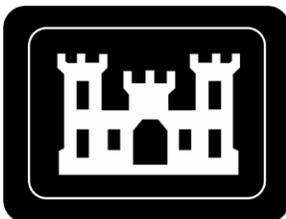


PUBLIC REVIEW DRAFT

DERIVATION OF SITE-SPECIFIC DCGLs FOR NORTH COUNTY STRUCTURES

ST. LOUIS, MISSOURI

June 25, 2004



U.S. Army Corps of Engineers
St. Louis District Office
Formerly Utilized Sites Remedial Action Program

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prepared by

U.S. Army Corps of Engineers, St. Louis District Office, Formerly Utilized Sites Remedial Action Program

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SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

Contributed to the preparation of this document and should not
be considered an eligible contractor for its review.

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ACRONYMS

Ac-227	actinium - 227
AEC	Atomic Energy Commission
ANL	Argonne National Laboratory
ARAR	Applicable Relevant and Appropriate Requirements
CERCLA	Comprehensive Environmental Restoration Cleanup Liability Act
CFR	Code of Federal Regulations
cm ³	cubic centimeters
COC	contaminant(s) of concern
CSM	conceptual site model
DCF	dose conversion factor
DCGL	derived concentration guideline levels
DOE	U.S. Department of Energy
dpm	disintegrations per minute
DSR	dose to source ratio
EPA	Environmental Protection Agency
FUSRAP	Formerly Utilized Sites Remedial Action Program
g	gram
m	meter
m ²	square meters
m ³	cubic meters
MED	Manhattan Engineering District
mrem/year	millirem per year
NRC	Nuclear Regulatory Commission
Pa-231	Protactinium - 231
pCi	picocurie
pCi/g	picocuries per gram
PNL	Pacific Northwest Laboratory
Ra-226	radium - 226
Ra-228	radium - 228
SAIC	Science Applications International Corporation
SNM	special nuclear material
TEDE	total effective dose equivalent
Th-230	thorium - 230
Th-232	thorium - 232
U-234	uranium - 234
U-235	uranium - 235
U-238	uranium - 238
USACE	U.S. Army Corps of Engineers

1.0 INTRODUCTION

1.1 PURPOSE

The purpose of this report is to present derived concentration guideline levels (DCGLs) for North County Structures at the St. Louis Formerly Utilized Sites Remedial Action Program (FUSRAP) sites. The RESRAD-BUILD¹ computer code (Version 3.1) was used to determine dose to source ratios (DSR) for individual radionuclides. The DSR was used to calculate individual radionuclide DCGLs that were equivalent to 15 millirem per year (mrem/year). The use of the DCGLs specified herein for structures is protective under the Comprehensive Environmental Restoration Cleanup Liability Act (CERCLA) for all scenarios to include residential. Pending revision of RESRAD-BUILD to calculate risks associated with structures, protectiveness will be documented by comparison with ARARs and using EPA guidance that 15 mrem per year equates to 3×10^{-4} risk. Institutional controls are not required for any structure or area that is suitable for unrestricted use and unlimited exposure. This report also describes how compliance may be demonstrated with dose-based limits using applicable isotopic DCGLs to calculate site-specific gross Alpha or gross Beta DCGLs.

1.2 SCOPE

The scope of this document is limited to North County structures that have been impacted by transport of soil containing radionuclides from Manhattan Engineering District/Atomic Energy Commission (MED/AEC) operations and are currently part of the FUSRAP managed by the U.S. Army Corps of Engineers (USACE). This document addresses MED/AEC-related surficial contamination on structures within St Louis North County sites. To the extent possible, DCGLs are derived in this report using applicable information from prior FUSRAP documents to ensure consistency between dose models. For the purposes of this document, structures include (but are not limited to):

- Buildings and portions of buildings, including roof areas and foundations,
- Footings, retaining walls, and stop logs,
- Piping and ducting,
- Utility poles,
- Bridges and supporting structures,
- Pavement,
- Consolidated material to be left in place, and
- Other similar items where surficial contamination is of concern.

¹Under the sponsorship of the U.S. Department of Energy, the Environmental Assessment Division of Argonne National Laboratory developed the RESRAD family of computer codes to assess human health and environmental risk at sites contaminated with radioactive materials. Additional information on the RESRAD family of codes including RESRAD-BUILD is found on the Internet site <http://web.ead.anl.gov/resrad/home2/>.

2.0 SITE HISTORY AND DESCRIPTION

From 1942 to 1957, under contracts with the MED and the AEC, the St. Louis Downtown Site (SLDS) was used to produce uranium compounds by processing various forms of uranium-bearing feed materials. In 1946, the MED acquired the 21.7-acre tract of land now known as the St. Louis Airport Site (SLAPS) to store residues and scrap from uranium processing at the Mallinckrodt Plant. In 1966 and 1967, most of the stored residues were sold and removed from the SLAPS. On-site structures at the SLAPS were razed and buried on the property. Buried deposits of uranium-238 (U-238), radium-226 (Ra-226), and thorium-230 (Th-230) remain on the SLAPS property. The company that purchased the vast majority of the material stored at the SLAPS moved the materials to the Hazelwood Interim Storage Site (HISS) on Latty Avenue. Most of this material was later shipped to Colorado. Over time, residues migrated from the sites (via runoff onto adjacent properties and into Coldwater Creek or windblown) or were released or otherwise deposited when material was hauled along road and rail transportation routes, contaminating the soil and sediment at the SLAPS and Latty Avenue VPs.

2.1 NORTH COUNTY VPS

The North County VPs consist of three main groups of properties:

1. Those that are contiguous to SLAPS or HISS and were potentially impacted by contamination transport mechanisms,
2. Those properties potentially impacted by movement of contaminated residuals from SLAPS to the HISS on possible haul routes, and
3. Properties potentially impacted by CWC and the associated deposition of sediment. In some cases, soil contamination may have subsequently been spread to structures.

Depending on the history of the structure's use, its location, its date of construction, and the history of the surrounding soils, the potential for surficial contamination may exist on the exterior only, the interior only, on or under the foundation only, or in any combination of these locations.

The potential radiological contaminants at the North County VPs are members of the naturally occurring uranium, thorium, and actinium decay series. The predominant contaminant is Th-230, a member of the uranium decay series.

3.0 DEVELOPMENT OF DERIVED CONCENTRATION GUIDELINE LEVELS

This section describes the method for deriving DCGLs for North County Structures. The method is broken into five components, each of which is described in the sections that follow:

- Selecting a dose limit,
- Developing the conceptual site model (CSM),
- Identifying potential exposure scenarios,
- Identifying the most limiting scenario, and
- Calculating radionuclide-specific DCGLs from RESRAD-BUILD output.

3.1 SELECTION OF ANNUAL PUBLIC DOSE LIMIT

Several factors were taken into consideration for the selection of the annual public dose limit.

- 10 CFR Part 20, Subpart E, *Radiological Criteria for License Termination*, requires cleanup to 25 mrem/year.
- *Feasibility Study for the St. Louis North County Site* (USACE 2003) indicates a limiting dose of 19 mrem/year (Table D-11) based upon the benchmark dose approach. A benchmark dose is the dose that is found to be equivalent to 40 CFR 192 cleanup standards for Ra-226 of 5 picocuries per gram (pCi/g) surface and 15 pCi/g subsurface, using modeling.
- EPA OSWER 9200.4-18, *Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination*, recommends that cleanup attain a dose of 15 mrem/year. This level equates to approximately 3 E-4 increased lifetime risk and is consistent with levels generally considered protective.

The Nuclear Regulatory Commission (NRC) requires cleanup to 25 mrem/year. The North County feasibility study establishes 19 mrem/year as a benchmark dose in accordance with relevant and appropriate guidance for cleanup of radionuclides in soil. The ARAR of 5 pCi/g of Ra-226 was used to set the benchmark dose. The EPA guidance recommends 15 mrem/year as clean up criteria. Since the EPA has a lower limit of 15 mrem/year, the 10 CFR 20 limit and benchmark dose will automatically be satisfied if DCGLs equivalent to the EPA limit are met. The impact to the cost of the overall project due to DCGLs based on 15 mrem/year versus 19 mrem/year is not anticipated to be significant due to the number of buildings likely to be impacted. Therefore, DCGLs in this report were developed based on the 15 mrem/year limit. Other DCGLs may be developed by the use of contaminant-to-dose ratios; however, the receptor scenarios and dose pathways described below would remain consistent.

3.2 CONCEPTUAL SITE MODEL (CSM)

In order for an exposure to occur, there must be a contaminated medium, a receptor, and a complete pathway for the contaminant to reach the receptor. The relationship between these three factors is

described in the CSM. The CSM for North County structures is illustrated in Figure 3-1. Figure 3-1 identifies the contaminated medium considered in this report, potential receptors, and the exposure pathways that could lead to a radiological dose (in mrem/year) to potential receptors.

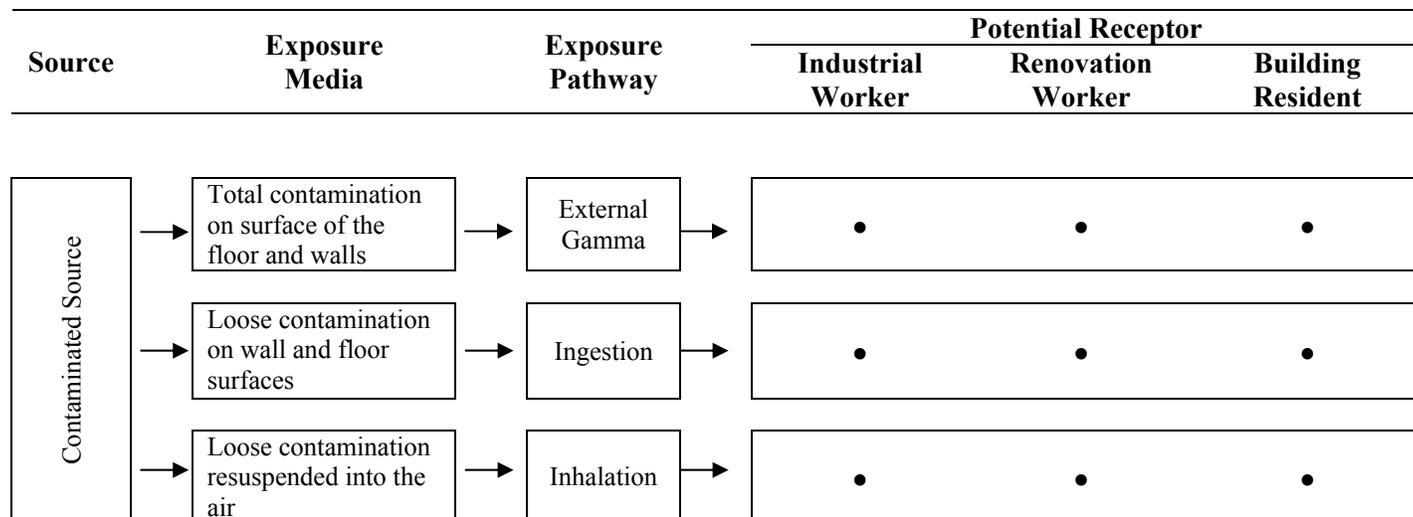


Figure 3-1. Conceptual Site Model for North County Structures

The CSM assumes that a potentially impacted building was intact and occupied. Three receptors² were considered: (1) an industrial worker, (2) a renovation worker, and (3) a building resident. Considering the potential buildings that may be impacted in North County, the industrial worker is considered the most likely long-term receptor for future use. The renovation worker is considered a conservative short-term receptor, assuming some remodeling is required to make the building suitable for future use. The building resident is not a likely receptor; however, to determine the most limiting scenario, a dose assessment for the building resident scenario was performed. Determination of the most limiting scenario is presented in section 3.4.

