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DERIVED CONCENTRATION GUIDELINE LEVEL (DCGL) DEVELOPMENT FOR RADIOLOGICAL SURVEYS CONDUCTED IN CLASS I BUILDINGS AT SEAD-12

SENECA ARMY DEPOT ACTIVITY, ROMULUS, NY

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1.0 INTRODUCTION

This preliminary report addresses the establishment of the action levels that will be used to determine whether unrestricted release criteria have been achieved in the Class I buildings at SEAD-12 at the Seneca Army Depot Activity in Romulus, NY. A list of the buildings and a brief historical description of each is provided in **Table 1**. The Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM, 1997) process was used to calculate the derived concentration guideline level (DCGL). The process consists of the following steps:

- Classifying each room based on the risk for residual radioactivity,
- Dividing the site into survey units,
- Determining DCGL values for small areas of elevated activity based on area factors ($DCGL_{EMC}$)
- Calculating radionuclide-specific DCGLs for uniform contamination at each survey unit ($DCGL_W$),
- Determining the number of measurements required to statistically demonstrate that each survey unit is less than the minimum DCGL,
- Verify that sampling grid size based on the size of the survey unit and the required number of measurements is adequate.

The DCGLs calculated will be used to determine if uniform contamination exists in any of the rooms of the buildings of SEAD-12 or if there are small areas of elevated activity. Table 4-3 of the SEAD-12 Project Scoping Plan references Table 5 of Part 38, Section 12 of the New York Code of Rules and Regulations (NYCRR) as preliminary guidelines for this survey. However, upon further discussion with NYSDOH, these guidelines were found to be inapplicable (refer to meeting minutes from November 17CK, 1999). Instead, the DCGL values referred to above will be modeled based on an acceptable dose equivalent exposure. The NYSDEC TAGM of 10 mrem/yr was used for this purpose.

2.0 RADIOLOGICAL BUILDING SURVEYS

This section provides background on the radiological building surveys being conducted at SEAD-12. Section 4.2.3 of the SEAD-12 Project Scoping Plan (Parsons ES, 1998) describes the radiological surveys to be conducted at SEAD-12. These surveys consist of both grounds and building surveys. The radiological surveys in the buildings are currently being conducted and are the subject of this preliminary report. These surveys consist of the following types of measurements:

- Alpha, beta and gamma scanning measurements as described in Section 4.2.3.1 of the Project Scoping Plan,
- Alpha, beta, and gamma direct measurements collected at the nodes of an established grid as described in Section 4.2.3.2 of the Project Scoping Plan,
- Exposure rate measurements as described in Section 4.2.3.3 of the Project Scoping Plan,
- Removable radiation surveys (consisting of gross alpha, beta, gamma, and tritium smears) as described in Section 4.2.3.4 of the Project Scoping Plan, and
- Material samples to be collected at a frequency of 1 per 1000 sq.ft. of building floor area or where necessary to further investigate elevated levels of radioactivity that may be fixed rather than removable.

Scanning measurements will be used to determine if small areas of elevated levels of activity exist anywhere in the buildings. Such results will be compared to the $DCGL_{EMC}$ to determine if such areas exist. This comparison is described in Section 8.2.5 of MARSSIM.

Direct measurements will be grouped as a data set per room and statistically compared to direct measurements collected from a reference area. $DCGL_W$ values derived will be added to the background dataset to determine if direct measurements from a Class 1 room exceed the allowable exposure over background. Section 8.4 of MARSSIM describes the data comparison to $DCGL_W$ values.

Exposure rate measurements are used primarily to monitor the health and safety of the survey crew and as a diagnostic tool in finding areas of elevated activity.

Smear data will also be used for diagnostic purposes to determine if elevated levels of removable activity are present. Smears are the only type of data collected to test for the presence of tritium (radiological instruments used during the survey will not detect the presence of tritium).

Material samples will be used to verify that elevated fixed contamination is not present or that where there are elevated levels, which radionuclide is the source of the activity.

3.0 ROOM CLASSIFICATIONS AND SURVEY UNITS

Based on the historical information, individual rooms within buildings under investigation at SEAD-12 were divided into impacted and non-impacted areas based on the criteria identified in MARSSIM. Non-impacted areas have no reasonable potential for residual contamination and therefore were not included in the survey effort expect to establish background levels. Impacted areas are areas that have some potential for containing contaminated material and are further subdivided into the following three MARSSIM defined classes based on the potential for residual contamination.

- Class 1 areas: Areas that have, or had prior to remediation, a potential for radioactive contamination (based on site operating history) or known contamination (based on previous radiological surveys). Examples of Class 1 areas include: 1) site areas previously subjected to remedial actions, 2) locations where leaks or spills are known to have occurred, 3) former burial or disposal sites, 4) waste storage sites, and 5) areas with contaminants in discrete solid pieces of material high specific activity. Note that areas containing contamination in excess of the derived concentration guideline level (DCGL) prior to remediation should be classified as Class 1 areas.
- Class 2 areas: These areas have, or had prior to remediation, a potential for radioactive contamination or known contamination, but are not expected to exceed the DCGL. To justify changing an area's classification from Class 1 to Class 2, the existing data (from the historical assessment, scoping surveys, or characterization surveys) should provide a high degree of confidence that no individual measurement would exceed the DCGL. Other justifications for this change in an area's classification may be appropriate based on the outcome of the data quality objective (DQO) process. Examples of areas that might be classified as Class 2 for the final status survey include: 1) locations where radioactive materials were present in an unsealed form (e.g., process facilities), 2) potentially contaminated transport routes, 3) areas downwind from stack release points, 4) upper walls and ceilings of some buildings or rooms subjected to airborne radioactivity, 5) areas where low concentrations of radioactive materials were handled, and 6) areas on the perimeter of former contamination control areas.

- Class 3 areas: Any impacted areas that are not expected to contain any residual radioactivity, or are expected to contain levels of residual radioactivity at a small fraction of the DCGL, based on site operating history and previous radiological surveys. Examples of areas that might be classified as Class 3 include buffer zones around Class 1 or Class 2 areas, and areas with very low potential for residual contamination but insufficient information to justify a non-impacted classification.

The scope of the current survey is restricted to Class 1 areas; therefore, the survey areas considered in this report were Class 1 areas. DCGLs for Class 2 and Class 3 areas will be developed before those areas are surveyed.

In order to model dose and calculate DCGL values, each room within a building was considered as one survey unit, regardless of number of rooms. This was discussed and agreed upon with NYSDOH. Room size, height, and construction materials were also considered in defining the survey units. The Class 1 buildings were presented in **Table 1**. The number of rooms is listed in **Table 2.**

4.0 DCGL DEVELOPMENT

This section describes the development of $DCGL_W$ values. The $DCGL_W$ is described as the concentration of residual radioactivity distinguishable from background that, if distributed uniformly throughout a survey unit, would result in a total effective dose equivalent (TEDE) of 10 millirem per year (NYSDEC TAGM) to an average member of the critical group. The $DCGL_W$ values were estimated by assuming uniform contamination in a room. This was simulated in RESRAD-Build by if the entire floor area is the size of the source. As described in MARSSIM, an independent modeling procedure was used to calculate the radionuclide-specific DCGLs for each survey unit. RESRAD-Build was determined to be the most appropriate model for establishing the DCGLs at Seneca Army Depot and is described further in below. The $DCGL_W$ will be added to direct measurements made in the background dataset and this new dataset will then be compared to direct measurements from a survey unit using Wilcoxen Rank Sum test (hence, the "W" in $DCGL_W$). This will be performed in accordance with the procedures outlined in Section 8 of MARSSIM.

