.00E+00	1.00E+00	1.00E+03
1	1.45E-03	1.45E-03	7.50E-05

Receptor Dose/Yr Averaged Over Exposure Duration

(mrem/yr)

	Evaluation Time [yr]		
	0.00E+00	1.00E+00	1.00E+03
1	1.45E-03	1.45E-03	7.51E-05

APPENDIX D.2:

RESRAD-BUILD INPUT/OUTPUT FILE FOR URANIUM

Title : U-238 DCGL for HD (Chapman)
Input File : C:\Program Files\RESRAD_Family\BUILD\HD U238chain-2006-01-11.bld

RESRAD-BUILD Table of Contents

RESRAD-BUILD Input Parameters

Number of Sources : 5
Number of Receptors: 1
Total Time   : 3.650000E+02 days
Fraction Inside   : 5.000000E-01

Receptor Information

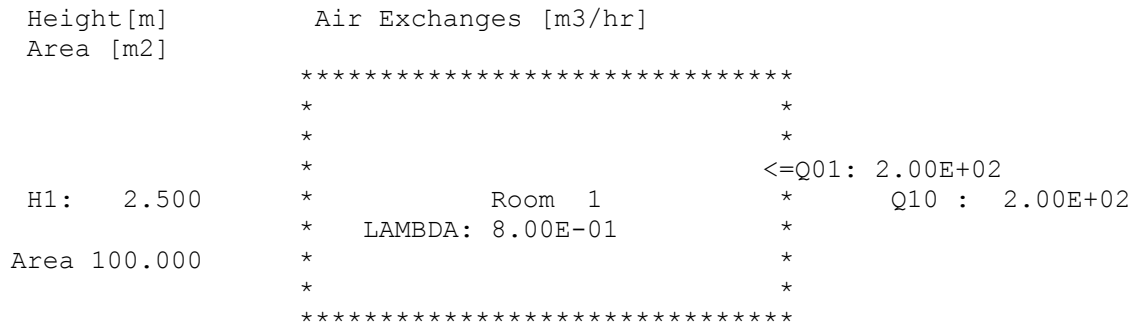
Receptor	Room	x [m]	y [m]	z [m]	FracTime	Inhalation [m3/day]	Ingestion(Dust) [m2/hr]
1	1	5.000	5.000	1.000	1.000	1.80E+01	1.00E-04

Receptor-Source Shielding Relationship

Receptor	Source	Density [g/cm3]	Thickness [cm]	Material
1	1	2.40E+00	0.00E+00	Concrete
1	2	2.40E+00	0.00E+00	Concrete
1	3	2.40E+00	0.00E+00	Concrete
1	4	2.40E+00	0.00E+00	Concrete
1	5	2.40E+00	0.00E+00	Concrete

======== Building Information ========

Building Air Exchange Rate: 8.00E-01 1/hr



Deposition velocity: 1.00E-02 [m/s] Resuspension Rate: 5.00E-07 [1/s]

======== Source Information ========

Source: 1
Location:: Room : 1 x: 5.00 y: 5.00 z: 0.00[m]
Geometry:: Type: Area Area:1.00E+02 [m2] Direction: z
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 5.000E-01
Time to Remove: 1.000E+04 [day]

Radon Release Fraction: 1.000E-01

Contamination::

Nuclide	Concentration	Dose Conversion Factor (Library: FGR 13 Morbidity		
	[pCi/m2]	Ingestion [mrem/pCi]	Inhalation [mrem/pCi]	Submersion [mrem/yr/ (pCi/m3)]
U-238	1.000E+00	2.687E-04	1.180E-01	1.597E-04
U-235	4.700E-02	2.673E-04	1.230E-01	9.019E-04
U-234	1.000E+00	2.830E-04	1.320E-01	8.912E-07
PA-231	4.700E-02	1.060E-02	1.280E+00	2.009E-04
TH-230	1.000E+00	5.480E-04	3.260E-01	2.032E-06
AC-227	4.700E-02	1.480E-02	6.724E+00	2.161E-03
RA-226	1.000E+00	1.321E-03	8.594E-03	1.035E-02
PB-210	1.000E+00	5.376E-03	1.380E-02	1.043E-05

Source: 2
Location:: Room : 1 x: 0.00 y: 5.00 z: 1.25[m]
Geometry:: Type: Area Area:2.50E+01 [m2] Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 5.000E-01
Time to Remove: 1.000E+04 [day]

Radon Release Fraction: 1.000E-01

Contamination::

Nuclide	Concentration [pCi/m2]	Dose Conversion Factor (Library: FGR 13 Morbidity Ingestion [mrem/pCi]	Inhalation [mrem/pCi]	Submersion [mrem/yr/(pCi/m3)]
U-238	1.000E+00	2.687E-04	1.180E-01	1.597E-04
U-235	4.700E-02	2.673E-04	1.230E-01	9.019E-04
U-234	1.000E+00	2.830E-04	1.320E-01	8.912E-07
PA-231	4.700E-02	1.060E-02	1.280E+00	2.009E-04
TH-230	1.000E+00	5.480E-04	3.260E-01	2.032E-06
AC-227	4.700E-02	1.480E-02	6.724E+00	2.161E-03
RA-226	1.000E+00	1.321E-03	8.594E-03	1.035E-02
PB-210	1.000E+00	5.376E-03	1.380E-02	1.043E-05