Although not shown in Figure 3-1, the CSM assumes that receptors are exposed in a single room with a contaminated source. It is also assumed that the ingestion pathway is completed through the re-deposition of suspended dust particles followed by inadvertent hand-to-mouth transfer. This approach represents the RESRAD-BUILD default pathway for ingestion. The direct ingestion pathway (without considering re-deposition) is assumed to be negligible for all scenarios.

The complete exposure pathways for all three scenarios are:

- External gamma exposure,
- Indirect ingestion of re-deposited non-fixed contamination, and
- Inhalation of re-suspended non-fixed contamination.

The external gamma pathway is independent of the contaminant nature (loose or fixed). However, the ingestion and inhalation pathways are subject only to the quantity of loose contamination that may be

² Receptor scenarios are based primarily upon NRC guidance found in NUREG/CR-5512.

inadvertently transferred to the mouth or re-suspended into the air. Section 3.3 provides additional details regarding the potential exposure scenarios and presents the exposure parameters used in dose modeling.

Although the CSM (consisting of three scenarios) assumed an intact and occupied building, an additional conceptual model was considered. The scenario for this model was the “onsite resident – post demolition”. This model assumed that the contaminated structure was demolished, buried onsite, and a residence established over the rubble. Due to the type and location of buildings that may potentially be impacted, this was not a likely model. However, a dose assessment using RESRAD Version 6.21 was performed to use in determining the most limiting scenario. Determination of the most limiting scenario is presented in section 3.4.

3.3 POTENTIAL EXPOSURE SCENARIOS

As shown in the CSM, three potential building occupancy (assuming the building was left intact and was occupied) exposure scenarios were considered: 1) industrial worker, 2) renovation worker, and 3) building resident. A fourth scenario, the onsite resident – post demolition, was also considered.

The CSM assumed a simple, one-room configuration that is easy to conceptualize and can represent rooms in any North County building. Contamination was assumed to be distributed uniformly over the entire floor and all four walls from the floor up to 2 meters. The CSM also assumed an area source. Tables 3-1 through 3-3 present the RESRAD-BUILD input parameter values used in the derivation of building DCGLs for the industrial worker, renovation worker, and building resident, respectively. The parameters were determined by using applicable guidance in the following priority:

1. Risk Assessment Guidance for Superfund
2. NRC guidance (NUREGs, etc.)
3. ANSI guidance
4. RESRAD-BUILD default values

Table 3-4 presents the RESRAD non-default parameter values used in the derivation of building DCGLs for the onsite resident – post demolition. The onsite resident scenario was based upon the same assumptions that were used in the risk assessments performed in the *Feasibility Study for the North County Site* (USACE 2003).

3.3.1 BUILDING OCCUPANCY – INDUSTRIAL WORKER

The industrial worker scenario assumes that the critical receptor is a typical industrial worker who works 8 hours per day for 250 days a year. The individual works in the building structure that is contaminated with surficial radioactive material. The radioactive material can be released into the indoor air by mechanisms such as mechanical removal (decontamination activities) or erosion (removal of surface contamination). The applicable pathways for the industrial worker include:

- External exposure to penetrating radiation from surface sources,
- Inhalation of airborne radioactive particulates, and
- Secondary ingestion of surface contamination.

Derivation of Site-Specific DCGLs for North County Structures

Table 3-1 Parameters for RESRAD-BUILD Building Occupancy Scenario (Industrial Worker)

Parameter	Description	Value	Justification
<i>Time Parameter</i>			
Exposure Duration	Amount of time that exposure occurs	365 days	NUREG/CR-5512, Volume 1, Section 3.2.1
Indoor Fraction	Fraction of the exposure duration that is spent inside the building	0.23	8 hours/day; 250 days/year
Evaluation Time	Times at which doses are calculated	0 year; 1 year	RESRAD-BUILD Default
<i>Building Parameters</i>			
Number of Rooms	Number of compartments in the building	1	RESRAD-BUILD Default
Deposition Velocity	Velocity at which airborne particles are deposited onto the floor surfaces	0.01 m/sec	RESRAD-BUILD Default (A sensitivity test resulted in no significant difference between the default value and the min. and max values listed in NUREG/CR-6697)
Resuspension Rate	Rate at which deposited material is resuspended into the air	5.0 E-07 sec ⁻¹	RESRAD-BUILD Default (Approximate midpoint between NUREG/CR-6697 min. and max values)
Building Exchange Rate	Total volume of air going out of the building per unit time divided by the total volume of the building	0.8 hr ⁻¹	RESRAD-BUILD Default Consistent with value of 0.75 hr ⁻¹ for conditioned spaces (cited by American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.)
Room Area	Floor Area of the room	100 m ²	NUREG/CR-5512, Volume 1, Section 6.2.1
Room Height	Height of the room	2.5 m	RESRAD-BUILD Default Consistent with NUREG/CR-6697 most likely value of 2.4 m
Room Exchange Rate	Total volume of air going out of the room per unit time divided by the total vol. of the room	0.8 hr ⁻¹	RESRAD-BUILD Default Same as building exchange rate due to single room
In/Out Flow Rate	Flow rates of air into and out of the room	200 m ³ /hr	Room volume (250 m ³) * Room exchange rate (0.8 hr ⁻¹)
<i>Receptor Parameters</i>			
Number of Receptors		1	RESRAD-BUILD Default
Room # Location	Room in which the receptor is located	1	RESRAD-BUILD Default
Time Fraction	Fraction of time within the building that the exposed individual spends at his receptor location	1	RESRAD-BUILD Default
Breathing Rate	Inhalation rate of airborne material at this location	33.6 m ³ /day	NUREG/CR-6697 most likely value (Breathing rate = 1.4 m ³ /hr)
Ingestion Rate	Ingestion rate of deposited dust for this location	1 E-04 m ² /hr	RESRAD-BUILD Default (Approximate midpoint between NUREG/CR-6697 min. and max values)
Receptor Location	Coordinates of the receptor	5m, 5m, 1m	Located in center of room at height of 1m

Derivation of Site-Specific DCGLs for North County Structures

Table 3-1 Parameters for RESRAD-BUILD Building Occupancy Scenario (Industrial Worker)

Parameter	Description	Value	Justification
<i>Shielding Parameters</i>			
Thickness	Thickness of the shielding between the contamination source and the receptor location	0	RESRAD-BUILD Default
Density	Density of the shielding material	Not Applicable	
Material	Identification of the shielding material	Not Applicable	
<i>Source Parameters</i>			
Number of Sources		5	Floor and four walls
Room # location	All sources are located in Room # 1	1	
Source Type		Area	Surface contamination only; volume source is not likely due to historical assessment of NC buildings. (No processing of materials or activation of building materials.)
Direction	Axis perpendicular to the exposed area	Floor (z), Ceiling (z), 4 walls (x,y,x,y)	NUREG/CR-5512, Volume 1, Section 6.2.1
Location	Center point of the source in the x, y, z direction	Floor: 5m, 5m, 0m; Walls: 10m, 5m, 1m 5m, 10m, 1m 0m, 5m, 1m; 5m, 0m, 1m	Entire floor and bottom 2 meters of each wall are uniformly contaminated.
Geometry: Area	Area of the exposed surface over which the contamination is evenly distributed	100, 20, 20, 20, 20 m ²	
Air Release Fraction	Fraction of the eroded material that is released into the air	0.07	Most likely value. NUREG/CR-6697
Direct Ingestion	Direct Ingestion rate of the source by any receptor in the room	0 /hr	RESRAD-BUILD Default
Removable Fraction	Fraction of the source that can be linearly removed between t =0 and lifetime	0.2	Most likely value. NUREG/CR-6697
Lifetime	Amount of time in which all of the removable fraction of the source is linearly eroded	10,000 days	Most likely value. NUREG/CR-6697
Radionuclides Concentration	Unit concentration is initially run; results are normalized to 15 mrem/yr to determine each isotopic DCGL	1 pCi/m ²	

3.3.1.1 NON-DEFAULT PARAMETERS

As stated in section 3.3, a hierarchical system was used to derive the RESRAD-BUILD parameters for each applicable scenario. Justification for each non-RESRAD-BUILD default parameter used is given as follows:

- The **Indoor Fraction** was set at 0.23. This equates to an industrial worker working a full work year (eight hours per day, five days per week, and fifty weeks per year) in the contaminated structure as discussed in NUREG/CR-5512 Section 3.2.1.
- The **Room Area** was set at 100 m². NUREG/CR-6697 recommends that site-specific values be used if available since the default value is an arbitrary value for a multi-occupant office room. North County structures that are likely to be impacted are primarily commercial manufacturing facilities with room areas much greater than the 36 m² default value. Therefore, 100 m² was selected as an average value somewhere between office room floor areas and manufacturing floor areas and equivalent to a Class 1 survey unit area.
- The **Breathing Rate** was set at 33.6 m³/day. This value is more conservative than the default value and is listed in NUREG/CR-6697 as the most likely value for the building occupancy - industrial worker scenario.
- The **Receptor and Source Locations** were set to place the receptor 1 meter (m) above the floor in the middle of a 10 m by 10 m room with 2.5 m walls that are contaminated from the floor up to 2 m (~6 feet). The walls and floor are uniformly contaminated.
- The **Air Release Fraction** was set at 0.07. This value is consistent with the default value of 0.1 and is listed in NUREG/CR-6697 as the most likely value.
- The **Removal Fraction** was set at 0.2. This value assumes that 20 % of the contamination is removable at any given time. This value also corresponds to the maximum allowable removable contamination fraction (or percentage) for both the DOE and NRC and is the most likely value as listed in NUREG/CR-6697. This is also a conservative value when compared to the newer NRC guidance most likely value of 0.1 listed in NUREG/CR-6755.
- The **Lifetime** was set at 10,000 days. This value is consistent with the 30-year exposure duration for a resident and the 25-year exposure duration for an industrial worker. This value is also the most likely value as listed in NUREG/CR-6697.

3.3.2 BUILDING OCCUPANCY – RENOVATION WORKER

The renovation worker scenario assumes that the critical receptor is a typical renovation worker who works 8 hours per day for 90 days a year on a building renovation project. The individual works inside the building structure that is contaminated with surficial radioactive material. The radioactive material can be released into the indoor air by mechanisms such as mechanical removal (decontamination activities) or erosion (removal of surface contamination). The applicable pathways for the industrial worker include

- External exposure to penetrating radiation from surface sources,
- Inhalation of airborne radioactive particulates, and
- Secondary ingestion of surface contamination.

Due to the amount of time the renovation worker spends in the same contaminated building compared to the industrial worker, it is not likely that the renovation worker scenario will be the most limiting.

However, several parameters are more conservative for the renovation worker and therefore the scenarios are compared in Section 3.4.