In addition to $DCGL_W$, and in accordance with MARSSIM, $DCGL_{EMC}$ values area also developed so that the grid spacing at which the direct measurements are collected is sufficiently small to ensure that "hot-spot" contamination is not overlooked. The $DCGL_{EMC}$ values will be used to compare with instrument scanning minimum detectable concentrations (MDCs) as required by MARSSIM to ensure that the instruments are sensitive enough to see any hot spot contamination. The $DCGL_{EMC}$ values were estimated by assuming the source size in RESRAD-Build is the size of the grid. This is numerically equivalent to the area factor procedure outlined in Section 5.5.2 of MARSSIM.

4.1 RESRAD-Build Input Parameters

The computer code RESRAD-Build, version 2.37 was used by Parsons ES to model residential and worker exposure scenarios for determining surface activity action levels (e.g., derived concentration guideline levels) for the unrestricted occupancy of buildings at Seneca Army Depot. Though it is unlikely that the survey areas will be used for residential occupancy, a residential scenario was evaluated to determine the worst-case DCGLs. As discussed within ANL/EAD/LD-3, *RESRAD-Build: A Computer Model for Analyzing the Radiological Doses Resulting from the Remediation and Occupancy of Buildings Contaminated with Radioactive Material*, the RESRAD-Build computer code is a pathway analysis model designed to evaluate the potential radiological dose incurred by an individual that works or lives in a building contaminated with radioactive material.

The model calculates the transport of radioactive material inside a building from one compartment to another with an indoor air quality model. The model considers the transport of radioactive dust particles and radon progeny due to air exchange, deposition and resuspension, and radioactive decay and in-growth. Shielding material can be specified for each receptor/source scenario for the external gamma dose calculations. Six exposure pathways are possible in the RESRAD-Build model: (1) external exposure directly from the source, (2) external exposure to materials deposited on the floor, (3) external exposure due to air submersion, (4) inhalation of airborne radioactive particulates, (5) inhalation of aerosol indoor radon progeny, and (6) inadvertent ingestion of radioactive material, either directly or from materials deposited on building surfaces.

RESRAD-Build requires 25 input parameters for the model set-up. The input parameters describe the building, receptor, and source specifications within five categories: exposure time, building specifications, receptor characteristics, shielding specifications, and source parameters. Parsons ES utilized site-specific data where available. Where no site-specific data was available, standard default values or conservative assumptions were used. The modeling effort included evaluation of a residential and worker occupation scenario. Input parameters are detailed in **Table 3**. These input variables and parameters, including any variation between the inputs for the two exposure scenarios are described below.

4.1.1 Building Parameters

RESRAD-Build allows up to three connected rooms to be modeled together and takes airflow between rooms and airflow out of the building into consideration. A one room, one receptor scenario was used to calculate dose in all buildings. The source and receptor are located in the center of the room for each survey unit. No air exchange occurs when the isotopes are isolated in one room with the receptor; therefore, the total activity of the isotopes remains in the one room. By modeling one receptor located at the same location as the source, the largest possible dose is calculated resulting in the most conservative DCGL value.

The largest, smallest and average room size were used in the model runs (as indicated in **Table 2**) for developing the DCGLs. For each room size (a total of three), the model was run assuming source sizes of 1m x 1m and 2m x 2m based on the grid sizes (established in Section 4.2.3 of the SEAD-12 Project Scoping Plan) in these rooms (for a total of 6 model runs). These room sizes for the given grid sizes would capture the range of DCGLs expected for all the survey units. The most conservative $DCGL_{EMC}$ resulting from the six model runs is used to compare with the minimum detectable activities (MDAs).

4.1.2 Source Parameters

RESRAD-Build is able to model four source types, which include area, point, line, and volume sources. An area contamination spread uniformly throughout the survey unit was used in the model in accordance with MARSSIM requirements. The source was located at floor level, and the contamination was assumed to be 50 percent removable, which is the default assumption for the model. The time of source removal is 365 days.

DCGLw values were estimated for all the isotopes of concern listed in the SEAD-12 Project Scoping Plan and shown in **Table 1** (Co-57, Co-60, Cs-137, H-3, Pm-147, Pu-239/240, Ra-226, Th-230, U-235, U-238, Am-241).

$DCGL_{EMC}$ values were estimated for Th-230, Am-241, Tc-99, and Cs-137 because $DCGL_{EMC}$ values are used only to compare with the scanning MDA. As discussed in **Section 5** below, field

instrument MDAs are estimated based on these selected isotopes since these were the sources available for instrument source checks. Furthermore, these isotopes capture the highest alpha, beta, and gamma energies among the isotopes of concern listed in **Table 1**. Field instrument calibration curves were also developed. For completeness, model runs for all the isotopes of concern will be included in the closure report.

4.1.3 Evaluation Time

RESRAD-Build calculates dose per receptor at user-specified time intervals beginning with an initial exposure time of zero years. At time zero, an arbitrary initial activity of 1.0E+06 pCi per m^2 was entered for all isotopes of concern listed in the work plan. At each successive time interval, new activities and associated doses were calculated for each isotope. For the purpose of modeling, evaluation times of 20, 40, 60, 80, and 100 years were chosen, which equates to an estimated building life of 100 years.

4.1.4 Receptor Parameters

An exposure duration of 350 days was used to incorporate a full year (with two weeks vacation) of exposure. This duration creates a "worst-case" residential exposure scenario. The resident is also assumed to spend 16 hours a day indoors. This assumption produces a higher dose resulting in a lower, conservative DCGL value. The receptor was located in the center of the modeled room at the same point as the source.

A worker scenario is also estimated to provide a more realistic estimate of DCGLs. An exposure duration of 200 days a year and an indoor time of 8 hours a day is assumed for the worker scenario.

The receptor is assumed to have a breathing rate of 18 m^3 per day which is representative of a residential scenario. The fraction of the source released into air was set at the model default value of 1E-6 based on NUREG 5512 guidance on resuspension factors. The direct ingestion of the source was not included in the model.

4.1.5 Shielding Parameters

The exposure scenario included only one room and assumed that shielding between the receptor and the source was not provided (i.e. zero thickness of concrete).

4.2 RESRAD-Build Modeling Results

The initial starting activity level for each radionuclide was assumed to be 1E+6 pCi/m^2. A relatively large source activity was used, so that the resulting dose would be greater than zero (RESRAD-Build assigns a zero value to dose values less than 1 mrem). DCGLs are independent of the source activity used. With this initial starting concentration, a resulting radionuclide-specific dose for each receptor over the exposure duration of 100 years was calculated using RESRAD-Build. The activity and resulting doses of each isotope were compiled into an Excel® spreadsheet to determine a threshold activity that would produce a total effective dose equivalent (TEDE) of 10 millirem per year per the following equation.

$$Activity_n = \frac{TEDE * Activity_{ini}}{Dose_{ini}}$$

Where:

- *TEDE* = total effective dose equivalent. This is equal to 10 mrem/yr (NYSDEC TAGM).
- $Activity_n$ is the activity necessary to achieve the TEDE (10 mrem per year) in units of pCi/m^2.
- $Activity_{nt}$ is the RESRAD modeled activity in pCi/m^2 for the parent isotope at the specified time interval t (1E+6 pCi/m^2 at t=0), and
- $Dose_{nt}$ is the total dose (in mrem) calculated by RESRAD-Build for the parent and daughter isotopes at time interval t.

