APPENDIX D-1

RESRAD DATA INPUT BASIS PARAMETERS

Radium Benchmark Dose Assessment

For

Ludeman Uranium In-situ Recovery Facility

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Radium Benchmark Dose Assessment

1.0 Introduction

On April 12, 1999, the U.S. Nuclear Regulatory Commission (NRC) issued a Final Rule (64 FR 17506) that requires the use of the existing soil radium standard to derive a dose criterion for the cleanup of byproduct material. The amendment to Criterion 6(6) of 10 CFR Part 40, Appendix A was effective on June 11, 1999. This "benchmark approach" requires that NRC licensees model the site-specific dose from the existing radium standard and then use that dose to determine the allowable quantity of other radionuclides that would result in a similar dose to the average member of the critical group. These determinations must then be submitted to NRC with the site reclamation plan or included in license applications. This report documents the modeling and assumptions made by Uranium One, Americas (UOA) to derive a standard for U-nat in soil for the proposed Ludeman in-situ uranium recovery (LISR) facility.

Concurrent with publication of the Final Rule, NRC published draft guidance (64 FR 17690) for performing the benchmark dose modeling required to implement the final rule. Final guidance (NRC, 2003) was published as Appendix E to the Standard Review Plan for In Situ Leach License Applications (NUREG-1569). This guidance discusses acceptable models and input parameters. This guidance, guidance from the RESRAD Users Manual (ANL, 2001), the Data Collection Handbook (ANL, 1993) and site-specific parameters were used in the modeling as discussed in the following sections.

2.0 Determination of Radium Benchmark Dose

RESRAD Version 6.4 computer code (RESRAD) was used to model the LISR site and calculate the maximum annual dose rate from the current radium cleanup standard.

The following supporting documentation for determination of the radium benchmark dose and the natural uranium soil standard (explained in Section 3.0) is attached:

- The RESRAD Data Input Basis (Attachment 1) provides a summary of the modeling performed with RESRAD and the values that were used for the input parameters. A sensitivity analysis was performed for parameters which are important to the major component dose pathways and for which no site specific data was available.
- Selected graphs produced with RESRAD that present the results of the sensitivity analysis performed on the input parameters are attached (Attachment 2).
- A full printout of the final RESRAD modeling results for the resident farmer scenario with the chosen input values is attached (Attachments 3.0 and 3.1). The printout provides the modeled maximum annual dose for calculated times for the 1,000-year time span and provides a breakdown of the fraction of dose due to each pathway.
- Graphs produced with RESRAD that present the modeling results for the maximum dose during the 1,000 year time span for radium-226 and natural uranium. A series of graphs depicting the summed dose for all pathways and the component pathways that contributes to the total dose are attached (Attachments 4.0 and 4.1).

The maximum dose from Ra-226 contaminated soil at the 5 pCi/g above background cleanup standard, as determined by RESRAD, for the residential farmer scenario was 39.6 mrem/yr. This dose was based upon the 5 pCi/g surface (0 to 6-inch) Ra-226 standard and was noted at time, t = 0 years. The two major dose pathways were external exposure and plant ingestion (water independent). For these two pathways, a sensitivity analysis was performed for important parameters for which no site specific information was available. The 39.6 mrem/yr dose from radium is the level at which the natural uranium radiological end point soil standard will be based as described in the following section.

3.0 Determination of Natural Uranium Soil Standard

RESRAD was used to determine the concentration of natural uranium (U-nat) in soil distinguishable from background that would result in a maximum dose of 39.6 mrem/yr.

The method involved modeling the dose from a set concentration of U-nat in soil. This dose was then compared to the radium benchmark dose and scaled to arrive at the maximum allowable U-nat concentration in soil.

For ease of calculations, a preset concentration of 100 pCi/g U-nat was used for modeling the dose. The fractions used were 49.2 percent (or pCi/g) U-234, 48.6 percent (or pCi/g) U-238 and 2.2 percent (or pCi/g) U-235. The distribution coefficients that were selected for each radionuclide were RESRAD default values. A sensitivity analysis was performed using a range of distribution coefficients to evaluate potential effects of not using site specific data. All other input parameters were the same as those used in the Ra-226 benchmark modeling.

Using a U-nat concentration in soil of 100 pCi/g, RESRAD determined a maximum dose of 6.9 mrem/yr. at time, t = 0 years. The printout of the RESRAD data summary is provided in Attachment 3.1 and the dose figures generated with RESRAD are provided in Attachment 4.1.

To determine the uranium soil standard, the following formula was used:

$$\text{Uranium Limit} = \left(\frac{100\ \text{pCi/g U - nat}}{6.9\ \text{mrem/yr U - nat dose}} \right) \text{x } 39.6\ \text{mrem/yr radium benchmark dose}$$

$$\text{Uranium Limit} = 574\ \text{pCi/g U - nat}$$

The U-nat limit is applied to soil cleanup with the Ra-226 limit using the unity rule. To determine whether an area exceeds the cleanup standards, the standards are applied according to the following formula:

$$\left(\frac{\text{Soil Uranium Concentration}}{\text{Soil Uranium Limit}} \right) + \left(\frac{\text{Soil Radium Concentration}}{\text{Soil Radium Limit}} \right) < 1$$

This approach will be used at the LISR site to determine the radiological impact on the environment from releases of source and byproduct materials.

3.1 Uranium Chemical Toxicity Assessment

The chemical toxicity effects from uranium exposure are evaluated by assuming the same exposure scenario as that used for the radiation dose assessment. In the benchmark dose assessment for the resident farmer scenario, it was assumed that the diet consisted of 25 percent of the meat, fruits, and vegetables grown at the site. No intake of contaminated food through the aquatic or milk pathways was considered probable since it is unlikely the Ludeman area could support this activity with local vegetation. Also, the model showed that the contamination would not affect the groundwater quality. Therefore, the same model will be used in assessing the chemical toxicity. The intake from eating meat was shown to be negligible compared to the plant pathway and therefore is not shown here. This is confirmed by the results of the RESRAD calculations shown in Attachment 3.1 and the figures generated with RESRAD shown in Attachment 4.1.

The method and parameters for estimating the human intake of uranium from ingestion are taken from NUREG/CR-5512 Vol. 1 (NRC, 1992). The uptake of uranium in food is a product of the uranium concentration in soil and the soil-to-plant conversion factor. The annual intake in humans is then calculated by multiplying the annual consumption by the uranium concentration in the food. Since the soil-plant conversion factor is based on a dry weight, the annual consumption must be adjusted to a dry-weight basis by multiplying by the dry-weight to wet-weight ratio. Parameters for these calculations are given in Section 6.5.9 of the NUREG/CR-5512 Vol. 1 (NRC, 1992). Table 3-1 provides the parameters used in these calculation and results for leafy vegetables, other vegetables, and fruit. Annual intakes of 14 kg/year and 97 kg/year were assumed for leafy vegetables and other vegetables and fruit, respectively. Consistent with Attachment 3.1 dose calculations, it was assumed that 25 percent of the food was grown on the site. It was also assumed that the uranium concentration in the garden or orchard was 574 pCi/g. This corresponds to the uranium benchmark concentration for surface soils. Using a

conversion factor for U-nat of 1 mg = 677 pCi, then 574 pCi/g is equivalent to 848 mg/kg. The human intake shown in the first column of Table 3-1 is equal to the product of the parameters given in the subsequent columns. Table 3-1 shows that the total annual uranium intake from all food sources from the site is 56 mg/yr.

The two-compartment model of uranium toxicity in the kidney from oral ingestion was used (ICRP, 1995) to predict the burden of uranium in the kidney following chronic uranium ingestion. This model allows for the distribution of the two forms of uranium in the blood, and consists of a kidney with two compartments, as well as several other compartments for uranium distribution, storage and elimination including the skeleton, liver, red blood cells and other soft tissues.

Table 3-1: Annual Intake of Uranium from Ingestion

Human Intake (mg/yr)	Soil Concentration (mg/kg)	Soil to Plant Ratio (mg/kg plant to mg/kg soil)	Annual Consumption (kg)	Dry Weight Wet Weight Ratio	Food Source
10.1	848	1.7E-2	3.5	0.2	Leafy Vegetables
38.6	848	1.4E-2	13	0.25	Other Vegetables
7.3	848	4.0E-3	12	0.18	Fruit
56.0					Total

The total burden to the kidney is the sum of the two compartments. The mathematical representation for the kidney burden of uranium at steady state can be derived as follows (ICRP, 1995):

$$Q_P = \frac{IR \times f_1}{\lambda_P \left(1 - f_{ps} - f_{pr} - f_{pl} - f_{pk} - f_{pkl}\right)}$$

Where:

Q_P = uranium burden in the plasma, μg

IR = dietary consumption rate, mg U/d

f_l = fractional transfer of uranium from GI tract to blood, unit less

f_{ps} = fractional transfer of uranium from plasma to skeleton, unit less

f_{pr} = fractional transfer of uranium from plasma to red blood cells, unit less

f_{pl} = fractional transfer of uranium from plasma to liver, unit less

f_{pt} = fractional transfer of uranium from plasma to soft tissue, unit less

f_{pk1} = fractional transfer of uranium from plasma to kidney, compartment 1, unit less

λ_p = biological retention constant in the plasma, d^{-1}

The burden in kidney compartment 1 is:

$$Q_{k1} = \lambda_P \times Q_P \times \frac{f_{pk1}}{\lambda_{k1}}$$

Where:

Q_{k1} = uranium burden in kidney compartment 1, mg

λ_{k1} = biological retention constant of uranium in kidney compartment 1, d^{-1}

Similarly, for compartment 2 in the kidney, the burden is:

$$Q_{k2} = \lambda_P \times Q_P \times \frac{f_{pk2}}{\lambda_{k2}}$$

Where:

Q_{k2} = uranium burden in kidney compartment 2, μg;

λ_{k2} = biological retention constant of uranium in kidney compartment 2, d^{-1};

f_{pk2} = fractional transfer of uranium from plasma to kidney compartment 2, unitless.

The total burden to the kidney is then the sum of the two compartments is:

$$Q_{k1} + Q_{k2} = \frac{IR \times f_1}{\left(1 - f_{ps} - f_{pr} - f_{pl} - f_{pt} - f_{pk1}\right)} \times \left(\frac{f_{pk1}}{\lambda_{k1}} + \frac{f_{pk2}}{\lambda_{k2}}\right)$$

The parameter input values for the two-compartment kidney model include the daily intake of uranium estimated for residents at this site, and the ICRP69 values recommended by the ICRP as listed below (ICRP, 1995). The daily uranium intake rate was estimated to be 0.15 mg/day (56.0 mg/year) from ingestion while residing at this site.

$IR = 0.15$ mg/day
$f_1 = 0.02$
$f_{ps} = 0.105$
$f_{pr} = 0.007$
$f_{pl} = 0.0105$
$f_{pt} = 0.347$
$f_{pk1} = 0.00035$
$f_{pk2} = 0.084$
$\lambda_{k1} = \ln(2)/(5 \text{ yrs} * 365 \text{ days/yr})$
$\lambda_{k2} = \ln(2)/7$ days
where $\ln(2) = 0.693\ldots$

Given a daily uranium intake of 0.15 mg/day at this site and the above equation, the calculated uranium in the kidneys is 0.010 mg U, or a concentration of 0.034 μg U/g kidney. This is 3.4 percent of the 1.0 μg U/g value that has generally been understood to protect the kidney from the toxic effects of uranium. Some researchers have suggested that mild effects may be observable at levels as low as 0.1 μg U/g of kidney tissue. Using 0.1 μg U/g as a criterion, then the intake is 34 percent of the level where mild effects may be observable.

The EPA evaluated the chemical toxicity data and found that mild proteinuria has been observed at drinking water levels between 20 and 100 μg/liter. Assuming water intake of 2 liters/day, this corresponds to an intake of 0.04 to 0.2 mg/day. Using animal data and a

conservative factor of 100, the EPA arrived at a 30 μg/liter limit for use as a National Primary Drinking Water Standard (Federal Register/Vol.65, No.236/ December 7, 2000). This is equivalent to an intake of 0.06 mg/day for the average individual. Naturally, since large diverse populations are potentially exposed to drinking water sources regulated using these standards, the EPA is very conservative in developing limits.

This analysis indicates that a soil limit of 574 pCi/g of U-nat would result in an intake of approximately 0.15 mg/day. Using the most conservative daily limit corresponding to the National Primary Drinking Water standard, a soil limit of 230 pCi/g corresponds to the EPA intake limit from drinking water with a uranium concentration of 0.06 mg/day. Therefore exposure to soils containing 230 pCi/g of natural uranium should not result in chemical toxicity effects. Since the roots of a fruit tree would penetrate to a considerable depth, limiting subsurface uranium concentrations to 230 pCi/g will be considered appropriate as well.

4.0 References

ANL, 1993, "Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil", Environmental Assessment Division, Argonne National Laboratory, ANL/EAIS-8, Argonne, Illinois.

ICRP, 1995, *ICRP Publication 69 - Age-dependent Doses to Members of the Public from Intake of Radionuclides: Part 3 Ingestion Dose Coefficients*, International Commission on Radiation Protection, Tarrytown, New York.

NRC, 1992, *"Residual Radioactive Contamination from Decommissioning,"* U.S. Nuclear Regulatory Commission, NUREG/CRR-5512 (PNL-7994) Vol. 1, Washington, DC.

NRC, 2003, "Standard Review Plan for In situ Leach Uranium Extraction License Applications", Division of Fuel Cycle Safety and Safeguards, Office of Nuclear Material

Safety and Safeguards, U. S. Nuclear Regulatory Commission, NUREG-1569, Washington, DC.

NRCS, 2007, "2003 Annual National Resources Inventory", Natural Resources Conservation Service, U.S. Department of Agriculture, Washington, DC.

USGS, 2004, *Estimated Use of Water in the United States in 2000*, U.S. Geological Survey, U.S. Department of the Interior, USGS Circular 1268, Reston, Virginia.

APPENDIX D-1

RESRAD DATA INPUT BASIS PARAMETERS

RESRAD Data Input Basis

Parameters

This document summarizes the data input and modeling scenario that was used to determine the radium benchmark dose for the LISR Project. The modeling was performed using RESRAD for Windows Version 6.4 developed by the Environmental Assessment Division at Argonne National Laboratory.

The resident farmer scenario was used since this is the most likely land use near the site. The following sections describe the data parameters that were used to model site-specific conditions.

The data input was based upon five principal sources:

1. The Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil (Data Collection Handbook) (ANL, 1993)

2. The NUREG-1569 (NRC, 2003)

3. Site specific information to be included in the LISR license application

4. The Natural Resources Conservation Service (NRCS) 2003 Annual Natural Resources Inventory, State Report (NRCS, 2007)

5. The US Geological Survey (USGS) Circular 1268 (USGS, 2004)

Soil Concentration

1. Lead-210: Used 5.0 pCi/g per the NUREG-1569 (NRC, 2003).

No sensitivity analysis on this parameter was performed based on the guidance.

2. Radium-226: Used 5.0 pCi/g regulatory limit as basis for determining benchmark.

No sensitivity analysis on this parameter was performed based on the regulatory limit.

Distribution Coefficient (K_d)

The soil in the contaminated, unsaturated, and saturated zones are described as clay loam to loamy sand. All values found in the Data Collection Handbook (ANL, 1993).

1. Lead-210: Used the value for loam, 16,000 cm^3/g, for the contaminated, unsaturated, and saturated zones. The Data Collection Handbook specifies the following values (ANL, 1993):

    - Sand = 270 cm^3/g
    - Loam = 16,000 cm^3/g
    - Clay = 550 cm^3/g

Sensitivity analyses were performed on the external and plant (water independent) pathways with a multiple of 100 on the value for the contaminated zone (i.e. 160, 16,000, 1,600,000). No appreciable impacts on maximum dose were found when using the higher or lower K_d. The range of values covers the range of potential values at the site based upon sandy loam and loamy sand soil types. Graphs attached.

2. Radium 226: Used the value for loam, 36,000 cm^3/g, for the contaminated, unsaturated, and saturated zones. The Data Collection Handbook specifies the following values (ANL, 1993):

    - Sand = 500 cm^3/g
    - Loam = 36,000 cm^3/g
    - Clay = 9,100 cm^3/g

Sensitivity analyses were performed on the external and plant (water independent) pathways with a multiple of 100 on the value for the contaminated zone (i.e. 360, 36,000, 3,600,000). No appreciable impacts on maximum dose were found when using the higher or lower K_d. The range of values covers the range of potential values at the site based upon sandy loam and loamy sand soil types. Graphs attached.

Contaminated Zone

1. Area: Used the default value of 10,000 square meters.

Sensitivity analysis was performed on the external pathway with a multiple of 2 (i.e. 5,000, 10,000, and 20,000). There was no impact on maximum dose rate for the external dose pathway when using the larger value. There was a small decrease in maximum dose rate for the external dose pathway when using the smaller value. Therefore the use of the mid-range value for the area is conservative. Graph attached.

2. Thickness: Used 0.15 m (6 inches) based on regulatory requirement.

No sensitivity analysis on this parameter was performed based on the guidance.

3. Length parallel to aquifer flow: Used the default value of 100 meters, based on the square root of a 10,000 square meter contaminated zone.

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose.

Cover and Contaminated Zone

The topsoil of the area (the contaminated zone) is described as clay loam to loamy sand.

1. Cover depth: Used 0 meters in accordance with NUREG-1569 (NRC, 2003).

No sensitivity analysis on this parameter was performed based on the guidance.

2. Density of contaminated zone: Used the average density of the contaminated zone, 1.50 g/cm^3, based on site specific data.

No sensitivity analysis was performed because the value is site specific.

3. Contaminated zone erosion rate: Used the erosion rates for Wyoming listed in the NRCS 2003 National Resources Inventory, State Report (NCRS, 2007) to calculate the erosion rate. The erosion rates listed for Wyoming are 0.5 tons/acre-year from water erosion and 3.2 tons/acre-year from wind erosion (3.7 tons/acre-year total). Using the contaminated zone soil density (1.50 g/cm^3), the total erosion rate was calculated as shown below and used in RESRAD.

$$\text{Erosion Rate (m/yr)} = \frac{3.7\ \text{ton}}{\text{acre - yr}} \times \frac{9.07 \times 10^5\ \text{g}}{\text{ton}} \times \frac{\text{acre}}{4.047 \times 10^7\ \text{cm}^2} \times \frac{\text{cm}^3}{1.50\ \text{g}} \times \frac{\text{m}}{100\ \text{cm}} = 0.0006$$

Sensitivity analyses of the external and plant (water independent) pathways were performed with a multiple of 2 (i.e. 0.0012, 0.0006, and 0.0003). The maximum dose rate from the external pathway did not change when the value was changed. The maximum dose rate from the plant (water independent) pathway decreased slightly when using the smaller value. Also, the mid-range value is based on information specific to Wyoming. Therefore the mid-range value is both adequate for the model and conservative. Graph attached.

4. Contaminated zone total porosity: Used the average total porosity of the contaminated zone, 0.25, based on site specific data.

No sensitivity analysis was performed because the value is site specific.

5. Contaminated zone field capacity: Used the value obtained from subtracting the effective porosity of the contaminated zone from the total porosity of the contaminated zone, 0.06. The value used for the effective porosity of the contaminated zone was the average of the mean effective porosities for clay and sand (medium) listed in the Data Collection Handbook, 0.19 (ANL, 1993).

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose.

6. Contaminated zone hydraulic conductivity: Used the average of the representative hydraulic conductivity values for clay loam and loamy sand listed in the Data Collection Handbook, 2.47×10^4 m/yr (ANL, 1993).

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose.

7. Contaminated zone b parameter: Used the average of the b parameters for clay loam and loamy sand listed in the Data Collection Handbook, 6.45 (ANL, 1993).

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose.

8. Evapotranspiration Coefficient: Used the maximum evapotranspiration coefficient, 0.999, based on site specific data.

No sensitivity analysis was performed because the value is site specific.

9. Wind Speed: Used the average wind speed, 5.77 m/s, based on site specific data.

No sensitivity analysis was performed because the value is site specific.

10. Precipitation: Used the precipitation rate, 0.29 m/yr, based on site specific data.

No sensitivity analysis was performed because the value is site specific.

11. Irrigation Rate: Used the average irrigation rate for Wyoming listed in the USGS Circular 1268, 1.33 m/yr (4.36 ft/yr) (USGS, 2004).

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose.

12. Runoff Coefficient: From the Data Collection Handbook, the equation for runoff coefficient for an agricultural environment is shown below (ANL, 1993).

$$\text{Runoff Coefficient} = 1 - c_1 - c_2 - c_3$$

The values of c_1, c_2, and c_3 used were 0.2 (rolling land), 0.2 (intermediate combinations of clay and loam), and 0.1 (cultivated lands), respectively. The resulting runoff coefficient used is 0.5.

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose.

13. Watershed Area for Nearby Stream or Pond: Used the default value of 1,000,000 m^2.

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose.

14. Accuracy: Used the default value of 0.001.

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose.

Saturated Zone

1. Density of saturated zone: Used the average density of the saturated zone, 1.50 g/cm^3, based on site specific data.

No sensitivity analysis was performed because the value is site specific.

2. Saturated zone total porosity: Used the average total porosity of the contaminated zone, 0.25, based on site specific data.

No sensitivity analysis was performed because the value is site specific.

3. Saturated zone effective porosity: Used the value of 0.19 obtained from the average of the mean effective porosities for clay and sand (medium) listed in the Data Collection Handbook, 0.19 (ANL, 1993).

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose.

4. Saturated zone field capacity: Used the value obtained from subtracting the effective porosity of the saturated zone from the total porosity of the saturated zone, 0.06.

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose.

5. Saturated zone hydraulic conductivity: Used the average of the representative hydraulic conductivity values for clay loam and loamy sand listed in the Data Collection Handbook, 2.47 x 10^4 m/yr (ANL, 1993).

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose.

6. Saturated zone hydraulic gradient: Used the default value of 0.02.

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose.

6. Saturated zone b parameter: Used the average of the b parameters for clay loam and loamy sand listed in the Data Collection Handbook, 6.45 (ANL, 1993).

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose.

7. Water Table Drop Rate: Used the default value of 0.001 m/yr.

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose.

8. Well Pump Intake Depth: Used the site specific value of 54.9 m.

No sensitivity analysis was performed because the site specific value is used.

10. Model for Water Transport Parameters: Used non-dispersion per NUREG-1569 (NRC, 2003).

No sensitivity analysis on this parameter was performed based on the guidance.

11. Well Pumping Rate: Used the default value of 250 m^3/yr.

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose.

Unsaturated Zone

1. Unsaturated zone thickness: Used the site specific value of 53.3 m.

No sensitivity analysis was performed because the value is site specific.

2. Density of unsaturated zone: Used the average density of the saturated zone, 1.50 g/cm^3, based on site specific data.

No sensitivity analysis was performed because the value is site specific.

3. Unsaturated zone total porosity: Used the average total porosity of the contaminated zone, 0.25, based on site specific data.

No sensitivity analysis was performed because the value is site specific.

4. Unsaturated zone effective porosity: Used the value of 0.19 obtained from the average of the mean effective porosities for clay and sand (medium) listed in the Data Collection Handbook, 0.19 (ANL, 1993).

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose.

5. Unsaturated zone field capacity: Used the value obtained from subtracting the effective porosity of the unsaturated zone from the total porosity of the unsaturated zone, 0.06.

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose.

6. Unsaturated zone hydraulic conductivity: Used the average of the representative hydraulic conductivity values for clay loam and loamy sand listed in the Data Collection Handbook, 2.47 x 10^4 m/yr (ANL, 1993).

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose.

7. Unsaturated zone b parameter: Used the average of the b parameters for clay loam and loamy sand listed in the Data Collection Handbook, 6.45 (ANL, 1993).

No sensitivity analysis was performed since water dependent pathways were not significant contributors to dose.

Occupancy

1. Inhalation Rate: Used the default value of 8,400 m^3/yr.

No sensitivity analysis was performed since inhalation pathways were not significant contributors to dose.

2. Mass Loading for Inhalation: Used the default value of 0.0001 g/m^3.

No sensitivity analysis was performed since inhalation pathways were not significant contributors to dose.

3. Exposure Duration: Used the default value of 30 years.

4. Indoor dust filtration factor: Used the default value of 0.4.

No sensitivity analysis was performed since inhalation pathways were not significant contributors to dose.

5. External gamma shielding factor: Used the value of 0.55. The NUREG-1569 requires that a value between 0.33 and 0.55 be used.

Sensitivity analysis of the external pathway was performed using a multiple of 1.5 (i.e., 0.367, 0.55 and 0.825). Using the lower value resulted in a decrease in the maximum dose rate for the external exposure pathway. Using the higher value resulted in an increase in the maximum dose rate for the external exposure pathway. The value 0.55 is the most conservative value in the range specified by the NUREG-1569. Graph attached.

6. Indoor/Outdoor Fractions: Used the defaults of 0.5 indoors and 0.25 outdoors for farmer scenario in the NUREG-1569 (NRC, 2003).

No sensitivity analyses on these parameters were performed based on the guidance.

7. Shape of contaminated zone: A circular shape was used.

Ingestion: Dietary

1. Consumption Rates:

A. Fruit, vegetable and grain: Used the default value of 160 kg/yr. This value was used based upon EPA estimated consumption. NRC Reg. Guide 1.109 has an estimated consumption for an adult of 190 kg/yr. RESRAD adjusts for contaminated and uncontaminated fractions based upon the size of the contaminated area (ANL, 1993).

B. Leafy vegetable: Used the default value of 14 kg/yr. NRC Reg. Guide 1.109 has an estimated consumption for an adult of 64 kg/yr, while NRC estimates for dose from nuclear power plants uses a consumption rate of 30 kg/yr. RESRAD adjusts

for contaminated and uncontaminated fractions based upon the size of the contaminated area (ANL, 1993).

C. Milk: Used the default value of 92 L/yr.

D. Meat and poultry: Used the default value of 63 kg/yr.

E. Fish/Seafood: Used the default values of 5.4 kg/yr for fish and 0.9 kg/yr for other seafood.

F. Soil ingestion: Used the default value of 36.5 g/yr.

G. Drinking water intake: Used the default value of 510 L/yr (1.4 L/d).

2. Contaminated Fractions:

NUREG-1569 states that for sites with over 25 acres (approximately 10,000 square meters) of contamination, the fraction of diet from contaminated area should be assumed to be 25% (0.25) (NRC, 2003).

No sensitivity analyses on these parameters were performed.

A. Water: Used the value of 0 due to the aquifer being exempt from being used for drinking water.

B. Livestock Water: Used default value of 1 (i.e., 100% is from contaminated water). All current water use for livestock around the site is from private wells and will likely continue to be in the foreseeable future.

C. Irrigation Water: Used the default value of 1 (i.e., 100% is from contaminated water). All current water use for irrigation around the site is from private wells and will likely continue to be in the foreseeable future.

D. Plant food: Used 0.25 as percentage of plant food that is contaminated.

E. Meat: Used 0.25 as percentage of meat that is contaminated.

F. Aquatic food: Used the value of 0 due to the semiarid environment of the site.

G. Milk: Used the value of 0 due to no consumption of locally produced and consumed milk per NUREG-1569 (NRC, 2003).

Ingestion: Nondietary

1. Consumption Rates:

A. Livestock fodder intake for meat: Used the default value of 68 kg/day.

B. Livestock water intake for meat: Used the default value of 50 L/day. According to NRC Regulatory Guide 1.109 (NRC, 1977), the water ingestion rate for beef cattle is 50 L/d.

C. Livestock intake of soil for meat: Used the default value of 0.5 g/day.

D. Mass loading for foliar deposition: Used the default value of 0.0001 g/m^3.

Sensitivity analysis on the plant (water independent) pathway was run with a multiple of 100 (i.e., 0.000001, 0.0001, and 0.01 g/m^3). Using the higher value resulted in a small increase in the maximum dose rate. Using the lower value did not result in a change in the maximum dose rate. According to the Data Collection Handbook, the mid-range

value has been used by the EPA for screening calculations. Therefore the mid-range value is justified for use in the model. Graph attached.

E. Depth of soil mixing layer: Used the default value of 0.15 meters.

F. Depth of roots: Used 0.3 meters as a screening level based upon NUREG-1569. The root depth varies for different plants. For some plants, such as beets, carrots, lettuce, and so forth, it does not extend below about 0.3 m, which is the basis of the NRC guidance. For others, such as fruit trees, the roots may extend 2 or 3 m below the surface. Tap roots for some crops (e.g., alfalfa) can extend to 5 m. Most of the plant roots from which nutrients are obtained, however, usually extend to less than 1 m below the surface.

Sensitivity analysis on the plant (water independent) pathway was run with a multiple of 2 (i.e. 0.15, 0.3, and 0.6). There was a significant impact on the maximum dose. Assumption of a shallow root system increased the dose significantly. The NRC guidance is based on the shallow-rooted plants used for consumption. Therefore, the use of the root depth recommended in the NUREG-1569 in the model is conservative. Graph attached.

G. Groundwater fractional usage:

- Drinking water: Used the value of 0 due to the aquifer being exempt from being used for drinking water.
- Livestock water: Used the default value of 1.
- Irrigation water: Used the default value of 1.

Storage Times

Used the default values for all storage times (vegetables, meats, fodder, etc.).