3.3.2.1 NON-DEFAULT PARAMETERS

As stated in section 3.3, a hierarchical system was used to derive the RESRAD-BUILD parameters for each applicable scenario. Justification for each non-default parameter used is given as follows:

- The **Indoor Fraction** was set at 0.08. This equates to a renovation worker working *less* than a full work year (eight hours per day; ninety days per year) in the contaminated structure as discussed in NUREG/CR-5512 Section 3.1.1. The worker is assumed to be in only one renovation per year.
- The **Room Area** was set at 100 m². NUREG/CR-6697 recommends that site-specific values be used if available since the default value is an arbitrary value for a multi-occupant office room. North County structures that are likely to be impacted are primarily commercial manufacturing facilities with room areas much greater than the 36 m² default value. Therefore, 100 m² was selected as an average value somewhere between office room floor areas and manufacturing floor areas and equivalent to a Class 1 survey unit area.
- The **Resuspension Rate** was set at 1.4 E-5 sec⁻¹. This is the maximum value as listed in NUREG/CR-6697. This rate was chosen to assume that renovation activities would cause more of the contamination to go airborne than the industrial worker activities.
- The **Breathing Rate** was set at 46 m³/day. This value is more conservative than the default value and is listed in NUREG/CR-6697 as the maximum value that represents workers in light industry and falls within the range of moderate to heavy work activities.
- The **Ingestion Rate** was set at 2E-4 m²/hr. Since this rate is expressed as the surface area contacted per unit time and it is likely that renovation workers will have more contact with contaminated surfaces than industrial workers, the default rate was doubled. This value is consistent with the max value of 2.9E-4 m²/hr listed in NUREG/CR-6697.
- The **Receptor and Source Locations** were set to place the receptor 1 meter (m) above the floor in the middle of a 10 m by 10 m room with 2.5 m walls that are contaminated from the floor up to 2 m (~6 feet). The walls and floor are uniformly contaminated.
- The **Air Release Fraction** was set at 0.07. This value is consistent with the default value of 0.1 and is listed in NUREG/CR-6697 as the most likely value.
- The **Removal Fraction** was set at 0.2. This value assumes that 20 % of the contamination is removable at any given time. This value also corresponds to the maximum allowable removable contamination fraction (or percentage) for both the DOE and NRC and is the most likely value as listed in NUREG/CR-6697. This is also a conservative value when compared to the newer NRC guidance most likely value of 0.1 listed in NUREG/CR-6755.
- The **Lifetime** was set at 10,000 days. This value is consistent with the 30-year exposure duration for a resident and the 25-year exposure duration for an industrial worker. This value is also the most likely value as listed in NUREG/CR-6697.

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Table 3-2 Parameters for RESRAD-BUILD Building Renovation Scenario

Parameter	Description	Value	Justification
<i>Time Parameter</i>			
Exposure Duration	Amount of time that exposure occurs	365 days	NUREG/CR-5512, Volume 1, Section 3.2.1
Indoor Fraction	Fraction of the exposure duration that is spent inside the building	0.08	8 hours/day; 90 days/year
Evaluation Time	Times at which doses are calculated	0 year; 1 year	RESRAD-BUILD Default
<i>Building Parameters</i>			
Number of Rooms	Number of compartments in the building	1	RESRAD-BUILD Default
Deposition Velocity	Velocity at which airborne particles are deposited onto the floor surfaces	0.01 m/sec	RESRAD-BUILD Default (A sensitivity test resulted in no significant difference between the default value and the min. and max values listed in NUREG/CR-6697)
Resuspension Rate	Rate at which deposited material is resuspended into the air	1.4 E-05 sec ⁻¹	NUREG/CR-6697 maximum value
Building Exchange Rate	Total volume of air going out of the building per unit time divided by the total volume of the building	0.8 hr ⁻¹	RESRAD-BUILD Default Consistent with value of 0.75 hr ⁻¹ for conditioned spaces (cited by American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.)
Room Area	Floor Area of the room	100 m ²	NUREG/CR-5512, Volume 1, Section 6.2.1
Room Height	Height of the room	2.5 m	RESRAD-BUILD Default Consistent with NUREG/CR-6697 most likely value of 2.4 m
Room Exchange Rate	Total volume of air going out of the room per unit time divided by the total volume of the room	0.8 hr ⁻¹	RESRAD-BUILD Default Same as building exchange rate due to single room
In/Out Flow Rate	Flow rates of air into and out of the room	200 m ³ /hr	Room volume (250 m ³) * Room exchange rate (0.8 hr ⁻¹)
<i>Receptor Parameters</i>			
Number of Receptors		1	RESRAD-BUILD Default
Room # Location	Room in which the receptor is located	1	RESRAD-BUILD Default
Time Fraction	Fraction of time within the building that the exposed individual spends at his receptor location	1	RESRAD-BUILD Default
Breathing Rate	Inhalation rate of airborne material at this location	46 m ³ /day	NUREG/CR-6697 maximum value
Ingestion Rate	Ingestion rate of deposited dust for this location	2 E-04 m ² /hr	Consistent with NUREG /CR-6697 max value of 2.9E-4
Receptor Location	Coordinates of the receptor	5m, 5m, 1m	Located in center of room at height of 1m

Derivation of Site-Specific DCGLs for North County Structures

Table 3-2 Parameters for RESRAD-BUILD Building Renovation Scenario

Parameter	Description	Value	Justification
<i>Shielding Parameters</i>			
Thickness	Thickness of the shielding between the contamination source and the receptor location	0	RESRAD-BUILD Default
Density	Density of the shielding material	Not Applicable	
Material	Identification of the shielding material	Not Applicable	
<i>Source Parameters</i>			
Number of Sources		5	Floor and four walls
Room # location	All sources are located in Room # 1	1	
Source Type		Area	Surface contamination only; volume source is not likely due to historical assessment of NC buildings. (No processing of materials or activation of building materials.)
Direction	Axis perpendicular to the exposed area	Floor (z), Ceiling (z), 4 walls (x,y,x,y)	NUREG/CR-5512, Volume 1, Section 6.2.1
Location	Center point of the source in the x, y, z direction	Floor: 5m, 5m, 0m; Walls: 10m, 5m, 1m 5m, 10m, 1m 0m, 5m, 1m 5m, 0m, 1m	Entire floor and bottom 2 meters of each wall are uniformly contaminated.
Geometry: Area	Area of the exposed surface over which the contamination is evenly distributed	100, 20, 20, 20, 20 m ²	
Air Release Fraction	Fraction of the eroded material that is released into the air	0.07	Most likely value. NUREG/CR-6697
Direct Ingestion	Direct Ingestion rate of the source by any receptor in the room	0 /hr	RESRAD-BUILD Default
Removable Fraction	Fraction of the source that can be linearly removed between t =0 and lifetime	0.2	Most likely value. NUREG/CR-6697
Lifetime	Amount of time in which all of the removable fraction of the source is linearly eroded	10,000 days	Most likely value. NUREG/CR-6697
Radionuclides Concentration	Unit concentration is initially run; results are normalized to 15 mrem/yr to determine each isotopic DCGL	1 pCi/m ²	

3.3.3 BUILDING OCCUPANCY – RESIDENT

This scenario assumes that North County structures that may be impacted are used as residences. Zoning requirements, deed restrictions, and other limitations are all elements of institutional controls. USACE is not planning on implementing any ICs for structures at the NC site. Reviews of the locations of structures at the NC site reveal an industrialized area, under airport flight paths, that is unsuitable for residential construction. Since the North County buildings most likely to be impacted are commercial manufacturing facilities that would require extensive renovation to turn them into residential buildings, the residual radioactivity (if any) would likely be removed during renovation.

For residences along the haul routes, the credibility for the interior rooms to have become contaminated was evaluated. While loose surface contamination might be tracked into a residence via foot traffic, contamination at notable levels is not likely. In addition, residences are generally maintained so that walls are painted, carpet replaced, floors resurfaced, floors cleaned, etc. For comparison purposes, however, the same source term in the site conceptual model was used for all three building occupancy scenarios.

Additionally, investigations of vicinity properties (containing residences) completed to date have revealed no contamination in excess of remedial goals.

Therefore this is an unlikely scenario due to the nature of buildings likely to be impacted. This scenario assumes the critical receptor is a building resident who lives in the superficially contaminated building 16.4 hours per day for 350 days a year. The radioactive material can be released into the indoor air by mechanisms such as mechanical removal (decontamination activities) or erosion (removal of surface contamination). The applicable pathways for the industrial worker include:

- External exposure to penetrating radiation from surface sources,
- Inhalation of airborne radioactive particulates, and
- Secondary ingestion of surface contamination.

3.3.3.1 NON-DEFAULT PARAMETERS

As stated in section 3.3, a hierarchical system was used to derive the RESRAD-BUILD parameters for each applicable scenario. Justification for each non-default parameter used is given as follows:

- The **Indoor Fraction** was set at 0.66. This equates to a resident living for a full year (16.4 hours per day, 350 days per year) in the contaminated structure. These values were based upon the onsite resident values for exposure duration that were used in the *Feasibility Study for the St. Louis North County Site* (USACE 2003).
- The **Room Area** was set at 100 m² to be consistent with the other building occupancy scenarios. Since most North County structures that are likely to be impacted are commercial manufacturing facilities, it is likely that most of the contamination in these structures, if any, would be removed during the building renovation required to turn these facilities into residential units. 100 m² was selected as an average value somewhere between office room floor areas and manufacturing floor areas and equivalent to a Class 1 survey unit area.
- The **Resuspension Rate** was set at 5 E-9 sec⁻¹. This is the value listed in NUREG/CR-6697 Table 7.2-1 for residents performing normal activities. This value also represents particle sizes of 1 to 5 microns.

- The **Breathing Rate** was set at 21.6 m³/day. This value is more conservative than the default value and is listed in NUREG/CR-6697 Table 5.1-3 as a recommended default value for the indoor inhalation rate for the residential scenario.
- The **Receptor and Source Locations** were set to place the receptor 1 meter (m) above the floor in the middle of a 10 m by 10 m room with 2.5 m walls that are contaminated from the floor up to 2 m (~6 feet). The walls and floor are uniformly contaminated.
- The **Air Release Fraction** was set at 0.07. This value is consistent with the default value of 0.1 and is listed in NUREG/CR-6697 as the most likely value.
- The **Removal Fraction** was set at 0.2. This value assumes that 20 % of the contamination is removable at any given time. This value also corresponds to the maximum allowable removable contamination fraction (or percentage) for both the DOE and NRC and is the most likely value as listed in NUREG/CR-6697.
- The **Lifetime** was set at 10,000 days. This value is consistent with the 30-year exposure duration for a resident and the 25-year exposure duration for an industrial worker. This value is also the most likely value as listed in NUREG/CR-6697.