The lowest calculated radionuclide-specific threshold activity ($Activity_n$) over the 100 year exposure period was established as the DCGL. The activity is then converted to dpm/100 cm^2 using the following equation.

$$DCGL = \frac{(Activity_n * 2.22\ dpm - m^2 / pCi)}{100\ cm^2}$$

Because of the number of conservative estimates and the unknown nature of contamination, the sum of fractions rule is not applied to derive the DCGL values.

The RESRAD-Build calculated DCGLw and $DCGL_{EMC}$ for each survey unit are presented in **Tables 4 and 5**, respectively. The most conservative $DCGL_w$ values for Co-60 and Cs-137 estimated by site-specific modeling and presented in this report are 3,400 and 14,000 dpm/100 cm^2, respectively. For comparison purposes, screening level $DCGL_w$ values for Co-60 and Cs-137 published in 63FR64132 (November 1998) are 2,800 and 11,000 dpm/100 cm^2, respectively, after adjusting the values for a TEDE of 10 mrem/year.

As shown in **Table 4,** the most conservative $DCGL_W$ values were obtained in the 12m x 12m x 5m room under the residential scenario, with the exception of Pu-239 and tritium. As shown in **Table 5,** the most conservative results $DCGL_{EMC}$ values were obtained with a 4 m^2 (2 x 2 m grid) in a 2m x 2m x 4m room under a residential scenario.

A sample RESRAD-Build output is provided in the Attachment to this report.

5.0 MINIMUM DETECTABLE ACTIVITIES (MDA) FOR FIELD INSTRUMENTS

Radionuclide-specific MDAs were calculated for each field instrument following the protocols identified in Section 6 of MARSSIM. The MDAs are dependent on the background radiation levels, instrument type, instrument efficiency, effective area of the detector, survey technique (i.e., static or scanning), geometry, mode of instrument operation (i.e., rate meter or scalar), and the time period over which the measurement was taken. The estimated radionuclide-specific MDAs calculated for each meter used for scanning measurements are provided in **Table 6**. The specific methodology used to estimate the MDAs for scanning and direct measurements is described in the following subsections.

5.1 Scanning Measurements

The scanning MDAs for all the instruments were calculated using the average background levels from the daily operational checks and radionuclide-specific efficiencies identified in **Table 6**. Additional instrument parameters required to estimate these efficiencies are also provided in **Table 6**. Scanning MDAs were estimated based on MARSSIM Eqns. 6-8, 6-9 and 6-10. The following MDA assumes a 95% detection of MDA_{scan} with a false positive rate of 60% as recommended in DG-4006 (NRC, 1998).

$$MDA_{scan} = \frac{60 * 1.38\sqrt{B * t}}{\sqrt{p}E_d E_s \frac{A}{100cm^2}}$$

MDA	=	Minimum detectable activity in dpm per 100 cm^2
B_R	=	Background rate in cpm
P	=	surveyor efficiency (0.5, MARSSIM)
t	=	Scan observation interval in minutes (0.03 mins, MARSSIM)
E_s	=	Source efficiency in counts per disintegration (0.5, MARSSIM)
E_d	=	Detector efficiency in counts per disintegration
A	=	Active probe area in cm^2

An observation interval is the time the source is under the probe during scanning. This is conservatively assumed at 2 seconds (0.03 minutes) per MARSSIM guidance.

5.2 Direct Measurements

The MDAs for direct measurements were also estimated using MARSSIM guidance provided in Eq. 6-7 and the subsequent example.

$$MDA = \frac{3 + 4.65\sqrt{B_R * t}}{t * E * \frac{A}{100}} \quad (4)$$

where,

MDA	=	Minimum detectable activity in dpm per 100 cm^2
B_R	=	Background rate in cpm
t	=	Counting time in minutes (1 minute)
E	=	Detector efficiency in counts per disintegration
A	=	Active probe area in cm^2

The static surface measurements were taken with the rate meter in the "slow" mode.

6.0 COMPARISON OF DCGL TO FIELD INSTRUMENT COUNTS

This section describes the comparison of instrument MDAs and instrument counts per minute (cpms) to DCGLs per the MARSSIM guidance.

6.1 Comparison of MDAs to DCGLs

Scanning measurements are conducted to assess the potential presence of localized contamination (i.e., "hot-spots") and direct measurements are conducted to detect average contamination in a survey area. The calculated scanning and static MDAs were compared to $DCGL_W$ and $DCGL_{EMC}$ values, respectively, to ensure that the field scanning instruments would be sensitive enough to detect localized contamination. The comparison is presented in **Table 7**. All of the scanning MDAs are less than 10% of the corresponding $DCGL_{EMC}$ values (**Table 6**).

The static surface measurements are used to assess compliance with the $DCGL_W$ to demonstrate that uniform contamination in excess of background levels would not contribute to a dose greater than 10 mrem per year. All of the MDAs are less than 10% of the corresponding DCGL value. It should be noted that the scanning MDAs are less than the $DCGL_W$ values as well. Thus, it can be concluded that by collecting both scanning and static measurements, any residual radioactivity in the buildings in excess of the $DCGL_W$ and $DCGL_{EMC}$ values will be adequately detected.

6.2 Instrument Count Rate Corresponding to DCGLs – Flag Values

A flag value was established for each type of field instrument based on the DCGLs calculated in **Section 4**. First, DCGL values were converted to instrument counts per minute (cpm) units. The minimum calculated count rate that is equal to the $DCGL_W$ value in cpm was established as the flag value above background for each type of instrument. The flag values are based on the following equation from MARSSIM:

$$\text{Instrument CPM} = \frac{A \times E \times DCGL}{100}$$

where,

DCGL = Derived concentration guideline limit in dpm per 100 cm^2
E = Detector efficiency in counts per disintegration
A = Active probe area in cm^2

The field flag values were based on the most conservative $DCGL_W$ values and are presented in **Table 8**. In order to maintain the as low as reasonably achievable (ALARA) principles, the instrument readings reported in **Table 8** that are based on the most conservative $DCGL_W$ values are used as "hot-spot" flag values in the field. These flag values are used in the field to indicate whether further investigation in a particular area may be necessary. When scanning or direct measurements exceed a flag value, additional investigation will be performed to verify if contamination exists and identify isotopes of concern. The additional investigation may involve comparing survey data to a survey area-specific DCGLS, additional surveying, smear or material sampling. Flag values are not used to determine if the building may satisfy unrestricted release criteria. Unrestricted release of the buildings will be determined using the MARSSIM methods referenced in **Section 2** of this report as well as the DCGLs derived in this report.