Source: 3
Location:: Room : 1 x: 10.00 y: 5.00 z: 1.25[m]
Geometry:: Type: Area Area:2.50E+01 [m2] Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 5.000E-01
Time to Remove: 1.000E+04 [day]

Radon Release Fraction: 1.000E-01

Contamination::

Nuclide	Concentration [pCi/m2]	Dose Conversion Factor (Library: FGR 13 Morbidity Ingestion [mrem/pCi]	Inhalation [mrem/pCi]	Submersion [mrem/yr/(pCi/m3)]
U-238	1.000E+00	2.687E-04	1.180E-01	1.597E-04

U-235	4.700E-02	2.673E-04	1.230E-01	9.019E-04
U-234	1.000E+00	2.830E-04	1.320E-01	8.912E-07
PA-231	4.700E-02	1.060E-02	1.280E+00	2.009E-04
TH-230	1.000E+00	5.480E-04	3.260E-01	2.032E-06
AC-227	4.700E-02	1.480E-02	6.724E+00	2.161E-03
RA-226	1.000E+00	1.321E-03	8.594E-03	1.035E-02
PB-210	1.000E+00	5.376E-03	1.380E-02	1.043E-05

Source: 4
Location:: Room : 1 x: 5.00 y: 0.00 z: 1.25[m]
Geometry:: Type: Area Area:2.50E+01 [m2] Direction: y
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 5.000E-01
Time to Remove: 1.000E+04 [day]

Radon Release Fraction: 1.000E-01

Contamination::

Nuclide	Concentration	Dose Conversion Factor (Library: FGR 13 Morbidity		
	[pCi/m2]	Ingestion [mrem/pCi]	Inhalation [mrem/pCi]	Submersion [mrem/yr/ (pCi/m3)]
U-238	1.000E+00	2.687E-04	1.180E-01	1.597E-04
U-235	4.700E-02	2.673E-04	1.230E-01	9.019E-04
U-234	1.000E+00	2.830E-04	1.320E-01	8.912E-07
PA-231	4.700E-02	1.060E-02	1.280E+00	2.009E-04
TH-230	1.000E+00	5.480E-04	3.260E-01	2.032E-06
AC-227	4.700E-02	1.480E-02	6.724E+00	2.161E-03
RA-226	1.000E+00	1.321E-03	8.594E-03	1.035E-02
PB-210	1.000E+00	5.376E-03	1.380E-02	1.043E-05

Title : U-238 DCGL for HD (Chapman)
Input File : C:\Program Files\RESRAD_Family\BUILD\HD U238chain-2006-01-11.bld

Source: 5
Location:: Room : 1 x: 5.00 y: 10.00 z: 1.25[m]
Geometry:: Type: Area Area:2.50E+01 [m2] Direction: y
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 5.000E-01
Time to Remove: 1.000E+04 [day]

Radon Release Fraction: 1.000E-01

Contamination::

Nuclide	Concentration	Dose Conversion Factor (Library: FGR 13 Morbidity		
	[pCi/m2]	Ingestion [mrem/pCi]	Inhalation [mrem/pCi]	Submersion [mrem/yr/ (pCi/m3)]
U-238	1.000E+00	2.687E-04	1.180E-01	1.597E-04
U-235	4.700E-02	2.673E-04	1.230E-01	9.019E-04
U-234	1.000E+00	2.830E-04	1.320E-01	8.912E-07
PA-231	4.700E-02	1.060E-02	1.280E+00	2.009E-04
TH-230	1.000E+00	5.480E-04	3.260E-01	2.032E-06
AC-227	4.700E-02	1.480E-02	6.724E+00	2.161E-03
RA-226	1.000E+00	1.321E-03	8.594E-03	1.035E-02
PB-210	1.000E+00	5.376E-03	1.380E-02	1.043E-05

 Title : U-238 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD U238chain-2006-01-11.bld
 Evaluation Time: 0.00000000E+00 years

```
          ================================================
          ================================================
          ===       Assessment for Time:  1              ===
          ===             Time =0.00E+00 yr              ===
          ================================================
          ================================================
```

======== Source Information ========

Source: 1
Location:: Room : 1 x: 5.00 y: 5.00 z: 0.00 [m]
Geometry:: Type: Area Area:1.00E+02 [m2] Direction: z
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 5.000E-01
Time to Remove: 1.000E+04 [day]

Contamination::	Nuclide	Concentration [pCi/m2]
	U-238	1.000E+00
	U-235	4.700E-02
	U-234	1.000E+00
	PA-231	4.700E-02
	TH-230	1.000E+00
	AC-227	4.700E-02
	RA-226	1.000E+00
	PB-210	1.000E+00

Source: 2
Location:: Room : 1 x: 0.00 y: 5.00 z: 1.25 [m]
Geometry:: Type: Area Area:2.50E+01 [m2] Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 5.000E-01
Time to Remove: 1.000E+04 [day]

Contamination::	Nuclide	Concentration [pCi/m2]
	U-238	1.000E+00
	U-235	4.700E-02
	U-234	1.000E+00

Title : U-238 DCGL for HD (Chapman)
Input File : C:\Program Files\RESRAD_Family\BUILD\HD U238chain-2006-01-11.bld
Evaluation Time: 0.00000000E+00 years

PA-231	4.700E-02
TH-230	1.000E+00
AC-227	4.700E-02
RA-226	1.000E+00
PB-210	1.000E+00

Source: 3
Location:: Room : 1 x: 10.00 y: 5.00 z: 1.25 [m]
Geometry:: Type: Area Area:2.50E+01 [m2] Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 5.000E-01
Time to Remove: 1.000E+04 [day]