Derivation of Site-Specific DCGLs for North County Structures

Table 3-3 Parameters for RESRAD-BUILD Building Occupancy Scenario (Resident)

Parameter	Description	Value	Justification
<i>Time Parameter</i>			
Exposure Duration	Amount of time that exposure occurs	365 days	NUREG/CR-5512, Volume 1, Section 3.2.1
Indoor Fraction	Fraction of the exposure duration that is spent inside the building	0.66	16.4 hours/day; 350 days/year (North County FS – Resident)
Evaluation Time	Times at which doses are calculated	0 year; 1 year	RESRAD-BUILD Default
<i>Building Parameters</i>			
Number of Rooms	Number of compartments in the building	1	RESRAD-BUILD Default
Deposition Velocity	Velocity at which airborne particles are deposited onto the floor surfaces	0.01 m/sec	RESRAD-BUILD Default (A sensitivity test resulted in no significant difference between the default value and the min. and max values listed in NUREG/CR-6697)
Resuspension Rate	Rate at which deposited material is resuspended into the air	5.0 E-09 sec ⁻¹	NUREG/CR-6697, Table 7.2-1 (1-5 um particle)
Building Exchange Rate	Total volume of air going out of the building per unit time divided by the total volume of the building	0.8 hr ⁻¹	RESRAD-BUILD Default Consistent with value of 0.75 hr ⁻¹ for conditioned spaces (cited by American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.)
Room Area	Floor Area of the room	100 m ²	NUREG/CR-5512, Volume 1, Section 6.2.1
Room Height	Height of the room	2.5 m	RESRAD-BUILD Default Consistent with NUREG/CR-6697 most likely value of 2.4 m
Room Exchange Rate	Total volume of air going out of the room per unit time divided by the total volume of the room	0.8 hr ⁻¹	RESRAD-BUILD Default Same as building exchange rate due to single room
In/Out Flow Rate	Flow rates of air into and out of the room	200 m ³ /hr	Room volume (250 m ³) * Room exchange rate (0.8 hr ⁻¹)
<i>Receptor Parameters</i>			
Number of Receptors		1	RESRAD-BUILD Default
Room # Location	Room in which the receptor is located	1	RESRAD-BUILD Default
Time Fraction	Fraction of time within the building that the exposed individual spends at his receptor location	1	RESRAD-BUILD Default
Breathing Rate	Inhalation rate of airborne material at this location	21.6 m ³ /day	NUREG/CR-6697 Table 5.1-3 (Breathing rate = 0.9 m ³ /hr)
Ingestion Rate	Ingestion rate of deposited dust for this location	1 E-04 m ² /hr	RESRAD-BUILD Default (Approximate midpoint between NUREG/CR-6697 min. and max values)
Receptor Location	Coordinates of the receptor	5m, 5m, 1m	Located in center of room at height of 1m

Derivation of Site-Specific DCGLs for North County Structures

Table 3-3 Parameters for RESRAD-BUILD Building Occupancy Scenario (Resident)

Parameter	Description	Value	Justification
<i>Shielding Parameters</i>			
Thickness	Thickness of the shielding between the contamination source and the receptor location	0	RESRAD-BUILD Default
Density	Density of the shielding material	Not Applicable	
Material	Identification of the shielding material	Not Applicable	
<i>Source Parameters</i>			
Number of Sources		5	Floor and four walls
Room # location	All sources are located in Room # 1	1	
Source Type		Area	Surface contamination only; volume source is not likely due to historical assessment of NC buildings. (No processing of materials or activation of building materials.)
Direction	Axis perpendicular to the exposed area	Floor (z), Ceiling (z), 4 walls (x,y,x,y)	NUREG/CR-5512, Volume 1, Section 6.2.1
Location	Center point of the source in the x, y, z direction	Floor: 5m, 5m, 0m; Walls: 10m, 5m, 1m 5m, 10m, 1m 0m, 5m, 1m 5m, 0m, 1m	Entire floor and bottom 2 meters of each wall are uniformly contaminated.
Geometry: Area	Area of the exposed surface over which the contamination is evenly distributed	100, 20, 20, 20, 20 m ²	
Air Release Fraction	Fraction of the eroded material that is released into the air	0.07	Most likely value. NUREG/CR-6697
Direct Ingestion	Direct Ingestion rate of the source by any receptor in the room	0 g/hr	RESRAD-BUILD Default
Removable Fraction	Fraction of the source that can be linearly removed between t =0 and lifetime	0.2	Most likely value. NUREG/CR-6697
Lifetime	Amount of time in which all of the removable fraction of the source is linearly eroded	10,000 days	Most likely value. NUREG/CR-6697
Radionuclides Concentration	Unit concentration is initially run; results are normalized to 15 mrem/yr to determine each isotopic DCGL	1 pCi/m ²	

3.3.4 ONSITE RESIDENT – POST DEMOLITION

The onsite resident – post demolition scenario assumes that the building structure (described in the three scenarios above) is demolished, buried on site, and a residence is established on top of the rubble. This scenario assumes that the total activity in the structure (180 picocuries³) is distributed uniformly in the soil (3000 m³). This scenario assumes the same parameters used in the onsite resident scenario in the *Feasibility Study for the St. Louis North County Site* (USACE 2003).

3.3.4.1 NON-DEFAULT PARAMETERS

RESRAD Version 6.21 was used to evaluate this scenario. The non-default parameters are listed in Table 3-4. Justification for each non-default parameter can be found in the *Feasibility Study for the St. Louis North County Site* (USACE 2003).

Table 3-4 Non-Default RESRAD Parameter for Onsite Resident

Parameter	Value	Justification
Thickness of contamination zone	0.3 m	North County FS
Inhalation Rate	4836 m ³ /yr	North County FS
Mass Loading Factor	0.0001	North County FS
Exposure duration	30 yrs	EPA Risk Assessment Guidance
Fraction of time spend indoors	0.655	Exposure Factor Handbook
Fraction of time spent outdoor	0.0799	Exposure Factor Handbook
Soil ingestion	43.8 kg/yr	Weight Average Soil Ingestion by Adult & Child (Exposure Factor Handbook)

3.4 IDENTIFYING THE MOST LIMITING SCENARIO

As discussed in the Section 3.3, three potential building occupancy and one post-demolition exposure scenarios were considered. The purpose of this section is to document the results of each scenario assuming the same source term and determine which scenario is the most limiting. This section also discusses which scenarios are most likely.

The source term used for comparison of the three building occupancy scenarios was 1 pCi/m² of Th-230 uniformly distributed on the floor and all four walls from the floor up to 2 m. The source term used for the onsite resident post demolition was calculated by multiplying the uniform activity concentration (1 pCi/m²) by the total source area (180 m²) of the building occupancy scenarios and distributing it uniformly in the total volume of soil (3000 m³). Th-230 was chosen as the source term to compare scenarios because it is the primary contaminant of concern (COC).

$$180\text{m}^2 * \frac{1\text{pCi}}{\text{m}^2} * \frac{1}{10000\text{m}^2 * 0.3\text{m}} * \frac{\text{cm}^3}{1.5\text{g}} * \frac{1\text{m}^3}{1\text{E}6\text{cm}^3} = 4\text{E}-8 \frac{\text{pCi}}{\text{g}}$$

³ The total activity is calculated by multiplying the uniform activity concentration (1 pCi/m²) by the total source area (180 m²: floor 100 m² and four 20 m² walls).

Results of the dose evaluations are shown in Table 3-5.

Table 3-5 Equivalent Source Term Dose Results (1 pCi/m² Th-230)

Scenario	Industrial Worker	Renovation Worker	Building Resident	Onsite Resident
Dose (TEDE ¹) (mrem/yr)	7 E-5	3 E-5	2 E-4	6 E-9

¹ Total effective dose equivalent

As shown in the Table above, the scenarios in order of most limiting to least limiting (due to annual dose) are:

1. Building Resident
2. Industrial Worker
3. Renovation Worker
4. Onsite Resident

The results of the dose assessments for the scenarios show that the most limiting scenario would be for an individual who establishes a residence in the contaminated building. As discussed in Sections 3.3.3 and 3.3.3.1, the building resident scenario is very unlikely since the North County buildings most likely to be impacted are commercial manufacturing facilities that would require extensive renovation to turn them into residential buildings and the radioactivity (if any) would likely be removed during renovation. A variety of factors contribute to preclude conversion of industrial facilities for residential use. These include municipal zoning restrictions, the need for occupancy permits, and FAA surface use restrictions on within specified distances from the airport. Investigations of soils on vicinity properties containing residences have not detected levels of COCs exceeding proposed remedial goals. Therefore, the residential scenario is screened out and the industrial scenario is carried forward for the development of DCGLs. The likely most limiting scenario is the Building Occupancy – Industrial Worker. This scenario was selected for determining DCGLs.

3.5 CALCULATING DCGLS FROM RESRAD-BUILD OUTPUT

The industrial worker was the most likely limiting scenario, as demonstrated in Table 3-5.

To derive the surficial contamination DCGL values that would be equivalent to the benchmark dose limit of 15 mrem/yr, each North County COC plus Pa-231 and Ac-227 were put into the RESRAD-BUILD code with a source term of 1 pCi/m² for each radionuclide in order to determine a dose-to-source ratio. The DSR is a derived value, based upon the RESRAD modeling output, that can be used to convert the benchmark dose limit to units of surficial contamination (in pCi/m²).

Table 3-6 separates each radionuclide COC (plus Ac-227 and Pa-231) and then presents the derived DSR for that radionuclide and its associated progeny due to each source in the building. The DSRs from all sources for each of the radionuclides and progeny are subtotaled. The total DSR for a radionuclide COC is calculated by summing the DSR subtotals.

Table 3-6 Determination of Total Dose-to-Source Ratio (DSR) from All Sources

RADIONUCLIDE/ PROGENY ¹		SOURCE ² (based upon 1 pCi/m ²)					DSR SUBTOTAL ₃	TOTAL ⁴ DSR mrem/yr pCi/m ²
		1	2	3	4	5		
U-238	U-238	1.0E-05	2.0E-06	2.0E-06	2.0E-06	2.0E-06	1.8E-05	1.8E-05
	U-234	4.6E-11	9.3E-12	9.3E-12	9.3E-12	9.3E-12	8.3E-11	
	Th-230	8.0E-16	1.6E-16	1.6E-16	1.6E-16	1.6E-16	1.4E-15	
	Ra-226	1.2E-19	9.8E-21	9.8E-21	9.8E-21	9.8E-21	1.6E-19	
	Pb-210	4.3E-23	8.4E-24	8.4E-24	8.4E-24	8.4E-24	7.6E-23	
U-235	U-235	1.2E-05	2.1E-06	2.1E-06	2.1E-06	2.1E-06	2.0E-05	2.0E-05
	Pa-231	3.4E-09	6.8E-10	6.8E-10	6.8E-10	6.8E-10	6.1E-09	
	Ac-227	4.2E-10	8.8E-11	8.8E-11	8.8E-11	8.8E-11	7.5E-10	
U-234	U-234	1.1E-05	2.3E-06	2.3E-06	2.3E-06	2.3E-06	2.0E-05	2.0E-05
	Th-230	3.6E-10	7.3E-11	7.3E-11	7.3E-11	7.3E-11	6.5E-10	
	Ra-226	7.7E-14	6.4E-15	6.4E-15	6.4E-15	6.4E-15	1.0E-13	
	Pb-210	2.0E-16	4.0E-17	4.0E-17	4.0E-17	4.0E-17	3.6E-16	
Pa-231	Pa-231	1.1E-04	2.1E-05	2.1E-05	2.1E-05	2.1E-05	1.9E-04	2.4E-04
	Ac-227	2.5E-05	5.0E-06	5.0E-06	5.0E-06	5.0E-06	4.5E-05	
Th-232	Th-232	1.4E-04	2.7E-05	2.7E-05	2.7E-05	2.7E-05	2.4E-04	2.5E-04
	Th-228	2.1E-06	3.6E-07	3.6E-07	3.6E-07	3.6E-07	3.5E-06	
	Ra-228	1.4E-06	1.1E-07	1.1E-07	1.1E-07	1.1E-07	1.9E-06	
Th-230	Th-230	2.7E-05	5.4E-06	5.4E-06	5.4E-06	5.4E-06	4.8E-05	4.8E-05
	Ra-226	1.1E-08	9.1E-10	9.1E-10	9.1E-10	9.1E-10	1.5E-08	
	Pb-210	4.2E-11	8.3E-12	8.3E-12	8.3E-12	8.3E-12	7.5E-11	
Ac-227	Ac-227	5.1E-04	1.0E-04	1.0E-04	1.0E-04	1.0E-04	9.2E-04	9.2E-04
Ra-228	Ra-228	7.3E-06	5.3E-07	5.3E-07	5.3E-07	5.3E-07	9.4E-06	4.3E-05
	Th-228	2.0E-05	3.4E-06	3.4E-06	3.4E-06	3.4E-06	3.4E-05	
Ra-226	Ra-226	1.7E-05	1.4E-06	1.4E-06	1.4E-06	1.4E-06	2.3E-05	2.3E-05
	Pb-210	1.2E-07	2.4E-08	2.4E-08	2.4E-08	2.4E-08	2.2E-07	

¹ Each radionuclide was set to 1 pCi/m². Doses resulting from the parent and the progeny of each parent are listed.