7.0 GRID SPACING

Per MARSSIM requirements, the $DCGL_{EMC}$ values were compared against scanning instrument MDAs to ensure that no hot-spots were overlooked. The calculated scanning MDAs based on building survey results are presented in **Table** 7. The scanning instrument MDAs are all less than the corresponding $DCGL_{EMC}$ value. As such, additional data points or smaller sampling grids than those proposed in the SEAD-12 Project Scoping Plan are not required.

8.0 REFERENCES

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NRC, 1998, *Draft Regulatory Guide, Demonstrating Compliance With The Radiological Criteria for License Termination,* ***Residual Radioactive Contamination from Decommissioning*** , DG-4006, August, 1998.

Parsons ES, 1998. *Project Scoping Plan for Performing a CERCLA RI/FS at SEAD-12.* June 1998.

TABLES

Table 1
Seneca Army Depot Activity
Survey Unit Classification for Class 1 Buildings

Class One Survey Units	Rational For Classification	Radionuclides of Concern
ding 803	Used to store containerized radioactive waste and military items containing radionuclides.	Pu-239, U-238, U-235, Ra-226, Co-60, C
ding 804	Used to perform maintenance on military items that contained radionuclides.	Pu-239, U-238, U-235, Ra-226, H-3
ding 805	Used as a stores room for Building 804.	Pu-239, U-238, U-235, Ra-226, H-3
Room of Building 815 and areas of adjoining rooms to a nce of 2 meters from the access point to the Hot Room.	Used to perform maintainance on military items that contained radionuclides. Uranium bearing alloys were exposed to ambient air	Pu-239, U-238, U-235, Ra-226, Pm-147,
Room of Building 816 and areas of adjoining rooms to a nce of 2 meters from the access point of the Hot Room.	Used to perform maintainance on military items that contained radionuclides. Uranium bearing alloys were exposed to ambient air.	Pu-239, U-238, U-235, Ra-226, Pm-147,
ding 819	Used to perform quality assurance testing on military items that contained radionuclides.	Pu-239, U-238, U-235, Ra-226, Co-60, H

TABLE 2
SURVEY UNIT DIMENSIONS
AND CLASSIFICATIONS

Building	Number of Rooms	Max Room (m)	Min Room (m)	Other Room (m)	Class
803	5	3 x 4 x 6	3 x 4 x 6	3 x 4 x 6	1
804	6	7 x 6 x 5	2 x 2 x 5	5 x 4 x 5	1
805	1	5 x 12 x 4 [a]	5 x 12 x 4	5 x 12 x 4	1
815 Hot Room	1	3 x 5 x 4	3 x 5 x 4	3 x 5 x 4	1
816 Hot Room B	1	4 x 4 x 4	4 x 4 x 4	4 x 4 x 4	1
816 Hot Room C	1	4 x 2 x 4	4 x 2 x 4	4 x 2 x 4	1
819	11	12 x 12 x 5 [a,b]	2 x 2 x 4 [a,b]	6 x 5 x 2.5 [a,b]	1

[a] Room sizes included in $DCGL_w$ development

[b] Room sizes included in $DCGL_{emc}$ development

TABLE 3
RESRAD-BUILD MODEL INPUT PARAMETERS

Parameter	Value	Rationale
Building Parameters		
Number of Rooms	1	Assumes one contaminated room, conservative assumption since no air flow between rooms.
Deposition Velocity (m/s)	1.00E-02	Default value
Resuspension Rate (1/s)	5.00E-07	Default value
Building Exchange Rate (1/hr)	0.8	Default value
Room Area (m^2)	---	Dependent on survey unit – see Table 1
Room height (m)	---	Dependent on survey unit – see Table 1
Source Parameters		
Number of Sources	1	Assumes one source.
Source Geometry	Area	
Source Size	1 m^2 and 4 m^2	Corresponding to grid sizes of 1 x 1 m and 2 x 2 m for DCGLemc and area of floor for DCGLw (see Table 1 for areas)
Source Location	Center of Room	The source is conservatively located in the center of the room at the same point as the receptor.
Air Release Fraction	1.00E-06	NUREG 5512
Direct Ingestion Rate (1/hr)	0	Default value
Source Removable Fraction	0.5	Default value
Time of Source Removal (days)	365	Default value
Radon Release Fraction	0.1	Default value
Radionuclides	See Section 3.1	
Concentration (pCi/m^2)	1.00 E6	For each radionuclide. (DCGLs are independent of starting concentrations).
Shielding Parameters		
Thickness (cm)	0	Default value
Density (g/cc)	2.4	Default value
Material	Concrete	Default value
Receptor Parameters		
Exposure Duration for resident (days)	350	Assumes a full year of exposure, with two weeks vacation

Parameter	Value	Rationale
Exposure Duration for worker (days)	200	Assumes a 5-day work week, with two weeks vacation
Evaluation Times (years)	20, 40, 60, 80, 100	Building life of 100 years
Number of Receptors	1	One receptor located at the same point as the source.
Indoor Time Fraction for resident	0.68	For residential receptor 16.3 hrs/ 24 hour day (EPA, 1996)
Indoor Time Fraction for office worker	0.33	For office worker 8 hrs /24 hrs occupational receptor (EPA, 1996)
Breathing Rate (m^3/day)	18.0	Default value
Secondary Ingestion Rate (m^2/hr)	0.0001	Default value
Receptor Location	Center of Room	Receptors for all survey units will be conservatively located in the center of the room with the source contamination.

TABLE 4
DERIVED AVERAGE CONCENTRATION
GUIDELINE LIMITS (DCGLw) FOR SURVEY AREAS

Room Size (m)	2x2x4	6x5x2.5	5x12x4	12x12x5
Scenario	Worker (dpm/100cm^2)			
AM-241	2.35E+06	8.84E+05	7.26E+05	5.82E+05
CO-57	1.12E+06	3.89E+05	3.05E+05	2.36E+05
CO-60	4.69E+04	1.64E+04	1.29E+04	1.00E+04
CS-137	1.98E+05	6.94E+04	5.45E+04	4.26E+04
H-3	3.24E+13	2.08E+13	3.24E+13	4.03E+13
PM-147	3.59E+09	1.24E+09	9.69E+08	7.43E+08
PU-239	1.43E+07	8.30E+06	1.08E+07	1.19E+07
RA-226	4.86E+04	2.00E+04	1.65E+04	1.33E+04
TH-230	2.25E+06	9.30E+05	7.62E+05	6.12E+05
U-235	7.01E+05	2.47E+05	1.95E+05	1.53E+05
U-238	3.54E+06	1.27E+06	1.02E+06	8.03E+05
Scenario	Resident (dpm/100cm^2)			
AM-241	8.15E+05	3.06E+05	2.52E+05	**2.02E+05**
CO-57	3.87E+05	1.35E+05	1.06E+05	**8.18E+04**
CO-60	1.63E+04	5.67E+03	4.45E+03	**3.48E+03**
CS-137	6.90E+04	2.40E+04	1.88E+04	**1.48E+04**
H-3	1.12E+13	**7.19E+12**	1.12E+13	1.39E+13
PM-147	1.24E+09	4.30E+08	3.35E+08	**2.58E+08**
PU-239	4.94E+06	**2.88E+06**	3.75E+06	4.11E+06
RA-226	1.68E+04	6.96E+03	5.71E+03	**4.58E+03**
TH-230	7.80E+05	3.22E+05	2.65E+05	**2.12E+05**
U-235	2.43E+05	8.56E+04	6.77E+04	**5.30E+04**
U-238	1.23E+06	4.41E+05	3.53E+05	**2.78E+05**