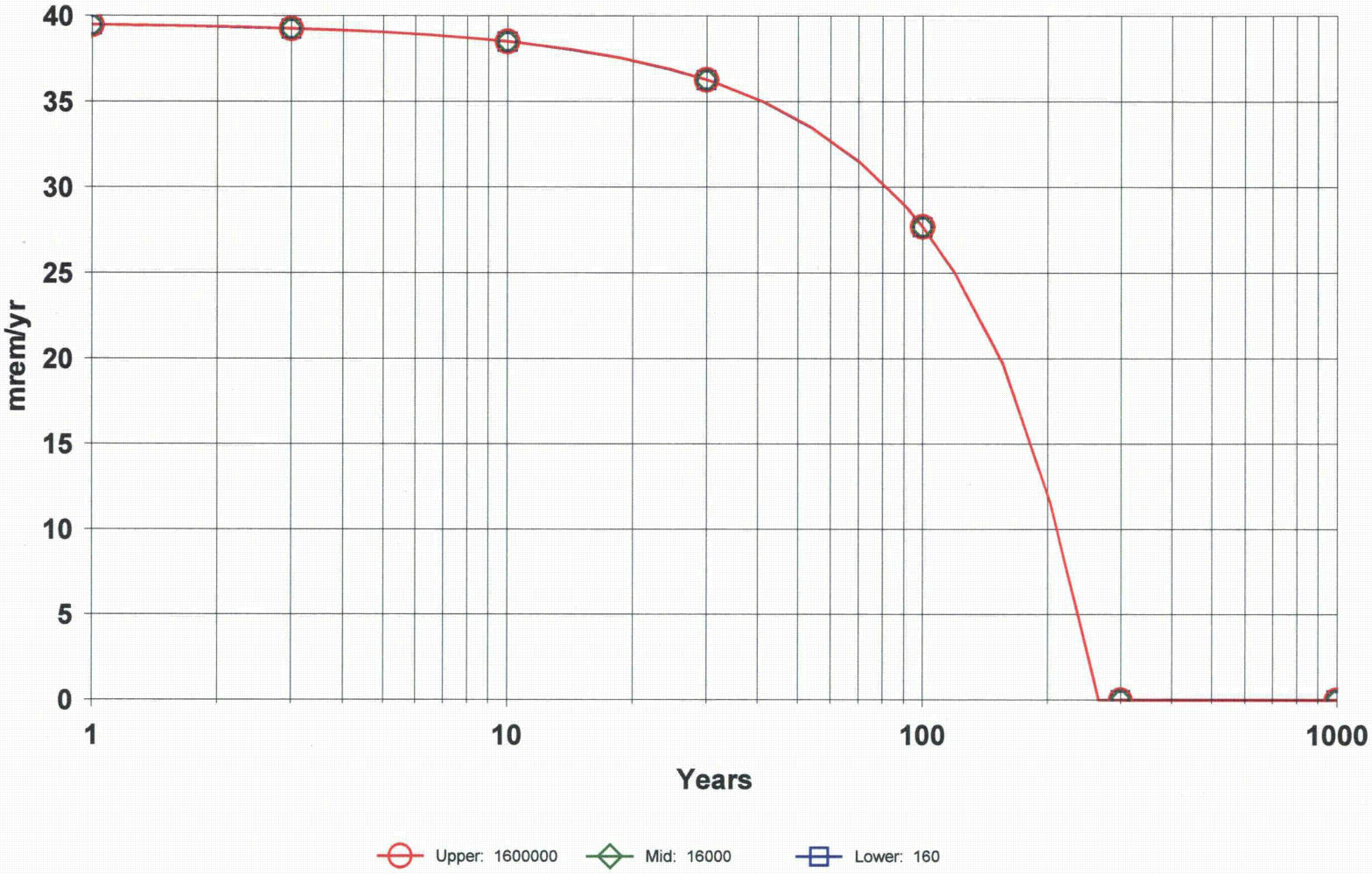
APPENDIX D-2

RESRAD INPUT BASIS PARAMETER SENSITIVITY ANALYSIS

APPENDIX D-2

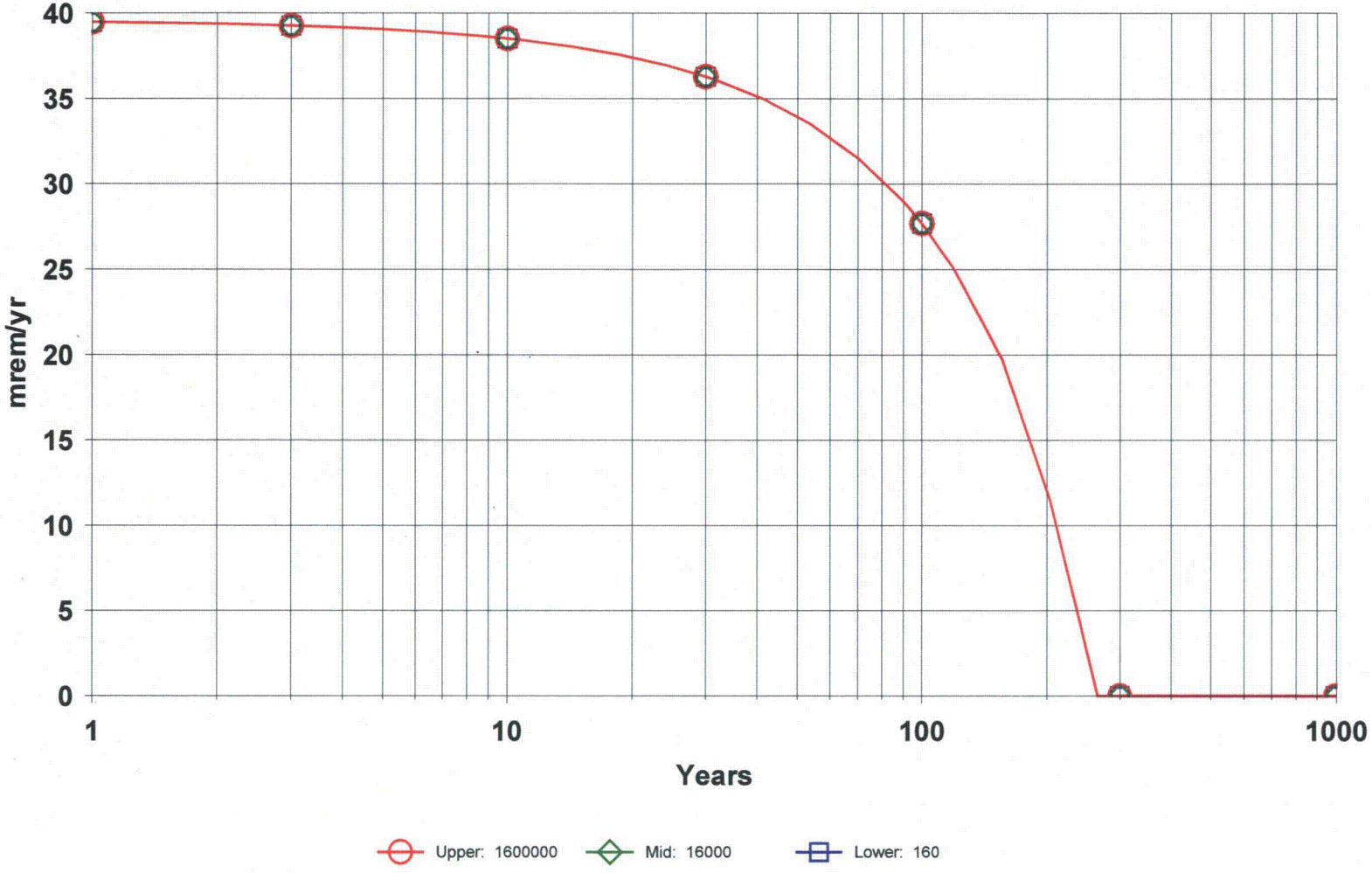
RESRAD INPUT PARAMETER SENSITIVITY ANALYSIS

DOSE: All Nuclides Summed, All Pathways Summed With SA on Pb-210 Contaminated Zone Distribution Coefficient



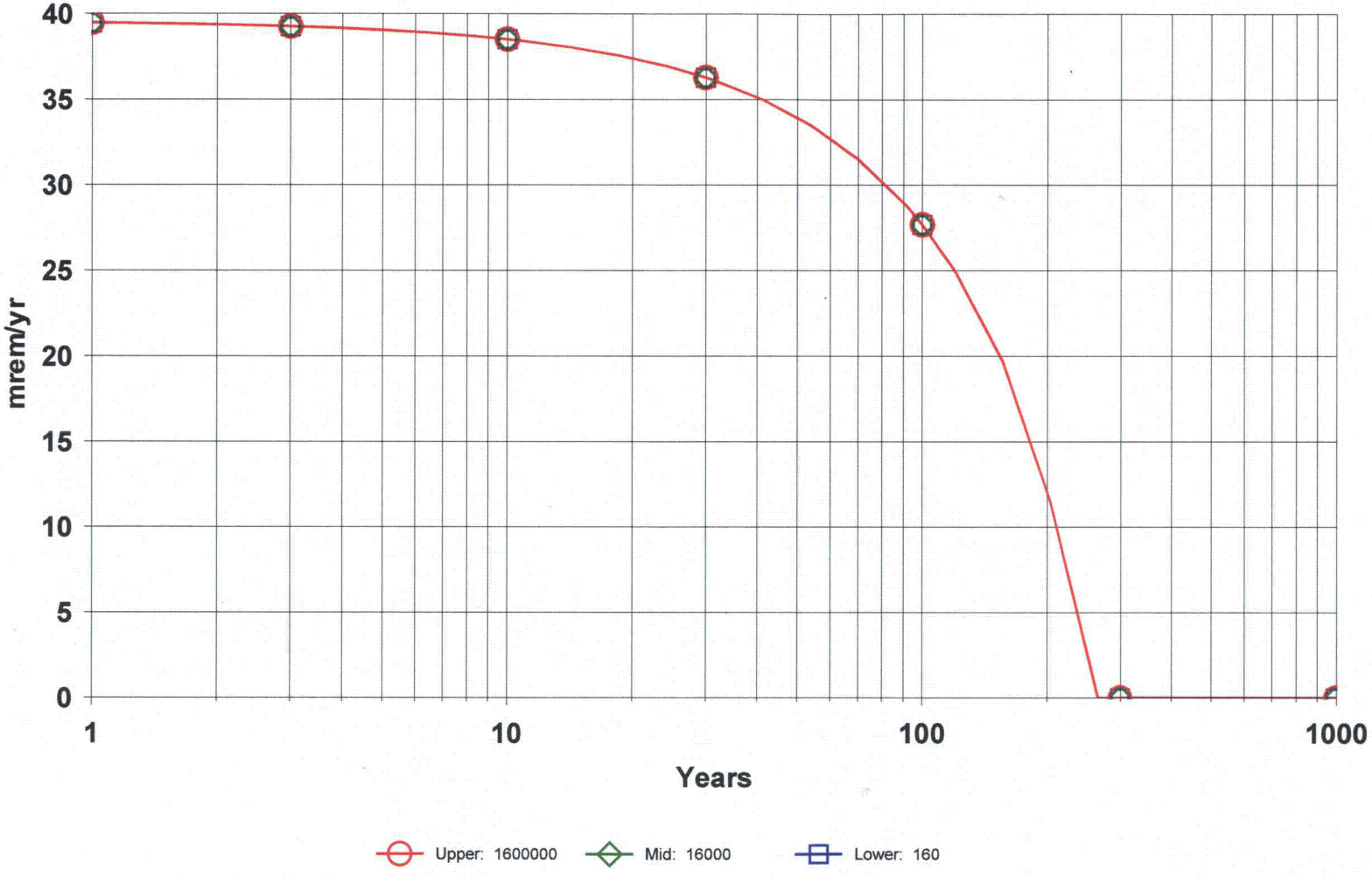
C:\RESRAD_FAMILY\RESRAD\USERFILES\LUDEMANRADIUMBENCHMARK.RAD 12/10/2008 13:36 GRAPHICS.ASC Includes All Pathways

DOSE: All Nuclides Summed, All Pathways Summed With SA on Pb-210 Saturated Zone Distribution Coefficient



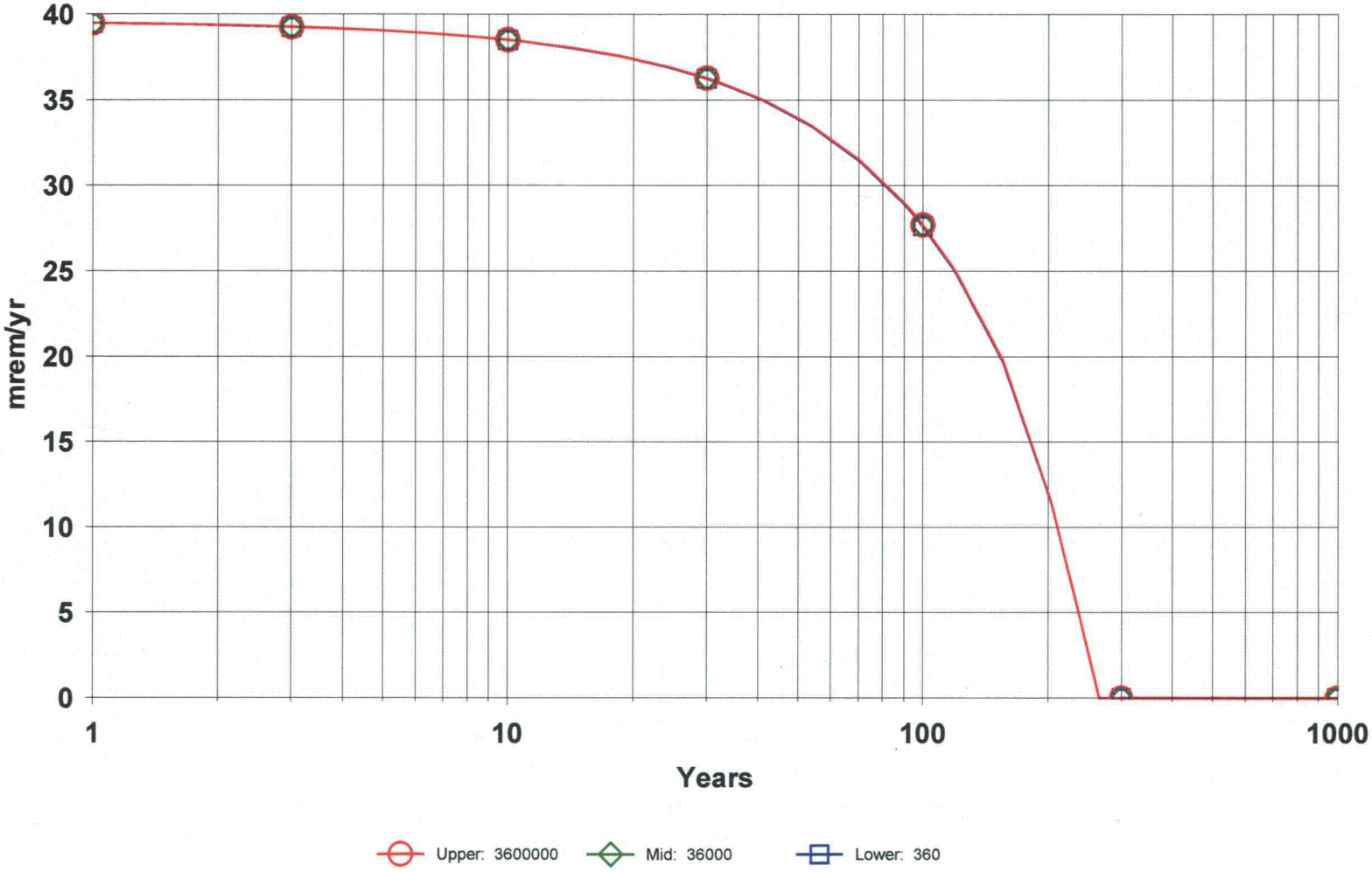
C:\RESRAD_FAMILY\RESRAD\USERFILES\LUDEMANRADIUMBENCHMARK.RAD 12/10/2008 13:36 GRAPHICS.ASC Includes All Pathways

DOSE: All Nuclides Summed, All Pathways Summed With SA on Pb-210 Unsaturated Zone Distribution Coefficient



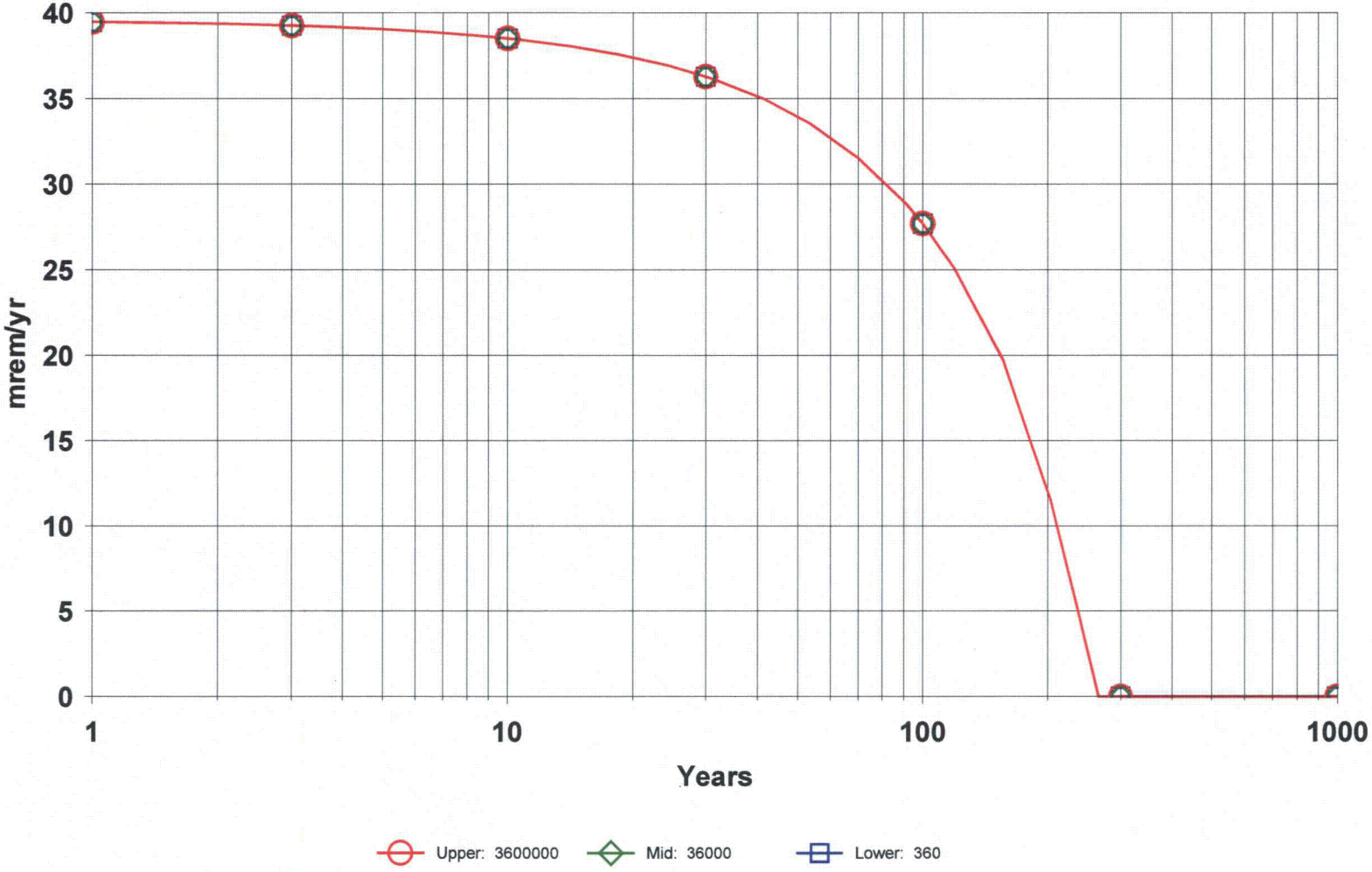
C:\RESRAD_FAMILY\RESRAD\USERFILES\LUDEMANRADIUMBENCHMARK.RAD 12/10/2008 13:36 GRAPHICS.ASC Includes All Pathways

DOSE: All Nuclides Summed, All Pathways Summed With SA on Ra-226 Contaminated Zone Distribution Coefficient



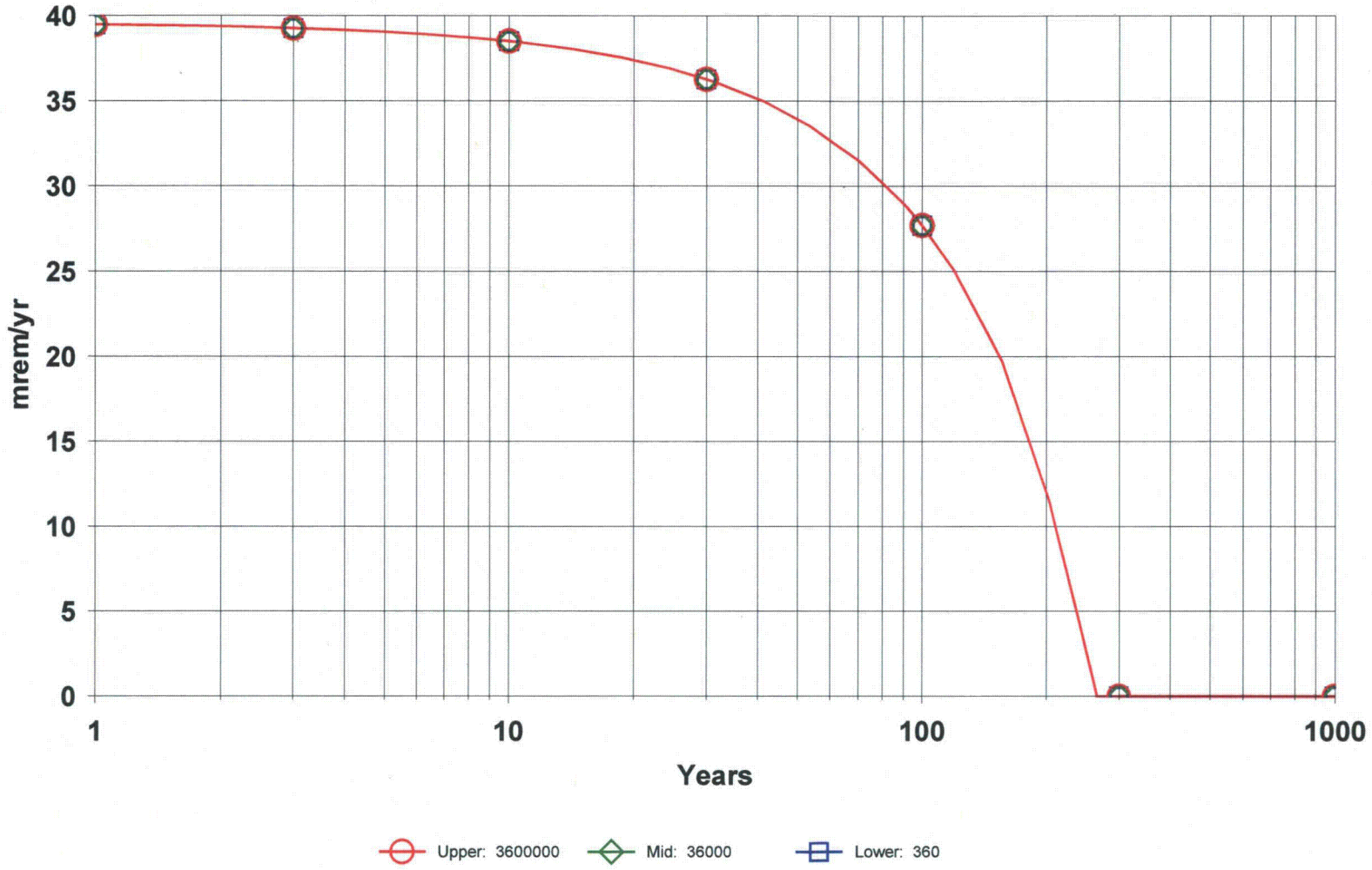
C:\RESRAD_FAMILY\RESRAD\USERFILES\LUDEMANRADIUMBENCHMARK.RAD 12/10/2008 13:36 GRAPHICS.ASC Includes All Pathways

DOSE: All Nuclides Summed, All Pathways Summed With SA on Ra-226 Unsaturated Zone Distribution Coefficient



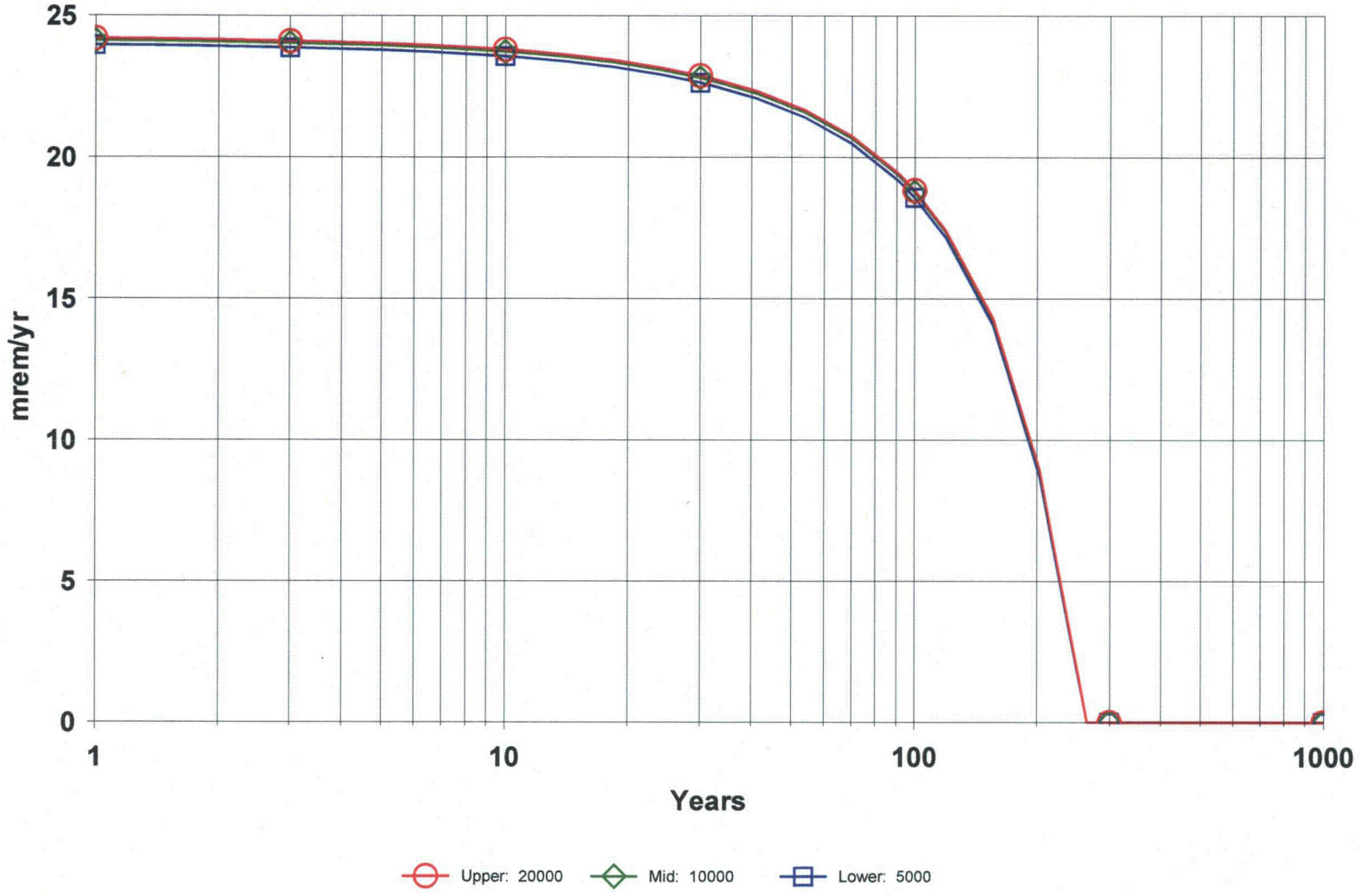
C:\RESRAD_FAMILY\RESRAD\USERFILES\LUDEMANRADIUMBENCHMARK.RAD 12/10/2008 13:36 GRAPHICS.ASC Includes All Pathways

DOSE: All Nuclides Summed, All Pathways Summed With SA on Ra-226 Saturated Zone Distribution Coefficient