Contamination::

Nuclide	Concentration [pCi/m2]
U-238	1.000E+00
U-235	4.700E-02
U-234	1.000E+00
PA-231	4.700E-02
TH-230	1.000E+00
AC-227	4.700E-02
RA-226	1.000E+00
PB-210	1.000E+00

Source: 4
Location:: Room : 1 x: 5.00 y: 0.00 z: 1.25 [m]
Geometry:: Type: Area Area:2.50E+01 [m2] Direction: y
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 5.000E-01
Time to Remove: 1.000E+04 [day]

Contamination::

Nuclide	Concentration [pCi/m2]
U-238	1.000E+00
U-235	4.700E-02
U-234	1.000E+00
PA-231	4.700E-02
TH-230	1.000E+00
AC-227	4.700E-02
RA-226	1.000E+00
PB-210	1.000E+00

 Title : U-238 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD U238chain-2006-01-11.bld
 Evaluation Time: 0.00000000E+00 years

 Source: 5
        Location:: Room : 1 x: 5.00 y: 10.00 z: 1.25 [m]
        Geometry:: Type: Area   Area:2.50E+01 [m2] Direction: y
        Pathway ::
             Direct Ingestion Rate: 0.000E+00 [1/hr]
             Fraction released to air: 1.000E-01
             Removable fraction: 5.000E-01
             Time to Remove: 1.000E+04 [day]

 Contamination::   Nuclide   Concentration
                                  [pCi/m2]
                     U-238   1.000E+00
                     U-235   4.700E-02
                     U-234   1.000E+00
                     PA-231   4.700E-02
                     TH-230   1.000E+00
                     AC-227   4.700E-02
                     RA-226   1.000E+00
                     PB-210   1.000E+00

 Title : U-238 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD U238chain-2006-01-11.bld
 Evaluation Time: 0.00000000E+00 years

RESRAD-BUILDDose Tables

Source Contributions to Receptor Doses

[mrem]

	Source 1	Source 2	Source 3	Source 4	Source 5	Total
Receptor 1	3.76E-04	8.83E-05	8.83E-05	8.83E-05	8.83E-05	7.29E-04
Total	3.76E-04	8.83E-05	8.83E-05	8.83E-05	8.83E-05	7.29E-04

 Title : U-238 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD U238chain-2006-01-11.bld
 Evaluation Time: 0.00000000E+00 years

Pathway Detail of Doses
[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	3.30E-05	6.94E-08	5.56E-10	3.32E-04	3.12E-06	8.01E-06
Total	3.30E-05	6.94E-08	5.56E-10	3.32E-04	3.12E-06	8.01E-06

Source: 2

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.60E-06	1.73E-08	1.39E-10	8.29E-05	7.80E-07	2.00E-06
Total	2.60E-06	1.73E-08	1.39E-10	8.29E-05	7.80E-07	2.00E-06

Source: 3

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.60E-06	1.73E-08	1.39E-10	8.29E-05	7.80E-07	2.00E-06
Total	2.60E-06	1.73E-08	1.39E-10	8.29E-05	7.80E-07	2.00E-06

Source: 4

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.60E-06	1.73E-08	1.39E-10	8.29E-05	7.80E-07	2.00E-06
Total	2.60E-06	1.73E-08	1.39E-10	8.29E-05	7.80E-07	2.00E-06

Source: 5

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.60E-06	1.73E-08	1.39E-10	8.29E-05	7.80E-07	2.00E-06
Total	2.60E-06	1.73E-08	1.39E-10	8.29E-05	7.80E-07	2.00E-06

 Title : U-238 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD U238chain-2006-01-11.bld
 Evaluation Time: 0.00000000E+00 years

Nuclide Detail of Doses

[mrem]

Source: 1

Nuclide	Receptor 1	Total
U-238		
U-238	4.13E-05	4.13E-05
U-234	6.41E-11	6.41E-11
TH-230	4.73E-16	4.73E-16
RA-226	1.78E-20	1.78E-20
PB-210	2.76E-23	2.76E-23
U-235		
U-235	2.15E-06	2.15E-06
PA-231	2.22E-10	2.22E-10
AC-227	1.16E-11	1.16E-11
U-234		
U-234	4.55E-05	4.55E-05
TH-230	5.03E-10	5.03E-10
RA-226	2.52E-14	2.52E-14
PB-210	4.68E-17	4.68E-17
PA-231		
PA-231	2.11E-05	2.11E-05
AC-227	1.65E-06	1.65E-06
TH-230		
TH-230	1.12E-04	1.12E-04
RA-226	8.41E-09	8.41E-09
PB-210	2.08E-11	2.08E-11
AC-227		
AC-227	1.04E-04	1.04E-04
RA-226		
RA-226	3.90E-05	3.90E-05
PB-210	1.44E-07	1.44E-07
PB-210		
PB-210	9.26E-06	9.26E-06

Source: 2

Nuclide	Receptor 1	Total
U-238		
U-238	1.02E-05	1.02E-05
U-234	1.60E-11	1.60E-11
TH-230	1.18E-16	1.18E-16