Notes:

-All values provided as dpm per 100 cm^2.
-Bold values are the most conservative.
-All DCGLs correspond to 10 mrem/yr at 0 years except for Th-230 where this dose maximum dose occurred at 100 years.
-DCGL values derived using RESRAD-Build

TABLE 5
DERIVED ELEVATED CONCENTRATION
GUIDELINE LIMITS (DCGLEMC) FOR SMALL AREAS OF ELEVATED ACTIVITIES

Room Size (m)	2 x 2 x 4	2 x 2 x 4	10x10x12	10x10x12	12 x 12x 5	12 x 12x 5
Grid size (m)	1x1	2x2	1x1	2x2	1x1	2x2
Scenario	Worker (dpm/100cm^2)					
AM-241	5.77E+06	1.77E+06	7.59E+06	2.52E+06	1.06E+07	3.62E+06
PU-240	1.82E+07	4.76E+06	6.85E+07	2.04E+07	4.01E+08	1.38E+08
TH-230	5.09E+06	1.49E+06	8.11E+06	2.63E+06	8.66E+06	2.89E+06
CS-137	5.90E+05	1.98E+05	5.90E+05	1.98E+05	5.61E+05	1.90E+05
TC-99	7.72E+11	1.93E+11	5.79E+12	1.45E+12	4.21E+13	1.05E+13
Scenario	Resident (dpm/100cm^2)					
AM-241	2.00E+06	**6.16E+05**	2.63E+06	8.73E+05	3.67E+06	1.26E+06
PU-240	6.32E+06	**1.65E+06**	2.38E+07	7.07E+06	1.39E+08	4.80E+07
TH-230	1.76E+06	**5.16E+05**	2.81E+06	9.12E+05	3.00E+06	1.01E+06
CS-137	2.04E+05	6.90E+04	2.04E+05	6.90E+04	1.95E+05	**6.5E+04**
TC-99	2.68E+11	**6.69E+10**	2.00E+12	5.02E+11	1.46E+13	3.64E+12

-All values provided as dpm per 100 cm^2.
-Bold values are the most conservative.
-All DCGLs correspond to 10 mrem/yr at 0 years except for Th-230 where maximum dose occurred at 100 years
–DCGLs derived using RESRAD-Build

TABLE 6
RADIONUCLIDE-SPECIFIC INSTRUMENT EFFICIENCIES AND MDAs

Instrument	Serial Number	Source	Radiation Type	Background (CPM)	Instrument Efficiency	Probe Area (cm^2)	Scanning MDA (dpm/100 cm2)
Floor Monitor	138256/136498	TH-230	Alpha	2.00E+00	1.21E-01	4.25E+02	118
Floor Monitor	138256/136498	TC-99	Beta	7.98E+02	2.21E-01	4.25E+02	1285
Floor Monitor	138262/136498	TH-230	Alpha	1.00E+00	8.79E-02	4.25E+02	115
Floor Monitor	138262/136499	TC-99	Beta	4.40E+02	2.04E-01	4.25E+02	1034
Hand held	138238/138734	TH-230	Alpha	1.00E+00	1.82E-01	1.00E+02	235
Hand held	138238/138734	TC-99	Beta	7.30E+01	2.02E-01	7.50E+01	2407
Hand held	138254/140515	TH-230	Alpha	1.00E+00	1.73E-01	1.00E+02	248
Hand held	138254/140515	TC-99	beta	8.10E+01	2.12E-01	1.00E+02	1812
Fidler	A981P/A397Q	AM-241	Gamma	6.49E+03	1.80E-02	1.26E+02	151843
Fidler	A959P/A386Q	AM-241	Gamma	6.49E+03	1.80E-02	1.26E+02	151843
Phoswich	133669/166008	Th-230	Alpha	2.00E+00	2.78E-01	8.60E+01	253
Phoswich	133669/166008	Tc-99	Beta	2.18E+02	2.54E-01	8.60E+01	2890
Phoswich	138254/155183	TH-230	Alpha	2.00E+00	2.89E-01	8.60E+01	243
Phoswich	138254/155183	Tc-99	Beta	2.18E+02	2.03E-01	8.60E+01	3625

TABLE 7

COMPARISON ON INSTRUMENT MDAS TO DCGLS

Instrument	Serial Numbers	Radiation Type	Scanning MDA (dpm/100 cm2)	Lowest $DCGL_{EMC}$ (dpm/100 cm2) (a)	Isotope $DCGL_{EMC}$ is based on	Direct MDA (dpm/100 cm2)	Lowest $DCGL_W$ (dpm/100 cm2) (a)
Floor Monitor	138256/136498	Alpha	118	5.2 E5	Th-230	19	4580
Floor Monitor	138256/136498	Beta	1285	6.7 E10	Tc-99	143	3480
Floor Monitor	138262/136499	Alpha	115	5.2 E5	Th-230	22	4580
Floor Monitor	138262/136499	Beta	1034	6.7 E10	Tc-99	158	3480
Hand held	138238/138734	Alpha	235	5.2 E5	Th-230	42	4580
Hand held	138238/138734	Beta	2407	6.7 E10	Tc-99	281	3480
Hand held	138254/140515	Alpha	248	5.2 E5	Th-230	44	4580
Hand held	138254/140515	Beta	1812	6.7 E10	Tc-99	211	3480
Fidler	A981P/A397Q	Low energy gamma	151843	6.2 E5	Am-241	16645	202000
Fidler	A959P/A386Q	Low energy gamma	151843	6.2 E5	Am-241	16645	202000
Phoswich	133669/166008	Alpha	253	5.2 E5	Th-230	40	4580
Phoswich	133669/166008	Beta	2890	6.7 E10	Tc-99	328	3480
Phoswich	138254/155183	Alpha	243	5.2 E5	Th-230	39	4580
Phoswich	138254/155183	Beta	3625	6.7 E10	Tc-99	411	3480

a) Values taken from bolded values on Tables 4 and 5

TABLE 8
INSTRUMENT FIELD VALUES BASED ON $DCGL_W$

DCGLw	Instrument	Area	Efficiency	Above Background Instrument Flag Value CPM	Average Background Value (a) CPM	Field Instru Va CP
3.48E+03	Beta Floor	4.25E+02	1.66E-01	2.45E+03	7.75E+02	3.23E
3.48E+03	Beta Hand Held	1.00E+02	1.00E-01	3.48E+02	1.75E+02	5.23E
4.58E+03	Alpha Floor	4.25E+02	2.40E-01	4.67E+03	3.8	4.67E
4.58E+03	Alpha Hand Held	1.00E+02	1.70E-01	7.79E+02	2.72	7.82E
2.02E+05	Fidler	1.26E+02	1.80E-02	4.58E+03	1.13E+04	1.58E
3.48E+03	Beta Phoswich	8.60E+01	2.00E-01	5.99E+02	NA	TE
4.58E+03	Alpha Phoswich	8.60E+01	2.70E-01	1.06E+03	NA	TE

a) Average background value is the average of the background direct measurements collected in Background Building 722.
NA – Not currently available
TBD To be determined after background data is collected.