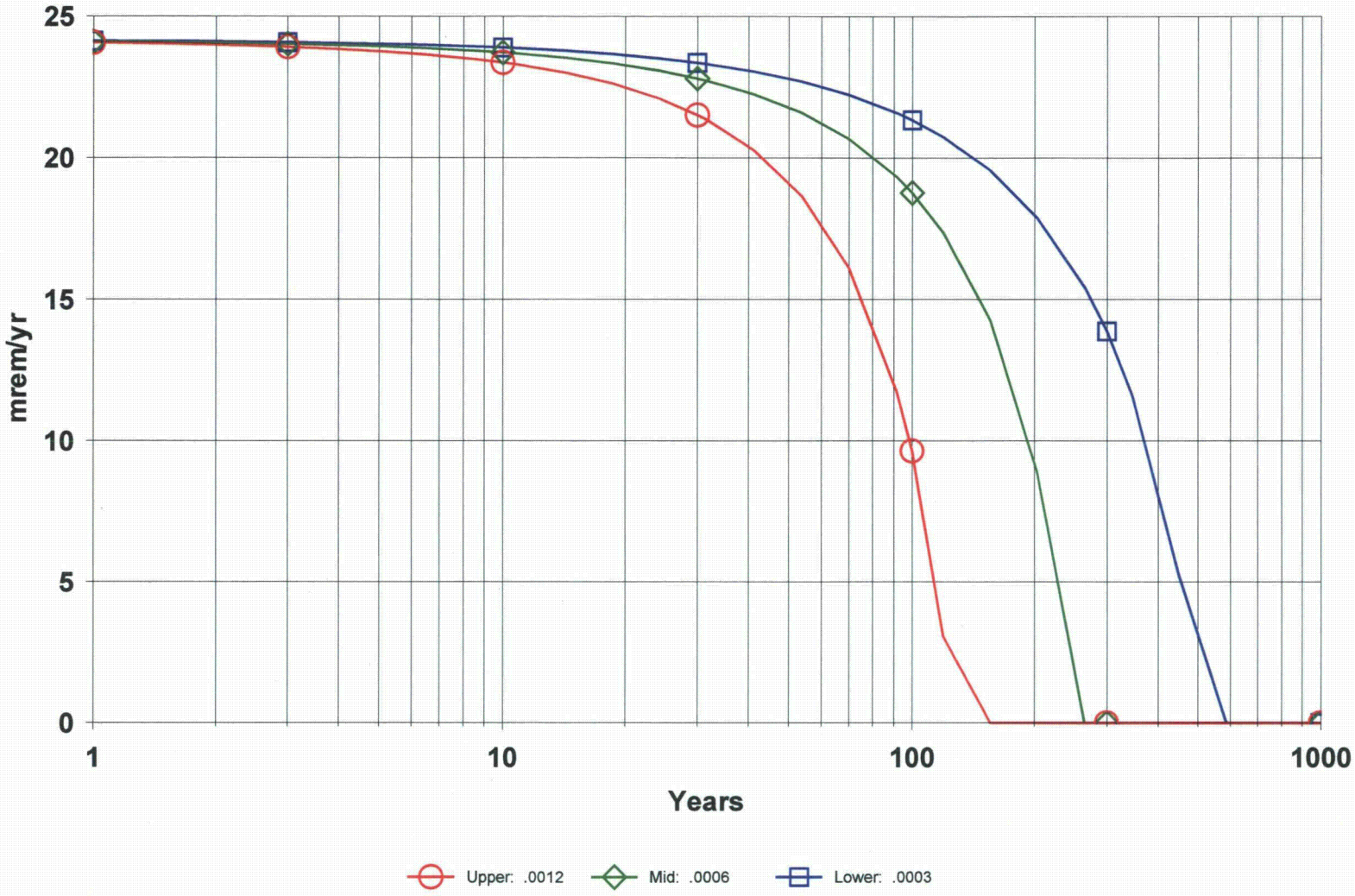
C:\RESRAD_FAMILY\RESRAD\USERFILES\LUDEMANRADIUMBENCHMARK.RAD 12/10/2008 15:09 GRAPHICS.ASC Includes All Pathways

DOSE: All Nuclides Summed, External With SA on Area of contaminated zone



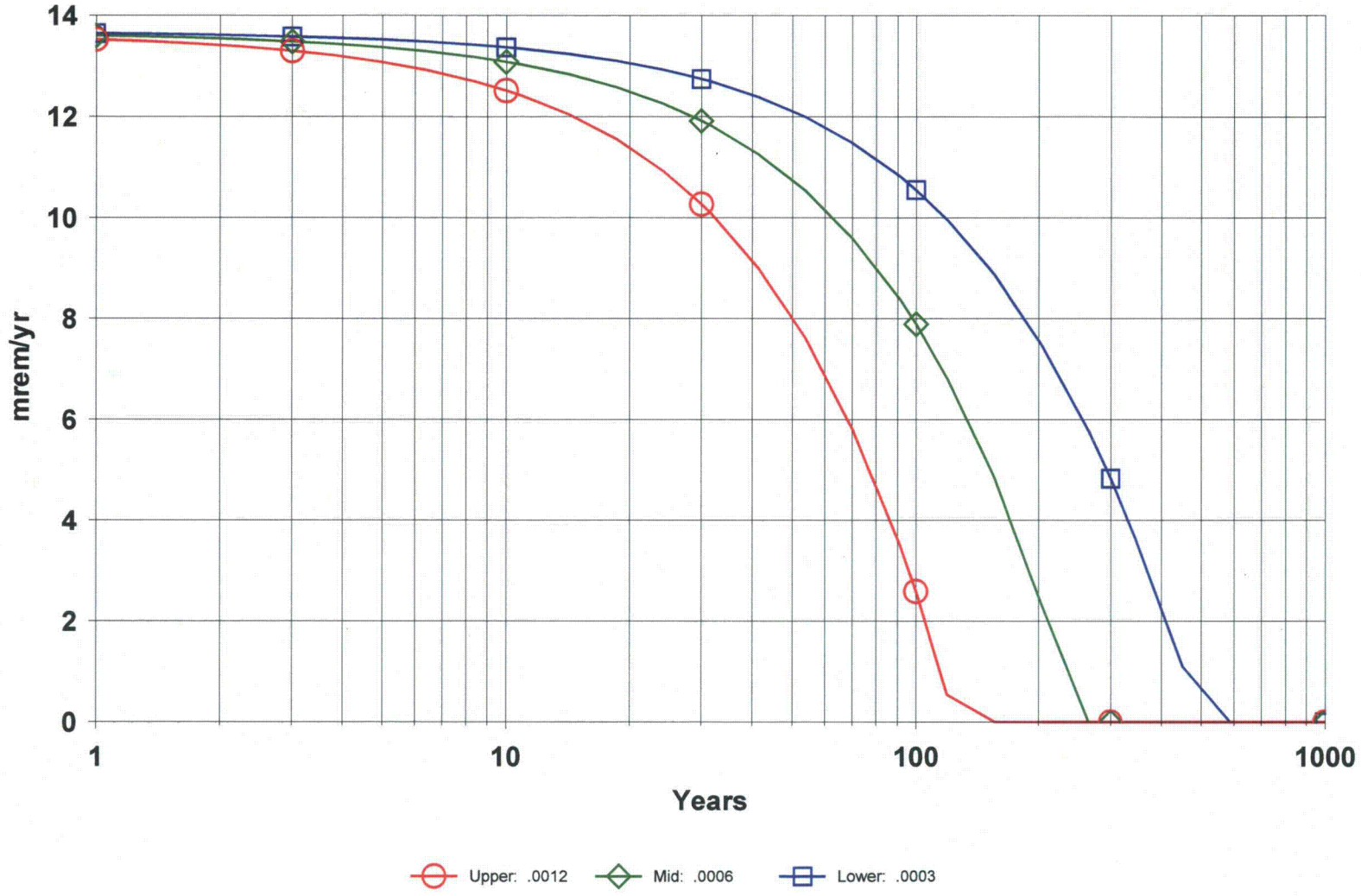
C:\RESRAD_FAMILY\RESRAD\USERFILES\LUDEMANRADIUMBENCHMARK.RAD 12/10/2008 15:09 GRAPHICS.ASC Pathways: External

DOSE: All Nuclides Summed, External With SA on Contaminated zone erosion rate



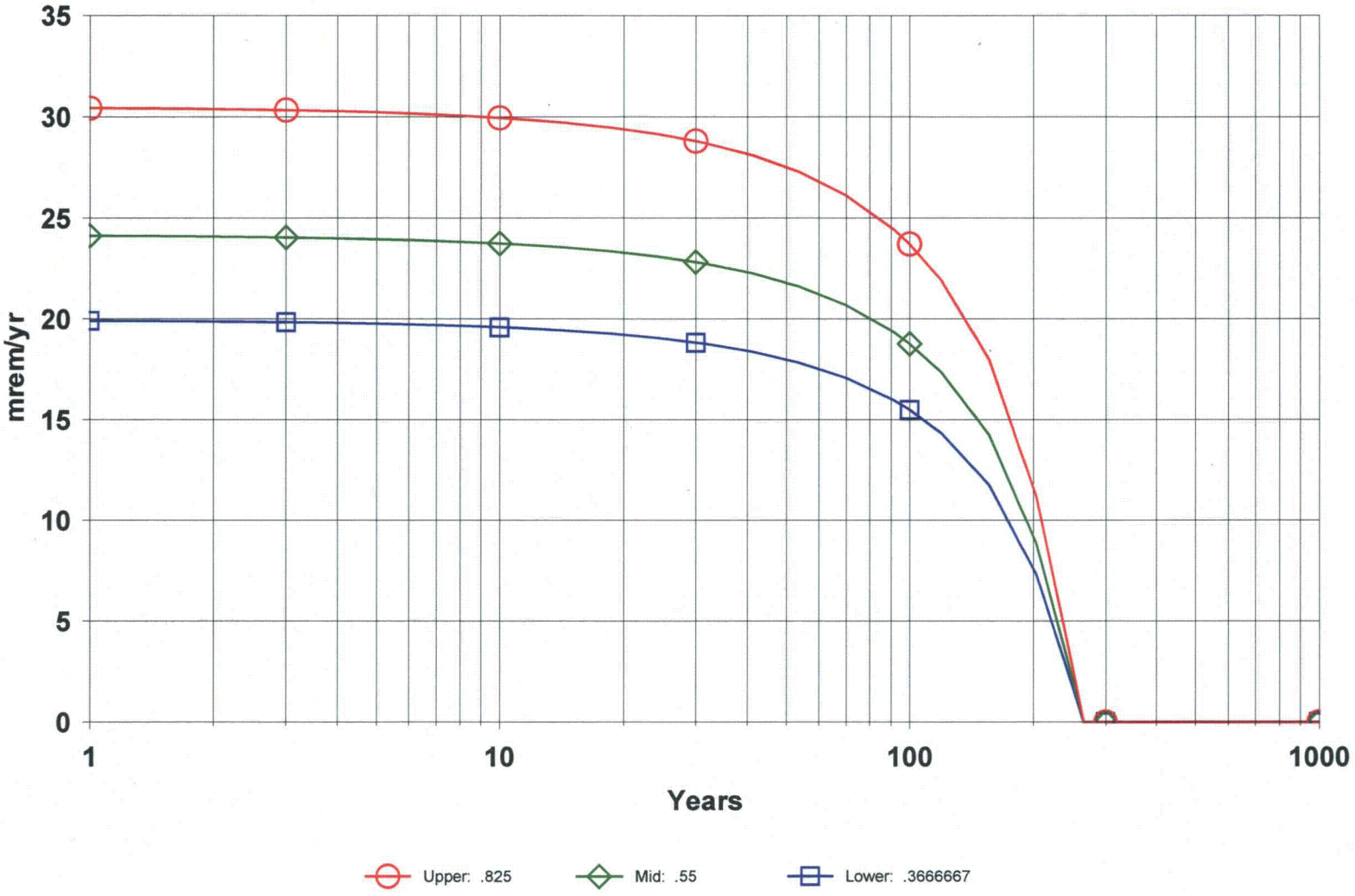
C:\RESRAD_FAMILY\RESRAD\USERFILES\LUDEMANRADIUMBENCHMARK.RAD 12/10/2008 15:09 GRAPHICS.ASC Pathways: External

DOSE: All Nuclides Summed, Plant (Water Independent) With SA on Contaminated zone erosion rate



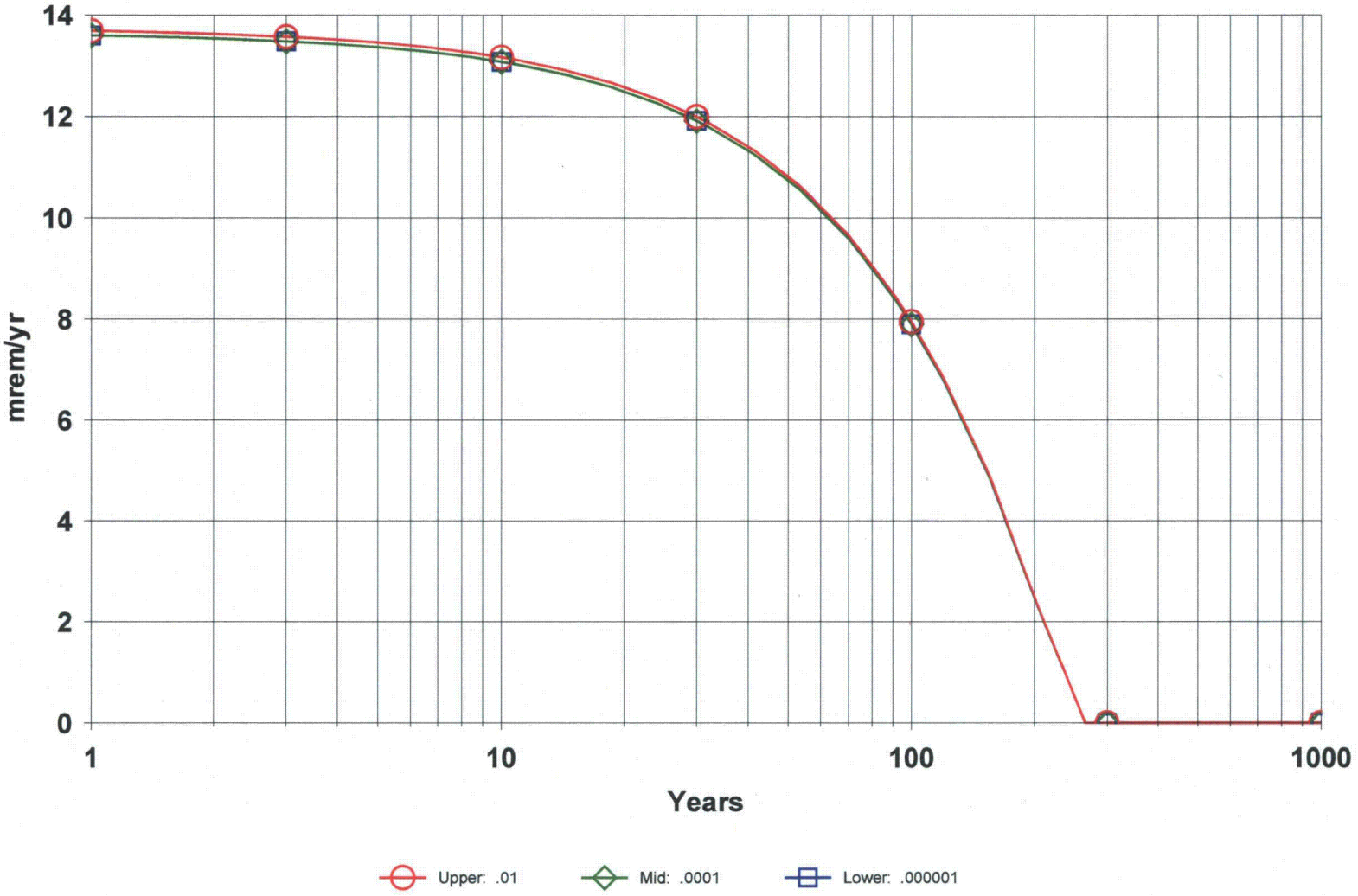
C:\RESRAD_FAMILY\RESRAD\USERFILES\LUDEMANRADIUMBENCHMARK.RAD 12/10/2008 15:09 GRAPHICS.ASC Pathways: Plant (Water Independent)

DOSE: All Nuclides Summed, External With SA on External Gamma Shielding factor



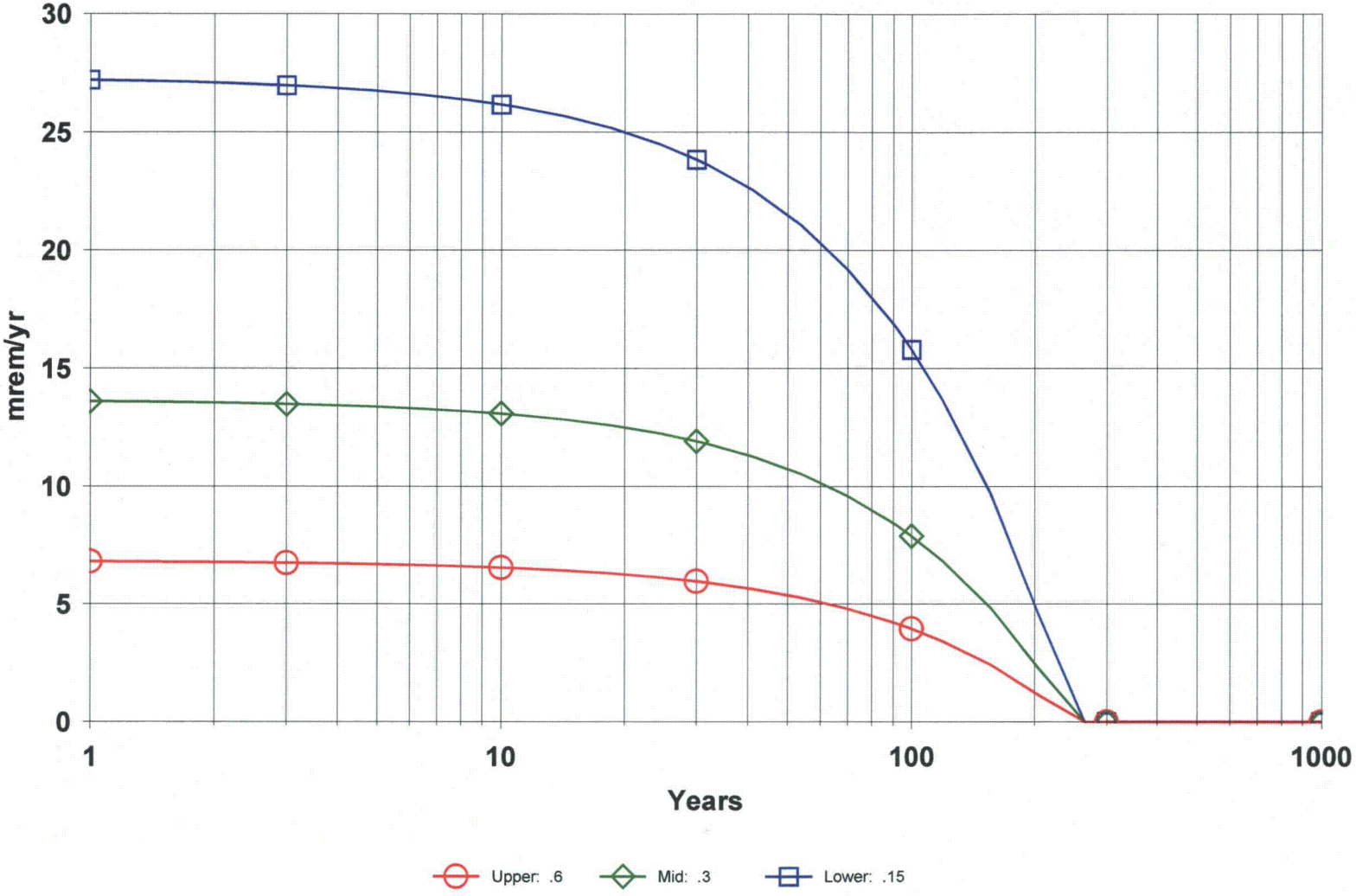
C:\RESRAD_FAMILY\RESRAD\USERFILES\LUDEMANRADIUMBENCHMARK.RAD 12/10/2008 15:09 GRAPHICS.ASC Pathways: External

DOSE: All Nuclides Summed, Plant (Water Independent) With SA on Mass loading for foliar deposition



C:\RESRAD_FAMILY\RESRAD\USERFILES\LUDEMANRADIUMBENCHMARK.RAD 12/10/2008 15:09 GRAPHICS.ASC Pathways: Plant (Water Independent)

DOSE: All Nuclides Summed, Plant (Water Independent) With SA on Depth of roots



C:\RESRAD_FAMILY\RESRAD\USERFILES\LUDEMANRADIUMBENCHMARK.RAD 12/10/2008 15:40 GRAPHICS.ASC Pathways: Plant (Water Independent)

APPENDIX D-3

RESRAD MODEL OUTPUT-RADIUM

APPENDIX D-3

RESRAD MODEL OUTPUT-RADIUM

Summary : [redacted]SRAD Default Parameters
File : C:\RESRAD_FAMILY\RESRAD\USERFILES\LUDEMANRADIUMBENCHMARK.RAD

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Dose Conversion Factor (and Related) Parameter Summary
Dose Library: FGR 11

0 Menu	Parameter	Current Value#	Base Case*	Parameter Name
A-1	DCF's for external ground radiation, (mrem/yr)/(pCi/g)			
A-1	At-218 (Source: FGR 12)	5.847E-03	5.847E-03	DCF1(1)
A-1	Bi-210 (Source: FGR 12)	3.606E-03	3.606E-03	DCF1(2)
A-1	Bi-214 (Source: FGR 12)	9.808E+00	9.808E+00	DCF1(3)
A-1	Pb-210 (Source: FGR 12)	2.447E-03	2.447E-03	DCF1(4)
A-1	Pb-214 (Source: FGR 12)	1.341E+00	1.341E+00	DCF1(5)
A-1	Po-210 (Source: FGR 12)	5.231E-05	5.231E-05	DCF1(6)
A-1	Po-214 (Source: FGR 12)	5.138E-04	5.138E-04	DCF1(7)
A-1	Po-218 (Source: FGR 12)	5.642E-05	5.642E-05	DCF1(8)
A-1	Ra-226 (Source: FGR 12)	3.176E-02	3.176E-02	DCF1(9)
A-1	Rn-222 (Source: FGR 12)	2.354E-03	2.354E-03	DCF1(10)
A-1	Tl-210 (Source: no data)	0.000E+00	-2.000E+00	DCF1(11)
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Pb-210+D	2.320E-02	1.360E-02	DCF2(1)
B-1	Ra-226+D	8.594E-03	8.580E-03	DCF2(2)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Pb-210+D	7.276E-03	5.370E-03	DCF3(1)
D-1	Ra-226+D	1.321E-03	1.320E-03	DCF3(2)
D-34	Food transfer factors:			
D-34	Pb-210+D , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(1,1)
D-34	Pb-210+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-04	8.000E-04	RTF(1,2)
D-34	Pb-210+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	3.000E-04	3.000E-04	RTF(1,3)
D-34				
D-34	Ra-226+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(2,1)
D-34	Ra-226+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(2,2)
D-34	Ra-226+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF(2,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Pb-210+D , fish	3.000E+02	3.000E+02	BIOFAC(1,1)
D-5	Pb-210+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(1,2)
D-5				
D-5	Ra-226+D , fish	5.000E+01	5.000E+01	BIOFAC(2,1)
D-5	Ra-226+D , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC(2,2)

#For DCF1(xxx) only, factors are for infinite depth & area. See ETFG table in Ground Pathway of Detailed Report.
*Base Case means Default.Lib w/o Associate Nuclide contributions.

Summary [redacted]SRAD Default Parameters
File : C:\RESRAD_FAMILY\RESRAD\USERFILES\LUDEMANRADIUMBENCHMARK.RAD

Site-Specific Parameter Summary

0 Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	1.000E+04	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	1.500E-01	2.000E+00	---	THICK0
R011	Length parallel to aquifer flow (m)	1.000E+02	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	2.500E+01	3.000E+01	---	BRDL
R011	Time since placement of material (yr)	0.000E+00	0.000E+00	---	TI
R011	Times for calculations (yr)	1.000E+00	1.000E+00	---	T(2)
R011	Times for calculations (yr)	3.000E+00	3.000E+00	---	T(3)
R011	Times for calculations (yr)	1.000E+01	1.000E+01	---	T(4)
R011	Times for calculations (yr)	3.000E+01	3.000E+01	---	T(5)
R011	Times for calculations (yr)	1.000E+02	1.000E+02	---	T(6)
R011	Times for calculations (yr)	3.000E+02	3.000E+02	---	T(7)
R011	Times for calculations (yr)	1.000E+03	1.000E+03	---	T(8)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(9)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): Pb-210	5.000E+00	0.000E+00	---	S1(1)
R012	Initial principal radionuclide (pCi/g): Ra-226	5.000E+00	0.000E+00	---	S1(2)
R012	Concentration in groundwater (pCi/L): Pb-210	not used	0.000E+00	---	W1(1)
R012	Concentration in groundwater (pCi/L): Ra-226	not used	0.000E+00	---	W1(2)
R013	Cover depth (m)	0.000E+00	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	not used	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	not used	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.500E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	6.000E-04	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	2.500E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity	6.000E-02	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	2.470E+04	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	6.450E+00	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	5.770E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	9.990E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	2.900E-01	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	1.330E+00	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	5.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	1.000E+06	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	1.000E-03	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)	1.500E+00	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	2.500E-01	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	1.900E-01	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	6.000E-02	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	2.470E+04	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	2.000E-02	2.000E-02	---	HGWT
R014	Saturated zone b parameter	6.450E+00	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	1.000E-03	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	5.490E+01	1.000E+01	---	DWIBWT
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	ND	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	2.500E+02	2.500E+02	---	UW

Site-Specific Parameter Summary (continued)

0 Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R015	Number of unsaturated zone strata	1	1	---	NS
R015	Unsat. zone 1, thickness (m)	5.330E+01	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	1.500E+00	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	2.500E-01	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	1.900E-01	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	6.000E-02	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	6.450E+00	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	2.470E+04	1.000E+01	---	HCUZ(1)
R016	Distribution coefficients for Pb-210				
R016	Contaminated zone (cm**3/g)	1.600E+04	1.000E+02	---	DCNUCC(1)
R016	Unsaturated zone 1 (cm**3/g)	1.600E+04	1.000E+02	---	DCNUCU(1,1)
R016	Saturated zone (cm**3/g)	1.600E+04	1.000E+02	---	DCNUCS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	4.097E-07	ALEACH(1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)
R016	Distribution coefficients for Ra-226				
R016	Contaminated zone (cm**3/g)	3.600E+04	7.000E+01	---	DCNUCC(2)
R016	Unsaturated zone 1 (cm**3/g)	3.600E+04	7.000E+01	---	DCNUCU(2,1)
R016	Saturated zone (cm**3/g)	3.600E+04	7.000E+01	---	DCNUCS(2)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.821E-07	ALEACH(2)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(2)
R017	Inhalation rate (m**3/yr)	8.400E+03	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	1.000E-04	1.000E-04	---	MLINH
R017	Exposure duration	3.000E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	4.000E-01	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	5.500E-01	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	5.000E-01	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	2.500E-01	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	1.000E+00	1.000E+00	>0 shows circular AREA.	FS
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE(1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE(2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE(3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE(4)
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE(5)
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE(6)
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE(7)
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE(8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE(9)
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)

Site-Specific Parameter Summary (continued)

0 Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA(1)
R017	Ring 2	not used	2.732E-01	---	FRACA(2)
R017	Ring 3	not used	0.000E+00	---	FRACA(3)
R017	Ring 4	not used	0.000E+00	---	FRACA(4)
R017	Ring 5	not used	0.000E+00	---	FRACA(5)
R017	Ring 6	not used	0.000E+00	---	FRACA(6)
R017	Ring 7	not used	0.000E+00	---	FRACA(7)
R017	Ring 8	not used	0.000E+00	---	FRACA(8)
R017	Ring 9	not used	0.000E+00	---	FRACA(9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)
R018	Fruits, vegetables and grain consumption (kg/yr)	1.600E+02	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	1.400E+01	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	9.200E+01	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	6.300E+01	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	5.400E+00	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	9.000E-01	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	3.650E+01	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	5.100E+02	5.100E+02	---	DWI
R018	Contamination fraction of drinking water	0.000E+00	1.000E+00	---	FDW
R018	Contamination fraction of household water	not used	1.000E+00	---	FHHW
R018	Contamination fraction of livestock water	1.000E+00	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	1.000E+00	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	0.000E+00	5.000E-01	---	FR9
R018	Contamination fraction of plant food	2.500E-01	-1	---	FPLANT
R018	Contamination fraction of meat	2.500E-01	-1	---	FMEAT
R018	Contamination fraction of milk	0.000E+00	-1	---	FMILK
R019	Livestock fodder intake for meat (kg/day)	6.800E+01	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	5.500E+01	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	5.000E+01	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	1.600E+02	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	5.000E-01	5.000E-01	---	LSI
R019	Mass loading for foliar deposition (g/m**3)	1.000E-04	1.000E-04	---	MLFD
R019	Depth of soil mixing layer (m)	1.500E-01	1.500E-01	---	DM
R019	Depth of roots (m)	3.000E-01	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	0.000E+00	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	1.000E+00	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	1.000E+00	1.000E+00	---	FGWIR
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)	7.000E-01	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy (kg/m**2)	1.500E+00	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	1.100E+00	1.100E+00	---	YV(3)
R19B	Growing Season for Non-Leafy (years)	1.700E-01	1.700E-01	---	TE(1)
R19B	Growing Season for Leafy (years)	2.500E-01	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	8.000E-02	8.000E-02	---	TE(3)

Site-Specific Parameter Summary (continued)

0 Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R19B	Translocation Factor for Non-Leafy	1.000E-01	1.000E-01	---	TIV(1)
R19B	Translocation Factor for Leafy	1.000E+00	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	1.000E+00	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	2.000E+01	2.000E+01	---	WLAM
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C14	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)
TITL	Number of graphical time points	32	---	---	NPTS

Site-Specific Parameter Summary (continued)

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

Summary of Pathway Selections

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

Summary : [redacted]SRAD Default Parameters
File : C:\RESRAD_FAMILY\RESRAD\USERFILES\LUDEMANRADIUMBENCHMARK.RAD

Contaminated Zone Dimensions		Initial Soil Concentrations, pCi/g	
Area:	10000.00 square meters	Pb-210	5.000E+00
Thickness:	0.15 meters	Ra-226	5.000E+00
Cover Depth:	0.00 meters		

0

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

t (years):	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
TDOSE(t):	3.957E+01	3.947E+01	3.926E+01	3.850E+01	3.627E+01	2.770E+01	0.000E+00	0.000E+00
M(t):	1.583E+00	1.579E+00	1.570E+00	1.540E+00	1.451E+00	1.108E+00	0.000E+00	0.000E+00

0Maximum TDOSE(t): 3.957E+01 mrem/yr at t = 0.000E+00 years

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

Radio-Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pb-210	1.503E-02	0.0004	2.861E-03	0.0001	0.000E+00	0.0000	7.778E+00	0.1965	3.786E-01	0.0096	0.000E+00	0.0000	9.787E-01	0.0247
Ra-226	2.414E+01	0.6101	1.121E-03	0.0000	0.000E+00	0.0000	5.878E+00	0.1485	2.016E-01	0.0051	0.000E+00	0.0000	1.957E-01	0.0049
Total	2.416E+01	0.6105	3.982E-03	0.0001	0.000E+00	0.0000	1.366E+01	0.3451	5.802E-01	0.0147	0.000E+00	0.0000	1.174E+00	0.0297

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

Radio-Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	9.153E+00	0.2313
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.042E+01	0.7687
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.957E+01	1.0000

*Sum of all water independent and dependent pathways.