RA-226	1.97E-21	1.97E-21
PB-210	6.83E-24	6.83E-24
U-235		
U-235	5.10E-07	5.10E-07
PA-231	5.54E-11	5.54E-11
AC-227	2.90E-12	2.90E-12
U-234		
U-234	1.14E-05	1.14E-05
TH-230	1.26E-10	1.26E-10
RA-226	2.80E-15	2.80E-15
PB-210	1.16E-17	1.16E-17
PA-231		
PA-231	5.26E-06	5.26E-06
AC-227	4.12E-07	4.12E-07
TH-230		
TH-230	2.80E-05	2.80E-05
RA-226	9.34E-10	9.34E-10
PB-210	5.16E-12	5.16E-12
AC-227		
AC-227	2.59E-05	2.59E-05
RA-226		
RA-226	4.33E-06	4.33E-06
PB-210	3.57E-08	3.57E-08
PB-210		
PB-210	2.29E-06	2.29E-06

Source: 3

Nuclide	Receptor 1	Total
U-238		
U-238	1.02E-05	1.02E-05
U-234	1.60E-11	1.60E-11
TH-230	1.18E-16	1.18E-16
RA-226	1.97E-21	1.97E-21
PB-210	6.83E-24	6.83E-24
U-235		
U-235	5.10E-07	5.10E-07
PA-231	5.54E-11	5.54E-11
AC-227	2.90E-12	2.90E-12
U-234		
U-234	1.14E-05	1.14E-05
TH-230	1.26E-10	1.26E-10
RA-226	2.80E-15	2.80E-15
PB-210	1.16E-17	1.16E-17
PA-231		
PA-231	5.26E-06	5.26E-06
AC-227	4.12E-07	4.12E-07
TH-230		
TH-230	2.80E-05	2.80E-05

RA-226	9.34E-10	9.34E-10
PB-210	5.16E-12	5.16E-12
AC-227		
AC-227	2.59E-05	2.59E-05
RA-226		
RA-226	4.33E-06	4.33E-06
PB-210	3.57E-08	3.57E-08
PB-210		
PB-210	2.29E-06	2.29E-06

Source: 4

Nuclide	Receptor 1	Total
U-238		
U-238	1.02E-05	1.02E-05
U-234	1.60E-11	1.60E-11
TH-230	1.18E-16	1.18E-16
RA-226	1.97E-21	1.97E-21
PB-210	6.83E-24	6.83E-24
U-235		
U-235	5.10E-07	5.10E-07
PA-231	5.54E-11	5.54E-11
AC-227	2.90E-12	2.90E-12
U-234		
U-234	1.14E-05	1.14E-05
TH-230	1.26E-10	1.26E-10
RA-226	2.80E-15	2.80E-15
PB-210	1.16E-17	1.16E-17
PA-231		
PA-231	5.26E-06	5.26E-06
AC-227	4.12E-07	4.12E-07
TH-230		
TH-230	2.80E-05	2.80E-05
RA-226	9.34E-10	9.34E-10
PB-210	5.16E-12	5.16E-12
AC-227		
AC-227	2.59E-05	2.59E-05
RA-226		
RA-226	4.33E-06	4.33E-06
PB-210	3.57E-08	3.57E-08
PB-210		
PB-210	2.29E-06	2.29E-06

 Title : U-238 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD U238chain-2006-01-11.bld
 Evaluation Time: 0.00000000E+00 years

Source: 5

Nuclide	Receptor 1	Total
U-238		
U-238	1.02E-05	1.02E-05
U-234	1.60E-11	1.60E-11
TH-230	1.18E-16	1.18E-16
RA-226	1.97E-21	1.97E-21
PB-210	6.83E-24	6.83E-24
U-235		
U-235	5.10E-07	5.10E-07
PA-231	5.54E-11	5.54E-11
AC-227	2.90E-12	2.90E-12
U-234		
U-234	1.14E-05	1.14E-05
TH-230	1.26E-10	1.26E-10
RA-226	2.80E-15	2.80E-15
PB-210	1.16E-17	1.16E-17
PA-231		
PA-231	5.26E-06	5.26E-06
AC-227	4.12E-07	4.12E-07
TH-230		
TH-230	2.80E-05	2.80E-05
RA-226	9.34E-10	9.34E-10
PB-210	5.16E-12	5.16E-12
AC-227		
AC-227	2.59E-05	2.59E-05
RA-226		
RA-226	4.33E-06	4.33E-06
PB-210	3.57E-08	3.57E-08
PB-210		
PB-210	2.29E-06	2.29E-06

 Title : U-238 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD U238chain-2006-01-11.bld
 Evaluation Time: 1.00000000 years

```
          ================================================
          ================================================
          ===       Assessment for Time:  2              ===
          ===             Time =1.00E+00 yr              ===
          ================================================
          ================================================


          ========  Source Information  ========
```

Source: 1
Location:: Room : 1 x: 5.00 y: 5.00 z: 0.00 [m]
Geometry:: Type: Area Area:1.00E+02 [m2] Direction: z
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 4.907E-01
Time to Remove: 1.000E+04 [day]

Contamination::	Nuclide	Concentration [pCi/m2]
	U-238	9.817E-01
	U-235	4.614E-02
	U-234	9.817E-01
	PA-231	4.614E-02
	TH-230	9.817E-01
	AC-227	4.614E-02
	RA-226	9.817E-01
	PB-210	9.817E-01

Source: 2
Location:: Room : 1 x: 0.00 y: 5.00 z: 1.25 [m]
Geometry:: Type: Area Area:2.50E+01 [m2] Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 4.907E-01
Time to Remove: 1.000E+04 [day]

Contamination::	Nuclide	Concentration [pCi/m2]
	U-238	9.817E-01
	U-235	4.614E-02
	U-234	9.817E-01