² Source 1 represents the floor; sources 2 – 5 represent each contaminated wall.

³ Dose subtotal per radionuclide due to sources 1 – 5.

⁴ Total DSR from each COC (plus Ac-227 and Pa-231) including dose from progeny due to sources 1 – 5. Total DSR is calculated by summing the dose subtotal values for each radionuclide and its progeny.

Derivation of Site-Specific DCGLs for North County Structures

Table 3-7 illustrates DSRs adjusted to an equivalent 15 mrem/yr dose for surface concentrations and radionuclide-specific DCGLs.

Table 3-7 Individual Radionuclide DCGLs Equivalent to 15 mrem/yr

Radionuclide	Dose to Source Ratio ¹	Surface Concentration	Surface DCGL ²
	(mrem/yr) / (pCi/m ²)	(pCi/m ²)	(dpm/100 cm ²)
Ac-227	9.2E-04	1.6E+04	400
Pa-231	2.4E-04	6.3E+04	1,400
Ra-226	2.3E-05	6.6E+05	15,000
Ra-228	4.3E-05	3.E+05	7,700
Th-230	4.8E-05	3.1E+05	6,900
Th-232	2.5E-04	6.1E+04	1,300
U-234	2.0E-05	7.7E+05	17,000
U-235	2.0E-05	7.4E+05	16,000
U-238	1.8E-05	8.4E+05	19,000

¹ Results from TOTAL DSR column in Table 3-6.

² Results rounded to no more than two significant digits.

4.0 UNCERTAINTY ANALYSIS

DCGL calculations use industry standard modeling tools and representative input parameters that are specifically designed to assess exposure to radionuclides. The approach used assures protectiveness of future receptors likely to be present in the North County structures that may be impacted. The contaminated room modeled in this report contains no windows or doors and contains no furniture. The receptor is assumed to spend 100% of on-site occupancy at the center of the contaminated room.

RESRAD-BUILD considers two pathways to generate the airborne concentration caused by the contaminated area sources. The primary source of airborne contamination is direct removal from the surface source, described by a removable fraction, time of source removal (lifetime), and air fraction. For this analysis, a removable fraction of 0.2 was set for both the walls and floor of the room. This means that the floor and four walls will erode at the same rate, which is conservative. It is likely that the floor will have more physical contact than the walls. The time to source removal is 10,000 days, defined as the most likely value by NUREG/CR 6697. Based on the removable fraction of 0.2, and lifetime of 10,000 days, the resuspension rate of the contaminants from the contaminated surface is equal to 2.3×10^{-10} . For the industrial worker scenario, the resuspension rate was set at 5×10^{-7} ; therefore, this scenario used a more conservative value (on the order of three magnitudes) for the resuspension rate.

Doses calculated using RESRAD-BUILD are heavily dependent on the code's dust resuspension model. Doses specific to the inhalation pathway require that contaminated dust be suspended in the air where the receptor breathes in the material, leading to a radiological dose. Doses specific to the ingestion pathway require that contaminated dust be suspended and then re-deposited on surfaces where the receptor inadvertently ingests the material, leading to a radiological dose. Both the inhalation and the ingestion pathways depend on the model's ability to accurately predict contaminant circulation within the occupied space. RESRAD-BUILD input parameters related to contaminant circulation are sometimes left as defaults, increasing the uncertainty in results. Resrad default and NRC guidance-based most likely parameter values are used. These values reasonably and conservatively represent current conditions or conditions that would be present in the event of future building occupancy.

The source term used in the building occupancy scenario was set for a uniform contamination of the floor and walls from the floor up to 2 m. It is unlikely that the walls would be as contaminated as the floor due to gravity and geometry. The approach outlined in this report ensures that doses are not underestimated regardless of geometry.

5.0 SUMMARY

5.1 SUMMARY OF DCGL DETERMINATION

A conceptual site model was established to determine the applicable pathways for two likely (industrial worker and renovation worker) and two unlikely (building occupancy - resident and onsite resident – post demolition) scenarios. The radionuclide-specific DCGL values calculated in this report for the most likely limiting scenario considered a potential dose limit (15 mrem/yr) that is protective of human health and the environment. The receptor was selected as a member of the respective critical group representing long-term or full-time employees (industrial worker). RESRAD-BUILD Version 3.1 was used to calculate DCGL concentrations using parameter values primarily from EPA and NRC guidance. Results presented in Table 5-1 are based upon 15 mrem/yr and 20% removable contamination.

Table 5-1 DCGL Results

Analyte	Surface DCGL (dpm/100 cm ²)
Ac-227	400
Pa-231	1,400
Ra-226	15,000
Ra-228	7,700
Th-230	6,900
Th-232	1,300
U-234	17,000
U-235	16,000
U-238	19,000

Table 5-1 results may be used to calculate gross Alpha or gross Beta DCGLs based upon known site-specific information. Using site-specific activity fractions, the gross Alpha or Beta DCGL can be calculated by the following equation:

$$\text{Gross Alpha or Beta DCGL} = \frac{1}{\frac{\text{ActivityFraction}_1}{\text{DCGL}_1} + \frac{\text{ActivityFraction}_2}{\text{DCGL}_2} + \frac{\text{ActivityFraction}_3}{\text{DCGL}_3} + \text{etc...}}$$

6.0 REFERENCES

- ANL 2000. *Development of Probabilistic RESRAD 6.0 and RESRAD-BUILD 3.0 Computer Codes*, ANL/EAD/TM-98, NUREG/CR-6697, prepared for the U.S. Nuclear Regulatory Commission, November.
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- USACE 2003. *Feasibility Study for the St. Louis North County Site*, St. Louis District, November.

APPENDIX A
RESRAD-BUILD OUTPUT

APPENDIX A – RESRAD-BUILD OUTPUT

Appendix A presents the RESRAD-BUILD Version 3.1 output for the industrial worker scenario. Each radionuclide COC plus Ac-227 and Pa-231 were used in the source term. Dose resulting from each individual radionuclide for each source is presented in Table 3-6.

Derivation of Site-Specific DCGLs for North County Structures

** RESRAD-BUILD Program Output, Version 3.1 05/27/03 14:52 Page: 1 **
Title : NC Building Occupancy-All Radionuclides
Input File : C:\Winbld\NCBDOccupancyAllRad.bld

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Derivation of Site-Specific DCGLs for North County Structures

** RESRAD-BUILD Program Output, Version 3.1 05/27/03 14:52 Page: 2 **
 Title : NC Building Occupancy-All Radionuclides
 Input File : C:\Winbld\NCBDOccupancyAllRad.bld

```

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

```

Number of Sources : 5
Number of Receptors: 1
Total Time : 3.650000E+02 days
Fraction Inside : 2.300000E-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	3.36E+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

Derivation of Site-Specific DCGLs for North County Structures

** RESRAD-BUILD Program Output, Version 3.1 05/27/03 14:52 Page: 3 **
Title : NC Building Occupancy-All Radionuclides
Input File : C:\Winbld\NCBDOccupancyAllRad.bld

==== Building Information ====

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

Height [m]	Air Exchanges [m3/hr]	
Area [m2]	*****	
	*	*
	*	*
	*	<=Q01: 2.00E+02
H1: 2.500	* Room 1	* Q10 : 2.00E+02
	* LAMBDA: 8.00E-01	*
Area 100.000	*	*
	*	*

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

Derivation of Site-Specific DCGLs for North County Structures

** RESRAD-BUILD Program Output, Version 3.1 05/27/03 14:52 Page: 4 **
 Title : NC Building Occupancy-All Radionuclides
 Input File : C:\Winbld\NCBDOccupancyAllRad.bld

==== 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: 7.000E-02
 Removable fraction: 2.000E-01
 Time to Remove: 1.000E+04 [day]

 Radon Release Fraction: 1.000E-01

Contamination::

Nuclide	Concentration [pCi/m2]	Dose Conversion Factors		
		Ingestion [mrem/pCi]	Inhalation [mrem/pCi]	Submersion [mrem/yr/ (pCi/m3)]
U-238	1.000E+00	2.690E-04	1.180E-01	1.600E-04
U-235	1.000E+00	2.670E-04	1.230E-01	9.030E-04
U-234	1.000E+00	2.830E-04	1.320E-01	8.930E-07
PA-231	1.000E+00	1.060E-02	1.280E+00	2.010E-04
TH-232	1.000E+00	2.730E-03	1.640E+00	1.020E-06
TH-230	1.000E+00	5.480E-04	3.260E-01	2.040E-06
TH-228	0.000E+00	8.080E-04	3.450E-01	9.410E-03
AC-227	1.000E+00	1.480E-02	6.720E+00	2.160E-03
RA-228	1.000E+00	1.440E-03	5.080E-03	5.590E-03
RA-226	1.000E+00	1.330E-03	8.600E-03	1.040E-02
PB-210	0.000E+00	7.270E-03	2.320E-02	1.050E-05

Derivation of Site-Specific DCGLs for North County Structures

** RESRAD-BUILD Program Output, Version 3.1 05/27/03 14:52 Page: 5 **
 Title : NC Building Occupancy-All Radionuclides
 Input File : C:\Winbld\NCBDOccupancyAllRad.bld

Source: 2

Location:: Room : 1 x: 5.00 y: 10.00 z: 1.00[m]
 Geometry:: Type: Area Area:2.00E+01 [m2] Direction: y
 Pathway ::
 Direct Ingestion Rate: 0.000E+00 [1/hr]
 Fraction released to air: 7.000E-02
 Removable fraction: 2.000E-01
 Time to Remove: 1.000E+04 [day]

 Radon Release Fraction: 1.000E-01

Contamination::

Nuclide	Concentration [pCi/m2]	Dose Conversion Factors		
		Ingestion [mrem/pCi]	Inhalation [mrem/pCi]	Submersion [mrem/yr/ (pCi/m3)]
U-238	1.000E+00	2.690E-04	1.180E-01	1.600E-04
U-235	1.000E+00	2.670E-04	1.230E-01	9.030E-04
U-234	1.000E+00	2.830E-04	1.320E-01	8.930E-07
PA-231	1.000E+00	1.060E-02	1.280E+00	2.010E-04
TH-232	1.000E+00	2.730E-03	1.640E+00	1.020E-06
TH-230	1.000E+00	5.480E-04	3.260E-01	2.040E-06
TH-228	0.000E+00	8.080E-04	3.450E-01	9.410E-03
AC-227	1.000E+00	1.480E-02	6.720E+00	2.160E-03
RA-228	1.000E+00	1.440E-03	5.080E-03	5.590E-03
RA-226	1.000E+00	1.330E-03	8.600E-03	1.040E-02
PB-210	0.000E+00	7.270E-03	2.320E-02	1.050E-05

Derivation of Site-Specific DCGLs for North County Structures

** RESRAD-BUILD Program Output, Version 3.1 05/27/03 14:52 Page: 6 **
 Title : NC Building Occupancy-All Radionuclides
 Input File : C:\Winbld\NCBDOccupancyAllRad.bld