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

Radio-Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pb-210	1.457E-02	0.0004	2.762E-03	0.0001	0.000E+00	0.0000	7.509E+00	0.1903	3.655E-01	0.0093	0.000E+00	0.0000	9.449E-01	0.0239
Ra-226	2.410E+01	0.6106	1.203E-03	0.0000	0.000E+00	0.0000	6.093E+00	0.1544	2.127E-01	0.0054	0.000E+00	0.0000	2.246E-01	0.0057
Total	2.411E+01	0.6110	3.965E-03	0.0001	0.000E+00	0.0000	1.360E+01	0.3446	5.782E-01	0.0146	0.000E+00	0.0000	1.170E+00	0.0296

0

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

Radio-Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.837E+00	0.2239
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.063E+01	0.7761
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.947E+01	1.0000

0*Sum of all water independent and dependent pathways.

Summary [redacted]ESRAD Default Parameters
File : C:\RESRAD_FAMILY\RESRAD\USERFILES\LUDEMANRADIUMBENCHMARK.RAD

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

Radio-Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pb-210	1.368E-02	0.0003	2.575E-03	0.0001	0.000E+00	0.0000	7.000E+00	0.1783	3.408E-01	0.0087	0.000E+00	0.0000	8.808E-01	0.0224
Ra-226	2.402E+01	0.6118	1.357E-03	0.0000	0.000E+00	0.0000	6.487E+00	0.1653	2.326E-01	0.0059	0.000E+00	0.0000	2.791E-01	0.0071
Total	2.403E+01	0.6122	3.932E-03	0.0001	0.000E+00	0.0000	1.349E+01	0.3436	5.734E-01	0.0146	0.000E+00	0.0000	1.160E+00	0.0295

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

Radio-Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.238E+00	0.2099
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.102E+01	0.7901
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.926E+01	1.0000

*Sum of all water independent and dependent pathways.

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

0 Radio-Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pb-210	1.098E-02	0.0003	2.012E-03	0.0001	0.000E+00	0.0000	5.471E+00	0.1421	2.663E-01	0.0069	0.000E+00	0.0000	6.885E-01	0.0179
Ra-226	2.372E+01	0.6161	1.803E-03	0.0000	0.000E+00	0.0000	7.612E+00	0.1977	2.900E-01	0.0075	0.000E+00	0.0000	4.374E-01	0.0114
Total	2.373E+01	0.6164	3.816E-03	0.0001	0.000E+00	0.0000	1.308E+01	0.3398	5.563E-01	0.0144	0.000E+00	0.0000	1.126E+00	0.0292

0

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

0 Radio-Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.439E+00	0.1673
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.206E+01	0.8327
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.850E+01	1.0000

0*Sum of all water independent and dependent pathways.

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

Radio-Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pb-210	5.852E-03	0.0002	9.905E-04	0.0000	0.000E+00	0.0000	2.693E+00	0.0742	1.311E-01	0.0036	0.000E+00	0.0000	3.389E-01	0.0093
Ra-226	2.281E+01	0.6288	2.488E-03	0.0001	0.000E+00	0.0000	9.226E+00	0.2544	3.759E-01	0.0104	0.000E+00	0.0000	6.882E-01	0.0190
Total	2.281E+01	0.6290	3.479E-03	0.0001	0.000E+00	0.0000	1.192E+01	0.3286	5.070E-01	0.0140	0.000E+00	0.0000	1.027E+00	0.0283

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

Radio-Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.170E+00	0.0874
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.310E+01	0.9126
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.627E+01	1.0000

*Sum of all water independent and dependent pathways.

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

Radio-Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pb-210	6.314E-04	0.0000	7.658E-05	0.0000	0.000E+00	0.0000	2.082E-01	0.0075	1.014E-02	0.0004	0.000E+00	0.0000	2.620E-02	0.0009
Ra-226	1.878E+01	0.6780	2.230E-03	0.0001	0.000E+00	0.0000	7.690E+00	0.2777	3.261E-01	0.0118	0.000E+00	0.0000	6.552E-01	0.0237
Total	1.878E+01	0.6780	2.307E-03	0.0001	0.000E+00	0.0000	7.898E+00	0.2852	3.362E-01	0.0121	0.000E+00	0.0000	6.814E-01	0.0246

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

Radio-Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.453E-01	0.0089
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.745E+01	0.9911
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	2.770E+01	1.0000

*Sum of all water independent and dependent pathways.

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

Radio-Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

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

Radio-Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

*Sum of all water independent and dependent pathways.

Summary : [redacted]SRAD Default Parameters
File : C:\RESRAD_FAMILY\RESRAD\USERFILES\LUDEMANRADIUMBENCHMARK.RAD

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

Radio-Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

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

Radio-Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
Pb-210	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Ra-226	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

0*Sum of all water independent and dependent pathways.

Summary : [redacted]SRAD Default Parameters
File : C:\RESRAD_FAMILY\RESRAD\USERFILES\LUDEMANRADIUMBENCHMARK.RAD

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

0 Parent (i)	Product (j)	Thread Fraction	DSR(j,t) At Time in Years (mrem/yr)/(pCi/g) 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Pb-210+D	Pb-210+D	1.000E+00	1.831E+00	1.767E+00	1.648E+00	1.288E+00	6.340E-01	4.905E-02	0.000E+00	0.000E+00
0Ra-226+D	Ra-226+D	1.000E+00	6.050E+00	6.036E+00	6.009E+00	5.911E+00	5.621E+00	4.454E+00	0.000E+00	0.000E+00
Ra-226+D	Pb-210+D	1.000E+00	3.353E-02	9.002E-02	1.948E-01	5.013E-01	9.994E-01	1.036E+00	0.000E+00	0.000E+00
Ra-226+D	ΣDSR(j)		6.084E+00	6.126E+00	6.203E+00	6.412E+00	6.620E+00	5.490E+00	0.000E+00	0.000E+00

The DSR includes contributions from associated (half-life ≤ 180 days) daughters.
0

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

0Nuclide (i)	t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Pb-210	1.366E+01	1.414E+01	1.517E+01	1.941E+01	3.943E+01	5.096E+02	*7.634E+13	*7.634E+13
Ra-226	4.109E+00	4.081E+00	4.030E+00	3.899E+00	3.776E+00	4.554E+00	*9.885E+11	*9.885E+11

*At specific activity limit
0

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

0Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
Pb-210	5.000E+00	0.000E+00	1.831E+00	1.366E+01	1.831E+00	1.366E+01
Ra-226	5.000E+00	29.80 ± 0.06	6.620E+00	3.776E+00	6.084E+00	4.109E+00

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

0Nuclide (j)	Parent (i)	THF(i)	DOSE(j,t), mrem/yr t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Pb-210	Pb-210	1.000E+00	9.153E+00	8.837E+00	8.238E+00	6.439E+00	3.170E+00	2.453E-01	0.000E+00	0.000E+00
Pb-210	Ra-226	1.000E+00	1.677E-01	4.501E-01	9.742E-01	2.506E+00	4.997E+00	5.181E+00	0.000E+00	0.000E+00
Pb-210	ΣDOSE(j)		9.320E+00	9.287E+00	9.212E+00	8.946E+00	8.167E+00	5.427E+00	0.000E+00	0.000E+00
0Ra-226	Ra-226	1.000E+00	3.025E+01	3.018E+01	3.004E+01	2.955E+01	2.810E+01	2.227E+01	0.000E+00	0.000E+00

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

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated

0Nuclide (j)	Parent (i)	THF(i)	S(j,t), pCi/g t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
Pb-210	Pb-210	1.000E+00	5.000E+00	4.847E+00	4.555E+00	3.664E+00	1.968E+00	2.234E-01	4.458E-04	1.584E-13
Pb-210	Ra-226	1.000E+00	0.000E+00	1.530E-01	4.449E-01	1.333E+00	3.009E+00	4.629E+00	4.452E+00	3.287E+00
Pb-210	ΣS(j):		5.000E+00	5.000E+00	5.000E+00	4.997E+00	4.977E+00	4.852E+00	4.452E+00	3.287E+00
0Ra-226	Ra-226	1.000E+00	5.000E+00	4.998E+00	4.994E+00	4.978E+00	4.935E+00	4.788E+00	4.390E+00	3.242E+00

THF(i) is the thread fraction of the parent nuclide.
0RESCALC.EXE execution time = 18.66 seconds

APPENDIX D-4

RESRAD MODEL OUTPUT-URANIUM

APPENDIX D-4

RESRAD MODEL OUTPUT-URANIUM

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Summary : [redacted]RAD Default Parameters
File : C:\RESRAD_FAMILY\RESRAD\USERFILES\LUDEMANURANIUMBENCHMARK.RAD

Dose Conversion Factor (and Related) Parameter Summary
Dose Library: FGR 11

0 Menu	Parameter	Current Value#	Base Case*	Parameter Name
A-1	DCF's for external ground radiation, (mrem/yr)/(pCi/g)			
A-1	Ac-227 (Source: FGR 12)	4.951E-04	4.951E-04	DCF1(1)
A-1	At-218 (Source: FGR 12)	5.847E-03	5.847E-03	DCF1(2)
A-1	Bi-210 (Source: FGR 12)	3.606E-03	3.606E-03	DCF1(3)
A-1	Bi-211 (Source: FGR 12)	2.559E-01	2.559E-01	DCF1(4)
A-1	Bi-214 (Source: FGR 12)	9.808E+00	9.808E+00	DCF1(5)
A-1	Fr-223 (Source: FGR 12)	1.980E-01	1.980E-01	DCF1(6)
A-1	Pa-231 (Source: FGR 12)	1.906E-01	1.906E-01	DCF1(7)
A-1	Pa-234 (Source: FGR 12)	1.155E+01	1.155E+01	DCF1(8)
A-1	Pa-234m (Source: FGR 12)	8.967E-02	8.967E-02	DCF1(9)
A-1	Pb-210 (Source: FGR 12)	2.447E-03	2.447E-03	DCF1(10)
A-1	Pb-211 (Source: FGR 12)	3.064E-01	3.064E-01	DCF1(11)
A-1	Pb-214 (Source: FGR 12)	1.341E+00	1.341E+00	DCF1(12)
A-1	Po-210 (Source: FGR 12)	5.231E-05	5.231E-05	DCF1(13)
A-1	Po-211 (Source: FGR 12)	4.764E-02	4.764E-02	DCF1(14)
A-1	Po-214 (Source: FGR 12)	5.138E-04	5.138E-04	DCF1(15)
A-1	Po-215 (Source: FGR 12)	1.016E-03	1.016E-03	DCF1(16)
A-1	Po-218 (Source: FGR 12)	5.642E-05	5.642E-05	DCF1(17)
A-1	Ra-223 (Source: FGR 12)	6.034E-01	6.034E-01	DCF1(18)
A-1	Ra-226 (Source: FGR 12)	3.176E-02	3.176E-02	DCF1(19)
A-1	Rn-219 (Source: FGR 12)	3.083E-01	3.083E-01	DCF1(20)
A-1	Rn-222 (Source: FGR 12)	2.354E-03	2.354E-03	DCF1(21)
A-1	Th-227 (Source: FGR 12)	5.212E-01	5.212E-01	DCF1(22)
A-1	Th-230 (Source: FGR 12)	1.209E-03	1.209E-03	DCF1(23)
A-1	Th-231 (Source: FGR 12)	3.643E-02	3.643E-02	DCF1(24)
A-1	Th-234 (Source: FGR 12)	2.410E-02	2.410E-02	DCF1(25)
A-1	Tl-207 (Source: FGR 12)	1.980E-02	1.980E-02	DCF1(26)
A-1	Tl-210 (Source: no data)	0.000E+00	-2.000E+00	DCF1(27)
A-1	U-234 (Source: FGR 12)	4.017E-04	4.017E-04	DCF1(28)
A-1	U-235 (Source: FGR 12)	7.211E-01	7.211E-01	DCF1(29)
A-1	U-238 (Source: FGR 12)	1.031E-04	1.031E-04	DCF1(30)
B-1	Dose conversion factors for inhalation, mrem/pCi:			
B-1	Ac-227+D	6.724E+00	6.700E+00	DCF2(1)
B-1	Pa-231	1.280E+00	1.280E+00	DCF2(2)
B-1	Pb-210+D	2.320E-02	1.360E-02	DCF2(3)
B-1	Ra-226+D	8.594E-03	8.580E-03	DCF2(4)
B-1	Th-230	3.260E-01	3.260E-01	DCF2(5)
B-1	U-234	1.320E-01	1.320E-01	DCF2(6)
B-1	U-235+D	1.230E-01	1.230E-01	DCF2(7)
B-1	U-238	1.180E-01	1.180E-01	DCF2(8)
B-1	U-238+D	1.180E-01	1.180E-01	DCF2(9)
D-1	Dose conversion factors for ingestion, mrem/pCi:			
D-1	Ac-227+D	1.480E-02	1.410E-02	DCF3(1)
D-1	Pa-231	1.060E-02	1.060E-02	DCF3(2)
D-1	Pb-210+D	7.276E-03	5.370E-03	DCF3(3)
D-1	Ra-226+D	1.321E-03	1.320E-03	DCF3(4)
D-1	Th-230	5.480E-04	5.480E-04	DCF3(5)
D-1	U-234	2.830E-04	2.830E-04	DCF3(6)

Dose Conversion Factor (and Related) Parameter Summary (continued)
Dose Library: FGR 11

0 Menu	Parameter	Current Value#	Base Case*	Parameter Name
D-1	U-235+D	2.673E-04	2.660E-04	DCF3(7)
D-1	U-238	2.550E-04	2.550E-04	DCF3(8)
D-1	U-238+D	2.687E-04	2.550E-04	DCF3(9)
D-34	Food transfer factors:			
D-34	Ac-227+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(1,1)
D-34	Ac-227+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	2.000E-05	2.000E-05	RTF(1,2)
D-34	Ac-227+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	2.000E-05	2.000E-05	RTF(1,3)
D-34				
D-34	Pa-231 , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(2,1)
D-34	Pa-231 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	5.000E-03	5.000E-03	RTF(2,2)
D-34	Pa-231 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(2,3)
D-34				
D-34	Pb-210+D , plant/soil concentration ratio, dimensionless	1.000E-02	1.000E-02	RTF(3,1)
D-34	Pb-210+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	8.000E-04	8.000E-04	RTF(3,2)
D-34	Pb-210+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	3.000E-04	3.000E-04	RTF(3,3)
D-34				
D-34	Ra-226+D , plant/soil concentration ratio, dimensionless	4.000E-02	4.000E-02	RTF(4,1)
D-34	Ra-226+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-03	1.000E-03	RTF(4,2)
D-34	Ra-226+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	1.000E-03	1.000E-03	RTF(4,3)
D-34				
D-34	Th-230 , plant/soil concentration ratio, dimensionless	1.000E-03	1.000E-03	RTF(5,1)
D-34	Th-230 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	1.000E-04	1.000E-04	RTF(5,2)
D-34	Th-230 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	5.000E-06	5.000E-06	RTF(5,3)
D-34				
D-34	U-234 , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(6,1)
D-34	U-234 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(6,2)
D-34	U-234 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(6,3)
D-34				
D-34	U-235+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(7,1)
D-34	U-235+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(7,2)
D-34	U-235+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(7,3)
D-34				
D-34	U-238 , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(8,1)
D-34	U-238 , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(8,2)
D-34	U-238 , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(8,3)
D-34				
D-34	U-238+D , plant/soil concentration ratio, dimensionless	2.500E-03	2.500E-03	RTF(9,1)
D-34	U-238+D , beef/livestock-intake ratio, (pCi/kg)/(pCi/d)	3.400E-04	3.400E-04	RTF(9,2)
D-34	U-238+D , milk/livestock-intake ratio, (pCi/L)/(pCi/d)	6.000E-04	6.000E-04	RTF(9,3)
D-5	Bioaccumulation factors, fresh water, L/kg:			
D-5	Ac-227+D , fish	1.500E+01	1.500E+01	BIOFAC(1,1)
D-5	Ac-227+D , crustacea and mollusks	1.000E+03	1.000E+03	BIOFAC(1,2)
D-5				
D-5	Pa-231 , fish	1.000E+01	1.000E+01	BIOFAC(2,1)
D-5	Pa-231 , crustacea and mollusks	1.100E+02	1.100E+02	BIOFAC(2,2)
D-5				
D-5	Pb-210+D , fish	3.000E+02	3.000E+02	BIOFAC(3,1)
D-5	Pb-210+D , crustacea and mollusks	1.000E+02	1.000E+02	BIOFAC(3,2)

Dose Conversion Factor (and Related) Parameter Summary (continued)
Dose Library: FGR 11

0 Menu	Parameter	Current Value#	Base Case*	Parameter Name
D-5	Ra-226+D , fish	5.000E+01	5.000E+01	BIOFAC(4,1)
D-5	Ra-226+D , crustacea and mollusks	2.500E+02	2.500E+02	BIOFAC(4,2)
D-5				
D-5	Th-230 , fish	1.000E+02	1.000E+02	BIOFAC(5,1)
D-5	Th-230 , crustacea and mollusks	5.000E+02	5.000E+02	BIOFAC(5,2)
D-5				
D-5	U-234 , fish	1.000E+01	1.000E+01	BIOFAC(6,1)
D-5	U-234 , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(6,2)
D-5				
D-5	U-235+D , fish	1.000E+01	1.000E+01	BIOFAC(7,1)
D-5	U-235+D , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(7,2)
D-5				
D-5	U-238 , fish	1.000E+01	1.000E+01	BIOFAC(8,1)
D-5	U-238 , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(8,2)
D-5				
D-5	U-238+D , fish	1.000E+01	1.000E+01	BIOFAC(9,1)
D-5	U-238+D , crustacea and mollusks	6.000E+01	6.000E+01	BIOFAC(9,2)

#For DCF1(xxx) only, factors are for infinite depth & area.. See ETFG table in Ground Pathway of Detailed Report.
*Base Case means Default.Lib w/o Associate Nuclide contributions.

Summary : [redacted]SRAD Default Parameters
File : C:\RESRAD_FAMILY\RESRAD\USERFILES\LUDEMANURANIUMBENCHMARK.RAD

Site-Specific Parameter Summary

0 Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R011	Area of contaminated zone (m**2)	1.000E+04	1.000E+04	---	AREA
R011	Thickness of contaminated zone (m)	1.500E-01	2.000E+00	---	THICK0
R011	Length parallel to aquifer flow (m)	1.000E+02	1.000E+02	---	LCZPAQ
R011	Basic radiation dose limit (mrem/yr)	2.500E+01	3.000E+01	---	BRDL
R011	Time since placement of material (yr)	0.000E+00	0.000E+00	---	TI
R011	Times for calculations (yr)	1.000E+00	1.000E+00	---	T(2)
R011	Times for calculations (yr)	3.000E+00	3.000E+00	---	T(3)
R011	Times for calculations (yr)	1.000E+01	1.000E+01	---	T(4)
R011	Times for calculations (yr)	3.000E+01	3.000E+01	---	T(5)
R011	Times for calculations (yr)	1.000E+02	1.000E+02	---	T(6)
R011	Times for calculations (yr)	3.000E+02	3.000E+02	---	T(7)
R011	Times for calculations (yr)	1.000E+03	1.000E+03	---	T(8)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(9)
R011	Times for calculations (yr)	not used	0.000E+00	---	T(10)
R012	Initial principal radionuclide (pCi/g): U-234	4.920E+01	0.000E+00	---	S1(6)
R012	Initial principal radionuclide (pCi/g): U-235	2.200E+00	0.000E+00	---	S1(7)
R012	Initial principal radionuclide (pCi/g): U-238	4.860E+01	0.000E+00	---	S1(8)
R012	Concentration in groundwater (pCi/L): U-234	not used	0.000E+00	---	W1(6)
R012	Concentration in groundwater (pCi/L): U-235	not used	0.000E+00	---	W1(7)
R012	Concentration in groundwater (pCi/L): U-238	not used	0.000E+00	---	W1(8)
R013	Cover depth (m)	0.000E+00	0.000E+00	---	COVER0
R013	Density of cover material (g/cm**3)	not used	1.500E+00	---	DENSCV
R013	Cover depth erosion rate (m/yr)	not used	1.000E-03	---	VCV
R013	Density of contaminated zone (g/cm**3)	1.500E+00	1.500E+00	---	DENSCZ
R013	Contaminated zone erosion rate (m/yr)	6.000E-04	1.000E-03	---	VCZ
R013	Contaminated zone total porosity	2.500E-01	4.000E-01	---	TPCZ
R013	Contaminated zone field capacity	6.000E-02	2.000E-01	---	FCCZ
R013	Contaminated zone hydraulic conductivity (m/yr)	2.470E+04	1.000E+01	---	HCCZ
R013	Contaminated zone b parameter	6.450E+00	5.300E+00	---	BCZ
R013	Average annual wind speed (m/sec)	5.770E+00	2.000E+00	---	WIND
R013	Humidity in air (g/m**3)	not used	8.000E+00	---	HUMID
R013	Evapotranspiration coefficient	9.990E-01	5.000E-01	---	EVAPTR
R013	Precipitation (m/yr)	2.900E-01	1.000E+00	---	PRECIP
R013	Irrigation (m/yr)	1.330E+00	2.000E-01	---	RI
R013	Irrigation mode	overhead	overhead	---	IDITCH
R013	Runoff coefficient	5.000E-01	2.000E-01	---	RUNOFF
R013	Watershed area for nearby stream or pond (m**2)	1.000E+06	1.000E+06	---	WAREA
R013	Accuracy for water/soil computations	1.000E-03	1.000E-03	---	EPS
R014	Density of saturated zone (g/cm**3)	1.500E+00	1.500E+00	---	DENSAQ
R014	Saturated zone total porosity	2.500E-01	4.000E-01	---	TPSZ
R014	Saturated zone effective porosity	1.900E-01	2.000E-01	---	EPSZ
R014	Saturated zone field capacity	6.000E-02	2.000E-01	---	FCSZ
R014	Saturated zone hydraulic conductivity (m/yr)	2.470E+04	1.000E+02	---	HCSZ
R014	Saturated zone hydraulic gradient	2.000E-02	2.000E-02	---	HGWT
R014	Saturated zone b parameter	6.450E+00	5.300E+00	---	BSZ
R014	Water table drop rate (m/yr)	1.000E-03	1.000E-03	---	VWT
R014	Well pump intake depth (m below water table)	5.490E+01	1.000E+01	---	DWIBWT

Site-Specific Parameter Summary (continued)

0 Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R014	Model: Nondispersion (ND) or Mass-Balance (MB)	ND	ND	---	MODEL
R014	Well pumping rate (m**3/yr)	2.500E+02	2.500E+02	---	UW
R015	Number of unsaturated zone strata	1	1	---	NS
R015	Unsat. zone 1, thickness (m)	5.330E+01	4.000E+00	---	H(1)
R015	Unsat. zone 1, soil density (g/cm**3)	1.500E+00	1.500E+00	---	DENSUZ(1)
R015	Unsat. zone 1, total porosity	2.500E-01	4.000E-01	---	TPUZ(1)
R015	Unsat. zone 1, effective porosity	1.900E-01	2.000E-01	---	EPUZ(1)
R015	Unsat. zone 1, field capacity	6.000E-02	2.000E-01	---	FCUZ(1)
R015	Unsat. zone 1, soil-specific b parameter	6.450E+00	5.300E+00	---	BUZ(1)
R015	Unsat. zone 1, hydraulic conductivity (m/yr)	2.470E+04	1.000E+01	---	HCUZ(1)
R016	Distribution coefficients for U-234				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(6)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(6,1)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCS(6)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.310E-04	ALEACH(6)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(6)
R016	Distribution coefficients for U-235				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(7)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(7,1)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCS(7)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.310E-04	ALEACH(7)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(7)
R016	Distribution coefficients for U-238				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(8)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(8,1)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCS(8)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.310E-04	ALEACH(8)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(8)
R016	Distribution coefficients for daughter Ac-227				
R016	Contaminated zone (cm**3/g)	2.000E+01	2.000E+01	---	DCNUCC(1)
R016	Unsaturated zone 1 (cm**3/g)	2.000E+01	2.000E+01	---	DCNUCU(1,1)
R016	Saturated zone (cm**3/g)	2.000E+01	2.000E+01	---	DCNUCS(1)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	3.268E-04	ALEACH(1)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(1)
R016	Distribution coefficients for daughter Pa-231				
R016	Contaminated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCC(2)
R016	Unsaturated zone 1 (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCU(2,1)
R016	Saturated zone (cm**3/g)	5.000E+01	5.000E+01	---	DCNUCS(2)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.310E-04	ALEACH(2)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(2)

Site-Specific Parameter Summary (continued)

0 Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R016	Distribution coefficients for daughter Pb-210				
R016	Contaminated zone (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCC(3)
R016	Unsaturated zone 1 (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCU(3,1)
R016	Saturated zone (cm**3/g)	1.000E+02	1.000E+02	---	DCNUCS(3)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	6.552E-05	ALEACH(3)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(3)
R016	Distribution coefficients for daughter Ra-226				
R016	Contaminated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCC(4)
R016	Unsaturated zone 1 (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCU(4,1)
R016	Saturated zone (cm**3/g)	7.000E+01	7.000E+01	---	DCNUCS(4)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	9.357E-05	ALEACH(4)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(4)
R016	Distribution coefficients for daughter Th-230				
R016	Contaminated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCC(5)
R016	Unsaturated zone 1 (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCU(5,1)
R016	Saturated zone (cm**3/g)	6.000E+04	6.000E+04	---	DCNUCS(5)
R016	Leach rate (/yr)	0.000E+00	0.000E+00	1.093E-07	ALEACH(5)
R016	Solubility constant	0.000E+00	0.000E+00	not used	SOLUBK(5)
R017	Inhalation rate (m**3/yr)	8.400E+03	8.400E+03	---	INHALR
R017	Mass loading for inhalation (g/m**3)	1.000E-04	1.000E-04	---	MLINH
R017	Exposure duration	3.000E+01	3.000E+01	---	ED
R017	Shielding factor, inhalation	4.000E-01	4.000E-01	---	SHF3
R017	Shielding factor, external gamma	5.500E-01	7.000E-01	---	SHF1
R017	Fraction of time spent indoors	5.000E-01	5.000E-01	---	FIND
R017	Fraction of time spent outdoors (on site)	2.500E-01	2.500E-01	---	FOTD
R017	Shape factor flag, external gamma	1.000E+00	1.000E+00	>0 shows circular AREA.	FS
R017	Radii of shape factor array (used if FS = -1):				
R017	Outer annular radius (m), ring 1:	not used	5.000E+01	---	RAD_SHAPE(1)
R017	Outer annular radius (m), ring 2:	not used	7.071E+01	---	RAD_SHAPE(2)
R017	Outer annular radius (m), ring 3:	not used	0.000E+00	---	RAD_SHAPE(3)
R017	Outer annular radius (m), ring 4:	not used	0.000E+00	---	RAD_SHAPE(4)
R017	Outer annular radius (m), ring 5:	not used	0.000E+00	---	RAD_SHAPE(5)
R017	Outer annular radius (m), ring 6:	not used	0.000E+00	---	RAD_SHAPE(6)
R017	Outer annular radius (m), ring 7:	not used	0.000E+00	---	RAD_SHAPE(7)
R017	Outer annular radius (m), ring 8:	not used	0.000E+00	---	RAD_SHAPE(8)
R017	Outer annular radius (m), ring 9:	not used	0.000E+00	---	RAD_SHAPE(9)
R017	Outer annular radius (m), ring 10:	not used	0.000E+00	---	RAD_SHAPE(10)
R017	Outer annular radius (m), ring 11:	not used	0.000E+00	---	RAD_SHAPE(11)
R017	Outer annular radius (m), ring 12:	not used	0.000E+00	---	RAD_SHAPE(12)