ATTACHMENT – Sample RESRAD-Build Output

Title : Seneca, 12x12x5 room and source, residen
Input File : C:\WINBLD\12X12X5A.I

RESRAD-BUILD Table of Contents

Title : Seneca, 12x12x5 room and source, residen
Input File : C:\WINBLD\12X12X5A.I

RESRAD-BUILD Input Parameters

Number of Sources : 1
Number of Receptors: 1
Total Time : 3.500000E+02 days
Fraction Inside : 6.800000E-01

Receptor Information

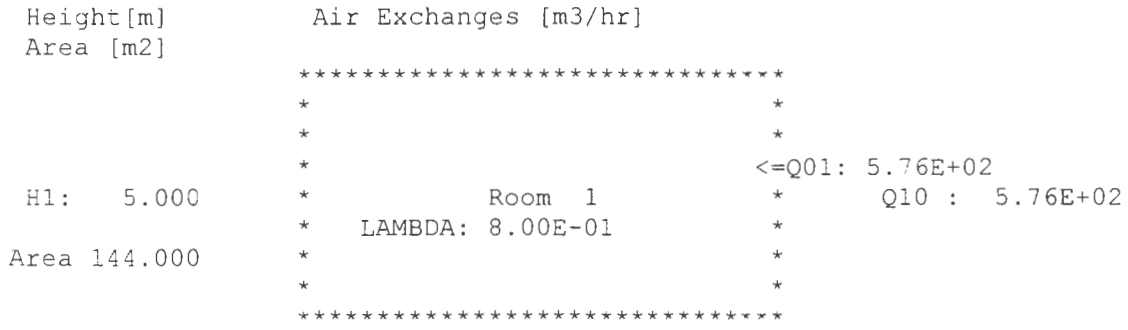
Receptor	Room	x [m]	y [m]	z [m]	FracTime	Inhalation [m3/day]	Ingestion(Dust) [m2/hr]
1	1	6.000	6.000	1.000	1.000	1.80E+01	1.00E-04

Receptor-Source Shielding Relationship

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

ÍÍÍÍÍÍÍÍ Building Information ÍÍÍÍÍÍÍÍ

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: 6.00 y: 6.00 z: 0.00[m]

Geometry:: Type: Area Area:1.44E+02 [m2] Direction: z

Pathway ::

Direct Ingestion Rate:	0.000E+00 [1/hr]
Fraction released to air:	1.000E-06
Removable fraction:	5.000E-01
Time to Remove:	3.650E+02 [day]
Radon Release Fraction:	1.000E-01

Contamination::

Nuclide	Concentration	Dose Conversion Factors				
		Ingestion	Inhalation	External (Surface)	External (Volume)	Submersion
	[pCi/m2]	[mrem/pCi]	[mrem/pCi]	[mrem/yr/ (pCi/m2)]	[mrem/yr/ (pCi/m3)]	[mrem/yr/ (pCi/m3)]
AM-241	1.000E+06	3.640E-03	4.440E-01	3.220E-06	2.740E-08	9.570E-05
PU-239	1.000E+06	3.540E-03	4.290E-01	4.290E-08	1.850E-10	4.960E-07
NP-237	0.000E+00	4.440E-03	5.400E-01	2.620E-05	6.880E-07	1.210E-03
U-238	1.000E+06	2.690E-04	1.180E-01	3.530E-06	9.510E-08	1.600E-04
U-235	1.000E+06	2.670E-04	1.230E-01	1.950E-05	4.740E-07	9.030E-04
U-234	0.000E+00	2.830E-04	1.320E-01	8.750E-08	2.520E-10	8.930E-07
U-233	0.000E+00	2.890E-04	1.350E-01	8.380E-08	8.750E-10	1.910E-06
PA-231	0.000E+00	1.060E-02	1.280E+00	4.760E-06	1.190E-07	2.010E-04
TH-230	1.000E+06	5.480E-04	3.260E-01	8.780E-08	7.570E-10	2.040E-06
TH-229	0.000E+00	4.030E-03	2.160E+00	3.680E-05	9.870E-07	1.720E-03
AC-227	0.000E+00	1.480E-02	6.720E+00	4.530E-05	1.260E-06	2.160E-03
RA-226	1.000E+06	1.330E-03	8.600E-03	1.940E-04	7.000E-06	1.040E-02
PB-210	0.000E+00	7.270E-03	2.320E-02	4.140E-07	3.820E-09	1.430E-05
SM-147	0.000E+00	1.850E-04	7.470E-02	0.000E+00	0.000E+00	0.000E+00
PM-147	1.000E+06	1.050E-06	2.580E-05	3.990E-09	3.140E-11	8.110E-08
CO-60	1.000E+06	2.690E-05	2.190E-04	2.750E-04	1.020E-05	1.470E-02

Title : Seneca, 12x12x5 room and source, residen
Input File : C:\WINBLD\12X12X5A.IEvaluation Time: 0.000000 years

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

Source Information

Source: 1
Location:: Room : 1 x: 6.00 y: 6.00 z: 0.00 [m]
Geometry:: Type: Area Area:1.44E+02 [m2] Direction: z
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-06
Removable fraction: 5.000E-01
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [pCi/m2]
AM-241	1.000E+06
PU-239	1.000E+06
NP-237	0.000E+00
U-238	1.000E+06
U-235	1.000E+06
U-234	0.000E+00
U-233	0.000E+00
PA-231	0.000E+00
TH-230	1.000E+06
TH-229	0.000E+00
AC-227	0.000E+00
RA-226	1.000E+06
PB-210	0.000E+00
SM-147	0.000E+00
PM-147	1.000E+06
CO-60	1.000E+06

RESRAD-BUILD Dose Tables

Source Contributions to Receptor Doses

[mrem]

	Source 1	Total
Receptor 1	1.2E+02	1.2E+02
Total	1.2E+02	1.2E+02

Pathway Detail of Doses

[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	1.14E+02	3.03E-05	2.35E-07	8.85E-02	3.21E+00	1.57E-03
Total	1.14E+02	3.03E-05	2.35E-07	8.85E-02	3.21E+00	1.57E-03

Nuclide Detail of Doses
[mrem]

Source: 1

Nuclide	Receptor 1	Total
AM-241		
AM-241	1.09E+00	1.09E+00
PU-239		
PU-239	5.35E-02	5.35E-02
U-238		
U-238	7.90E-01	7.90E-01
U-235		
U-235	4.15E+00	4.15E+00
TH-230		
TH-230	5.29E-02	5.29E-02
RA-226		
RA-226	4.80E+01	4.80E+01
PM-147		
PM-147	8.54E-04	8.54E-04
CO-60		
CO-60	6.32E+01	6.32E+01

Title : Seneca, 12x12x5 room and source, residen
Input File : C:\WINBLD\12X12X5A.IEvaluation Time: 20.0000 years