Source: 3

Location:: Room : 1 x: 10.00 y: 5.00 z: 1.00[m]
 Geometry:: Type: Area Area:2.00E+01 [m2] Direction: x
 Pathway ::
 Direct Ingestion Rate: 0.000E+00 [1/hr]
 Fraction released to air: 7.000E-02
 Removable fraction: 2.000E-01
 Time to Remove: 1.000E+04 [day]
 Radon Release Fraction: 1.000E-01

Contamination::

Nuclide	Concentration [pCi/m2]	Dose Conversion Factors		
		Ingestion [mrem/pCi]	Inhalation [mrem/pCi]	Submersion [mrem/yr/ (pCi/m3)]
U-238	1.000E+00	2.690E-04	1.180E-01	1.600E-04
U-235	1.000E+00	2.670E-04	1.230E-01	9.030E-04
U-234	1.000E+00	2.830E-04	1.320E-01	8.930E-07
PA-231	1.000E+00	1.060E-02	1.280E+00	2.010E-04
TH-232	1.000E+00	2.730E-03	1.640E+00	1.020E-06
TH-230	1.000E+00	5.480E-04	3.260E-01	2.040E-06
TH-228	0.000E+00	8.080E-04	3.450E-01	9.410E-03
AC-227	1.000E+00	1.480E-02	6.720E+00	2.160E-03
RA-228	1.000E+00	1.440E-03	5.080E-03	5.590E-03
RA-226	1.000E+00	1.330E-03	8.600E-03	1.040E-02
PB-210	0.000E+00	7.270E-03	2.320E-02	1.050E-05

Derivation of Site-Specific DCGLs for North County Structures

** RESRAD-BUILD Program Output, Version 3.1 05/27/03 14:52 Page: 7 **
 Title : NC Building Occupancy-All Radionuclides
 Input File : C:\Winbld\NCBDOccupancyAllRad.bld

Source: 4

Location:: Room : 1 x: 0.00 y: 5.00 z: 1.00[m]
 Geometry:: Type: Area Area:2.00E+01 [m2] Direction: x
 Pathway ::
 Direct Ingestion Rate: 0.000E+00 [1/hr]
 Fraction released to air: 7.000E-02
 Removable fraction: 2.000E-01
 Time to Remove: 1.000E+04 [day]

 Radon Release Fraction: 1.000E-01

Contamination::

Nuclide	Concentration [pCi/m2]	Dose Conversion Factors		
		Ingestion [mrem/pCi]	Inhalation [mrem/pCi]	Submersion [mrem/yr/ (pCi/m3)]
U-238	1.000E+00	2.690E-04	1.180E-01	1.600E-04
U-235	1.000E+00	2.670E-04	1.230E-01	9.030E-04
U-234	1.000E+00	2.830E-04	1.320E-01	8.930E-07
PA-231	1.000E+00	1.060E-02	1.280E+00	2.010E-04
TH-232	1.000E+00	2.730E-03	1.640E+00	1.020E-06
TH-230	1.000E+00	5.480E-04	3.260E-01	2.040E-06
TH-228	0.000E+00	8.080E-04	3.450E-01	9.410E-03
AC-227	1.000E+00	1.480E-02	6.720E+00	2.160E-03
RA-228	1.000E+00	1.440E-03	5.080E-03	5.590E-03
RA-226	1.000E+00	1.330E-03	8.600E-03	1.040E-02
PB-210	0.000E+00	7.270E-03	2.320E-02	1.050E-05

Derivation of Site-Specific DCGLs for North County Structures

** RESRAD-BUILD Program Output, Version 3.1 05/27/03 14:52 Page: 8 **
 Title : NC Building Occupancy-All Radionuclides
 Input File : C:\Winbld\NCBDOccupancyAllRad.bld

Source: 5

Location:: Room : 1 x: 5.00 y: 0.00 z: 1.00[m]
 Geometry:: Type: Area Area:2.00E+01 [m2] Direction: y
 Pathway ::
 Direct Ingestion Rate: 0.000E+00 [1/hr]
 Fraction released to air: 7.000E-02
 Removable fraction: 2.000E-01
 Time to Remove: 1.000E+04 [day]

 Radon Release Fraction: 1.000E-01

Contamination::

Nuclide	Concentration [pCi/m2]	Dose Conversion Factors		
		Ingestion [mrem/pCi]	Inhalation [mrem/pCi]	Submersion [mrem/yr/ (pCi/m3)]
U-238	1.000E+00	2.690E-04	1.180E-01	1.600E-04
U-235	1.000E+00	2.670E-04	1.230E-01	9.030E-04
U-234	1.000E+00	2.830E-04	1.320E-01	8.930E-07
PA-231	1.000E+00	1.060E-02	1.280E+00	2.010E-04
TH-232	1.000E+00	2.730E-03	1.640E+00	1.020E-06
TH-230	1.000E+00	5.480E-04	3.260E-01	2.040E-06
TH-228	0.000E+00	8.080E-04	3.450E-01	9.410E-03
AC-227	1.000E+00	1.480E-02	6.720E+00	2.160E-03
RA-228	1.000E+00	1.440E-03	5.080E-03	5.590E-03
RA-226	1.000E+00	1.330E-03	8.600E-03	1.040E-02
PB-210	0.000E+00	7.270E-03	2.320E-02	1.050E-05

Derivation of Site-Specific DCGLs for North County Structures

** RESRAD-BUILD Program Output, Version 3.1 05/27/03 14:52 Page: 10 **
Title : NC Building Occupancy-All Radionuclides
Input File : C:\Winbld\NCBDOccupancyAllRad.bld
Evaluation Time: 0.000000 years

Source: 2

Location:: Room : 1 x: 5.00 y: 10.00 z: 1.00 [m]
Geometry:: Type: Area Area:2.00E+01 [m2] Direction: y
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 7.000E-02
Removable fraction: 2.000E-01
Time to Remove: 1.000E+04 [day]

Contamination::	Nuclide	Concentration [pCi/m2]
	U-238	1.000E+00
	U-235	1.000E+00
	U-234	1.000E+00
	PA-231	1.000E+00
	TH-232	1.000E+00
	TH-230	1.000E+00
	TH-228	0.000E+00
	AC-227	1.000E+00
	RA-228	1.000E+00
	RA-226	1.000E+00
	PB-210	0.000E+00

Derivation of Site-Specific DCGLs for North County Structures

** RESRAD-BUILD Program Output, Version 3.1 05/27/03 14:52 Page: 11 **
Title : NC Building Occupancy-All Radionuclides
Input File : C:\Winbld\NCBDOccupancyAllRad.bld
Evaluation Time: 0.000000 years

Source: 3

Location:: Room : 1 x: 10.00 y: 5.00 z: 1.00 [m]
Geometry:: Type: Area Area:2.00E+01 [m2] Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 7.000E-02
Removable fraction: 2.000E-01
Time to Remove: 1.000E+04 [day]

Contamination::	Nuclide	Concentration [pCi/m2]
	U-238	1.000E+00
	U-235	1.000E+00
	U-234	1.000E+00
	PA-231	1.000E+00
	TH-232	1.000E+00
	TH-230	1.000E+00
	TH-228	0.000E+00
	AC-227	1.000E+00
	RA-228	1.000E+00
	RA-226	1.000E+00
	PB-210	0.000E+00

Derivation of Site-Specific DCGLs for North County Structures

** RESRAD-BUILD Program Output, Version 3.1 05/27/03 14:52 Page: 12 **
Title : NC Building Occupancy-All Radionuclides
Input File : C:\Winbld\NCBDOccupancyAllRad.bld
Evaluation Time: 0.000000 years

Source: 4

Location:: Room : 1 x: 0.00 y: 5.00 z: 1.00 [m]
Geometry:: Type: Area Area:2.00E+01 [m2] Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 7.000E-02
Removable fraction: 2.000E-01
Time to Remove: 1.000E+04 [day]

Contamination::	Nuclide	Concentration [pCi/m2]
	U-238	1.000E+00
	U-235	1.000E+00
	U-234	1.000E+00
	PA-231	1.000E+00
	TH-232	1.000E+00
	TH-230	1.000E+00
	TH-228	0.000E+00
	AC-227	1.000E+00
	RA-228	1.000E+00
	RA-226	1.000E+00
	PB-210	0.000E+00

Derivation of Site-Specific DCGLs for North County Structures

** RESRAD-BUILD Program Output, Version 3.1 05/27/03 14:52 Page: 13 **
Title : NC Building Occupancy-All Radionuclides
Input File : C:\Winbld\NCBDOccupancyAllRad.bld
Evaluation Time: 0.000000 years

Source: 5

Location:: Room : 1 x: 5.00 y: 0.00 z: 1.00 [m]
Geometry:: Type: Area Area:2.00E+01 [m2] Direction: y
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 7.000E-02
Removable fraction: 2.000E-01
Time to Remove: 1.000E+04 [day]

Contamination::	Nuclide	Concentration [pCi/m2]
	U-238	1.000E+00
	U-235	1.000E+00
	U-234	1.000E+00
	PA-231	1.000E+00
	TH-232	1.000E+00
	TH-230	1.000E+00
	TH-228	0.000E+00
	AC-227	1.000E+00
	RA-228	1.000E+00
	RA-226	1.000E+00
	PB-210	0.000E+00

Derivation of Site-Specific DCGLs for North County Structures

** RESRAD-BUILD Program Output, Version 3.1 05/27/03 14:52 Page: 14 **
 Title : NC Building Occupancy-All Radionuclides
 Input File : C:\Winbld\NCBDOccupancyAllRad.bld
 Evaluation Time: 0.000000 years

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 RESRAD-BUILD Dose Tables
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Source Contributions to Receptor Doses

[mrem]

	Source 1	Source 2	Source 3	Source 4	Source 5	Total
Receptor 1	8.75E-04	1.71E-04	1.71E-04	1.71E-04	1.71E-04	1.56E-03
Total	8.75E-04	1.71E-04	1.71E-04	1.71E-04	1.71E-04	1.56E-03

Derivation of Site-Specific DCGLs for North County Structures

** RESRAD-BUILD Program Output, Version 3.1 05/27/03 14:52 Page: 15 **
 Title : NC Building Occupancy-All Radionuclides
 Input File : C:\Winbld\NCBDOccupancyAllRad.bld
 Evaluation Time: 0.000000 years

Pathway Detail of Doses

[mrem]

Source: 1						
Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	3.07E-05	1.69E-08	1.33E-10	8.36E-04	4.81E-06	3.73E-06
Total	3.07E-05	1.69E-08	1.33E-10	8.36E-04	4.81E-06	3.73E-06

Source: 2						
Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	1.99E-06	3.38E-09	2.65E-11	1.67E-04	9.61E-07	7.46E-07
Total	1.99E-06	3.38E-09	2.65E-11	1.67E-04	9.61E-07	7.46E-07

Source: 3						
Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	1.99E-06	3.38E-09	2.65E-11	1.67E-04	9.61E-07	7.46E-07
Total	1.99E-06	3.38E-09	2.65E-11	1.67E-04	9.61E-07	7.46E-07

Source: 4						
Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	1.99E-06	3.38E-09	2.65E-11	1.67E-04	9.61E-07	7.46E-07
Total	1.99E-06	3.38E-09	2.65E-11	1.67E-04	9.61E-07	7.46E-07

Source: 5						
Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	1.99E-06	3.38E-09	2.65E-11	1.67E-04	9.61E-07	7.46E-07
Total	1.99E-06	3.38E-09	2.65E-11	1.67E-04	9.61E-07	7.46E-07