PA-231	4.614E-02
TH-230	9.817E-01
AC-227	4.614E-02
RA-226	9.817E-01
PB-210	9.817E-01

Source: 3
Location:: Room : 1 x: 10.00 y: 5.00 z: 1.25 [m]
Geometry:: Type: Area Area:2.50E+01 [m2] Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 4.907E-01
Time to Remove: 1.000E+04 [day]

Contamination::

Nuclide	Concentration [pCi/m2]
U-238	9.817E-01
U-235	4.614E-02
U-234	9.817E-01
PA-231	4.614E-02
TH-230	9.817E-01
AC-227	4.614E-02
RA-226	9.817E-01
PB-210	9.817E-01

Source: 4
Location:: Room : 1 x: 5.00 y: 0.00 z: 1.25 [m]
Geometry:: Type: Area Area:2.50E+01 [m2] Direction: y
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 4.907E-01
Time to Remove: 1.000E+04 [day]

Contamination::

Nuclide	Concentration [pCi/m2]
U-238	9.817E-01
U-235	4.614E-02
U-234	9.817E-01
PA-231	4.614E-02
TH-230	9.817E-01
AC-227	4.614E-02
RA-226	9.817E-01
PB-210	9.817E-01

 Title : U-238 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD U238chain-2006-01-11.bld
 Evaluation Time: 1.00000000 years

 Source: 5
        Location:: Room : 1 x: 5.00 y: 10.00 z: 1.25 [m]
        Geometry:: Type: Area   Area:2.50E+01 [m2] Direction: y
        Pathway ::
             Direct Ingestion Rate: 0.000E+00 [1/hr]
             Fraction released to air: 1.000E-01
             Removable fraction: 4.907E-01
             Time to Remove: 1.000E+04 [day]

          Contamination::   Nuclide   Concentration
                                           [pCi/m2]
                              U-238   9.817E-01
                              U-235   4.614E-02
                              U-234   9.817E-01
                              PA-231   4.614E-02
                              TH-230   9.817E-01
                              AC-227   4.614E-02
                              RA-226   9.817E-01
                              PB-210   9.817E-01

 Title : U-238 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD U238chain-2006-01-11.bld
 Evaluation Time: 1.00000000 years

RESRAD-BUILDDose Tables

Source Contributions to Receptor Doses

[mrem]

	Source 1	Source 2	Source 3	Source 4	Source 5	Total
Receptor 1	3.75E-04	8.82E-05	8.82E-05	8.82E-05	8.82E-05	7.28E-04
Total	3.75E-04	8.82E-05	8.82E-05	8.82E-05	8.82E-05	7.28E-04

 Title : U-238 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD U238chain-2006-01-11.bld
 Evaluation Time: 1.00000000 years

Pathway Detail of Doses
[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	3.24E-05	6.94E-08	5.56E-10	3.32E-04	3.06E-06	8.01E-06
Total	3.24E-05	6.94E-08	5.56E-10	3.32E-04	3.06E-06	8.01E-06

Source: 2

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.55E-06	1.73E-08	1.39E-10	8.29E-05	7.66E-07	2.00E-06
Total	2.55E-06	1.73E-08	1.39E-10	8.29E-05	7.66E-07	2.00E-06

Source: 3

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.55E-06	1.73E-08	1.39E-10	8.29E-05	7.66E-07	2.00E-06
Total	2.55E-06	1.73E-08	1.39E-10	8.29E-05	7.66E-07	2.00E-06

Source: 4

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.55E-06	1.73E-08	1.39E-10	8.29E-05	7.66E-07	2.00E-06
Total	2.55E-06	1.73E-08	1.39E-10	8.29E-05	7.66E-07	2.00E-06

Source: 5

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.55E-06	1.73E-08	1.39E-10	8.29E-05	7.66E-07	2.00E-06
Total	2.55E-06	1.73E-08	1.39E-10	8.29E-05	7.66E-07	2.00E-06

 Title : U-238 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD U238chain-2006-01-11.bld
 Evaluation Time: 1.00000000 years

Nuclide Detail of Doses
=======================
[mrem]

Source: 1

Nuclide	Receptor 1	Total
U-238		
U-238	4.13E-05	4.13E-05
U-234	1.93E-10	1.93E-10
TH-230	3.32E-15	3.32E-15
RA-226	2.63E-19	2.63E-19
PB-210	8.21E-22	8.21E-22
U-235		
U-235	2.14E-06	2.14E-06
PA-231	6.67E-10	6.67E-10
AC-227	8.10E-11	8.10E-11
U-234		
U-234	4.55E-05	4.55E-05
TH-230	1.51E-09	1.51E-09
RA-226	1.74E-13	1.74E-13
PB-210	7.01E-16	7.01E-16
PA-231		
PA-231	2.11E-05	2.11E-05
AC-227	4.89E-06	4.89E-06
TH-230		
TH-230	1.12E-04	1.12E-04
RA-226	2.49E-08	2.49E-08
PB-210	1.45E-10	1.45E-10
AC-227		
AC-227	1.00E-04	1.00E-04
RA-226		
RA-226	3.83E-05	3.83E-05
PB-210	4.27E-07	4.27E-07
PB-210		
PB-210	8.97E-06	8.97E-06

Source: 2

Nuclide	Receptor 1	Total
U-238		
U-238	1.02E-05	1.02E-05
U-234	4.81E-11	4.81E-11
TH-230	8.30E-16	8.30E-16