Summary : [redacted]RAD Default Parameters
File : C:\RESRAD_FAMILY\RESRAD\USERFILES\LUDEMANURANIUMBENCHMARK.RAD

Site-Specific Parameter Summary (continued)

0 Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R017	Fractions of annular areas within AREA:				
R017	Ring 1	not used	1.000E+00	---	FRACA(1)
R017	Ring 2	not used	2.732E-01	---	FRACA(2)
R017	Ring 3	not used	0.000E+00	---	FRACA(3)
R017	Ring 4	not used	0.000E+00	---	FRACA(4)
R017	Ring 5	not used	0.000E+00	---	FRACA(5)
R017	Ring 6	not used	0.000E+00	---	FRACA(6)
R017	Ring 7	not used	0.000E+00	---	FRACA(7)
R017	Ring 8	not used	0.000E+00	---	FRACA(8)
R017	Ring 9	not used	0.000E+00	---	FRACA(9)
R017	Ring 10	not used	0.000E+00	---	FRACA(10)
R017	Ring 11	not used	0.000E+00	---	FRACA(11)
R017	Ring 12	not used	0.000E+00	---	FRACA(12)
R018	Fruits, vegetables and grain consumption (kg/yr)	1.600E+02	1.600E+02	---	DIET(1)
R018	Leafy vegetable consumption (kg/yr)	1.400E+01	1.400E+01	---	DIET(2)
R018	Milk consumption (L/yr)	9.200E+01	9.200E+01	---	DIET(3)
R018	Meat and poultry consumption (kg/yr)	6.300E+01	6.300E+01	---	DIET(4)
R018	Fish consumption (kg/yr)	5.400E+00	5.400E+00	---	DIET(5)
R018	Other seafood consumption (kg/yr)	9.000E-01	9.000E-01	---	DIET(6)
R018	Soil ingestion rate (g/yr)	3.650E+01	3.650E+01	---	SOIL
R018	Drinking water intake (L/yr)	5.100E+02	5.100E+02	---	DWI
R018	Contamination fraction of drinking water	0.000E+00	1.000E+00	---	FDW
R018	Contamination fraction of household water	not used	1.000E+00	---	FHHW
R018	Contamination fraction of livestock water	1.000E+00	1.000E+00	---	FLW
R018	Contamination fraction of irrigation water	1.000E+00	1.000E+00	---	FIRW
R018	Contamination fraction of aquatic food	0.000E+00	5.000E-01	---	FR9
R018	Contamination fraction of plant food	2.500E-01	-1	---	FPLANT
R018	Contamination fraction of meat	2.500E-01	-1	---	FMEAT
R018	Contamination fraction of milk	0.000E+00	-1	---	FMILK
R019	Livestock fodder intake for meat (kg/day)	6.800E+01	6.800E+01	---	LFI5
R019	Livestock fodder intake for milk (kg/day)	5.500E+01	5.500E+01	---	LFI6
R019	Livestock water intake for meat (L/day)	5.000E+01	5.000E+01	---	LWI5
R019	Livestock water intake for milk (L/day)	1.600E+02	1.600E+02	---	LWI6
R019	Livestock soil intake (kg/day)	5.000E-01	5.000E-01	---	LSI
R019	Mass loading for foliar deposition (g/m**3)	1.000E-04	1.000E-04	---	MLFD
R019	Depth of soil mixing layer (m)	1.500E-01	1.500E-01	---	DM
R019	Depth of roots (m)	3.000E-01	9.000E-01	---	DROOT
R019	Drinking water fraction from ground water	0.000E+00	1.000E+00	---	FGWDW
R019	Household water fraction from ground water	not used	1.000E+00	---	FGWHH
R019	Livestock water fraction from ground water	1.000E+00	1.000E+00	---	FGWLW
R019	Irrigation fraction from ground water	1.000E+00	1.000E+00	---	FGWIR
R19B	Wet weight crop yield for Non-Leafy (kg/m**2)	7.000E-01	7.000E-01	---	YV(1)
R19B	Wet weight crop yield for Leafy (kg/m**2)	1.500E+00	1.500E+00	---	YV(2)
R19B	Wet weight crop yield for Fodder (kg/m**2)	1.100E+00	1.100E+00	---	YV(3)
R19B	Growing Season for Non-Leafy (years)	1.700E-01	1.700E-01	---	TE(1)
R19B	Growing Season for Leafy (years)	2.500E-01	2.500E-01	---	TE(2)
R19B	Growing Season for Fodder (years)	8.000E-02	8.000E-02	---	TE(3)

Site-Specific Parameter Summary (continued)

0 Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
R19B	Translocation Factor for Non-Leafy	1.000E-01	1.000E-01	---	TIV(1)
R19B	Translocation Factor for Leafy	1.000E+00	1.000E+00	---	TIV(2)
R19B	Translocation Factor for Fodder	1.000E+00	1.000E+00	---	TIV(3)
R19B	Dry Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RDRY(1)
R19B	Dry Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RDRY(2)
R19B	Dry Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01	---	RDRY(3)
R19B	Wet Foliar Interception Fraction for Non-Leafy	2.500E-01	2.500E-01	---	RWET(1)
R19B	Wet Foliar Interception Fraction for Leafy	2.500E-01	2.500E-01	---	RWET(2)
R19B	Wet Foliar Interception Fraction for Fodder	2.500E-01	2.500E-01	---	RWET(3)
R19B	Weathering Removal Constant for Vegetation	2.000E+01	2.000E+01	---	WLAM
C14	C-12 concentration in water (g/cm**3)	not used	2.000E-05	---	C12WTR
C14	C-12 concentration in contaminated soil (g/g)	not used	3.000E-02	---	C12CZ
C14	Fraction of vegetation carbon from soil	not used	2.000E-02	---	CSOIL
C14	Fraction of vegetation carbon from air	not used	9.800E-01	---	CAIR
C14	C-14 evasion layer thickness in soil (m)	not used	3.000E-01	---	DMC
C14	C-14 evasion flux rate from soil (1/sec)	not used	7.000E-07	---	EVSN
C14	C-12 evasion flux rate from soil (1/sec)	not used	1.000E-10	---	REVSN
C14	Fraction of grain in beef cattle feed	not used	8.000E-01	---	AVFG4
C14	Fraction of grain in milk cow feed	not used	2.000E-01	---	AVFG5
STOR	Storage times of contaminated foodstuffs (days):				
STOR	Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	---	STOR_T(1)
STOR	Leafy vegetables	1.000E+00	1.000E+00	---	STOR_T(2)
STOR	Milk	1.000E+00	1.000E+00	---	STOR_T(3)
STOR	Meat and poultry	2.000E+01	2.000E+01	---	STOR_T(4)
STOR	Fish	7.000E+00	7.000E+00	---	STOR_T(5)
STOR	Crustacea and mollusks	7.000E+00	7.000E+00	---	STOR_T(6)
STOR	Well water	1.000E+00	1.000E+00	---	STOR_T(7)
STOR	Surface water	1.000E+00	1.000E+00	---	STOR_T(8)
STOR	Livestock fodder	4.500E+01	4.500E+01	---	STOR_T(9)
R021	Thickness of building foundation (m)	not used	1.500E-01	---	FLOOR1
R021	Bulk density of building foundation (g/cm**3)	not used	2.400E+00	---	DENSFL
R021	Total porosity of the cover material	not used	4.000E-01	---	TPCV
R021	Total porosity of the building foundation	not used	1.000E-01	---	TPFL
R021	Volumetric water content of the cover material	not used	5.000E-02	---	PH2OCV
R021	Volumetric water content of the foundation	not used	3.000E-02	---	PH2OFL
R021	Diffusion coefficient for radon gas (m/sec):				
R021	in cover material	not used	2.000E-06	---	DIFCV
R021	in foundation material	not used	3.000E-07	---	DIFFL
R021	in contaminated zone soil	not used	2.000E-06	---	DIFCZ
R021	Radon vertical dimension of mixing (m)	not used	2.000E+00	---	HMIX
R021	Average building air exchange rate (1/hr)	not used	5.000E-01	---	REXG
R021	Height of the building (room) (m)	not used	2.500E+00	---	HRM
R021	Building interior area factor	not used	0.000E+00	---	FAI
R021	Building depth below ground surface (m)	not used	-1.000E+00	---	DMFL
R021	Emanating power of Rn-222 gas	not used	2.500E-01	---	EMANA(1)
R021	Emanating power of Rn-220 gas	not used	1.500E-01	---	EMANA(2)
TITL	Number of graphical time points	32	---	---	NPTS

Site-Specific Parameter Summary (continued)

0 Menu	Parameter	User Input	Default	Used by RESRAD (If different from user input)	Parameter Name
TITL	Maximum number of integration points for dose	17	---	---	LYMAX
TITL	Maximum number of integration points for risk	257	---	---	KYMAX

Summary of Pathway Selections

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

Summary : [redacted]RAD Default Parameters
File : C:\RESRAD_FAMILY\RESRAD\USERFILES\LUDEMANURANIUMBENCHMARK.RAD

Contaminated Zone Dimensions		Initial Soil Concentrations, pCi/g	
Area:	10000.00 square meters	U-234	4.920E+01
Thickness:	0.15 meters	U-235	2.200E+00
Cover Depth:	0.00 meters	U-238	4.860E+01

0

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

t (years):	0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
TDOSE(t):	6.867E+00	6.852E+00	6.823E+00	6.718E+00	6.409E+00	5.178E+00	0.000E+00	0.000E+00
M(t):	2.747E-01	2.741E-01	2.729E-01	2.687E-01	2.564E-01	2.071E-01	0.000E+00	0.000E+00

0Maximum TDOSE(t): 6.867E+00 mrem/yr at t = 0.000E+00 years

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

Radio-Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	1.003E-02	0.0015	1.627E-01	0.0237	0.000E+00	0.0000	7.559E-01	0.1101	4.355E-02	0.0063	0.000E+00	0.0000	3.804E-01	0.0554
U-235	8.183E-01	0.1192	6.779E-03	0.0010	0.000E+00	0.0000	3.198E-02	0.0047	1.853E-03	0.0003	0.000E+00	0.0000	1.607E-02	0.0023
U-238	3.389E+00	0.4935	1.437E-01	0.0209	0.000E+00	0.0000	7.090E-01	0.1032	4.085E-02	0.0059	0.000E+00	0.0000	3.568E-01	0.0520
Total	4.218E+00	0.6142	3.132E-01	0.0456	0.000E+00	0.0000	1.497E+00	0.2180	8.625E-02	0.0126	0.000E+00	0.0000	7.532E-01	0.1097

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

Radio-Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.353E+00	0.1970
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.750E-01	0.1274
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.639E+00	0.6756
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.867E+00	1.0000

*Sum of all water independent and dependent pathways.

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

Radio-Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	1.003E-02	0.0015	1.620E-01	0.0236	0.000E+00	0.0000	7.528E-01	0.1099	4.337E-02	0.0063	0.000E+00	0.0000	3.788E-01	0.0553
U-235	8.179E-01	0.1194	6.753E-03	0.0010	0.000E+00	0.0000	3.196E-02	0.0047	1.878E-03	0.0003	0.000E+00	0.0000	1.602E-02	0.0023
U-238	3.386E+00	0.4941	1.431E-01	0.0209	0.000E+00	0.0000	7.061E-01	0.1030	4.068E-02	0.0059	0.000E+00	0.0000	3.553E-01	0.0518
Total	4.214E+00	0.6149	3.119E-01	0.0455	0.000E+00	0.0000	1.491E+00	0.2176	8.593E-02	0.0125	0.000E+00	0.0000	7.501E-01	0.1095

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

Radio-Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.347E+00	0.1966
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.745E-01	0.1276
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.631E+00	0.6758
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.852E+00	1.0000

*Sum of all water independent and dependent pathways.

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

Radio-Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	1.003E-02	0.0015	1.607E-01	0.0235	0.000E+00	0.0000	7.466E-01	0.1094	4.301E-02	0.0063	0.000E+00	0.0000	3.757E-01	0.0551
U-235	8.169E-01	0.1197	6.701E-03	0.0010	0.000E+00	0.0000	3.191E-02	0.0047	1.927E-03	0.0003	0.000E+00	0.0000	1.592E-02	0.0023
U-238	3.378E+00	0.4952	1.419E-01	0.0208	0.000E+00	0.0000	7.002E-01	0.1026	4.034E-02	0.0059	0.000E+00	0.0000	3.523E-01	0.0516
Total	4.205E+00	0.6164	3.093E-01	0.0453	0.000E+00	0.0000	1.479E+00	0.2167	8.528E-02	0.0125	0.000E+00	0.0000	7.439E-01	0.1090

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

Radio-Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.336E+00	0.1958
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.734E-01	0.1280
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.613E+00	0.6762
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.823E+00	1.0000

*Sum of all water independent and dependent pathways.

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

Radio-Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	1.006E-02	0.0015	1.560E-01	0.0232	0.000E+00	0.0000	7.247E-01	0.1079	4.175E-02	0.0062	0.000E+00	0.0000	3.647E-01	0.0543
U-235	8.133E-01	0.1211	6.525E-03	0.0010	0.000E+00	0.0000	3.175E-02	0.0047	2.090E-03	0.0003	0.000E+00	0.0000	1.557E-02	0.0023
U-238	3.352E+00	0.4991	1.378E-01	0.0205	0.000E+00	0.0000	6.797E-01	0.1012	3.916E-02	0.0058	0.000E+00	0.0000	3.420E-01	0.0509
Total	4.176E+00	0.6216	3.003E-01	0.0447	0.000E+00	0.0000	1.436E+00	0.2138	8.300E-02	0.0124	0.000E+00	0.0000	7.223E-01	0.1075

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

Radio-Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.297E+00	0.1931
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.693E-01	0.1294
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.551E+00	0.6775
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.718E+00	1.0000

*Sum of all water independent and dependent pathways.

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

Radio-Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	1.037E-02	0.0016	1.426E-01	0.0223	0.000E+00	0.0000	6.626E-01	0.1034	3.817E-02	0.0060	0.000E+00	0.0000	3.335E-01	0.0520
U-235	8.017E-01	0.1251	6.055E-03	0.0009	0.000E+00	0.0000	3.121E-02	0.0049	2.484E-03	0.0004	0.000E+00	0.0000	1.462E-02	0.0023
U-238	3.270E+00	0.5102	1.259E-01	0.0196	0.000E+00	0.0000	6.214E-01	0.0970	3.580E-02	0.0056	0.000E+00	0.0000	3.127E-01	0.0488
Total	4.082E+00	0.6369	2.746E-01	0.0428	0.000E+00	0.0000	1.315E+00	0.2052	7.646E-02	0.0119	0.000E+00	0.0000	6.608E-01	0.1031

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

Radio-Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	1.187E+00	0.1853
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.561E-01	0.1336
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	4.366E+00	0.6812
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	6.409E+00	1.0000

*Sum of all water independent and dependent pathways.

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

Radio-Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	1.327E-02	0.0026	9.640E-02	0.0186	0.000E+00	0.0000	4.484E-01	0.0866	2.581E-02	0.0050	0.000E+00	0.0000	2.254E-01	0.0435
U-235	7.306E-01	0.1411	4.422E-03	0.0009	0.000E+00	0.0000	2.680E-02	0.0052	3.032E-03	0.0006	0.000E+00	0.0000	1.108E-02	0.0021
U-238	2.853E+00	0.5510	8.501E-02	0.0164	0.000E+00	0.0000	4.195E-01	0.0810	2.417E-02	0.0047	0.000E+00	0.0000	2.110E-01	0.0408
Total	3.597E+00	0.6947	1.858E-01	0.0359	0.000E+00	0.0000	8.947E-01	0.1728	5.301E-02	0.0102	0.000E+00	0.0000	4.475E-01	0.0864

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

Radio-Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	8.093E-01	0.1563
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	7.759E-01	0.1498
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	3.593E+00	0.6939
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	5.178E+00	1.0000

*Sum of all water independent and dependent pathways.

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

Radio-Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

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

Radio-Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

*Sum of all water independent and dependent pathways.

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

Radio-Nuclide	Ground		Inhalation		Radon		Plant		Meat		Milk		Soil	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

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

Radio-Nuclide	Water		Fish		Radon		Plant		Meat		Milk		All Pathways*	
	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.	mrem/yr	fract.
U-234	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-235	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
U-238	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000
Total	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000	0.000E+00	0.0000

*Sum of all water independent and dependent pathways.

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

0 Parent (i)	Product (j)	Thread Fraction	DSR(j,t) At Time in Years (mrem/yr)/(pCi/g) 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
U-234	U-234	1.000E+00	2.749E-02	2.738E-02	2.715E-02	2.636E-02	2.411E-02	1.633E-02	0.000E+00	0.000E+00
U-234	Th-230	1.000E+00	1.679E-07	4.919E-07	1.130E-06	3.283E-06	8.729E-06	1.963E-05	0.000E+00	0.000E+00
U-234	Ra-226+D	1.000E+00	3.849E-09	2.721E-08	1.440E-07	1.273E-06	1.026E-05	8.958E-05	0.000E+00	0.000E+00
U-234	Pb-210+D	1.000E+00	1.248E-11	1.628E-10	1.711E-09	3.973E-08	7.568E-07	1.203E-05	0.000E+00	0.000E+00
U-234	ΣDSR(j)		2.749E-02	2.738E-02	2.715E-02	2.637E-02	2.413E-02	1.645E-02	0.000E+00	0.000E+00
0U-235+D	U-235+D	1.000E+00	3.977E-01	3.974E-01	3.967E-01	3.943E-01	3.867E-01	3.459E-01	0.000E+00	0.000E+00
U-235+D	Pa-231	1.000E+00	3.385E-05	1.053E-04	2.471E-04	7.252E-04	1.933E-03	4.339E-03	0.000E+00	0.000E+00
U-235+D	Ac-227+D	1.000E+00	3.015E-07	1.936E-06	9.597E-06	7.668E-05	4.991E-04	2.438E-03	0.000E+00	0.000E+00
U-235+D	ΣDSR(j)		3.977E-01	3.975E-01	3.970E-01	3.951E-01	3.891E-01	3.527E-01	0.000E+00	0.000E+00
0U-238	U-238	5.400E-05	1.329E-06	1.324E-06	1.313E-06	1.275E-06	1.165E-06	7.874E-07	0.000E+00	0.000E+00
0U-238+D	U-238+D	9.999E-01	9.546E-02	9.528E-02	9.492E-02	9.364E-02	8.983E-02	7.393E-02	0.000E+00	0.000E+00
U-238+D	U-234	9.999E-01	3.894E-08	1.164E-07	2.694E-07	7.847E-07	2.085E-06	4.652E-06	0.000E+00	0.000E+00
U-238+D	Th-230	9.999E-01	1.620E-13	1.097E-12	5.675E-12	4.897E-11	3.774E-10	2.792E-09	0.000E+00	0.000E+00
U-238+D	Ra-226+D	9.999E-01	2.710E-15	4.115E-14	4.817E-13	1.264E-11	2.958E-10	8.526E-09	0.000E+00	0.000E+00
U-238+D	Pb-210+D	9.999E-01	7.415E-18	1.983E-16	4.454E-15	3.038E-13	1.714E-11	9.614E-10	0.000E+00	0.000E+00
U-238+D	ΣDSR(j)		9.546E-02	9.528E-02	9.492E-02	9.364E-02	8.983E-02	7.393E-02	0.000E+00	0.000E+00

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

0

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

0Nuclide (i)	t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
U-234	9.094E+02	9.131E+02	9.207E+02	9.482E+02	1.036E+03	1.520E+03	*6.247E+09	*6.247E+09
U-235	6.285E+01	6.289E+01	6.298E+01	6.327E+01	6.425E+01	7.089E+01	*2.161E+06	*2.161E+06
U-238	2.619E+02	2.624E+02	2.634E+02	2.670E+02	2.783E+02	3.381E+02	*3.361E+05	*3.361E+05

*At specific activity limit

0

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

0Nuclide (i)	Initial (pCi/g)	tmin (years)	DSR(i,tmin)	G(i,tmin) (pCi/g)	DSR(i,tmax)	G(i,tmax) (pCi/g)
U-234	4.920E+01	0.000E+00	2.749E-02	9.094E+02	2.749E-02	9.094E+02
U-235	2.200E+00	0.000E+00	3.977E-01	6.285E+01	3.977E-01	6.285E+01
U-238	4.860E+01	0.000E+00	9.546E-02	2.619E+02	9.546E-02	2.619E+02

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

0Nuclide (j)	Parent (i)	THF(i)	DOSE(j,t), mrem/yr t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
U-234	U-234	1.000E+00	1.353E+00	1.347E+00	1.336E+00	1.297E+00	1.186E+00	8.033E-01	0.000E+00	0.000E+00
U-234	U-238	9.999E-01	1.892E-06	5.657E-06	1.309E-05	3.813E-05	1.013E-04	2.261E-04	0.000E+00	0.000E+00
U-234	ΣDOSE(j)		1.353E+00	1.347E+00	1.336E+00	1.297E+00	1.186E+00	8.036E-01	0.000E+00	0.000E+00
0Th-230	U-234	1.000E+00	8.259E-06	2.420E-05	5.561E-05	1.615E-04	4.295E-04	9.660E-04	0.000E+00	0.000E+00
Th-230	U-238	9.999E-01	7.872E-12	5.331E-11	2.758E-10	2.380E-09	1.834E-08	1.357E-07	0.000E+00	0.000E+00
Th-230	ΣDOSE(j)		8.259E-06	2.420E-05	5.561E-05	1.615E-04	4.295E-04	9.661E-04	0.000E+00	0.000E+00
0Ra-226	U-234	1.000E+00	1.894E-07	1.339E-06	7.084E-06	6.261E-05	5.047E-04	4.407E-03	0.000E+00	0.000E+00
Ra-226	U-238	9.999E-01	1.317E-13	2.000E-12	2.341E-11	6.143E-10	1.438E-08	4.144E-07	0.000E+00	0.000E+00
Ra-226	ΣDOSE(j)		1.894E-07	1.339E-06	7.084E-06	6.261E-05	5.047E-04	4.408E-03	0.000E+00	0.000E+00
0Pb-210	U-234	1.000E+00	6.142E-10	8.008E-09	8.420E-08	1.955E-06	3.723E-05	5.920E-04	0.000E+00	0.000E+00
Pb-210	U-238	9.999E-01	3.604E-16	9.639E-15	2.165E-13	1.476E-11	8.330E-10	4.672E-08	0.000E+00	0.000E+00
Pb-210	ΣDOSE(j)		6.142E-10	8.008E-09	8.420E-08	1.955E-06	3.723E-05	5.920E-04	0.000E+00	0.000E+00
0U-235	U-235	1.000E+00	8.750E-01	8.742E-01	8.728E-01	8.675E-01	8.507E-01	7.610E-01	0.000E+00	0.000E+00
0Pa-231	U-235	1.000E+00	7.448E-05	2.316E-04	5.437E-04	1.595E-03	4.253E-03	9.546E-03	0.000E+00	0.000E+00
0Ac-227	U-235	1.000E+00	6.632E-07	4.259E-06	2.111E-05	1.687E-04	1.098E-03	5.364E-03	0.000E+00	0.000E+00
0U-238	U-238	5.400E-05	6.461E-05	6.434E-05	6.381E-05	6.194E-05	5.663E-05	3.827E-05	0.000E+00	0.000E+00
U-238	U-238	9.999E-01	4.639E+00	4.631E+00	4.613E+00	4.551E+00	4.366E+00	3.593E+00	0.000E+00	0.000E+00
U-238	ΣDOSE(j)		4.639E+00	4.631E+00	4.613E+00	4.551E+00	4.366E+00	3.593E+00	0.000E+00	0.000E+00

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

Summary : [redacted]RAD Default Parameters
File : C:\RESRAD_FAMILY\RESRAD\USERFILES\LUDEMANURANIUMBENCHMARK.RAD

Individual Nuclide Soil Concentration
Parent Nuclide and Branch Fraction Indicated

0Nuclide (j)	Parent (i)	THF(i)	S(j,t), pCi/g t= 0.000E+00	1.000E+00	3.000E+00	1.000E+01	3.000E+01	1.000E+02	3.000E+02	1.000E+03
U-234	U-234	1.000E+00	4.920E+01	4.919E+01	4.918E+01	4.913E+01	4.900E+01	4.855E+01	4.726E+01	4.304E+01
U-234	U-238	9.999E-01	0.000E+00	1.378E-04	4.132E-04	1.376E-03	4.117E-03	1.360E-02	3.972E-02	1.207E-01
U-234	ΣS(j):		4.920E+01	4.919E+01	4.918E+01	4.914E+01	4.901E+01	4.856E+01	4.730E+01	4.316E+01
0Th-230	U-234	1.000E+00	0.000E+00	4.429E-04	1.328E-03	4.426E-03	1.326E-02	4.397E-02	1.301E-01	4.126E-01
Th-230	U-238	9.999E-01	0.000E+00	6.200E-10	5.579E-09	6.195E-08	5.566E-07	6.145E-06	5.430E-05	5.662E-04
Th-230	ΣS(j):		0.000E+00	4.429E-04	1.328E-03	4.426E-03	1.326E-02	4.398E-02	1.301E-01	4.132E-01
0Ra-226	U-234	1.000E+00	0.000E+00	9.591E-08	8.628E-07	9.572E-06	8.577E-05	9.382E-04	8.079E-03	7.720E-02
Ra-226	U-238	9.999E-01	0.000E+00	8.953E-14	2.416E-12	8.937E-11	2.403E-09	8.778E-08	2.278E-06	7.358E-05
Ra-226	ΣS(j):		0.000E+00	9.591E-08	8.628E-07	9.572E-06	8.577E-05	9.383E-04	8.082E-03	7.728E-02
0Pb-210	U-234	1.000E+00	0.000E+00	9.861E-10	2.621E-08	9.196E-07	2.147E-05	5.214E-04	6.558E-03	7.271E-02
Pb-210	U-238	9.999E-01	0.000E+00	6.914E-16	5.530E-14	6.536E-12	4.704E-10	4.089E-08	1.690E-06	6.717E-05
Pb-210	ΣS(j):		0.000E+00	9.861E-10	2.621E-08	9.196E-07	2.147E-05	5.214E-04	6.560E-03	7.278E-02
0U-235	U-235	1.000E+00	2.200E+00	2.200E+00	2.199E+00	2.197E+00	2.191E+00	2.171E+00	2.115E+00	1.930E+00
0Pa-231	U-235	1.000E+00	0.000E+00	4.654E-05	1.396E-04	4.648E-04	1.391E-03	4.589E-03	1.338E-02	4.041E-02
0Ac-227	U-235	1.000E+00	0.000E+00	7.330E-07	6.457E-06	6.669E-05	4.940E-04	3.196E-03	1.192E-02	3.892E-02
0U-238	U-238	5.400E-05	2.624E-03	2.624E-03	2.623E-03	2.621E-03	2.614E-03	2.590E-03	2.523E-03	2.302E-03
U-238	U-238	9.999E-01	4.860E+01	4.859E+01	4.858E+01	4.853E+01	4.841E+01	4.797E+01	4.673E+01	4.263E+01
U-238	ΣS(j):		4.860E+01	4.859E+01	4.858E+01	4.854E+01	4.841E+01	4.797E+01	4.673E+01	4.263E+01

THF(i) is the thread fraction of the parent nuclide.
0RESCALC.EXE execution time = 1.28 seconds