Derivation of Site-Specific DCGLs for North County Structures

** RESRAD-BUILD Program Output, Version 3.1 05/27/03 14:52 Page: 16 **
Title : NC Building Occupancy-All Radionuclides
Input File : C:\Winbld\NCBDOccupancyAllRad.bld
Evaluation Time: 0.000000 years

Nuclide Detail of Doses

[mrem]

Source: 1

Nuclide	Receptor	Total
	1	
U-238		
U-238	1.00E-05	1.00E-05
U-234	1.54E-11	1.54E-11
TH-230	1.14E-16	1.14E-16
RA-226	6.97E-21	6.97E-21
PB-210	0.00E+00	0.00E+00
U-235		
U-235	1.17E-05	1.17E-05
PA-231	1.13E-09	1.13E-09
AC-227	5.98E-11	5.98E-11
U-234		
U-234	1.09E-05	1.09E-05
TH-230	1.21E-10	1.21E-10
RA-226	1.10E-14	1.10E-14
PB-210	1.36E-17	1.36E-17
PA-231		
PA-231	1.07E-04	1.07E-04
AC-227	8.47E-06	8.47E-06
TH-232		
TH-232	1.35E-04	1.35E-04
TH-228	3.44E-07	3.44E-07
RA-228	5.10E-07	5.10E-07
TH-230		
TH-230	2.69E-05	2.69E-05
RA-226	3.67E-09	3.67E-09
PB-210	6.05E-12	6.05E-12
AC-227		
AC-227	5.30E-04	5.30E-04
RA-228		
TH-228	8.25E-06	8.25E-06
RA-228	8.30E-06	8.30E-06
RA-226		
RA-226	1.70E-05	1.70E-05
PB-210	4.18E-08	4.18E-08

Derivation of Site-Specific DCGLs for North County Structures

** RESRAD-BUILD Program Output, Version 3.1 05/27/03 14:52 Page: 17 **
Title : NC Building Occupancy-All Radionuclides
Input File : C:\Winbld\NCBDOccupancyAllRad.bld
Evaluation Time: 0.000000 years

Source: 2

Nuclide	Receptor	Total
	1	
U-238		
U-238	1.97E-06	1.97E-06
U-234	3.08E-12	3.08E-12
TH-230	2.28E-17	2.28E-17
RA-226	5.81E-22	5.81E-22
PB-210	0.00E+00	0.00E+00
U-235		
U-235	2.13E-06	2.13E-06
PA-231	2.25E-10	2.25E-10
AC-227	1.19E-11	1.19E-11
U-234		
U-234	2.18E-06	2.18E-06
TH-230	2.42E-11	2.42E-11
RA-226	9.16E-16	9.16E-16
PB-210	2.68E-18	2.68E-18
PA-231		
PA-231	2.13E-05	2.13E-05
AC-227	1.69E-06	1.69E-06
TH-232		
TH-232	2.70E-05	2.70E-05
TH-228	5.82E-08	5.82E-08
RA-228	3.70E-08	3.70E-08
TH-230		
TH-230	5.38E-06	5.38E-06
RA-226	3.06E-10	3.06E-10
PB-210	1.19E-12	1.19E-12
AC-227		
AC-227	1.06E-04	1.06E-04
RA-228		
TH-228	1.40E-06	1.40E-06
RA-228	6.04E-07	6.04E-07
RA-226		
RA-226	1.41E-06	1.41E-06
PB-210	8.25E-09	8.25E-09

Derivation of Site-Specific DCGLs for North County Structures

** RESRAD-BUILD Program Output, Version 3.1 05/27/03 14:52 Page: 18 **
Title : NC Building Occupancy-All Radionuclides
Input File : C:\Winbld\NCBDOccupancyAllRad.bld
Evaluation Time: 0.000000 years

Source: 3

Nuclide	Receptor	Total
	1	
U-238		
U-238	1.97E-06	1.97E-06
U-234	3.08E-12	3.08E-12
TH-230	2.28E-17	2.28E-17
RA-226	5.81E-22	5.81E-22
PB-210	0.00E+00	0.00E+00
U-235		
U-235	2.13E-06	2.13E-06
PA-231	2.25E-10	2.25E-10
AC-227	1.19E-11	1.19E-11
U-234		
U-234	2.18E-06	2.18E-06
TH-230	2.42E-11	2.42E-11
RA-226	9.16E-16	9.16E-16
PB-210	2.68E-18	2.68E-18
PA-231		
PA-231	2.13E-05	2.13E-05
AC-227	1.69E-06	1.69E-06
TH-232		
TH-232	2.70E-05	2.70E-05
TH-228	5.82E-08	5.82E-08
RA-228	3.70E-08	3.70E-08
TH-230		
TH-230	5.38E-06	5.38E-06
RA-226	3.06E-10	3.06E-10
PB-210	1.19E-12	1.19E-12
AC-227		
AC-227	1.06E-04	1.06E-04
RA-228		
TH-228	1.40E-06	1.40E-06
RA-228	6.04E-07	6.04E-07
RA-226		
RA-226	1.41E-06	1.41E-06
PB-210	8.25E-09	8.25E-09

Derivation of Site-Specific DCGLs for North County Structures

** RESRAD-BUILD Program Output, Version 3.1 05/27/03 14:52 Page: 19 **
Title : NC Building Occupancy-All Radionuclides
Input File : C:\Winbld\NCBDOccupancyAllRad.bld
Evaluation Time: 0.000000 years

Source: 4

Nuclide	Receptor	Total
	1	
U-238		
U-238	1.97E-06	1.97E-06
U-234	3.08E-12	3.08E-12
TH-230	2.28E-17	2.28E-17
RA-226	5.81E-22	5.81E-22
PB-210	0.00E+00	0.00E+00
U-235		
U-235	2.13E-06	2.13E-06
PA-231	2.25E-10	2.25E-10
AC-227	1.19E-11	1.19E-11
U-234		
U-234	2.18E-06	2.18E-06
TH-230	2.42E-11	2.42E-11
RA-226	9.16E-16	9.16E-16
PB-210	2.68E-18	2.68E-18
PA-231		
PA-231	2.13E-05	2.13E-05
AC-227	1.69E-06	1.69E-06
TH-232		
TH-232	2.70E-05	2.70E-05
TH-228	5.82E-08	5.82E-08
RA-228	3.70E-08	3.70E-08
TH-230		
TH-230	5.38E-06	5.38E-06
RA-226	3.06E-10	3.06E-10
PB-210	1.19E-12	1.19E-12
AC-227		
AC-227	1.06E-04	1.06E-04
RA-228		
TH-228	1.40E-06	1.40E-06
RA-228	6.04E-07	6.04E-07
RA-226		
RA-226	1.41E-06	1.41E-06
PB-210	8.25E-09	8.25E-09

Derivation of Site-Specific DCGLs for North County Structures

** RESRAD-BUILD Program Output, Version 3.1 05/27/03 14:52 Page: 20 **
Title : NC Building Occupancy-All Radionuclides
Input File : C:\Winbld\NCBDOccupancyAllRad.bld
Evaluation Time: 0.000000 years

Source: 5

Nuclide	Receptor	Total
	1	
U-238		
U-238	1.97E-06	1.97E-06
U-234	3.08E-12	3.08E-12
TH-230	2.28E-17	2.28E-17
RA-226	5.81E-22	5.81E-22
PB-210	0.00E+00	0.00E+00
U-235		
U-235	2.13E-06	2.13E-06
PA-231	2.25E-10	2.25E-10
AC-227	1.19E-11	1.19E-11
U-234		
U-234	2.18E-06	2.18E-06
TH-230	2.42E-11	2.42E-11
RA-226	9.16E-16	9.16E-16
PB-210	2.68E-18	2.68E-18
PA-231		
PA-231	2.13E-05	2.13E-05
AC-227	1.69E-06	1.69E-06
TH-232		
TH-232	2.70E-05	2.70E-05
TH-228	5.82E-08	5.82E-08
RA-228	3.70E-08	3.70E-08
TH-230		
TH-230	5.38E-06	5.38E-06
RA-226	3.06E-10	3.06E-10
PB-210	1.19E-12	1.19E-12
AC-227		
AC-227	1.06E-04	1.06E-04
RA-228		
TH-228	1.40E-06	1.40E-06
RA-228	6.04E-07	6.04E-07
RA-226		
RA-226	1.41E-06	1.41E-06
PB-210	8.25E-09	8.25E-09

Derivation of Site-Specific DCGLs for North County Structures

** RESRAD-BUILD Program Output, Version 3.1 05/27/03 14:52 Page: 22 **
Title : NC Building Occupancy-All Radionuclides
Input File : C:\Winbld\NCBDOccupancyAllRad.bld
Evaluation Time: 1.00000 years

Source: 2

Location:: Room : 1 x: 5.00 y: 10.00 z: 1.00 [m]
Geometry:: Type: Area Area:2.00E+01 [m2] Direction: y
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 7.000E-02
Removable fraction: 1.941E-01
Time to Remove: 1.000E+04 [day]

Contamination::	Nuclide	Concentration [pCi/m2]
	U-238	9.927E-01
	U-235	9.927E-01
	U-234	9.927E-01
	PA-231	9.927E-01
	TH-232	9.927E-01
	TH-230	9.927E-01
	TH-228	3.017E-01
	AC-227	9.927E-01
	RA-228	9.927E-01
	RA-226	9.927E-01
	PB-210	3.038E-02

Derivation of Site-Specific DCGLs for North County Structures

** RESRAD-BUILD Program Output, Version 3.1 05/27/03 14:52 Page: 23 **
Title : NC Building Occupancy-All Radionuclides
Input File : C:\Winbld\NCBDOccupancyAllRad.bld
Evaluation Time: 1.00000 years

Source: 3

Location:: Room : 1 x: 10.00 y: 5.00 z: 1.00 [m]
Geometry:: Type: Area Area:2.00E+01 [m2] Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 7.000E-02
Removable fraction: 1.941E-01
Time to Remove: 1.000E+04 [day]

Contamination::	Nuclide	Concentration [pCi/m2]
	U-238	9.927E-01
	U-235	9.927E-01
	U-234	9.927E-01
	PA-231	9.927E-01
	TH-232	9.927E-01
	TH-230	9.927E-01
	TH-228	3.017E-01
	AC-227	9.927E-01
	RA-228	9.927E-01
	RA-226	9.927E-01
	PB-210	3.038E-02

Derivation of Site-Specific DCGLs for North County Structures

** RESRAD-BUILD Program Output, Version 3.1 05/27/03 14:52 Page: 24 **
Title : NC Building Occupancy-All Radionuclides
Input File : C:\Winbld\NCBDOccupancyAllRad.bld
Evaluation Time: 1.00000 years

Source: 4

Location:: Room : 1 x: 0.00 y: 5.00 z: 1.00 [m]
Geometry:: Type: Area Area:2.00E+01 [m2] Direction: x
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 7.000E-02
Removable fraction: 1.941E-01
Time to Remove: 1.000E+04 [day]

Contamination::	Nuclide	Concentration [pCi/m2]
	U-238	9.927E-01
	U-235	9.927E-01
	U-234	9.927E-01
	PA-231	9.927E-01
	TH-232	9.927E-01
	TH-230	9.927E-01
	TH-228	3.017E-01
	AC-227	9.927E-01
	RA-228	9.927E-01
	RA-226	9.927E-01
	PB-210	3.038E-02