RA-226	2.93E-20	2.93E-20
PB-210	2.04E-22	2.04E-22
U-235		
U-235	5.10E-07	5.10E-07
PA-231	1.67E-10	1.67E-10
AC-227	2.02E-11	2.02E-11
U-234		
U-234	1.14E-05	1.14E-05
TH-230	3.78E-10	3.78E-10
RA-226	1.94E-14	1.94E-14
PB-210	1.74E-16	1.74E-16
PA-231		
PA-231	5.26E-06	5.26E-06
AC-227	1.22E-06	1.22E-06
TH-230		
TH-230	2.80E-05	2.80E-05
RA-226	2.77E-09	2.77E-09
PB-210	3.59E-11	3.59E-11
AC-227		
AC-227	2.50E-05	2.50E-05
RA-226		
RA-226	4.27E-06	4.27E-06
PB-210	1.06E-07	1.06E-07
PB-210		
PB-210	2.22E-06	2.22E-06

Source: 3

Nuclide	Receptor 1	Total
U-238		
U-238	1.02E-05	1.02E-05
U-234	4.81E-11	4.81E-11
TH-230	8.30E-16	8.30E-16
RA-226	2.93E-20	2.93E-20
PB-210	2.04E-22	2.04E-22
U-235		
U-235	5.10E-07	5.10E-07
PA-231	1.67E-10	1.67E-10
AC-227	2.02E-11	2.02E-11
U-234		
U-234	1.14E-05	1.14E-05
TH-230	3.78E-10	3.78E-10
RA-226	1.94E-14	1.94E-14
PB-210	1.74E-16	1.74E-16
PA-231		
PA-231	5.26E-06	5.26E-06
AC-227	1.22E-06	1.22E-06
TH-230		
TH-230	2.80E-05	2.80E-05

RA-226	2.77E-09	2.77E-09
PB-210	3.59E-11	3.59E-11
AC-227		
AC-227	2.50E-05	2.50E-05
RA-226		
RA-226	4.27E-06	4.27E-06
PB-210	1.06E-07	1.06E-07
PB-210		
PB-210	2.22E-06	2.22E-06

Source: 4

Nuclide	Receptor 1	Total
U-238		
U-238	1.02E-05	1.02E-05
U-234	4.81E-11	4.81E-11
TH-230	8.30E-16	8.30E-16
RA-226	2.93E-20	2.93E-20
PB-210	2.04E-22	2.04E-22
U-235		
U-235	5.10E-07	5.10E-07
PA-231	1.67E-10	1.67E-10
AC-227	2.02E-11	2.02E-11
U-234		
U-234	1.14E-05	1.14E-05
TH-230	3.78E-10	3.78E-10
RA-226	1.94E-14	1.94E-14
PB-210	1.74E-16	1.74E-16
PA-231		
PA-231	5.26E-06	5.26E-06
AC-227	1.22E-06	1.22E-06
TH-230		
TH-230	2.80E-05	2.80E-05
RA-226	2.77E-09	2.77E-09
PB-210	3.59E-11	3.59E-11
AC-227		
AC-227	2.50E-05	2.50E-05
RA-226		
RA-226	4.27E-06	4.27E-06
PB-210	1.06E-07	1.06E-07
PB-210		
PB-210	2.22E-06	2.22E-06

 Title : U-238 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD U238chain-2006-01-11.bld
 Evaluation Time: 1.00000000 years

Source: 5

Nuclide	Receptor 1	Total
U-238		
U-238	1.02E-05	1.02E-05
U-234	4.81E-11	4.81E-11
TH-230	8.30E-16	8.30E-16
RA-226	2.93E-20	2.93E-20
PB-210	2.04E-22	2.04E-22
U-235		
U-235	5.10E-07	5.10E-07
PA-231	1.67E-10	1.67E-10
AC-227	2.02E-11	2.02E-11
U-234		
U-234	1.14E-05	1.14E-05
TH-230	3.78E-10	3.78E-10
RA-226	1.94E-14	1.94E-14
PB-210	1.74E-16	1.74E-16
PA-231		
PA-231	5.26E-06	5.26E-06
AC-227	1.22E-06	1.22E-06
TH-230		
TH-230	2.80E-05	2.80E-05
RA-226	2.77E-09	2.77E-09
PB-210	3.59E-11	3.59E-11
AC-227		
AC-227	2.50E-05	2.50E-05
RA-226		
RA-226	4.27E-06	4.27E-06
PB-210	1.06E-07	1.06E-07
PB-210		
PB-210	2.22E-06	2.22E-06

 Title : U-238 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD U238chain-2006-01-11.bld
 Evaluation Time: 1000.00000 years

```
          ================================================
          ================================================
          ===       Assessment for Time:  3              ===
          ===             Time =1.00E+03 yr              ===
          ================================================
          ================================================
```

======== Source Information ========

Source: 1
Location:: Room : 1 x: 5.00 y: 5.00 z: 0.00 [m]
Geometry:: Type: Area Area:1.00E+02 [m2] Direction: z
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 1.000E+04 [day]

Contamination::	Nuclide	Concentration [pCi/m2]
	U-238	5.000E-01
	U-235	2.350E-02
	U-234	5.000E-01
	PA-231	2.350E-02
	TH-230	5.000E-01
	AC-227	2.350E-02
	RA-226	5.000E-01
	PB-210	5.000E-01

Source: 2
Location:: Room : 1 x: 0.00 y: 5.00 z: 1.25 [m]
Geometry:: Type: Area Area:2.50E+01 [m2] Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 1.000E+04 [day]