Assessment for Time: 2
Time =2.00E+01 yr

Source Information

Source: 1
Location:: Room : 1 x: 6.00 y: 6.00 z: 0.00 [m]
Geometry:: Type: Area Area:1.44E+02 [m2] Direction: z
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-06
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [pCi/m2]
AM-241	4.842E+05
PU-239	4.997E+05
NP-237	3.188E+00
U-238	5.000E+05
U-235	5.000E+05
U-234	2.835E+01
U-233	1.401E-04
PA-231	2.115E+02
TH-230	4.999E+05
TH-229	8.842E-08
AC-227	5.515E+01
RA-226	5.000E+05
PB-210	2.315E+05
SM-147	1.231E-05
PM-147	2.535E+03
CO-60	3.604E+04

RESRAD-BUILD Dose Tables

Source Contributions to Receptor Doses
[mrem]

	Source 1	Total
Receptor 1	2.9E+01	2.9E+01
Total	2.9E+01	2.9E+01

Pathway Detail of Doses
[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.77E+01	0.00E+00	0.00E+00	0.00E+00	1.60E+00	0.00E+00
Total	2.77E+01	0.00E+00	0.00E+00	0.00E+00	1.60E+00	0.00E+00

Nuclide Detail of Doses

[mrem]

Source: 1

Nuclide	Receptor 1	Total
AM-241		
AM-241	5.15E-01	5.15E-01
NP-237	1.90E-05	1.90E-05
U-233	4.85E-12	4.85E-12
TH-229	7.54E-13	7.54E-13
PU-239		
PU-239	1.33E-02	1.33E-02
U-235	4.07E-08	4.07E-08
PA-231	2.50E-12	2.50E-12
AC-227	3.77E-12	3.77E-12
U-238		
U-238	3.91E-01	3.91E-01
U-234	1.30E-06	1.30E-06
TH-230	8.40E-11	8.40E-11
RA-226	3.53E-10	3.53E-10
PB-210	1.66E-13	1.66E-13
U-235		
U-235	2.07E+00	2.07E+00
PA-231	2.54E-04	2.54E-04
AC-227	5.46E-04	5.46E-04
TH-230		
TH-230	1.65E-02	1.65E-02
RA-226	2.07E-01	2.07E-01
PB-210	1.80E-04	1.80E-04
RA-226		
RA-226	2.38E+01	2.38E+01
PB-210	3.77E-02	3.77E-02
SM-147		
SM-147	0.00E+00	0.00E+00
PM-147	2.16E-06	2.16E-06
CO-60		
CO-60	2.28E+00	2.28E+00

Title : Seneca, 12x12x5 room and source, residen
Input File : C:\WINBLD\12X12X5A.IEvaluation Time: 40.0000 years

Assessment for Time: 3
Time =4.00E+01 yr

Source Information

Source: 1
Location:: Room : 1 x: 6.00 y: 6.00 z: 0.00 [m]
Geometry:: Type: Area Area:1.44E+02 [m2] Direction: z
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-06
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [pCi/m2]
AM-241	4.689E+05
PU-239	4.994E+05
NP-237	6.275E+00
U-238	5.000E+05
U-235	5.000E+05
U-234	5.670E+01
U-233	5.546E-04
PA-231	4.230E+02
TH-230	4.998E+05
TH-229	7.014E-07
AC-227	1.840E+02
RA-226	5.000E+05
PB-210	3.558E+05
SM-147	1.237E-05
PM-147	1.285E+01
CO-60	2.597E+03

RESRAD-BUILD Dose Tables

Source Contributions to Receptor Doses

[mrem]

		Source 1	Total
Receptor	1	2.7E+01	2.7E+01
Total		2.7E+01	2.7E+01

Pathway Detail of Doses
[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.56E+01	0.00E+00	0.00E+00	0.00E+00	1.60E+00	0.00E+00
Total	2.56E+01	0.00E+00	0.00E+00	0.00E+00	1.60E+00	0.00E+00

Nuclide Detail of Doses
[mrem]

Source: 1

Nuclide	Receptor 1	Total
AM-241		
AM-241	4.99E-01	4.99E-01
NP-237	3.74E-05	3.74E-05
U-233	1.92E-11	1.92E-11
TH-229	5.98E-12	5.98E-12
PU-239		
PU-239	1.33E-02	1.33E-02
U-235	8.15E-08	8.15E-08
PA-231	1.00E-11	1.00E-11
AC-227	2.62E-11	2.62E-11
U-238		
U-238	3.91E-01	3.91E-01
U-234	2.60E-06	2.60E-06
TH-230	3.36E-10	3.36E-10
RA-226	2.82E-09	2.82E-09
PB-210	2.37E-12	2.37E-12
U-235		
U-235	2.07E+00	2.07E+00
PA-231	5.08E-04	5.08E-04
AC-227	1.82E-03	1.82E-03
TH-230		
TH-230	1.65E-02	1.65E-02
RA-226	4.12E-01	4.12E-01
PB-210	6.02E-04	6.02E-04
RA-226		
RA-226	2.36E+01	2.36E+01
PB-210	5.76E-02	5.76E-02
SM-147		
SM-147	0.00E+00	0.00E+00
PM-147	1.10E-08	1.10E-08
CO-60		
CO-60	1.64E-01	1.64E-01

Assessment for Time: 4
Time =6.00E+01 yr

Source Information

Source: 1
Location:: Room : 1 x: 6.00 y: 6.00 z: 0.00 [m]
Geometry:: Type: Area Area:1.44E-02 [m2] Direction: z
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-06
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [pCi/m2]
AM-241	4.541E+05
PU-239	4.991E+05
NP-237	9.264E+00
U-238	5.000E+05
U-235	5.000E+05
U-234	8.504E+01
U-233	1.235E-03
PA-231	6.343E+02
TH-230	4.997E+05
TH-229	2.347E-06
AC-227	3.518E+02
RA-226	5.000E+05
PB-210	4.225E+05
SM-147	1.237E-05
PM-147	6.518E-02
CO-60	1.872E+02

RESRAD-BUILD Dose Tables

Source Contributions to Receptor Doses

[mrem]

	Source 1	Total
Receptor 1	2.7E+01	2.7E+01
Total	2.7E+01	2.7E+01

Title : Seneca, 12x12x5 room and source, residen
Input File : C:\WINBLD\12X12X5A.IEvaluation Time: 60.0000 years

Pathway Detail of Doses
[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.55E+01	0.00E+00	0.00E+00	0.00E+00	1.60E+00	0.00E+00
Total	2.55E+01	0.00E+00	0.00E+00	0.00E+00	1.60E+00	0.00E+00

Nuclide Detail of Doses

[mrem]

Source: 1

Nuclide	Receptor 1	Total
AM-241		
AM-241	4.83E-01	4.83E-01
NP-237	5.52E-05	5.52E-05
U-233	4.27E-11	4.27E-11
TH-229	2.00E-11	2.00E-11
PU-239		
PU-239	1.33E-02	1.33E-02
U-235	1.22E-07	1.22E-07
PA-231	2.25E-11	2.25E-11
AC-227	7.80E-11	7.80E-11
U-238		
U-238	3.91E-01	3.91E-01
U-234	3.90E-06	3.90E-06
TH-230	7.56E-10	7.56E-10
RA-226	9.49E-09	9.49E-09
PB-210	1.08E-11	1.08E-11
U-235		
U-235	2.07E+00	2.07E+00
PA-231	7.62E-04	7.62E-04
AC-227	3.48E-03	3.48E-03
TH-230		
TH-230	1.65E-02	1.65E-02
RA-226	6.16E-01	6.16E-01
PB-210	1.15E-03	1.15E-03
RA-226		
RA-226	2.34E+01	2.34E+01
PB-210	6.79E-02	6.79E-02
SM-147		
SM-147	0.00E+00	0.00E+00
PM-147	5.56E-11	5.56E-11
CO-60		
CO-60	1.18E-02	1.18E-02