APPENDIX D-5

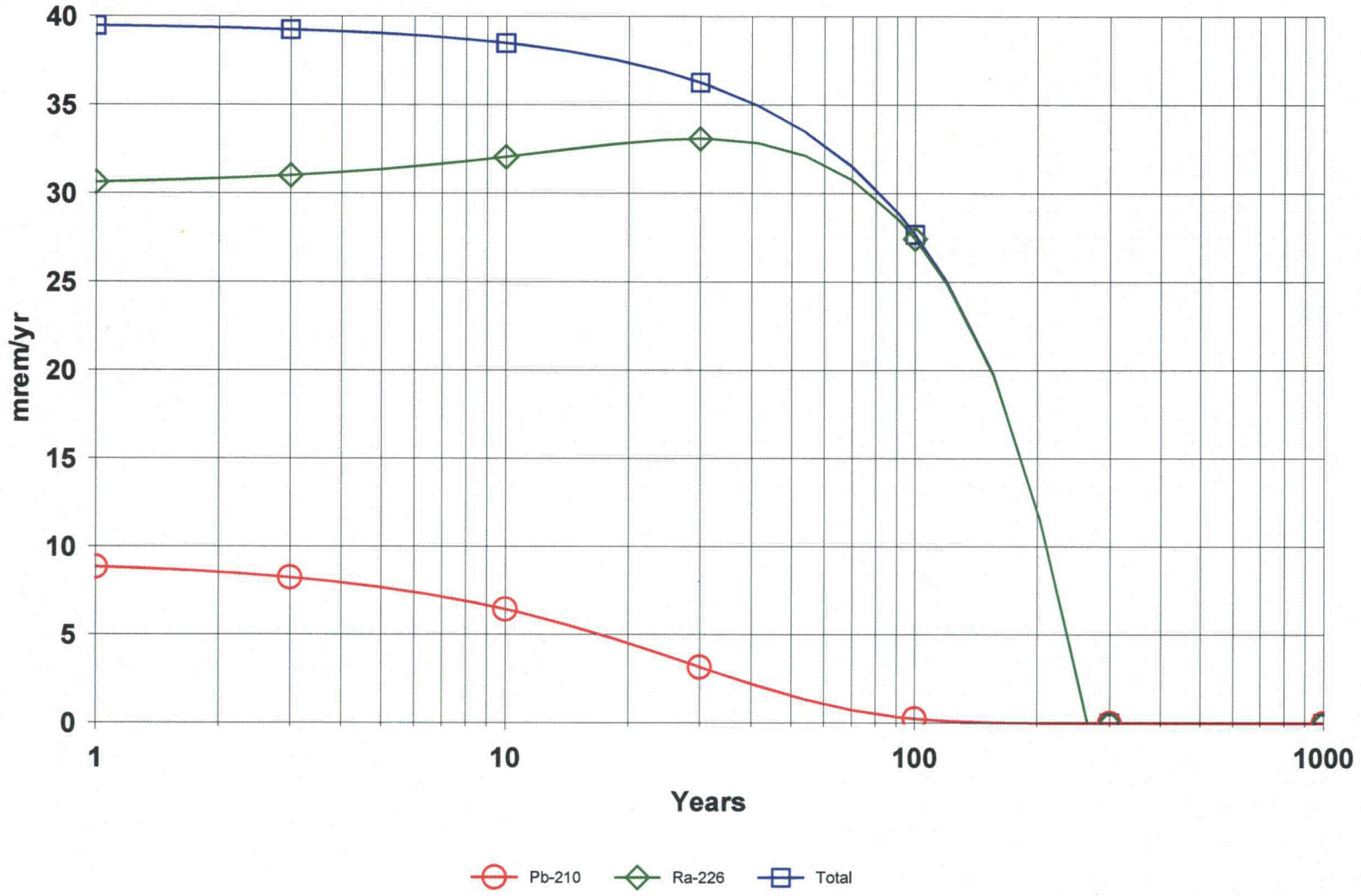
STANDARD GRAPHICS FOR RADIUM AND URANIUM DOSE MODELING

APPENDIX D-5

STANDARD GRAPHICS FOR RADIUM AND URANIUM DOSE MODELING

RADIUM DOSE GRAPHICS

DOSE: All Nuclides Summed, All Pathways Summed



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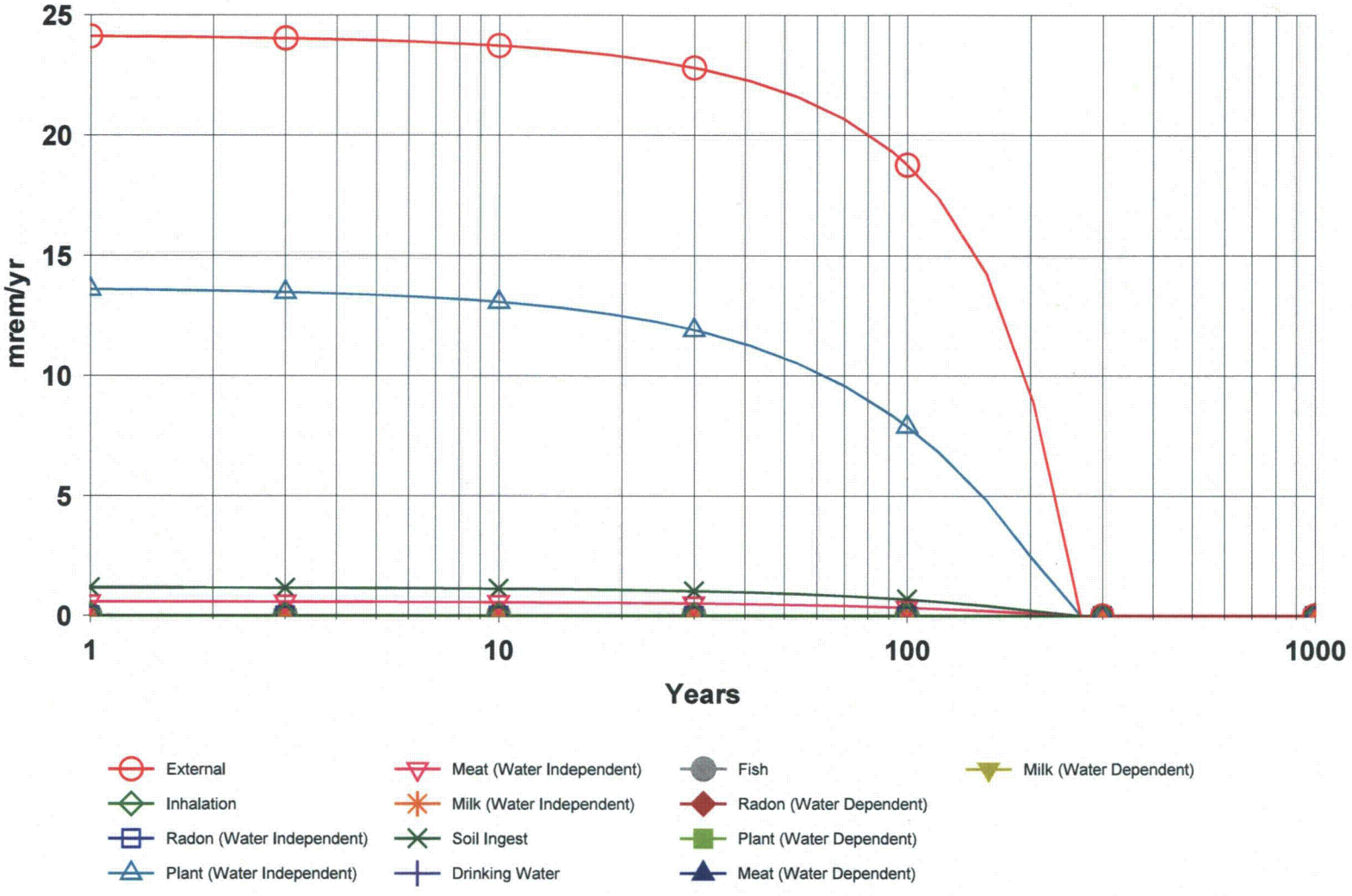
DOSE: All Nuclides Summed, Component Pathways



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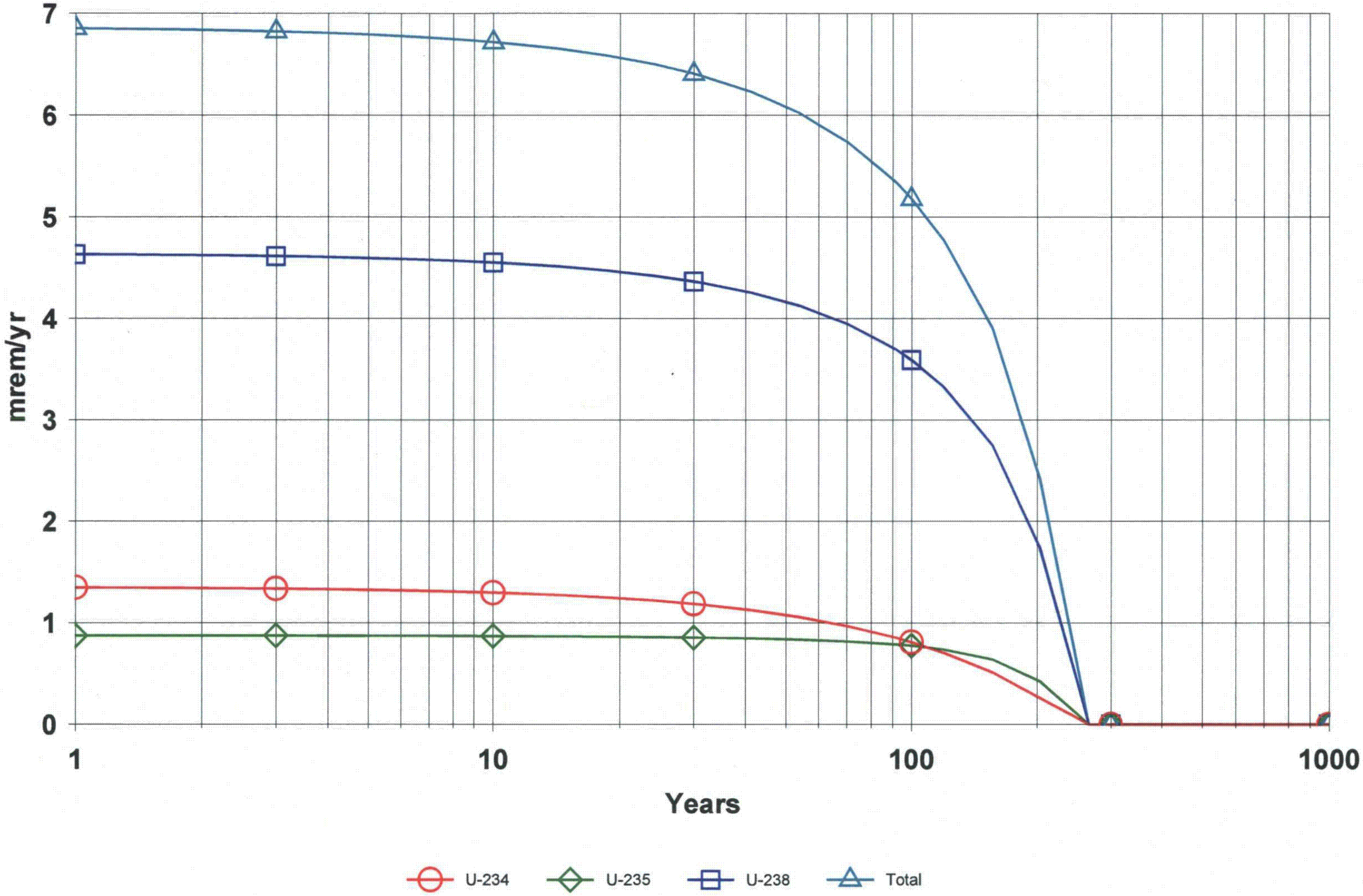
NATURAL URANIUM DOSE GRAPHICS

DOSE: All Nuclides Summed, All Pathways Summed



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APPENDIX E

FINANCIAL ASSURANCE

Closure Estimate
Ludeman ISR Project
Uranium One, Americas

uraniumone
investing in our energy

Restoration and Reclamation Cost Estimates at the End of Year 1
(no operation has occurred therefore no groundwater restoration or 11.e.2 byproduct disposal is required)

No.	Leuenberger Satellite Plant Cost Item	Cost
1	GROUNDWATER RESTORATION COST	$9,632,214
2a	PLANT EQUIPMENT REMOVAL AND DISPOSAL COST	$108,521
2b	BUILDING DEMOLITION AND DISPOSAL COST	$478,784
3	SOIL REMOVAL & DISPOSAL COST	$101,250
4	TOTAL WELL ABANDONMENT COST	$199,886
5	WELLFIELD EQUIPMENT REMOVAL & DISPOSAL COST	$755,846
6	TOPSOIL REPLACEMENT & REVEGETATION COST	$241,445
7	MISCELLANEOUS RECLAMATION COST	$87,335
8	SURGE POND RESTORATION & DISPOSAL COST	$202,451
	Subtotal Restoration and Reclamation Cost Estimate	$11,807,732
	Administration,Overhead and Contingency (25%)	$2,951,933
	Total	$14,759,666

No.	North Platte Satellite Plant Cost Item	Cost
1	GROUNDWATER RESTORATION COST	$5,918,105
2a	PLANT EQUIPMENT REMOVAL AND DISPOSAL COST	$107,112
2b	BUILDING DEMOLITION AND DISPOSAL COST	$329,949
3	SOIL REMOVAL & DISPOSAL COST	$101,654
4	TOTAL WELL ABANDONMENT COST	$327,164
5	WELLFIELD EQUIPMENT REMOVAL & DISPOSAL COST	$982,859
6	TOPSOIL REPLACEMENT & REVEGETATION COST	$354,260
7	MISCELLANEOUS RECLAMATION COST	$106,800
8	SURGE POND RESTORATION & DISPOSAL COST	$202,451
	Subtotal Restoration and Reclamation Cost Estimate	$8,430,354
	Administration,Overhead and Contingency (25%)	$2,107,588
	Total	$10,537,942

No.	Peterson Satellite Plant Cost Item	Cost
1	GROUNDWATER RESTORATION COST	$14,009,187
2a	PLANT EQUIPMENT REMOVAL AND DISPOSAL COST	$123,780
2b	BUILDING DEMOLITION AND DISPOSAL COST	$330,786
3	SOIL REMOVAL & DISPOSAL COST	$101,654
4	TOTAL WELL ABANDONMENT COST	$541,329
5	WELLFIELD EQUIPMENT REMOVAL & DISPOSAL COST	$1,396,617
6	TOPSOIL REPLACEMENT & REVEGETATION COST	$535,995
7	MISCELLANEOUS RECLAMATION COST	$145,125
8	SURGE POND RESTORATION & DISPOSAL COST	$202,451
	Subtotal Restoration and Reclamation Cost Estimate	$17,386,923
	Administration,Overhead and Contingency (25%)	$4,346,731
	Total	$21,733,654

TOTAL RESTORATION COST **$47,031,262**

Closu[redacted]t Estimate
Ludeman ISR Project
Uranium One, Americas

Worksheet 1, No. I –
GROUNDWATER RESTORATION

Cost Item	Leuenberger Satellite Plant				North Platte Plant			Peterson Plant			Notes
	Wellfield 1-80 Sand	Wellfield 2-90 Sand	Wellfield 3	Sub Total	Wellfield 4	Wellfield 5	Sub Total	Wellfield 6	Wellfield 7	Sub Total	
Technical Assumptions											
Wellfield Area (Ft^2)	2,800,000	1,400,000	200,000		3,200,000	2,600,000		2,800,000	6,800,000		
Wellfield Area (Acres)	64.3	32.1	4.6		73.5	59.7		64.3	156.1		
Affected Ore Zone Area (Ft^2)	2,800,000	1,400,000	200,000		3,200,000	2,600,000		2,800,000	6,800,000		
Avg Completed Thickness (Ft)	40	40	20		20	20		20	20		Checked with Geology 20 ft screen
Factor for Flare	1.44	1.44	1.44		1.44	1.44		1.44	1.44		Flare Factor is from License Application Section 6.6
Affected Volume:	161,280,000	80,640,000	5,760,000		92,160,000	74,880,000		80,640,000	195,840,000		
Porosity	0.25	0.25	0.25		0.25	0.25		0.25	0.25		Porosity consistent with IR/CR Porosity
Gallons per Cubic Foot	7.48	7.48	7.48		7.48	7.48		7.48	7.48		
Gallon per Pore Volume	301,593,600	150,796,800	10,771,200		172,339,200	140,025,600		##########	366,220,800		
Number of Wells in Unit(s)	769	149	56		879	714		769	1867		
Production Wells	280	47	20		320	260		280	680		
Injection Wells	429	72	31		490	398		429	1041		
Monitor Wells	60	30	5		69	56		60	146		
Average Well Spacing (Ft)	71	71	71		71	71		71	71		
Average Well Depth (Ft)	400	275	400		275	275		275	275		
I Groundwater Sweep											
A. Plant & Office											
Operating Assumptions:											
Flowrate (gpm)	300	300	300		300	300		300	300		Flow Rate based on License Application
PV's Required	1.00	1.00	1.00		1.00	1.00		1.00	1.00		
Total Gallons for Treatment	301,593,600	150,796,800	10,771,200		172,339,200	140,025,600		##########	366,220,800		
Total Kgals for Treatment	301,594	150,797	10,771		172,339	140,026		150,797	366,221		
Cost Assumptions:											
Power											
Avg Connected Hp	50	50	50		50	50		50	50		(100Hp originally) CR uses 40 Hp confirmed with Rick
Kwh's/Hp	0.75	0.75	0.75		0.75	0.75		0.75	0.75		
$/Kwh	0.05	0.05	0.05		0.05	0.05		0.05	0.05		$.02 plus demand charges per quote
Gallons per Minute	300	300	300		300	300		300	300		
Gallons per Hour	18000	18000	18000		18000	18000		18000	18000		
Cost per Hour	$1.88	$1.88	$1.88		$1.88	$1.88		$1.88	$1.88		
Cost per Kgal ($)	$0.104	$0.104	$0.104		$0.104	$0.104		$0.104	$0.104		
Chemicals											
Barium Chloride ($/Kgals)	$0.041	$0.041	$0.041		$0.041	$0.041		$0.041	$0.041		Costs from operating ISR facility experience (Cogema)
Antiscalent ($/Kgals)	$0.000	$0.000	$0.000		$0.000	$0.000		$0.000	$0.000		Costs from operating ISR facility experience (Cogema)
Elution ($/Kgals)	$0.099	$0.099	$0.099		$0.099	$0.099		$0.099	$0.099		Costs from operating ISR facility experience (Cogema)
Repair & Maintenance ($/Kgals)	$0.061	$0.061	$0.061		$0.061	$0.061		$0.061	$0.061		Costs from operating ISR facility experience (Cogema)
Analysis ($/Kgals)	$0.164	$0.164	$0.164		$0.164	$0.164		$0.164	$0.164		Costs from operating ISR facility experience (Cogema)
Total Cost per Kgal	$0.47	$0.47	$0.47		$0.47	$0.47		$0.47	$0.47		
Total Treatment Cost	$141,498	$70,749	$5,053		$80,856	$65,695		$70,749	$171,819		
Utilities											
Power ($/Month)	1,148				648			648			plant building only, i.e., lights, etc. (12,996 sf at $0.05/sf.) & maint building at Leuenberger (10000 sf)
Propane ($/Month)	800	400	400		400	400		400	400		
Time for Treatment											
Minutes for Treatment	1,005,312	502,656	35,904		574,464	466,752		502,656	1,220,736		
Hours for Treatment	16,755	8,378	598		9,574	7,779		8,378	20,346		
Days for Treatment	698	349	25		399	324		349	848		
Average Days per Month	30.4	30.4	30.4		30.4	30.4		30.4	30.4		
Months for Treatment	23.3	11.6	0.8		13.3	10.8		11.6	28.3		
Years for Treatment	1.94	0.97	0.07		1.11	0.90		0.97	2.35		
Utilities Cost ($)	$45,332	$4,654	$332		$13,936	$4,322		$12,194	$11,303		
TOTAL PLANT & OFFICE COST	**$186,830**	**$75,403**	**$5,386**	**$267,619**	**$94,792**	**$70,017**	**$164,809**	**$82,943**	**$183,122**	**$266,065**	
B. WELLFIELD											
Cost Assumptions:											
Power											
Avg Flow/Pump (gpm)	20	20	20		20	20		20	20		Utilized number from the 2011-2012 CR Surety Update
Avg Hp/Pump	3	3	3		3	3		3	3		Utilized Hp from IR/CR 2011-2012 surety
Avg # of Pumps Required	15	15	15		15	15		15	15		
Avg Connected Hp	45	45	45		45	45		45	45		
Kwh's/Hp	0.75	0.75	0.75		0.75	0.75		0.75	0.75		
$/Kwh	0.05	0.05	0.05		0.05	0.05		0.05	0.05		
Gallons per Minute	300	300	300		300	300		300	300		
Gallons per Hour	18000	18000	18000		18000	18000		18000	18000		
Costs per Hour ($)	$1.69	$1.69	$1.69		$1.69	$1.69		$1.69	$1.69		
Costs per Gallon ($)	$0.0001	$0.0001	$0.0001		$0.0001	$0.0001		$0.0001	$0.0001		
Costs per Kgal ($)	$0.09	$0.09	$0.09		$0.09	$0.09		$0.09	$0.09		
Repair & Maintenance ($/Kgals)	$0.016	$0.016	$0.016		$0.016	$0.016		$0.016	$0.016		
Total Cost per Kgal	$0.110	$0.110	$0.110		$0.110	$0.110		$0.110	$0.110		
TOTAL WELLFIELD COST	$33,100	$16,550	$1,182		$18,914	$15,368		$16,550	$40,193		
TOTAL GROUNDWATER SWEEP COST	**$219,930**	**$91,953**	**$6,568**	**$318,451**	**$113,706**	**$85,385**	**$199,091**	**$99,493**	**$223,314**	**$322,807**	

Worksheet 1, No. II
GROUNDWATER RESTORATION

Cost Item	Leuenberger Satellite Plant				North Platte Plant			Peterson Plant			Notes
	Wellfield 1-80 Sand	Wellfield 2-90 Sand	Wellfield 3	Sub Total	Wellfield 4-70 Sands	Wellfield 5-70 Sands	Sub Total	Wellfield 6-90 Sands	Wellfield 7-90 Sands	Sub Total	
II GW Treatment - RO											
A. PLANT											
Operating Assumptions:											
Flowrate (gpm)	600	600	600		600	600		600	600		600 gpm based on average flow to RO listed in LA
PV's Required	5.00	5.00	5.00		5.00	5.00		5.00	5.00		1 PV from Sweep and 5 from Ro for Total of 6 PV's
Total Gallons for Treatment	1,507,968,000	753,984,000	53,856,000		861,696,000	700,128,000		753,984,000	1,831,104,000		
Total Kgals for Treatment	1,507,968	753,984	53,856		861,696	700,128		753,984	1,831,104		
Feed to RO (gpm)	600	600	600		600	600		600	600		
Permeate Flow (gpm)	450	450	450		450	450		450	450		
Brine Flow (gpm)	150	150	150		150	150		150	150		
Average RO Recovery	75%	75%	75%		75%	75%		75%	75%		
Cost Assumptions:											
Power											
Avg Connected Hp	200	200	200		200	200		200	200		
kWh/Hp	0.75	0.75	0.75		0.75	0.75		0.75	0.75		
$/Kwh	0.05	0.05	0.05		0.05	0.05		0.05	0.05		$.02 plus demand charges per quote
Gallons per Minute	600	600	600		600	600		600	600		
Gallons per Hour	36000	36000	36000		36000	36000		36000	36000		
Cost per Hour ($)	$7.50	$7.50	$7.50		$7.50	$7.50		$7.50	$7.50		
Cost per Gallon ($)	$0.0002	$0.0002	$0.0002		$0.0002	$0.0002		$0.0002	$0.0002		
Cost per Kgal ($)	$0.21	$0.21	$0.21		$0.21	$0.21		$0.21	$0.21		
Chemicals											
Sulfuric Acid ($/Kgals)	$0.076	$0.076	$0.076		$0.076	$0.076		$0.076	$0.076		Costs from operating ISR facility experience (Cogema)
Caustic Soda ($/Kgals)	$0.111	$0.111	$0.111		$0.111	$0.111		$0.111	$0.111		Costs from operating ISR facility experience (Cogema)
Hydrochloric Acid ($Kgals)	$0.009	$0.009	$0.009		$0.009	$0.009		$0.009	$0.009		Costs from operating ISR facility experience (Cogema)
Hydrochloric Sulfide ($Kgals)	$0.304	$0.304	$0.304		$0.304	$0.304		$0.304	$0.304		Costs from operating ISR facility experience (Cogema)
Repair & Maintenance ($Kgals)	$0.279	$0.279	$0.279		$0.279	$0.279		$0.279	$0.279		Costs from operating ISR facility experience (Cogema)
Sampling & Analysis ($/Kgals)	$0.164	$0.164	$0.164		$0.164	$0.164		$0.164	$0.164		Costs from operating ISR facility experience (Cogema)
Total Cost per Kgal ($)	$1.15	$1.15	$1.15		$1.15	$1.15		$1.15	$1.15		
Total Pumping Cost ($)	$1,736,174	$868,087	$62,006		$992,099	$806,081		$868,087	$2,108,211		
Utilities											
Power ($/Month)	1,148	648	648		648	648		648	648		plant building only, i.e., lights, etc. (12,966 SF at $0.05/sf.)
Propane ($/Month)	800	400	400		400	400		400	400		
Time for Treatment											
Months for Treatment	27.7	15.5	15.5		27.7	27.7		15.5	15.5		Years of restoration for 6 pore volumes based on 300 gpm per wellfield for 1.29 years when the 90 sand will be restored. Then an additional 1.02 years at 600 gpm for the 80 sand restoration to be complete.
Utilities Cost ($)	$53,999	$16,223	$16,223		$29,051	$29,051		$16,223	$16,223		
TOTAL PLANT COST	**$1,790,172**	**$884,310**	**$78,229**	**$2,752,712**	**$1,021,150**	**$835,131**	**$1,856,281**	**$884,310**	**$2,124,434**	**$3,008,744**	
B. WELLFIELD											
Cost Assumptions:											
Power											
Avg Flow/Pump (gpm)	5	5	5		5	5		5	5		
Avg Hp/Pump	3	3	3		3	3		3	3		
Avg # of Pumps Required	280	47	20		320	260		280	680		Using Recovery Pumps
Avg Connected Hp	840	141	60		960	780		840	2040		
Kwh's/Hp	0.75	0.75	0.75		0.75	0.75		0.75	0.75		
$/Kwh	0.05	0.05	0.05		0.05	0.05		0.05	0.05		
Gallons per Minute	300	300	300		300	300		300	300		
Gallons per Hour	18000	18000	18000		18000	18000		18000	18000		
Costs per Hour ($)	$31.50	$5.29	$2.25		$36.00	$29.25		$31.50	$76.50		
Costs per Gallon ($)	$0.0018	$0.0003	$0.0001		$0.0020	$0.0016		$0.0018	$0.0043		
Costs per Kgal ($)	$1.75	$0.29	$0.13		$2.00	$1.63		$1.75	$4.25		
Repair & Maintenance ($/Kgals)	$0.016	$0.016	$0.016		$0.016	$0.016		$0.016	$0.016		
Total Cost per Kgal	$1.766	$0.310	$0.141		$2.016	$1.641		$1.766	$4.266		
MIT cost ($150/well)	$115,313	$22,345	$8,344		$131,850	$107,119		$115,313	$280,088		
TOTAL WELLFIELD COST	**$2,663,071**	**$233,547**	**$7,594**	**$241,140**	**$1,737,179**	**$1,148,910**	**$2,886,089**	**$1,331,536**	**$7,811,490**	**$9,143,025**	
TOTAL GW TREATMENT RO COST	**$4,568,556**	**$1,140,202**	**$94,167**	**$5,802,925**	**$2,890,179**	**$2,091,160**	**$4,981,339**	**$2,331,158**	**$10,216,011**	**$12,547,169**	

Worksheet 1, No III --
GROUNDWATER RESTORATION

	Leuenberger Satellite Plant				North Platte Plant			Peterson Plant			
Cost Item	Wellfield 1-80 Sand	Wellfield 2-90 Sand	Wellfield 3	Sub Total	Wellfield 4	Wellfield 5	Sub Total	Wellfield 6	Wellfield 7	Sub Total	**Notes**
III Deep Disposal Well											
Operating Assumptions:											
Total Disposal Requirement											
RO Brine Total Gallons	376,992,000	188,496,000	13,464,000		215,424,000	175,032,000		188,496,000	457,776,000		
RO Brine Total Kgallons	376,992	188,496	13,464		215,424	175,032		188,496	457,776		
Brine Concentration Factor	0.6	0.6	0.6		0.6	0.6		0.6	0.6		Confirmed 60% is good value with Engineer
Total Concentrated Brine (Gals)	226,195,200	113,097,600	8,078,400		129,254,400	105,019,200		113,097,600	274,665,600		
Months of RO Operation	27.7	15.5	15.5		27.7	27.7		15.5	15.5		
Average Monthly Reqm't (Gallons)	13,600,000	12,176,744	869,767		7,771,429	6,314,286		12,176,744	29,572,093		
Average Brine Flow (gpm)	100.0	100.0	100.0		100.0	100.0		100.0	100.0		
Total DDW Disposal (Gallons)	226,195,200	113,097,600	8,078,400		129,254,400	105,019,200		113,097,600	274,665,600		
Total DDW Disposal (Kgallons)	226,195	113,098	8,078		129,254	105,019		113,098	274,666		
Cost Assumptions:											
Avg Connected Hp	100	100	100		100	100		100	100		
Kwh's/Hp	0.75	0.75	0.75		0.75	0.75		0.75	0.75		
$/Kwh	0.05	0.05	0.05		0.05	0.05		0.05	0.05		$.02 plus demand charges per quote
Gallons per Minute	90.0	90.0	90.0		90.0	90.0		90.0	90.0		
Gallons per Hour	5400	5400	5400		5400	5400		5400	5400		
Cost per Hour ($)	$3.75	$3.75	$3.75		$3.75	$3.75		$3.75	$3.75		
Cost per Gallon ($)	$0.0007	$0.0007	$0.0007		$0.0007	$0.0007		$0.0007	$0.0007		
Cost per Kgal ($)	$0.69	$0.69	$0.69		$0.69	$0.69		$0.69	$0.69		
Chemicals											
RO Antiscalent ($/Kgals)	$0.192	$0.192	$0.192		$0.192	$0.192		$0.192	$0.192		Costs from operating ISR facility experience (Cogema)
WDW Antiscalent ($/Kgals)	$0.226	$0.226	$0.226		$0.226	$0.226		$0.226	$0.226		Costs from operating ISR facility experience (Cogema)
Sulfuric Acid ($/Kgals)	$0.280	$0.280	$0.280		$0.280	$0.280		$0.280	$0.280		Costs from operating ISR facility experience (Cogema)
Corrosion Inhibitor	$0.217	$0.217	$0.217		$0.217	$0.217		$0.217	$0.217		Costs from operating ISR facility experience (Cogema)
Algacide	$0.080	$0.080	$0.080		$0.080	$0.080		$0.080	$0.080		Costs from operating ISR facility experience (Cogema)
Other	$0.000	$0.000	$0.000		$0.000	$0.000		$0.000	$0.000		Costs from operating ISR facility experience (Cogema)
Repair & Maint. ($/Kgals)	$0.230	$0.230	$0.230		$0.230	$0.230		$0.230	$0.230		Costs from operating ISR facility experience (Cogema)
Total Cost per Kgal	$1.919	$1.919	$1.919		$1.919	$1.919		$1.919	$1.919		
TOTAL DEEP DISPOSAL WELL COST	**$434,169**	**$217,085**	**$15,506**	**$666,760**	**$248,097**	**$201,579**	**$449,675**	**$217,085**	**$527,205**	**$744,290**	