Contamination::	Nuclide	Concentration [pCi/m2]
	U-238	5.000E-01
	U-235	2.350E-02
	U-234	5.000E-01

PA-231	2.350E-02
TH-230	5.000E-01
AC-227	2.350E-02
RA-226	5.000E-01
PB-210	5.000E-01

Source: 3
Location:: Room : 1 x: 10.00 y: 5.00 z: 1.25 [m]
Geometry:: Type: Area Area:2.50E+01 [m2] Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 1.000E+04 [day]

Contamination::

Nuclide	Concentration [pCi/m2]
U-238	5.000E-01
U-235	2.350E-02
U-234	5.000E-01
PA-231	2.350E-02
TH-230	5.000E-01
AC-227	2.350E-02
RA-226	5.000E-01
PB-210	5.000E-01

Source: 4
Location:: Room : 1 x: 5.00 y: 0.00 z: 1.25 [m]
Geometry:: Type: Area Area:2.50E+01 [m2] Direction: y
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-01
Removable fraction: 0.000E+00
Time to Remove: 1.000E+04 [day]

Contamination::

Nuclide	Concentration [pCi/m2]
U-238	5.000E-01
U-235	2.350E-02
U-234	5.000E-01
PA-231	2.350E-02
TH-230	5.000E-01
AC-227	2.350E-02
RA-226	5.000E-01
PB-210	5.000E-01

 Title : U-238 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD U238chain-2006-01-11.bld
 Evaluation Time: 1000.00000 years

 Source: 5
        Location:: Room : 1 x: 5.00 y: 10.00 z: 1.25 [m]
        Geometry:: Type: Area   Area:2.50E+01 [m2] Direction: y
        Pathway ::
             Direct Ingestion Rate: 0.000E+00 [1/hr]
             Fraction released to air: 1.000E-01
             Removable fraction: 0.000E+00
             Time to Remove: 1.000E+04 [day]

          Contamination::   Nuclide   Concentration
                                           [pCi/m2]
                              U-238   5.000E-01
                              U-235   2.350E-02
                              U-234   5.000E-01
                              PA-231   2.350E-02
                              TH-230   5.000E-01
                              AC-227   2.350E-02
                              RA-226   5.000E-01
                              PB-210   5.000E-01

 Title : U-238 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD U238chain-2006-01-11.bld
 Evaluation Time: 1000.00000 years

RESRAD-BUILDDose Tables

Source Contributions to Receptor Doses

[mrem]

	Source 1	Source 2	Source 3	Source 4	Source 5	Total
Receptor 1	1.82E-05	1.71E-06	1.71E-06	1.71E-06	1.71E-06	2.51E-05
Total	1.82E-05	1.71E-06	1.71E-06	1.71E-06	1.71E-06	2.51E-05

 Title : U-238 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD U238chain-2006-01-11.bld
 Evaluation Time: 1000.00000 years

Pathway Detail of Doses
[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	1.67E-05	0.00E+00	0.00E+00	0.00E+00	1.57E-06	0.00E+00
Total	1.67E-05	0.00E+00	0.00E+00	0.00E+00	1.57E-06	0.00E+00

Source: 2

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	1.31E-06	0.00E+00	0.00E+00	0.00E+00	3.94E-07	0.00E+00
Total	1.31E-06	0.00E+00	0.00E+00	0.00E+00	3.94E-07	0.00E+00

Source: 3

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	1.31E-06	0.00E+00	0.00E+00	0.00E+00	3.94E-07	0.00E+00
Total	1.31E-06	0.00E+00	0.00E+00	0.00E+00	3.94E-07	0.00E+00

Source: 4

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	1.31E-06	0.00E+00	0.00E+00	0.00E+00	3.94E-07	0.00E+00
Total	1.31E-06	0.00E+00	0.00E+00	0.00E+00	3.94E-07	0.00E+00

Source: 5

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	1.31E-06	0.00E+00	0.00E+00	0.00E+00	3.94E-07	0.00E+00
Total	1.31E-06	0.00E+00	0.00E+00	0.00E+00	3.94E-07	0.00E+00

 Title : U-238 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD U238chain-2006-01-11.bld
 Evaluation Time: 1000.00000 years

Nuclide Detail of Doses

[mrem]

Source: 1

Nuclide	Receptor 1	Total
U-238		
U-238	3.25E-07	3.25E-07
U-234	4.83E-11	4.83E-11
TH-230	1.65E-13	1.65E-13
RA-226	2.90E-11	2.90E-11
PB-210	8.79E-14	8.79E-14
U-235		
U-235	7.94E-08	7.94E-08
PA-231	4.53E-10	4.53E-10
AC-227	3.62E-09	3.62E-09
U-234		
U-234	1.70E-08	1.70E-08
TH-230	1.16E-10	1.16E-10
RA-226	2.97E-08	2.97E-08
PB-210	9.28E-11	9.28E-11
PA-231		
PA-231	2.12E-08	2.12E-08
AC-227	1.75E-07	1.75E-07
TH-230		
TH-230	1.29E-08	1.29E-08
RA-226	6.14E-06	6.14E-06
PB-210	1.99E-08	1.99E-08
AC-227		
AC-227	2.73E-21	2.73E-21
RA-226		
RA-226	1.14E-05	1.14E-05
PB-210	3.83E-08	3.83E-08
PB-210		
PB-210	1.82E-21	1.82E-21