Derivation of Site-Specific DCGLs for North County Structures

** RESRAD-BUILD Program Output, Version 3.1 05/27/03 14:52 Page: 25 **
Title : NC Building Occupancy-All Radionuclides
Input File : C:\Winbld\NCBDOccupancyAllRad.bld
Evaluation Time: 1.00000 years

Source: 5

Location:: Room : 1 x: 5.00 y: 0.00 z: 1.00 [m]
Geometry:: Type: Area Area:2.00E+01 [m2] Direction: y
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 7.000E-02
Removable fraction: 1.941E-01
Time to Remove: 1.000E+04 [day]

Contamination::	Nuclide	Concentration [pCi/m2]
	U-238	9.927E-01
	U-235	9.927E-01
	U-234	9.927E-01
	PA-231	9.927E-01
	TH-232	9.927E-01
	TH-230	9.927E-01
	TH-228	3.017E-01
	AC-227	9.927E-01
	RA-228	9.927E-01
	RA-226	9.927E-01
	PB-210	3.038E-02

Derivation of Site-Specific DCGLs for North County Structures

** RESRAD-BUILD Program Output, Version 3.1 05/27/03 14:52 Page: 26 **
Title : NC Building Occupancy-All Radionuclides
Input File : C:\Winbld\NCBDOccupancyAllRad.bld
Evaluation Time: 1.00000 years

RESRAD-BUILD Dose Tables

Source Contributions to Receptor Doses

[mrem]

	Source	Source	Source	Source	Source	Total
	1	2	3	4	5	
Receptor 1	8.88E-04	1.73E-04	1.73E-04	1.73E-04	1.73E-04	1.58E-03
Total	8.88E-04	1.73E-04	1.73E-04	1.73E-04	1.73E-04	1.58E-03

Derivation of Site-Specific DCGLs for North County Structures

** RESRAD-BUILD Program Output, Version 3.1 05/27/03 14:52 Page: 27 **

Title : NC Building Occupancy-All Radionuclides

Input File : C:\Winbld\NCBDOccupancyAllRad.bld

Evaluation Time: 1.00000 years

Pathway Detail of Doses

[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	3.35E-05	1.82E-08	1.44E-10	8.41E-04	1.01E-05	3.77E-06
Total	3.35E-05	1.82E-08	1.44E-10	8.41E-04	1.01E-05	3.77E-06

Source: 2

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.17E-06	3.64E-09	2.88E-11	1.68E-04	2.01E-06	7.54E-07
Total	2.17E-06	3.64E-09	2.88E-11	1.68E-04	2.01E-06	7.54E-07

Source: 3

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.17E-06	3.64E-09	2.88E-11	1.68E-04	2.01E-06	7.54E-07
Total	2.17E-06	3.64E-09	2.88E-11	1.68E-04	2.01E-06	7.54E-07

Source: 4

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.17E-06	3.64E-09	2.88E-11	1.68E-04	2.01E-06	7.54E-07
Total	2.17E-06	3.64E-09	2.88E-11	1.68E-04	2.01E-06	7.54E-07

Source: 5

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.17E-06	3.64E-09	2.88E-11	1.68E-04	2.01E-06	7.54E-07
Total	2.17E-06	3.64E-09	2.88E-11	1.68E-04	2.01E-06	7.54E-07

Derivation of Site-Specific DCGLs for North County Structures

** RESRAD-BUILD Program Output, Version 3.1 05/27/03 14:52 Page: 28 **
Title : NC Building Occupancy-All Radionuclides
Input File : C:\Winbld\NCBDOccupancyAllRad.bld
Evaluation Time: 1.00000 years

Nuclide Detail of Doses

[mrem]

Source: 1

Nuclide	Receptor	Total
	1	
U-238		
U-238	1.00E-05	1.00E-05
U-234	4.64E-11	4.64E-11
TH-230	8.00E-16	8.00E-16
RA-226	1.17E-19	1.17E-19
PB-210	4.25E-23	4.25E-23
U-235		
U-235	1.17E-05	1.17E-05
PA-231	3.39E-09	3.39E-09
AC-227	4.16E-10	4.16E-10
U-234		
U-234	1.09E-05	1.09E-05
TH-230	3.63E-10	3.63E-10
RA-226	7.66E-14	7.66E-14
PB-210	2.03E-16	2.03E-16
PA-231		
PA-231	1.07E-04	1.07E-04
AC-227	2.51E-05	2.51E-05
TH-232		
TH-232	1.35E-04	1.35E-04
TH-228	2.11E-06	2.11E-06
RA-228	1.44E-06	1.44E-06
TH-230		
TH-230	2.69E-05	2.69E-05
RA-226	1.09E-08	1.09E-08
PB-210	4.20E-11	4.20E-11
AC-227		
AC-227	5.14E-04	5.14E-04
RA-228		
TH-228	2.00E-05	2.00E-05
RA-228	7.31E-06	7.31E-06
RA-226		
RA-226	1.69E-05	1.69E-05
PB-210	1.24E-07	1.24E-07

Derivation of Site-Specific DCGLs for North County Structures

** RESRAD-BUILD Program Output, Version 3.1 05/27/03 14:52 Page: 29 **
Title : NC Building Occupancy-All Radionuclides
Input File : C:\Winbld\NCBDOccupancyAllRad.bld
Evaluation Time: 1.00000 years

Source: 2

Nuclide	Receptor	Total
	1	
U-238		
U-238	1.97E-06	1.97E-06
U-234	9.26E-12	9.26E-12
TH-230	1.60E-16	1.60E-16
RA-226	9.75E-21	9.75E-21
PB-210	8.38E-24	8.38E-24
U-235		
U-235	2.13E-06	2.13E-06
PA-231	6.77E-10	6.77E-10
AC-227	8.28E-11	8.28E-11
U-234		
U-234	2.18E-06	2.18E-06
TH-230	7.26E-11	7.26E-11
RA-226	6.38E-15	6.38E-15
PB-210	4.01E-17	4.01E-17
PA-231		
PA-231	2.13E-05	2.13E-05
AC-227	4.99E-06	4.99E-06
TH-232		
TH-232	2.70E-05	2.70E-05
TH-228	3.56E-07	3.56E-07
RA-228	1.05E-07	1.05E-07
TH-230		
TH-230	5.38E-06	5.38E-06
RA-226	9.12E-10	9.12E-10
PB-210	8.28E-12	8.28E-12
AC-227		
AC-227	1.02E-04	1.02E-04
RA-228		
TH-228	3.38E-06	3.38E-06
RA-228	5.32E-07	5.32E-07
RA-226		
RA-226	1.40E-06	1.40E-06
PB-210	2.44E-08	2.44E-08

Derivation of Site-Specific DCGLs for North County Structures

** RESRAD-BUILD Program Output, Version 3.1 05/27/03 14:52 Page: 30 **
Title : NC Building Occupancy-All Radionuclides
Input File : C:\Winbld\NCBDOccupancyAllRad.bld
Evaluation Time: 1.00000 years

Source: 3

Nuclide	Receptor	Total
	1	
U-238		
U-238	1.97E-06	1.97E-06
U-234	9.26E-12	9.26E-12
TH-230	1.60E-16	1.60E-16
RA-226	9.75E-21	9.75E-21
PB-210	8.38E-24	8.38E-24
U-235		
U-235	2.13E-06	2.13E-06
PA-231	6.77E-10	6.77E-10
AC-227	8.28E-11	8.28E-11
U-234		
U-234	2.18E-06	2.18E-06
TH-230	7.26E-11	7.26E-11
RA-226	6.38E-15	6.38E-15
PB-210	4.01E-17	4.01E-17
PA-231		
PA-231	2.13E-05	2.13E-05
AC-227	4.99E-06	4.99E-06
TH-232		
TH-232	2.70E-05	2.70E-05
TH-228	3.56E-07	3.56E-07
RA-228	1.05E-07	1.05E-07
TH-230		
TH-230	5.38E-06	5.38E-06
RA-226	9.12E-10	9.12E-10
PB-210	8.28E-12	8.28E-12
AC-227		
AC-227	1.02E-04	1.02E-04
RA-228		
TH-228	3.38E-06	3.38E-06
RA-228	5.32E-07	5.32E-07
RA-226		
RA-226	1.40E-06	1.40E-06
PB-210	2.44E-08	2.44E-08

Derivation of Site-Specific DCGLs for North County Structures

** RESRAD-BUILD Program Output, Version 3.1 05/27/03 14:52 Page: 31 **
Title : NC Building Occupancy-All Radionuclides
Input File : C:\Winbld\NCBDOccupancyAllRad.bld
Evaluation Time: 1.00000 years

Source: 4

Nuclide	Receptor	Total
	1	
U-238		
U-238	1.97E-06	1.97E-06
U-234	9.26E-12	9.26E-12
TH-230	1.60E-16	1.60E-16
RA-226	9.75E-21	9.75E-21
PB-210	8.38E-24	8.38E-24
U-235		
U-235	2.13E-06	2.13E-06
PA-231	6.77E-10	6.77E-10
AC-227	8.28E-11	8.28E-11
U-234		
U-234	2.18E-06	2.18E-06
TH-230	7.26E-11	7.26E-11
RA-226	6.38E-15	6.38E-15
PB-210	4.01E-17	4.01E-17
PA-231		
PA-231	2.13E-05	2.13E-05
AC-227	4.99E-06	4.99E-06
TH-232		
TH-232	2.70E-05	2.70E-05
TH-228	3.56E-07	3.56E-07
RA-228	1.05E-07	1.05E-07
TH-230		
TH-230	5.38E-06	5.38E-06
RA-226	9.12E-10	9.12E-10
PB-210	8.28E-12	8.28E-12
AC-227		
AC-227	1.02E-04	1.02E-04
RA-228		
TH-228	3.38E-06	3.38E-06
RA-228	5.32E-07	5.32E-07
RA-226		
RA-226	1.40E-06	1.40E-06
PB-210	2.44E-08	2.44E-08

Derivation of Site-Specific DCGLs for North County Structures

** RESRAD-BUILD Program Output, Version 3.1 05/27/03 14:52 Page: 32 **
Title : NC Building Occupancy-All Radionuclides
Input File : C:\Winbld\NCBDOccupancyAllRad.bld
Evaluation Time: 1.00000 years

Source: 5

Nuclide	Receptor	Total
	1	
U-238		
U-238	1.97E-06	1.97E-06
U-234	9.26E-12	9.26E-12
TH-230	1.60E-16	1.60E-16
RA-226	9.75E-21	9.75E-21
PB-210	8.38E-24	8.38E-24
U-235		
U-235	2.13E-06	2.13E-06
PA-231	6.77E-10	6.77E-10
AC-227	8.28E-11	8.28E-11
U-234		
U-234	2.18E-06	2.18E-06
TH-230	7.26E-11	7.26E-11
RA-226	6.38E-15	6.38E-15
PB-210	4.01E-17	4.01E-17
PA-231		
PA-231	2.13E-05	2.13E-05
AC-227	4.99E-06	4.99E-06
TH-232		
TH-232	2.70E-05	2.70E-05
TH-228	3.56E-07	3.56E-07
RA-228	1.05E-07	1.05E-07
TH-230		
TH-230	5.38E-06	5.38E-06
RA-226	9.12E-10	9.12E-10
PB-210	8.28E-12	8.28E-12
AC-227		
AC-227	1.02E-04	1.02E-04
RA-228		
TH-228	3.38E-06	3.38E-06
RA-228	5.32E-07	5.32E-07
RA-226		
RA-226	1.40E-06	1.40E-06
PB-210	2.44E-08	2.44E-08