Worksheet 1, Nos. IV & V --
GROUNDWATER RESTORATION

Cost Item	Labor Cost Factors			Leuenberger Satellite Plant				North Platte Plant			Peterson Plant			Notes
				Wellfield 1-80 Sand	Wellfield 2-90 Sand	Wellfield 3	Sub Total	Wellfield 4	Wellfield 5	Sub Total	Wellfield 6	Wellfield 7	Sub Total	
IV STABILIZATION MONITORING														
Operating Assumptions:														
Time of Stabilization (mos)				12.0	12.0	12.0		12.0	12.0		12.0	12.0		
Frequency of Analysis (mos)				3	3	3		3	3		3	3		
Total Sets of Analysis				4	4	4		4	4		4	4		
Cost Assumptions:														
Power ($/Month)				$1,600	$1,600	$1,600		$1,600	$1,600		$1,600	$1,600		
Total Power Cost				$19,200	$19,200	$19,200		$19,200	$19,200		$19,200	$19,200		
Sampling & Analysis (each set)				$19,800	$9,900	$1,650		$22,770	$18,480		$19,800	$48,180		No. of Monitoring Wells @ $330 per event
Total Sampling & Analysis Cost ($)				$79,200	$39,600	$6,600		$91,080	$73,920		$79,200	$192,720		
Utilities ($/Month)				$400	$400	$400		$400	$400		$400	$400		
Total Utilities Cost ($)				$4,800	$4,800	$4,800		$4,800	$4,800		$4,800	$4,800		
TOTAL STABILIZATION COST				**$103,200**	**$63,600**	**$30,600**		**$115,080**	**$97,920**		**$103,200**	**$216,720**	**$730,320.00**	
V LABOR														
Cost Assumptions:	Cost/Hour	Hours/Year	Cost	No.										
Crew:														
1. Supervisor	29	2080	$60,320	1										
2. Operators	19	2080	$158,080	4										
3. Maintenance	19	2080	$158,080	4										
4. Vehicles	20.21	1000	$101,050	5										WDEQ Guideline No.12, Table D-1
Cost per Year			$477,530											
Time Required - Years				5.25										
TOTAL RESTORATION LABOR COST				**$2,506,679**	**$0**	**0$**				**0$**			**$2,506,678.77**	

Worksheet 1, Nos. VI, VII & Summary --
GROUNDWATER RESTORATION

Cost Item	Leuenberger Satellite Plant				North Platte Plant			Peterson Plant			Notes
	Wellfield 1-80 Sand	Wellfield 2-90 Sand	Wellfield 3	Sub Total	Wellfield 4	Wellfield 5	Sub Total	Wellfield 6	Wellfield 7	Sub Total	
VI RESTORATION CAPITAL REQUIREMENTS											
I Deep Disposal Well(s)	0	0	0		0	0		0	0		
II Plug and Abandon DDW	$140,000	0	0		$140,000	0		$140,000	0		Estimate on 2 disposal wells per Satelli
III Reverse Osmosis Unit	$0	0	0		0	0		0	0		
TOTAL RESTORATION CAPITAL REQUIREMENTS	**$140,000**	$0	$0	**$140,000**	**$140,000**	$0	**$140,000**	**$140,000**	$0	**$140,000**	
VII RESTORATION OF EXCURSION WELLS											
I Overlying Sand Well(s)											
Total Wells in Excursion	0	0	0		0	0		**$0**	0		Assume no excursions
Cost of Clean-Up	$100,000	$100,000	$100,000		$100,000	$100,000		$100,000	$100,000		
Total Overlying Sand Cleanup	$0	$0	$0		$0	$0		$0	$0		
II Ore Zone Wells											
Total Wells in Excursion	0	0	0		0	0		0	0		
Cost of Clean-Up	$100,000	$100,000	$100,000		$100,000	$100,000		$100,000	$100,000		
Total Ore Zone Cleanup	$0	$0	$0		$0	$0		$0	$0		
III Underlying Sand Wells											
Total Wells in Excursion	0	0	0		0	0		0	0		
Cost of Clean-Up	$100,000	$100,000	$100,000		$100,000	$100,000		$100,000	$100,000		
Total Underlying Sand Well Cleanup	$0	$0	$0		$0	$0		$0	$0		
TOTAL WELLFIELD COST											
TOTAL EXCURSION CLEANUP COST	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	
SUMMARY:											
I GROUNDWATER SWEEP	$219,930	$91,953	$6,568		$113,706	$85,385		$99,493	$223,314		
II REVERSE OSMOSIS	$4,568,556	$1,140,202	$94,167		$2,890,179	$2,091,160		$2,331,158	$10,216,011		
III WASTE DISPOSAL WELL	$434,169	$217,085	$15,506		$248,097	$201,579		$217,085	$527,205		
IV STABILIZATION	$103,200	$63,600	$30,600		$115,080	$97,920		$103,200	$216,720		
SUB TOTAL	**$5,325,855**	**$1,512,839**	**$146,841**		**$3,367,062**	**$2,476,044**		**$2,750,936**	**$11,183,251**		
V LABOR	$2,506,679	$0	$0		$0	$0		$0	$0		Included in OPEX costs
VI CAPITAL	$140,000	$0	$0		$75,000	$0		$75,000	$0		
VII EXCURSION CLEANUP	$0	$0	$0		$0	$0		$0	$0		
TOTAL GROUNDWATER RESTORATION COST	**$7,972,534**	**$1,512,839**	**$146,841**	**$9,632,214**	**$3,442,062**	**$2,476,044**	**$5,918,105**	**$2,825,936**	**$11,183,251**	**$14,009,187**	

Worksheet 2 a
SATELLITE PLANT EQUIPMENT REMOVAL AND DISPOSAL

Cost Item	Leuenberger Satellite Plant						North Platte Satellite Plant					Petterson Satellite Plant					Notes
	Satellite Process Building	Maintenance Building	Resin	External Tanks	Header Houses	Sub Total	Satellite Process Building	Resin	External Tanks	Header Houses	Sub Total	Satellite Process Building	Resin	External Tanks	Header Houses	Sub Total	
Volume (Yds^3)	100	25	110	20	55		100	110	20	73		100	110	20	120		Volume estimate uses 2.5 cubic yards per header house
Quantity per Truck Load (Yds^3)	20	20	20	20	20		20	20	20	20		20	20	20	20		
Number of Truck Loads	5.0	1.25	5.5	1	2.8		5.0	5.5	1	3.6		5.0	5.5	1	6.0		
I Decontamination Cost																	
Decontamination Cost ($/Load)	$900	$900	$900	$900	$900		$900	$900	$900	$900		$900	$900	$900	$900		Used WC number of $435 rather than $900 used for MR
Percent Requiring Decontamination	100%	25%	0%	50%	100%		100%	0%	50%	100%		100%	0%	50%	100%		
Total Cost	$4,500	$281	$0	$450	$2,475		$4,500	$0	$450	$3,263		$4,500	$0	$450	$5,400		
II Dismantle and Loading Cost																	
Cost per Truck Load ($)	$850	$850	$850	$850	$850		$850	$850	$850	$850		$850	$850	$850	$850		
Total Cost	$4,250	$1,063	$4,675	$850	$2,338		$4,250	$4,675	$850	$3,081		$4,250	$4,675	$850	$5,100		
III Oversize Charges																	
Percent Requiring Permits	40%	50%	0%	50%	40%		40%	0%	50%	40%		40%	0%	50%	40%		
Cost per Truck Load ($)	$500	$500	$500	$500	$500		$500	$500	$500	$500		$500	$500	$500	$500		$500 used for MR and CR
Total Cost	$1,000	$313	$0	$250	$550		$1,000	$0	$250	$725		$1,000	$0	$250	$1,200		
IV Transportation & Disposal																	
A. Landfill																	
Percent to be Shipped	80%	100%	0%	100%	80%		80%	0%	100%	80%		80%	0%	100%	80%		
Distance (Miles)	50	50	50	50	50		50	50	50	50		50	50	50	50		
Transport Cost ($/Ton-Mile)	$0.22	$0.22	$0.22	$0.22	$0.22		$0.22	$0.22	$0.22	$0.22		$0.22	$0.22	$0.22	$0.22		Based on an estimate from trucking company in 2010 adjusted for inflation.
Transportation Cost	$950	$297	$0	$238	$523		$950	$0	$238	$689		$950	$0	$238	$1,140		
Disposal Fee per Cubic Yard	$106	$106	$106	$106	$106		$106	$106	$106	$106		$106	$106	$106	$106		Cost based on WDEQ Guideline 12
Disposal Cost ($)	$8,480	$2,650	$0	$2,120	$4,664		$8,480	$0	$2,120	$6,148		$8,480	$0	$2,120	$10,176		
Total Cost	$9,430	$2,947	$0	$2,358	$5,187		$9,430	$0	$2,358	$6,837		$9,430	$0	$2,358	$11,316		
B. Licensed Site																	
Percent to be Shipped	20%	0%	100%	0%	20%		20%	100%	0%	20%		20%	100%	0%	20%		
Distance (Miles)	160	160	160	160	160		160	160	160	160		160	160	160	160		
Transport Cost ($/Ton-Mile)	$0.22	$0.22	$0.22	$0.22	$0.22		$0.22	$0.22	$0.22	$0.22		$0.22	$0.22	$0.22	$0.22		
Transport Cost	$3,456	$0	$19,008	$0	$1,901		$3,456	$19,008	$0	$2,506		$3,456	$19,008	$0	$4,147		
Disposal Cost ($/Ton)	$300	$300	$300	$300	$300		$300	$300	$300	$300		$300	$300	$300	$300		
Quantity per Truck Load (Yds^3)	20	20	20	20	20		20	20	20	20		20	20	20	20		
Quantity per Truck Load (Tons)	21.6	21.6	21.6	21.6	21.6		21.6	21.6	21.6	21.6		21.6	21.6	21.6	21.6		Based on avg 80lbs per cf
Disposal Cost	$6,480	$0	$35,640	$0	$3,564		$6,480	$35,640	$0	$4,698		$6,480	$35,640	$0	$7,776		
Total Cost	$15,910	$2,947	$35,640	$2,358	$8,751		$15,910	$35,640	$2,358	$11,535		$15,910	$35,640	$2,358	$19,092		
Total Cost	$25,341	$5,894	$35,640	$4,715	$13,937		$25,341	$35,640	$4,715	$18,372		$25,341	$35,640	$4,715	$30,409		
TOTAL COST	**$35,091**	**$7,550**	**$40,315**	**$6,265**	**$19,300**	**$108,521**	**$35,091**	**$40,315**	**$6,265**	**$25,441**	**$107,112**	**$35,091**	**$40,315**	**$6,265**	**$42,109**	**$123,780**	

Worksheet 2 b
SATELLITE PLANT BUILDING DEMOLITION AND DISPOSAL

Cost Item	Leuenberger Satellite Plant				North Platte Satellite Plant			Petterson Satellite Plant			Notes
	Satellite Process Building	Maintenance Building	Header Houses	Sub Total	Satellite Process Building	Header Houses	Sub Total	Satellite Process Building	Header Houses	Sub Total	
STRUCTURE DEMOLITION & DISPOSAL											
Structural Character											
Demolition Volume (Ft^3)	337,116	180,000	1485		337,116	1958		337,116	3240		Satellite plant building is 12,966 sf
Unit Cost of Demolition ($/ Ft^3)	$0.300	$0.300	$0.300		$0.300	$0.300		$0.300	$0.300		
Total Demolition Cost	$101,135	$54,000	$446		$101,135	$587		$101,135	$972		
Weight of Disposal Material in Tons	152	81	1		152	1		152	1		
Factor for Gutting	1	0.8	1		1	1		1	1		
Cost for Gutting ($)	$101,135	$43,200	$446		$101,135	$587		$101,135	$972		
Quantity per Truck Load (Ton)	21.6	21.6	21.6		21.6	21.6		21.6	21.6		
Number of Truckloads	7.0	3.8	0.0		7.0	0.0		7.0	0.1		
Distance to Landfill	50	50	50		50	50		50	50		
Unit Cost (Ton-Mile)	$0.22	$0.22	$0.22		$0.22	$0.22		$0.22	$0.22		
Transportation Cost	$1,668.72	$891.00	$7.35		$1,668.72	$9.69		$1,668.72	$16.04		
Disposal Cost ($/ton)	$106.00	$106.00	$106.00		$106.00	$106.00		$106.00	$106.00		
Disposal Cost ($)	$16,080.43	$8,586.00	$70.83		$16,080.43	$93.37		$16,080.43	$154.55		
TOTAL STRUCTURE DEMO & DISPOSAL	**$220,019**	**$106,677**	**$969**	**$327,665**	**$220,019**	**$1,278**	**$221,296**	**$220,019**	**$2,115**	**$222,133**	
CONCRETE DECONTAMINATION, DEMO & DISPOSAL											
Area	12966	8000	0		12966	0		12966	0		
Average Thickness (Ft)	0.75	0.75	0.75		0.75	0.75		0.75	0.75		
Volume (Ft^3)	9724.5	6000	0.0		9724.5	0.0		9724.5	0		
Weight of Disposal Concrete Assuming 145lbs/cubic foot	1,410,053	870,000	0		1,410,053	0		1,410,053	0		
Weight of Disposal in Tons	705	435	0		705	0		705	0		
Percent Requiring Decontamination	100%	0%	10%		100%	10%		100%	10%		
Volume Decontaminated (Ft^2)	9,725	0	0		9,725	0		9,725	0		
Decontamination ($/$Ft^2$)	$0.4500	$0.4500	$0.4500		$0.4500	$0.4500		$0.4500	$0.4500		
Decontamination Cost	$4,376	$0	$0		$4,376	$0		$4,376	$0		
Demolition ($/$Ft^2$)	$5.10	$5.10	$5.10		$5.10	$5.10		$5.10	$5.10		
Demolition Cost	$66,127	$40,800	$0		$66,127	$0		$66,127	$0		
Transportation & Disposal											
A. Onsite Disposal											
Percent to be Disposed Onsite	85%	100%	100%		85%	100%		85%	100%		
Transportation Cost	$0	$0	$0		$0	$0		$0	$0		
Disposal Cost per Cubic Yard ($)	$7.50	$7.50	$7.50		$7.50	$7.50		$7.50	$7.50		On-site disposal
Disposal Cost ($)	$2,701	$1,667	$0		$2,701	$0		$2,701	$0		
B. Licensed Site											
Percent to be Shipped	15%	0%	0%		15%	0%		15%	0%		
Distance (Miles)	160	160	160		160	160		160	160		
Unit Cost (Ton-Mile)	$0.22	$0.22	$0.22		$0.22	$0.22		$0.22	$0.22		
Transportation Cost ($)	$3,723	$0	$0		$3,723	$0		$3,723	$0		
Disposal Cost ($/Ton)	$300	$300	$300		$300	$300		$300	$300		
Disposal Cost ($)	$31,726	$0	$0		$31,726	$0		$31,726	$0		
TOTAL TRANSPORT & DISPOSAL COST	**$108,653**	**$42,467**	**$0**	**$151,119**	**$108,653**	**$0**	**$108,653**	**$108,653**	**$0**	**$108,653**	
TOTAL BUILDING DEMO & DISPOSAL COST	**$328,671**	**$149,144**	**$969**	**$478,784**	**$328,671**	**$1,278**	**$329,949**	**$328,671**	**$2,115**	**$330,786**	

Worksheet 3
SOIL REMOVAL & DISPOSAL

Cost Item	Leuenberger Satellite Plant				North Platte Satellite Plant			Peterson Satellite Plant			Notes
	Satellite Plant	Maintenance Building	Header Houses	Sub Total	Satellite Plant	Header Houses	Sub Total	Satellite Plant	Header Houses	Sub Total	
SOIL EXCAVATION, TRANSPORT & DISPOSAL											
Removal Under Building Footprints											
Excavation, Front End Loader	$55	$0	$0		$55	$0		$55	$0		$81.81/hr per WDEQ Guideline12 and 150 cy/hr
Quantity to be Shipped (Ft^3)	810	0	0		810	0		810	0		Assume removal of 3" of Contaminated Soil under Primary Areas over 25% of building area, Disposal at a Licensed facility (ft3)
Weight in Tons	40.5	0	0		40.51875	0		40.51875	0		
Distance (Miles)	160	160	160		160	160		160	160		
Transportation Unit Cost (Ton/Mile)	$0.220	$0.220	$0.220		$0.220	$0.220		$0.220	$0.220		
Transportation Cost	$1,426	$0	$0		$1,426	$0		$1,426	$0		
Disposal Fee ($/Ton)	$2,500	$2,500	$2,500		$2,500	$2,500		$2,500	$2,500		
Disposal Cost ($)	$101,250	$0	$0	$101,250	$101,297	$0	$101,297	$101,297	$0	$101,297	
Removal NPDES Pts.											
Quantity to be Shipped (Ft^3)	0	0	0		0	0		0	0		Zero discharge facility
Weight in Tons	0	0	0		0	0		0	0		
Distance (Miles)	160	160	160		160	160		160	160		
Transportation Cost Ton/Mile ($)	$0.220	$0.220	$0.220		$0.220	$0.220		$0.220	$0.220		
Transportation Cost	$0	$0	$0		$0	$0		$0	$0		
Disposal Fee ($/Ton)	$300	$300	$300		$300	$300		$300	$300		
Disposal Cost ($)	$0	$0	$0		$0	$0		$0	$0		
Total NPDES Removal Cost	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	
TOTAL SOILS EXC., TRANSPORT & DISPOSAL	**$101,250**	**$0**	**$0**	**$101,250**	**$101,297**	**$0**	**$101,297**	**$101,297**	**$0**	**$101,297**	
RADIATION SURVEY											
Area Required (Acres)	0.00	0.00	0.00		0.30	0.00		0.30	0.00		
Survey Cost ($/Acre)	$1,200	$1,200	$1,200		$1,200	$1,200		$1,200	$1,200		$1200 based on cost for Tetratech gamma survey
Number of Structures	0	0	0		0	0		0	0		
Cost per Structure ($)	$225	$225	$225		$225	$225		$225	$225		
TOTAL RAD SURVEY COST	**$0**	**$0**	**$0**	**$0**	**$357**	**$0**	**$357**	**$357**	**$0**	**$357**	
TOTAL SOIL REMOVAL & DISPOSAL COST	**$101,250**	**$0**	**$0**	**$101,250**	**$101,654**	**$0**	**$101,654**	**$101,654**	**$0**	**$101,654**	

Worksheet 5, No. I –
WELLFIELD EQUIPMENT REMOVAL & DISPOSAL

	Leuenberger Satellite Plant				North Platte Plant			Peterson Plant			
Cost Item	Wellfield 1-80 Sand	Wellfield 2-90 Sand	Wellfield 3	Sub Total	Wellfield 4	Wellfield 5	Sub Total	Wellfield 6	Wellfield 7	Sub Total	**Notes**
I Wellfield Piping											
A. Removal											
Total Number of Wells	769	149	56		879	714		769	1,867		Includes total injection and recovery wells
Feeder lines from HH to Injection wells 1" HDPE (Ft)	448,000	128,000	32,000		512,000	416,000		448,000	1,088,000		From Preliminary Design- MR Wellfield 1 & Wellfield 2 takeoffs Based on engineers estimate of 32,000 ft. per HH
Pregnant solution feeder lines from production wells to HH 1" HDPE (Ft)	224,000	64,000	16,000		256,000	208,000		224,000	544,000		Based on engineers estimate of 16,000 ft per HH
Total Quantity of 1" HDPE Piping (Ft)	672,000	192,000	48,000		768,000	624,000		672,000	1,632,000		
Plastic Volume (Ft^3)	2,203.79	629.65	157.41		2,518.62	2,046.38		2,203.79	5,352.06		ISCO specs.for 1" HDPE DR 11
Chipped Volume Assuming 30% Void Space (Ft^3)	2,864.93	818.55	204.64		3,274.20	2,660.29		2,864.93	6,957.68		
Disposal Weight (tons)	114.60	32.74	8.19		130.97	106.41		114.60	278.31		Year 1 buildout only to include Wellfield 1
Quantity per Truck Load (Tons)	21.6	21.6	22.6		24.6	25.6		26.6	27.6		Based on 20 cy per truckload and 80lbs per cf
Total Number of Truck Loads	6	2	1		6	5		5	11		
Total Length of Feeder line Trench (ft)	70,000	20,000	5,000		80,000	65,000		70,000	170,000		Use 5000 ft per HH based on engineer estimate for WC wellfield 7-1
Pipeline Removal Unit Cost ($/ft of trench)	$2.25	$2.25	$2.25		$2.25	$2.25		$2.25	$2.25		Quote - Jordan Construction
Total Cost for Trunkline Removal ($)	$157,500	$45,000	$11,250		$180,000	$146,250		$157,500	$382,500		
Total Cost - Removal	$157,500	$45,000	$11,250	**$213,750**	$180,000	$146,250	**$326,250**	$157,500	$382,500	**$540,000**	
B. Survey & Decontamination											
Percent Requiring Decontamination	0	0	0		0	0		0	0		No survey or decon needed. Total volume to low level disposal
Loads for Decontamination	0	0	0		0	0		0	0		
Cost for Decontamination ($/Load)	$600	$600	$600		$600	$600		$600	$600		
Cost for Decontamination ($)	$0	$0	$0	**$0**	$0	$0	**$0**	$0	$0	**$0**	
C. Transport & Disposal											
1.) Landfill											
a. Transportation											
Percent to be Shipped	0%	0%	100%		300%	400%		500%	600%		
Loads to be Shipped	0	0	1		18	20		25	66		
Distance (Miles)	50	50	50		50	50		50	50		
Transportation Cost (Ton/Mile) ($)	$0.22	$0.15	$0.15		$0.15	$0.15		$0.15	$0.15		
Transportation Cost ($)	$0	$0	$8	**$8**	$135	$150	**$285**	$188	$495	**$683**	
b. Disposal											
Disposal Fee per Yd^3	$58	$58	$58		$58	$58		$58	$58		
Yds^3 per Load	20	20	20		20	20		20	20		
Disposal Cost ($)	$0	$0	$1,160		$20,880	$23,200		$29,000	$76,560		
Total Cost - Landfill	$0	$0	$1,168	**$1,168**	$21,015	$23,350	**$44,365**	$29,188	$77,055	**$106,243**	
2.) Licensed Site											
a. Transportation											
Percent to be Shipped	100%	100%	200%		400%	500%		600%	700%		
Loads to be Shipped	2	2	2		24	25		30	77		
Tons to be Shipped	114.60	32.74	8.19		130.97	106.41		114.60	278.31		
Distance (Miles)	160	160	160		160	160		160	160		
Transportation Ton/Mile ($)	$0.220	$0.220	$0.220		$0.220	$0.220		$0.220	$0.220		
Transportation Cost ($)	$4,034	$1,153	$288		$4,610	$3,746		$4,034	$9,796		
b. Disposal											
Disposal Fee per ton	$300	$300	$301		$303	$304		$305	$306		
Disposal Cost ($)	$34,379	$9,823	$2,464		$39,683	$32,349		$34,952	$85,162		
Total Cost - Licensed Site	38,413	10,975	2,752		44,293	36,095		38,986	94,958		
Total Cost - Transport & Disposal	38,413	10,975	3,919		65,308	59,445		68,173	172,013		
Total Cost - WF Piping Removal & Disposal	**$195,913**	**$55,975**	**$15,169**	**$267,058**	**$245,308**	**$205,695**	**$451,003**	**$225,673**	**$554,513**	**$780,187**	

Worksheet 4 --
Well Abandonment

Cost Item	Leuenberger Satellite Plant				North Platte Plant			Peterson Plant			Notes
	Wellfield 1-80 Sand	Wellfield 2-90 Sand	Wellfield 3	Sub Total	Wellfield 4	Wellfield 5	Sub Total	Wellfield 6	Wellfield 7	Sub Total	
Number of Wells	769	149	56		879	714		769	1867		Includes injection, recovery and monitor wells.
Average Depth (ft)	400	275	400		275	275		275	275		
Average Diameter (inch)	5	5	5		5	5		5	5		
Area of Annulus (ft^2)	0.1364	0.1364	0.1364		0.1364	0.1364		0.1364	0.1364		
Materials											
Bentonite Chips Required (Ft^3/Well)	11.4	11.4	11.4		11.4	11.4		11.4	11.4		250 feet of clay above water
Bags of Chips Required/Well	15	15	15		15	15		15	15		
Cost per Bag ($)	$5.10	$5.10	$5.10		$5.10	$5.10		$5.10	$5.10		Quote from Casper Well services (August 2011)
Cost/Well Bentonite Chips ($)	$77	$77	$77		$77	$77		$77	$77		
Gravel Fill Required (Ft^3/Well)	15.70	15.70	15.70		15.70	15.70		15.70	15.70		Avg depth less 250 feet filled w/ gravel
Cost of Gravel/Yd^3 ($)	$20	$20	$21		$23	$24		$25	$26		
Cost/Well Gravel Fill ($)	$11.63	$11.63	$11.63		$11.63	$11.63		$11.63	$11.63		MR and CR use $11.63
Cement Cone/Markers Req'd/Well	1	1	1		1	1		1	1		
Cost of Cement Cones Markers ($)	$7.50	$7.50	$7.50		$7.50	$7.50		$7.50	$7.50		Cost per Guideline 12, Appendix L
Total Materials Cost per Well	$96	$96	$96		$96	$96		$96	$96		
Labor											
Hours Required per Well	1	1	1		1	1		1	1		
Labor Cost per Hour	$54.12	$54.12	$54.12		$54.12	$54.12		$54.12	$54.12		From 2011 Heavy Highway Prevailing Wages WDEQ Guideline 12, I
Total Labor Cost per Well ($)	$54.12	$54.12	$54.12		$54.12	$54.12		$54.12	$54.12		
Equipment Rental											
Hours Required per Well	1	1	1		1	1		1	1		
Backhoe w/Operator Cost/Hr ($)	$55.61	$55.61	$55.61		$55.61	$55.61		$55.61	$55.61		Cost from WDEQ Guideline 12, Table D-1
Total Equipment Cost per Well ($)	$55.61	$55.61	$55.61		$55.61	$55.61		$55.61	$55.61		Wages from 2011 Heavy Highway wages WDEQ 12, I
Total Cost per Well ($)	$205	$205	$205		$205	$205		$205	$205		
TOTAL WELL ABANDONMENT COST ($)	**$157,871**	**$30,592**	**$11,423**	**$199,886**	**$180,511**	**$146,653**	**$327,164**	**$157,871**	**$383,458**	**$541,329**	