Source: 2

Nuclide	Receptor 1	Total
U-238		
U-238	2.53E-08	2.53E-08
U-234	2.66E-12	2.66E-12
TH-230	9.66E-15	9.66E-15

RA-226	2.73E-12	2.73E-12
PB-210	6.05E-15	6.05E-15
U-235		
U-235	6.21E-09	6.21E-09
PA-231	3.35E-11	3.35E-11
AC-227	2.87E-10	2.87E-10
U-234		
U-234	9.40E-10	9.40E-10
TH-230	6.81E-12	6.81E-12
RA-226	2.80E-09	2.80E-09
PB-210	6.38E-12	6.38E-12
PA-231		
PA-231	1.57E-09	1.57E-09
AC-227	1.39E-08	1.39E-08
TH-230		
TH-230	7.54E-10	7.54E-10
RA-226	5.79E-07	5.79E-07
PB-210	1.37E-09	1.37E-09
AC-227		
AC-227	2.17E-22	2.17E-22
RA-226		
RA-226	1.07E-06	1.07E-06
PB-210	2.64E-09	2.64E-09
PB-210		
PB-210	1.25E-22	1.25E-22

Source: 3

Nuclide	Receptor 1	Total
U-238		
U-238	2.53E-08	2.53E-08
U-234	2.66E-12	2.66E-12
TH-230	9.66E-15	9.66E-15
RA-226	2.73E-12	2.73E-12
PB-210	6.05E-15	6.05E-15
U-235		
U-235	6.21E-09	6.21E-09
PA-231	3.35E-11	3.35E-11
AC-227	2.87E-10	2.87E-10
U-234		
U-234	9.40E-10	9.40E-10
TH-230	6.81E-12	6.81E-12
RA-226	2.80E-09	2.80E-09
PB-210	6.38E-12	6.38E-12
PA-231		
PA-231	1.57E-09	1.57E-09
AC-227	1.39E-08	1.39E-08
TH-230		
TH-230	7.54E-10	7.54E-10

RA-226	5.79E-07	5.79E-07
PB-210	1.37E-09	1.37E-09
AC-227		
AC-227	2.17E-22	2.17E-22
RA-226		
RA-226	1.07E-06	1.07E-06
PB-210	2.64E-09	2.64E-09
PB-210		
PB-210	1.25E-22	1.25E-22

Source: 4

Nuclide	Receptor 1	Total
U-238		
U-238	2.53E-08	2.53E-08
U-234	2.66E-12	2.66E-12
TH-230	9.66E-15	9.66E-15
RA-226	2.73E-12	2.73E-12
PB-210	6.05E-15	6.05E-15
U-235		
U-235	6.21E-09	6.21E-09
PA-231	3.35E-11	3.35E-11
AC-227	2.87E-10	2.87E-10
U-234		
U-234	9.40E-10	9.40E-10
TH-230	6.81E-12	6.81E-12
RA-226	2.80E-09	2.80E-09
PB-210	6.38E-12	6.38E-12
PA-231		
PA-231	1.57E-09	1.57E-09
AC-227	1.39E-08	1.39E-08
TH-230		
TH-230	7.54E-10	7.54E-10
RA-226	5.79E-07	5.79E-07
PB-210	1.37E-09	1.37E-09
AC-227		
AC-227	2.17E-22	2.17E-22
RA-226		
RA-226	1.07E-06	1.07E-06
PB-210	2.64E-09	2.64E-09
PB-210		
PB-210	1.25E-22	1.25E-22

 Title : U-238 DCGL for HD (Chapman)
 Input File : C:\Program Files\RESRAD_Family\BUILD\HD U238chain-2006-01-11.bld
 Evaluation Time: 1000.00000 years

Source: 5

Nuclide	Receptor 1	Total
U-238		
U-238	2.53E-08	2.53E-08
U-234	2.66E-12	2.66E-12
TH-230	9.66E-15	9.66E-15
RA-226	2.73E-12	2.73E-12
PB-210	6.05E-15	6.05E-15
U-235		
U-235	6.21E-09	6.21E-09
PA-231	3.35E-11	3.35E-11
AC-227	2.87E-10	2.87E-10
U-234		
U-234	9.40E-10	9.40E-10
TH-230	6.81E-12	6.81E-12
RA-226	2.80E-09	2.80E-09
PB-210	6.38E-12	6.38E-12
PA-231		
PA-231	1.57E-09	1.57E-09
AC-227	1.39E-08	1.39E-08
TH-230		
TH-230	7.54E-10	7.54E-10
RA-226	5.79E-07	5.79E-07
PB-210	1.37E-09	1.37E-09
AC-227		
AC-227	2.17E-22	2.17E-22
RA-226		
RA-226	1.07E-06	1.07E-06
PB-210	2.64E-09	2.64E-09
PB-210		
PB-210	1.25E-22	1.25E-22

Title : U-238 DCGL for HD (Chapman)
Input File : C:\Program Files\RESRAD_Family\BUILD\HD U238chain-2006-01-11.bld
Full Summary

RESRAD-BUILD Dose (Time) Tables

Receptor Dose Received for the Exposure Duration

(mrem)

	Evaluation Time [yr]		
	0.00E+00	1.00E+00	1.00E+03
1	7.29E-04	7.28E-04	2.51E-05

Receptor Dose/Yr Averaged Over Exposure Duration

(mrem/yr)

	Evaluation Time [yr]		
	0.00E+00	1.00E+00	1.00E+03
1	7.29E-04	7.29E-04	2.51E-05