Title : Seneca, 12x12x5 room and source, residen
Input File : C:\WINBLD\12X12X5A.IEvaluation Time: 80.0000 years

Assessment for Time: 5
Time =8.00E+01 yr

Source Information

Source: 1
Location:: Room : 1 x: 6.00 y: 6.00 z: 0.00 [m]
Geometry:: Type: Area Area:1.44E+02 [m2] Direction: z
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-06
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [pCi/m2]
AM-241	4.398E+05
PU-239	4.988E+05
NP-237	1.216E+01
U-238	5.000E+05
U-235	5.000E+05
U-234	1.134E+02
U-233	2.172E-03
PA-231	8.456E+02
TH-230	4.996E+05
TH-229	5.518E-06
AC-227	5.401E+02
RA-226	5.000E+05
PB-210	4.584E+05
SM-147	1.237E-05
PM-147	3.305E-04
CO-60	1.349E+01

RESRAD-BUILD Dose Tables

Source Contributions to Receptor Doses

[mrem]

	Source 1	Total
Receptor 1	2.7E+01	2.7E+01
Total	2.7E+01	2.7E+01

Pathway Detail of Doses

[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.55E+01	0.00E+00	0.00E+00	0.00E+00	1.60E+00	0.00E+00
Total	2.55E+01	0.00E+00	0.00E+00	0.00E+00	1.60E+00	0.00E+00

Nuclide Detail of Doses
ïïïïïïïïïïïïïïïïïïïïïï
[mrem]

Source: 1

Nuclide	Receptor 1	Total
AM-241		
AM-241	4.68E-01	4.68E-01
NP-237	7.25E-05	7.25E-05
U-233	7.52E-11	7.52E-11
TH-229	4.71E-11	4.71E-11
PU-239		
PU-239	1.33E-02	1.33E-02
U-235	1.63E-07	1.63E-07
PA-231	4.00E-11	4.00E-11
AC-227	1.65E-10	1.65E-10
U-238		
U-238	3.91E-01	3.91E-01
U-234	5.20E-06	5.20E-06
TH-230	1.34E-09	1.34E-09
RA-226	2.25E-08	2.25E-08
PB-210	3.11E-11	3.11E-11
U-235		
U-235	2.07E+00	2.07E+00
PA-231	1.02E-03	1.02E-03
AC-227	5.35E-03	5.35E-03
TH-230		
TH-230	1.64E-02	1.64E-02
RA-226	8.18E-01	8.18E-01
PB-210	1.76E-03	1.76E-03
RA-226		
RA-226	2.32E+01	2.32E+01
PB-210	7.32E-02	7.32E-02
SM-147		
SM-147	0.00E+00	0.00E+00
PM-147	2.82E-13	2.82E-13
CO-60		
CO-60	8.53E-04	8.53E-04

Title : Seneca, 12x12x5 room and source, residen
Input File : C:\WINBLD\12X12X5A.IEvaluation Time: 100.000 years

Assessment for Time: 6
Time =1.00E+02 yr

Source Information

Source: 1
Location:: Room : 1 x: 6.00 y: 6.00 z: 0.00 [m]
Geometry:: Type: Area Area:1.44E+02 [m2] Direction: z
Pathway ::
Direct Ingestion Rate: 0.000E+00 [1/hr]
Fraction released to air: 1.000E-06
Removable fraction: 0.000E+00
Time to Remove: 3.650E+02 [day]

Contamination::

Nuclide	Concentration [pCi/m2]
AM-241	4.259E+05
PU-239	4.986E+05
NP-237	1.496E+01
U-238	5.000E+05
U-235	5.000E+05
U-234	1.417E+02
U-233	3.359E-03
PA-231	1.057E+03
TH-230	4.996E+05
TH-229	1.069E-05
AC-227	7.393E+02
RA-226	5.000E+05
PB-210	4.777E+05
SM-147	1.237E-05
PM-147	1.676E-06
CO-60	9.725E-01

Title : Seneca, 12x12x5 room and source, residen
Input File : C:\WINBLD\12X12X5A.IEvaluation Time: 100.000 years

RESRAD-BUILD Dose Tables

Source Contributions to Receptor Doses

[mrem]

	Source 1	Total
Receptor 1	2.7E+01	2.7E+01
Total	2.7E+01	2.7E+01

Pathway Detail of Doses

[mrem]

Source: 1

Receptor	External	Deposition	Immersion	Inhalation	Radon	Ingestion
1	2.54E+01	0.00E+00	0.00E+00	0.00E+00	1.60E+00	0.00E+00
Total	2.54E+01	0.00E+00	0.00E+00	0.00E+00	1.60E+00	0.00E+00

Nuclide Detail of Doses
[mrem]

Source: 1

Nuclide	Receptor 1	Total
AM-241		
AM-241	4.53E-01	4.53E-01
NP-237	8.92E-05	8.92E-05
U-233	1.16E-10	1.16E-10
TH-229	9.12E-11	9.12E-11
PU-239		
PU-239	1.33E-02	1.33E-02
U-235	2.03E-07	2.03E-07
PA-231	6.25E-11	6.25E-11
AC-227	2.89E-10	2.89E-10
U-238		
U-238	3.91E-01	3.91E-01
U-234	6.50E-06	6.50E-06
TH-230	2.10E-09	2.10E-09
RA-226	4.38E-08	4.38E-08
PB-210	6.94E-11	6.94E-11
U-235		
U-235	2.07E+00	2.07E+00
PA-231	1.27E-03	1.27E-03
AC-227	7.32E-03	7.32E-03
TH-230		
TH-230	1.64E-02	1.64E-02
RA-226	1.02E+00	1.02E+00
PB-210	2.41E-03	2.41E-03
RA-226		
RA-226	2.30E+01	2.30E+01
PB-210	7.57E-02	7.57E-02
SM-147		
SM-147	0.00E+00	0.00E+00
PM-147	1.43E-15	1.43E-15
CO-60		
CO-60	6.15E-05	6.15E-05

Title : Seneca, 12x12x5 room and source, residen
Input File : C:\WINBLD\12X12X5A.I

RESRAD-BUILD Dose (Time) Tables

Receptor Doses Received for the Exposure Duration
(mrem)

	Evaluation Time [yr]					
	0.00E+00	2.00E+01	4.00E+01	6.00E+01	8.00E+01	1.00E+02
1	1.17E+02	2.93E+01	2.72E+01	2.71E+01	2.71E+01	2.70E+01

Receptor Dose/Yr Averaged Over Exposure Duration
(mrem/yr)

	Evaluation Time [yr]					
	0.00E+00	2.00E+01	4.00E+01	6.00E+01	8.00E+01	1.00E+02
1	1.22E+02	3.06E+01	2.84E+01	2.83E+01	2.82E+01	2.82E+01