Worksheet 5, No. II
WELLFIELD EQUIPMENT REMOVAL & DISPOSAL

Cost Item	Leuenberger Satellite Plant				North Platte Plant			Peterson Plant			Notes
	Wellfield 1-80 Sand	Wellfield 2-90 Sand	Wellfield 3	Sub Total	Wellfield 4	Wellfield 5	Sub Total	Wellfield 6	Wellfield 7	Sub Total	
II Production Well Pumps											
A. Pump and Tubing Removal											
Number of Production Wells	280	47	20		320	260		280	680		
Cost of Removal ($/well)	$200	$201	$201		$201	$201		$201	$201		
Cost of Removal ($)	$56,000	$9,447	$4,020		$64,320	$52,260		$56,280	$136,680		
Number of Pumps per Truck Load	180	180	180		180	180		180	180		
Number of Truck Loads (Pumps)	1.56	0.26	0.11		1.78	1.44		1.56	3.78		
Weight of Pumps	21.56	20.26	20.11		21.78	21.44		21.56	23.78		Assume 20 T per truck
B. Survey & Decontamination (Pumps)											
Percent Requiring Decontamination	50%	50%	50%		50%	50%		50%	50%		
Loads for Decontamination	0.78	0.13	0.06		0.89	0.72		0.78	1.89		
Cost for Decontamination ($/Load)	$600	$600	$600		$600	$600		$600	$600		
Cost for Decontamination ($)	$467	$78	$33		$533	$433		$467	$1,133		
C. Tubing Volume Reduction & Loading											
Length per Well (Ft)	400	275	400		275	275		275	275		
Total Quantity (Ft^3)	367.3	42.4	26.2		288.6	234.5		252.5	613.3		Thickness Based on ISCO DR 11 1" HDPE PSI 160 (R1=.05479', R2=.04425')
Chipped Volume Assuming 30% Void Space (Ft^3)	477.5	55.1	34.1		375.2	304.8		328.3	797.2		
Cost of Removal ($/Ft)	$0.03	$0.03	$0.03		$0.03	$0.03		$0.03	$0.03		
Cost of Removal ($)	$3,360.00	$387.75	$240.00		$2,640.00	$2,145.00		$2,310.00	$5,610.00		
Quantity per Truck Load (Ft^3)	540	540	540		540	540		540	540		
Number of Truck Loads	1	1	1		1	1		1	2		
D. Transport & Disposal											
1.) Landfill											
a. Transportation											
Percent to be Shipped (Pumps)	50%	50%	50%		50%	50%		50%	50%		
Loads to be Shipped	0.8	0.1	0.1		0.9	0.7		0.8	1.9		
Distance (Miles)	50	50	50		50	50		50	50		
Transportation Ton/Mile ($)	$0.22	$0.22	$0.22		$0.22	$0.22		$0.22	$0.22		
Transportation Cost ($)	$185	$31	$13		$211	$172		$185	$449		
b. Disposal											
Disposal Fee per Yd^3	$58	$58	$58		$58	$58		$58	$58		
Yds^3 per Load	20	20	20		20	20		20	20		
Disposal Cost ($)	$902	$151	$64		$1,031	$838		$902	$2,191		
Total Cost - Landfill	$1,087	$182	$78		$1,242	$1,009		$1,087	$2,640		
2.) Licensed Site											
a. Transportation											
Percent to be Shipped (Pumps)	50%	50%	50%		50%	50%		50%	50%		
Percent to be Shipped (Tubing)	100%	100%	100%		100%	100%		100%	100%		
Loads to be Shipped	2.00	2.00	2.00		2.00	2.00		2.00	4.00		
Distance (Miles)	50	50	50		50	50		50	50		
Transportation Ton/Mile ($)	$0.22	$0.22	$0.22		$0.22	$0.22		$0.22	$0.22		
Transportation Cost ($)	$475	$475	$475		$475	$475		$475	$950		
b. Disposal											
Disposal Cost per Ft^3	$300	$300	$300		$300	$300		$300	$300		
Disposal Fee per Yd^3	20	20	20		20	20		20	20		
Quantity Per Truck Load (Yds^3)	$12,000	$12,000	$12,000		$12,000	$12,000		$12,000	$24,000		
Disposal Cost ($)	$12,475	$12,475	$12,475		$12,475	$12,475		$12,475	$24,950		
Total Cost - Licensed Site	$12,950	$12,950	$12,950		$12,950	$12,950		$12,950	$25,901		
Total Cost - Transport & Disposal	$14,037	$13,133	$13,028		$14,193	$13,960		$14,037	$28,541		
Total Cost - Pump Removal & Disposal	**$73,864**	**$23,046**	**$17,321**	**$114,231**	**$81,686**	**$68,798**	**$150,484**	**$73,094**	**$171,964**	**$245,058**	

Worksheet 5, No. III
WELLFIELD EQUIPMENT REMOVAL & DISPOSAL

Cost Item	Leuenberger Satellite Plant				North Platte Plant			Peterson Plant			Notes
	Wellfield 1-80 Sand	Wellfield 2-90 Sand	Wellfield 3	Sub Total	Wellfield 4	Wellfield 5	Sub Total	Wellfield 6	Wellfield 7	Sub Total	
III Buried Trunkline											
A. Removal											
Trunk lines from Satellite Plant to HH 8" HDPE Pipe (Ft)	50,000	50,000	50,000		50,000	50,000		50,000	50,000		Based on engineer estimate of 50,000 ft per wellfield.
Pregnant solution trunk lines from HH to Satellite Plant 8" HDPE Pipe (Ft)	0	0	0		0	0		0	0		
Total Quantity of HDPE Piping (Ft)	50,000	50,000	50,000		50,000	50,000		50,000	50,000		assume avg 8-in dia.
Plastic Volume (Ft^3)	33,729	33,729	33,729		33,729	33,729		33,729	33,729		Thickness Based on ISCO DR 11 8" PSI 160 (R1=.7188', R2=.5494')
Chipped Volume Assuming 30% Void Space (Ft^3)	43,847	43,847	43,847		43,847	43,847		43,847	43,847		
Disposal Tons	327	327	327		327	327		327	327		13.089lb/ft per ISCO
Quantity per Truck Load (Tons)	21.6	21.6	22.6		24.6	25.6		26.6	27.6		
Total Number of Truck Loads	16	16	15		14	13		13	12		
Total Length of Trunkline Trench (ft)	4,000	2,000	4,300		6,000	15,000		8,000	8,000		
Pipeline Removal Unit Cost ($/ft of trench)	$4.00	$4.00	$5.00		$7.00	$8.00		$9.00	$10.00		
Total Cost for Trunkline Removal ($)	$16,000	$8,000	$21,500	**$45,500**	$42,000	$120,000	**$162,000**	$72,000	$80,000	**$152,000**	
B. Survey & Decontamination											
Percent Requiring Decontamination	0	0	0		0	0		0	0		No survey or decon needed. Total volume to low level disposal
Loads for Decontamination	0	0	0		0	0		0	0		
Cost for Decontamination ($/Load)	$600	$600	$600		$600	$600		$600	$600		
Cost for Survey & Decontamination ($)	$0	$0	$0	**$0**	$0	$0	**$0**	$0	$0	**$0**	
C. Transportation & Disposal											
1.) Landfill											
a. Transportation											
Percent to be Shipped	0%	0%	0%		0%	0%		0%	0%		
Loads to be Shipped	0	0	0		0	0		0	0		
Distance (Miles)	50	50	50		50	50		50	50		
Transportation Cost (Ton/Mile) ($)	$0.22	$0.22	$0.22		$0.22	$0.22		$0.22	$0.22		
Transportation Cost ($)	$0	$0	$0		$0	$0		$0	$0		
b. Disposal											
Disposal Fee per Yd^3	$58	$58	$58		$58	$58		$58	$58		
Yds^3 per Load	20	20	20		20	20		20	20		
Disposal Cost ($)	$0	$0	$0		$0	$0		$0	$0		
Total Cost - Landfill	$0	$0	$0		$0	$0		$0	$0		
2.) Licensed Site											
a. Transportation											
Percent to be Shipped	100%	100%	100%		100%	100%		100%	100%		
Loads to be Shipped	16	16	15		14	13		13	12		
Tons to be Shipped	327.23	327.23	327.23		327.23	327.23		327.23	327.23		
Distance (Miles)	160	160	160		160	160		160	160		
Transportation Ton/Mile ($)	$0.220	$0.220	$0.220		$0.220	$0.220		$0.220	$0.220		
Transportation Cost ($)	$11,518	$11,518	$11,518		$11,518	$11,518		$11,518	$11,518		
b. Disposal											
Disposal Fee per ton	$300	$300	$300		$300	$300		$300	$300		
Disposal Cost ($)	$98,168	$98,168	$98,168		$98,168	$98,168		$98,168	$98,168		
Total Cost - Licensed Site	$109,686	$109,686	$109,686	**$329,057**	$109,686	$109,686	**$219,372**	$109,686	$109,686	**$219,372**	
Total Cost Transportation & Disposal	**$109,686**	**$109,686**	**$109,686**	**$329,057**	**$109,686**	**$109,686**	**$219,372**	**$109,686**	**$109,686**	**$219,372**	
Total Cost - Buried Trunkline Removal & Disposal	**$125,686**	**$117,686**	**$131,186**	**$374,557**	**$151,686**	**$229,686**	**$381,372**	**$181,686**	**$189,686**	**$371,372**	
TOTAL WELLFIELD EQUIPMENT REMOVAL & DISPOSAL COST	**$395,463**	**$196,707**	**$163,677**	**$755,846**	**$478,680**	**$504,179**	**$982,859**	**$480,453**	**$916,163**	**$1,396,617**	

Closure Cost Estimate
Ludeman ISR Project
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Worksheet 6, No. I
TOPSOIL REPLACEMENT & REVEGETATION

	Satellite Plant				
Cost Item	Leuenberger	North Platte	Peterson	Sub Total	**Notes**
I Satellite Plant Building & Maint Bldg (Leuenberger only)					
A. Topsoil Handling & Grading					
Affected Area (Acres)	1.9	1.2	1.2		Assume disturbed area is 4 times area of bldg
Average Affected Thickness (Ins)	12	12	12		
Topsoil Volume (Yds^3)	3,106	1,921	1,921		
Unit Cost	$0.90	$0.90	$0.90		Cost per WDEQ Guideline 12, Appendix B
Sub Total - Topsoil	$2,795	$1,729	$1,729		
B. Radiation Survey & Soil Analysis					
Unit Cost ($/Ac)	$1,200	$1,200	$1,200		$1200 based on cost for Tetratech gamma survey
Sub Total - Survey & Analysis	$2,310	$1,429	$1,429		
C. Revegetation					
Fertilizer ($/Ac)	$0.00	$0.00	$0.00		
Seeding Prep & Seeding ($/Ac)	$280.00	$280.00	$280.00		Used for MR and IR/CR
Mulching & Crimping ($/Ac)	$0.00	$0.00	$0.00		
Sub Total Cost/Acre	$280.00	$280.00	$280.00		
Sub Total Revegetation	$539	$333	$333		
TOTAL PLANT AND OFFICE BUILDING TOPSOIL REPLACEMENT & REVEG COST	**$5,645**	**$3,491**	**$3,491**	**$12,627**	

Worksheet 6, Nos. II & III
TOPSOIL REPLACEMENT & REVEGETATION

Cost Item	Leuenberger Satellite Plant				North Platte Plant			Peterson Plant			Notes
	Wellfield 1-80 Sand	Wellfield 2-90 Sand	Wellfield 3	Sub Total	Wellfield 4	Wellfield 5	Sub Total	Wellfield 6	Wellfield 7	Sub Total	
II Wellfields											
A. Topsoil Handling & Grading											
Affected Area (Acres)	25	8	3		30	28		27	61		Equals trench length times 15 feet wide
Average Affected Thickness (Inch)	12	12	12		12	12		12	12		
Topsoil Volume (Yds^3)	41,111	12,222	5,167		47,778	44,444		43,333	98,889		
Unit Cost - Haul/Place/Grading ($/cy)	$0.90	$0.90	$0.90		$0.90	$0.90		$0.90	$0.90		Cost per WDEQ Guideline 12, Appendix B
Sub Total - Topsoil	$37,000	$11,000	$4,650		$43,000	$40,000		$39,000	$89,000		
B. Radiation Survey & Soil Analysis											
Unit Cost ($/Ac)	$1,200	$1,200	$1,200		$1,200	$1,200		$1,200	$1,200		$1200 based on cost for Tetratech gamma survey
Sub Total - Survey & Analysis	$30,579	$9,091	$3,843		$35,537	$33,058		$32,231	$73,554		
C. Spill Cleanup											
Affected Area (Acres)	0	0	0		0	0		0	0		
Affected Area (Ft^2)	0	0	0		0	0		0	0		
Affected Area Thickness (Ft)	0.5	0.5	0.5		0.5	0.5		0.5	0.5		
Affected Volume (Ft^3)	0	0	0		0	0		0	0		
Quantity per Truckload (Ft^3)	540	540	540		540	540		540	540		
Quantity to be Shipped (Loads)	0	0	0		0	0		0	0		
Distance (Miles)	160	160	160		160	160		160	160		
Transportation Cost (Ton/Mile) ($)	$0.22	$0.22	$0.22		$0.22	$0.22		$0.22	$0.22		
Transportation Cost ($)	$0	$0	$0		$0	$0		$0	$0		
Handling Cost ($/Load)	$400	$400	$400		$400	$400		$400	$400		
Handling Cost ($)	$0	$0	$0		$0	$0		$0	$0		
Disposal Fee ($/Ton)	$300	$300	$300		$300	$300		$300	$300		
Disposal Cost ($)	$0	$0	$0		$0	$0		$0	$0		
Sub Total - Spill Cleanup	$0	$0	$0		$0	$0		$0	$0		
D. Revegetation											
Fertilizer ($/Ac)	$0.00	$0.00	$0.00		$0.00	$0.00		$0.00	$0.00		
Seeding Prep & Seeding ($/Ac)	$280.00	$280.00	$280.00		$280.00	$280.00		$280.00	$280.00		Used for MR and IR/CR
Mulching & Crimping ($/Ac)	$0.00	$0.00	$0.00		$0.00	$0.00		$0.00	$0.00		
Sub Total Cost/Acre	$280.00	$280.00	$280.00		$280.00	$280.00		$280.00	$280.00		
Sub Total Revegetation	$7,135	$2,121	$897		$8,292	$7,713		$7,521	$17,163		
Sub Total - Wellfields	$74,713	$22,212	$9,390		$86,829	$80,771		$78,752	$179,716		
TOTAL WELLFIELDS COST	**$74,713**	**$22,212**	**$9,390**	**$106,315**	**$86,829**	**$80,771**	**$167,601**	**$78,752**	**$179,716**	**$258,468**	
III Roads											
A. Topsoil Handling & Grading											
Affected Area (Acres)	0.91	0.91	0.91		0.91	0.91		0.91	0.91		3305 feet by 12 feet wide- 2 track access
Average Affected Thickness (Ins)	12	12	12		12	12		12	12		
Topsoil Volume (Yds^3)	1,469	1,469	1,469		1,469	1,469		1,469	1,469		
Unit Cost - Haul/Place/Grading ($/cy)	$0.90	$0.90	$0.90		$0.90	$0.90		$0.90	$0.90		Cost per WDEQ Guideline 12, Appendix B
Sub Total - Topsoil	$1,322	$1,322	$1,322		$1,322	$1,322		$1,322	$1,322		
B. Radiation Survey & Soil Analysis											
Unit Cost ($/Ac)	$800	$800	$800		$800	$800		$800	$800		
Sub Total - Survey & Analysis	$728	$728	$728		$728	$728		$728	$728		
C. Revegetation											
Fertilizer ($/Ac)	$0	$0	$0		$0	$0		$0	$0		
Seeding Prep & Seeding ($/Ac)	$280	$280	$280		$280	$280		$280	$280		Used for MR and IR/CR
Mulching & Crimping ($/Ac)	$0	$0	$0		$0	$0		$0	$0		
Sub Total Cost/Acre	$280	$280	$280		$280	$280		$280	$280		
Sub Total Revegetation	$255	$255	$255		$255	$255		$255	$255		
Sub Total - Roads	$2,305	$2,305	$2,305		$2,305	$2,305		$2,305	$2,305		
TOTAL ROADS COST	**$2,305.31**	**$2,305.31**	**$2,305.31**	**$6,916**	**$2,305.31**	**$2,305.31**	**$4,611**	**$2,305.31**	**$2,305.31**	**$4,611**	

Worksheet 6, Nos IV & V
TOPSOIL REPLACEMENT & REVEGETATION

Cost Item	Leuenberger Satellite Plant				North Platte Plant			Peterson Plant			Notes
	Wellfield 1-80 Sand	Wellfield 2-90 Sand	Wellfield 3	Sub Total	Wellfield 4	Wellfield 5	Sub Total	Wellfield 6	Wellfield 7	Sub Total	
IV Other											
A. Topsoil Handling & Grading											
Affected Area (Acres)	4	4	1		4	4		4	4		
Average Affected Thickness (Ins)	6	6	6		6	6		6	6		
Topsoil Volume (Yds^3)	3,227	3,227	807		3,227	3,227		3,227	3,227		
Unit Cost - Haul/Place/Grading ($/Ac)	$0.90	$0.90	$0.90		$0.90	$0.90		$0.90	$0.90		
Sub Total - Topsoil	$2,904	$2,904	$726		$2,904	$2,904		$2,904	$2,904		
B. Radiation Survey & Soil Analysis											
Unit Cost ($/Ac)	$800	$800	$800		$800	$800		$800	$800		
Sub Total - Survey & Analysis	$3,200	$3,200	$800		$3,200	$3,200		$3,200	$3,200		
C. Revegetation											
Fertilizer ($/Ac)	$0.00	$0.00	$0.00		$0.00	$0.00		$0.00	$0.00		
Seeding Prep & Seeding ($/Ac)	$280.00	$280.00	$280.00		$280.00	$280.00		$280.00	$280.00		Used price from WC and MR surety estimates
Mulching & Crimping ($/Ac)	$0.00	$0.00	$0.00		$0.00	$0.00		$0.00	$0.00		
Sub Total Cost/Acre	$280.00	$280.00	$280.00		$280.00	$280.00		$280.00	$280.00		
Sub Total Revegetation	$1,120	$1,120	$280		$1,120	$1,120		$1,120	$1,120		
Sub Total - Other	$7,224	$7,224	$1,806		$7,224	$7,224		$7,224	$7,224		
TOTAL OTHER COST	**$7,224**	**$7,224**	**$1,806**	**$16,254**	**$7,224**	**$7,224**	**$14,448**	**$7,224**	**$7,224**	**$14,448**	
V Remedial Action											
A. Topsoil Handling & Grading											
Affected Area (Acres)	25	8	3		30	28		27	61		
Average Affected Thickness (Ins)	12	12	12		12	12		12	12		
Topsoil Volume (Yds^3)	41,111	12,222	5,167		47,778	44,444		43,333	98,889		
Unit Cost - Haul/Place/Grading ($/cy)	$0.90	$0.90	$0.90		$0.90	$0.90		$0.90	$0.90		Cost per WDEQ Guideline 12, Appendix B
Sub Total - Topsoil	$37,000	$11,000	$4,650		$43,000	$40,000		$39,000	$89,000		
B. Radiation Survey & Soil Analysis											
Unit Cost ($/Ac)	$1,200	$1,200	$1,200		$1,200	$1,200		$1,200	$1,200		$1200 based on cost for Tetratech gamma survey
Sub Total - Survey & Analysis	$30,579	$9,091	$3,843		$35,537	$33,058		$32,231	$73,554		
C. Revegetation											
Fertilizer ($/Ac)											
Seeding Prep & Seeding ($/Ac)	$280.00	$280.00	$280.00		$280.00	$280.00		$280.00	$280.00		Cost from WC and MR surety estimates 2011
Mulching & Crimping ($/Ac)											
Sub Total Cost/Acre	$280.00	$280.00	$280.00		$280.00	$280.00		$280.00	$280.00		
Sub Total Revegetation	$7,135	$2,121	$897		$8,292	$7,713		$7,521	$17,163		
TOTAL REMEDIAL ACTION	**$74,713**	**$22,212**	**$9,390**	**$106,315**	**$86,829**	**$80,771**	**$167,601**	**$78,752**	**$179,716**	**$258,468**	
TOTAL TOPSOIL REPLACEMENT & REVEGETATION COST (Total of 6I through 6V)	**$164,601**	**$53,954**	**$22,891**	**$241,445**	**$183,188**	**$171,072**	**$354,260**	**$167,033**	**$368,962**	**$535,995**	

Closure Cost Estimate
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Worksheet 7, Nos I - VII
MISCELLANEOUS RECLAMATION

	Cost Item	Leuenberger Satellite Plant				North Platte Plant			Peterson Plant			Notes
		Wellfield 1-80 Sand	Wellfield 2-90 Sand	Wellfield 3	Sub Total	Wellfield 4	Wellfield 5	Sub Total	Wellfield 6	Wellfield 7	Sub Total	
I	**Fence Removal & Disposal**											
	Quantity (Ft)	11,637	10,086	0		14,400	16,800		12,000	24,750		Scaled off on map
	Cost of Removal/Disposal ($/Ft)	$1.50	$1.50	$1.50		$1.50	$1.50		$1.50	$1.50		
	Cost of Removal/Disposal ($)	$17,456	$15,129	$0	**$32,585**	$21,600	$25,200	**$46,800**	$18,000	$37,125	**$55,125**	
II	**Powerline Removal & Disposal**											
	Quantity (Ft)	7,500	7,500	7,500		7,500	7,500		7,500	7,500		Power to Wells, header houses. Other power already in place by CBM companies
	Cost of Removal/Disposal ($/Ft)	$0.50	$0.50	$1.50		$3.50	$4.50		$5.50	$6.50		
	Cost of Removal/Disposal ($)	$3,750	$3,750	$11,250	**$18,750**	$26,250	$33,750	**$60,000**	$41,250	$48,750	**$90,000**	
III	**Powerpole Removal & Disposal**											
	Quantity	25	25	25		25	25		25	25		Overhead powerpoles and lines will remain in place for future gas production
	Cost of Removal/Disposal ($/Each)	0	0	0		0	0		0	0		
	Cost of Removal/Disposal ($)	$0.00	$0.00	$0.00	**$0**	$0.00	$0.00	**$0**	$0.00	$0.00	**$0**	
IV	**Transformer Removal & Disposal**											
	Quantity	4	4	0		0	0		0	0		
	Cost of Removal/Disposal ($/Each)	4500	4500	4500		4500	4500		4500	4500		Tri-County Electric will remove at no cost, WDEQ Guideline No.12, App. H
	Cost of Removal/Disposal ($)	18000	18000	0	**$36,000**	0	0	**$0**	0	0	**$0**	
V	**Culvert Removal & Disposal**											
	Quantity (Ft)	0	0	0		0	0		0	0		None
	Cost of Removal/Disposal ($/Ft)	$4.56	$4.56	$4.56		$4.56	$4.56		$4.56	$4.56		($91.24/20') WDEQ Guideline No.12, App. J
	Cost of Removal/Disposal ($)	$0.00	$0.00	$0.00	**$0**	$0.00	$0.00	**$0**	$0.00	$0.00	**$0**	
VI	**Guardrail Removal**											
	Quantity (Ft)	0	0	0		0	0		0	0		None
	Cost of Removal/Disposal ($/Ft)	$6.50	$6.50	$6.50		$6.50	$6.50		$6.50	$6.50		
	Cost of Removal/Disposal ($)	$0	0	0	**$0**	0	0	**$0**	0	0	**$0**	
VII	**Low Water Stream Crossing**											
	Quantity	0	0	0		0	0		0	0		None
	Cost of Removal/Disposal ($/Each)	$8,000	$8,000	$8,000		$8,000	$8,000		$8,000	$8,000		
	Cost of Removal/Disposal ($)	$0	$0	$0	**$0**	$0	$0	**$0**	$0	$0	**$0**	
	TOTAL MISCELLANEOUS COST	**$39,206**	**$36,879**	**$11,250**	**$87,335**	**$47,850**	**$58,950**	**$106,800**	**$59,250**	**$85,875**	**$145,125**	

Worksheet 8, Nos I - VIII
POND RECLAMATION COST

	Cost Item	Leuenberger Satellite Plant		North Platte Plant		Petersen Plant		NOTES
		Surge Pond 1	Surge Pond 2	Surge Pond 1	Surge Pond 2	Surge Pond 1	Surge Pond 2	
I	POND SLUDGE:							
	Average Sludge Depth (Ft)	0.15625	0	0.15625	0	0.15625	0	WC uses a sludge volume of 0.15625
	Average Area of Sludge (Ft^2)	32,670	32,670	32,670	32,670	32,670	32,670	Pond size from MR 0.75 acres per pond
	Volume of Sludge (Ft^3)	5,104.69	0.00	5,104.69	0.00	5,104.69	0.00	
	Volume of Sludge (Yds^3)	189	0	189	0	189	0	
	Volume of Sludge Per Truck Load (Yds^3)	20	20	20	20	20	20	
	# of Truck Loads of Sludge	9	0	9	0	9	0	
	Sludge Handling Cost Per Load ($)	$240	$240	$240	$240	$240	$240	
	Total Sludge Handling Cost ($)	$2,269	$0	$2,269	$0	$2,269	$0	
	Transportation & Disposal							
	Percent To Be Shipped to Licensed Site	100%	100%	100%	100%	100%	100%	
	Transportation Cost per Truckload	$2,100.00	$2,100.00	$2,100.00	$2,100.00	$2,100.00	$2,100.00	
	Transportation Cost ($)	$19,851.56	$0.00	$19,851.56	$0.00	$19,851.56	$0.00	
	Disposal Cost Per Cubic Foot ($)	$11.00	$11.00	$11.00	$11.00	$11.00	$11.00	Used WC 2011 surety disposal cost for liner
	Quantity Per Truck Load (Yds^3)	20.0	20.0	20.0	20.0	20.0	20.0	
	Quantity Per Truck Load (Ft^3)	540	540	540	540	540	540	
	Disposal Cost ($)	$56,151.56	$0.00	$56,151.56	$0.00	$56,151.56	$0.00	
	Total Transportation & Disposal ($)	$76,003.13	$0.00	$76,003.13	$0.00	$76,003.13	$0.00	
	TOTAL SLUDGE COST ($)	$78,271.88	$0.00	$78,271.88	$0.00	$78,271.88	$0.00	
II	POND LINER:							
	Total Pond Area (Acres)	1.60	1.60	1.60	1.60	1.60	1.60	MR uses acreage of 1.6 for liner area
	Total Pond Area (Ft^2)	69696	69,696	69696	69,696	69,696	69696	
	Factor For Sloping Sides	20%	20%	20%	20%	20%	20%	Used WC numbers for factor no number in MR
	Total Liner Area (Ft^2)	83635	83635	83635	83635	83635	83635	
	Liner Thickness (Mil)	30	30	30	30	30	30	
	Liner Thickness (inches)	0.0300	0.0300	0.0300	0.0300	0.0300	0.0300	
	Liner Thickness (Ft)	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	
	"Swell" Factor	25%	25%	25%	25%	25%	25%	Used WC number none in MR
	Liner Volume (Ft^3)	261	261	261	261	261	261	
	Truck Loads of Liner	0.5	0.5	0.5	0.5	0.5	0.5	
	Liner Handling Cost ($)							
	Labor Crew Cost per Hour ($)	160.18	$160.18	160.18	$160.18	$160.18	160.18	
	Hours per Load	2	$2	2	$2	$2	2	
	Liner Handling Cost Per Load ($)	$320	$320	320	$320	$320	$320	
	Total Liner Handling Cost ($)	$160	$160	$160	$160	$160	$160	
	Transportation & Disposal							
	Percent To Be Shipped to Licensed Site	100%	100%	100%	100%	100%	100%	
	Transportation Cost per Truckload	$2,100	$2,100	$2,100	$2,100	$2,100	$2,100	
	Transportation Cost ($)	$1,050	$1,050	$1,050	$1,050	$1,050	$1,050	
	Disposal Cost Per Cubic Foot ($)	$11	$11	$11	$11	$11	$11	
	Quantity Per Truck Load (Ft^3)	540	540	540	540	540	540	
	Disposal Cost ($)	2970	2970	2970	2970	2970	2970	
	Total Transportation & Disposal ($)	$4,020	$4,020	$4,020	$4,020	$4,020	$4,020	
	TOTAL LINER COST ($)	$4,180	$4,180	$4,180	$4,180	$4,180	$4,180	
III	POND BACKFILL:							
	Backfill required (Yds^3)	24,039	24,039	24,039	24,039	24,039	24,039	
	Backfill Cost ($/Yd^3$)	$0.90	$0.90	$0.90	$0.90	$0.90	$0.90	Cost per WDEQ Guideline 12, Appendix B
	TOTAL BACKFILL COST ($)	$21,635	$21,635	21635	21635	$21,635	21635	
IV	RADIATION SURVEY							
	Areal required (acres)	1.60	1.60	1.60	1.60	1.60	1.60	
	Survey Cost ($/acre)	$1,200	$1,200	$1,200	$1,200	$1,200	$1,200	$1200 based on cost for Tetratech gamma survey
	TOTAL SURVEY COST ($)	$1,920	$1,920	$1,920	$1,920	$1,920	$1,920	
V	LEAK DETECTION SYSTEM REMOVAL							
	Volume of Gravel and Piping (Ft^3) (Assume 3")	2,187	2,187	2,187	2,187	2,187	2,187	Based on ration of 6 ponds at Ludeman compaired to 12 ponds and 26,250 ft^3 for WC
	Quantity per Truckload (Ft^3)	540	540	540	540	540	540	
	Quantity to be Shipped to Licensed Site (Loads)	4.05	4.05	4.05	4.05	4.05	4.05	
	Transportation Cost per Truckload	$2,100	$2,100	$2,100	$2,100	$2,100	$2,100	Based on estimate for 2011 WC surety
	Transportation Cost ($)	$9,000	$9,000	$9,000	$9,000	$9,000	$9,000	
	Handling Cost per load	1,297	1,297	1,297	1,297	1,297	1,297	Based on WC 2011 estimate
	Disposal Fee per Cubic Foot ($)	$11	$11	$11	$11	$11	$11	
	Disposal Cost ($)	24,057	24,057	24,057	24,057	24,057	24,057	
	TOTAL LEAK DETECTION SYSTEM REMOVAL	$34,354.46	$34,354.46	34354.458	34354.458	$34,354.46	34354.458	
	TOTAL POND RECLAMATION COST	$140,361.33	$62,089.46	$140,361.33	$62,089.46	$140,361.33	$62,089.46	
		Leuenberger	$202,451	North Platte	$202,451	Peterson	$202,451	

TOTAL SLUDGE COST ($)	$234,816
TOTAL LINER COST ($)	$25,080
TOTAL BACKFILL COST ($)	$129,810
TOTAL RADIATION SURVEY COST ($)	$11,520
LEAK DETECTION SYSTEM REMOVAL	$206,127