Removal Action at Ra/Sr Treatment System Area
Site Specific Air Modeling Scenarios/Input Assumptions and Results

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PROJECT: 17823
CAT. 13.4.3.1.2

Introduction

Objective:

The objective of this task is to assess whether emissions generated during removal action activities would have an effective dose equivalent rate below the 10 mrem/yr standard, in compliance with the requirements of 40 CFR Part 61 Subpart H - National Emissions Standards for Hazardous Air Pollutants (NESHAP) for Emissions of Radionuclides from USDOE Facilities.

Methods:

The emissions rates for excavation, active stockpiling and waste container loading were calculated using the ASTM RBCA Box Model. The 95% upper confidence limit (UCL) of the Ra-226 and Sr-90 concentrations of soil samples from the excavation from the Draft Final Engineering Evaluation/Cost Analysis (EE/CA) for the Southwest Trenches, Radium-226/Strontium-90 (Ra/Sr) Treatment Systems, and Domestic Septic System Areas for the DOE Areas at the Laboratory for Energy-Related Health Research (LEHR) Site University of California at Davis, California (WA 1998e) were used with the calculated emissions rates to determine the CAP88-PC inputs. There were only three sludge samples collected from the strontium treatment system Tank A. Therefore the maximum Sr-90 concentration found in the Tank A sludge was used to calculate the CAP88PC inputs.

Activities:

This modeling includes emissions from all of the excavation activities scoped in Task Plan 11.

CAP88-PC Dose Assessment Model

Release Scenario 1: Excavation of Soil, Concrete & Sludge

Assumptions:

- 1,395 cubic yards (CY) of low-level radioactive soil and concrete will be excavated (Reference: Task Plan 11)
- 30 CY of low-level radioactive sludge will be excavated (Reference: Task Plan 11)
- 10% soil moisture content soil and concrete; 50% for Tank A sludge.
- Backhoe excavation emissions factor (E_{15} = 3.2E-03 kg/m^3 for concrete & soil; E_{15} =1.96E-03 for sludge) from empirical equation ($E_{15} = 0.0029 * d^{0.7} * M^{-0.3}$) (d= drop height, m= moisture content). (Referenced from Air/Superfund National Technical Guidance Study Series Volume III – Estimation of Air Emissions from Cleanup Activities at Superfund Sites, Table 24.)

- 465 hours of backhoe digging time for soil and concrete (30 CY/10 hr-day).
- 10 hours of backhoe digging time for the Tank A sludge (30 CY/10 hr-day).
- Excavation area is 6,300 ft^2 at 60 ft (W) x 105 ft (L).
- Tank A area is 144 ft^2 at 6 ft (W) x 24 ft (L)
- Backhoe emission rate for soil and concrete= 7.3 g/hr, sludge =4.49 g/hr (see Table 4 & 8, respectively).
- Soil and Concrete Ra-226 activity of 12.9 pCi/g calculated from 95% UCL (1999 Air modeling)
- Soil and Concrete Sr-90 activity of 0.9 pCi/g calculated from 95% UCL
- Sludge Sr-90 activity of 18,600 pCi/g
- Activities of Ra-226 and Sr-90 are distributed evenly for the entire excavation area.
- The 1999 annual precipitation, 1999 ambient temperature and the Sacramento wind file were used as CAP88PC inputs.
- PM-10 emissions from soil and concrete excavation= 1.24E-02 g/ m^2-hr (see Table 4); PM-10 emissions from sludge excavation= 3.35E-01 g/ m^2-hr (see Table 8)

Release Scenario2: Storage Piles

Assumptions:

- The excavated soil and concrete will be put into an active stockpile; the pile will be 10 ft by 10 ft, approximately 25 cubic yards in volume.
- Low-level radioactive soil and concrete will be stockpiled from 8/1/00- 10/4/00
- Stockpiling will occur for 47 days for ten hours a day
- Stockpiles will be covered during non-working hours
- The sludge will be directly loaded.
- PM-30 emissions from active stockpiles= 3.90E-01 g/m^2-hr (see Table 5)

Release Scenario 3: Handling of Storage Piles

Assumptions:

- No physical handling of the storage piles (i.e., separating coarse aggregates/materials from fine aggregates/materials using a shaker or other methods that will generated additional dust emissions) will occur

- PM-10 emission from handling of storage piles = 0 g/m^2-hr (see Table 6)

Release Scenario 4: Loading of Storage Piles

Assumptions:

- The excavated soil and concrete will be put into an active stockpile; the pile will be 10 ft by 10 ft, approximately 25 cubic yards in volume.

- Low-level radioactive soil and concrete will be stockpiled from 8/1/00- 10/4/00

- Loading will occur for 47 days for ten hours a day

- PM-10 emission from loading of storage piles = 5.44E-02 g/m^2-hr (see Table 7)

Results

Results from the CAP88-PC modeling run concluded an effective dose equivalent (EDE) rate of 4.29E-02 mrem per year. This value in addition to the EDE rate from the Western and Eastern Dog Pens of 5.05E-04 mrem per year (WA, 1999) totals well below the 10 mrem/yr standard in the requirements of 40 CFR Part 61 Subpart H- NESHAP for Emissions of Radionuclides from USDOE Facilities. The CAP88-PC value is very conservative since it assumes that Ra-226 and Sr-90 maximum concentrations are distributed evenly throughout the entire excavation area.

Reference:

Weiss Associates, 1999, Final Radionuclide Annual Report for Laboratory for Energy-Related Health Research University of California, Davis, May.

Table 1. Ra/Sr Treatment System Areas Radionuclides of Concern Excavation, 10 CFR 61 Construction Exemption Calculation Summa

Chemical Name	Total Annual Average [1] PM-10 Inhalation Loading		FGR No. 11 Table 2.1 Inhalation Intakes	Dose Based upon FGR No. 11 Table 2.1	% of 40 CFR61 Standard of 10 mrem/yr
	(pCi/m^3)	(Ci/m^3)	(mrem/pCi)	(mrem)	(%)
Radium-226	1.7E-04	1.7E-16	8.57E-03 (2)	1.0E-02	0.10%
Strontium-90	3.8E-03	3.8E-15	3.23E-03 (3)	8.9E-02	0.8915%

Notes:

1 = Total annual average PM-10 loading based upon maximum 1-hr concentrations resulting for each phase of the Ra/Sr Treatment System Areas remediation.

2 = Committed effective dose equivalent per unit intake ($h_{E,50}$) for Ra-226 (Class=W; f_1=2.0e-01), computed using w_T from ICRP-26. From "Federal Guidance Report No. 11" : Table 2.1. Inhalation Intakes (EPA-5201/1-88-020).

3 = Committed effective dose equivalent per unit intake ($h_{E,50}$) for Sr-90 (Class=Y; f_1=1.0e-02), computed using w_T from ICRP-26. From "Federal Guidance Report No. 11" : Table 2.1. Inhalation Intakes (EPA-5201/1-88-020).

Table 2. Ra/Sr Treatment System Areas Radionuclide of Concern Excavation Particulate Modeling Results and 10 CFR 61 Construction Exemption Calculation

Chemical Name	Max Soil Concentration[1] (pCi/g)	Resuspension Factor[2] (pCi/m^3) / (pCi/g)	Excavation Modeling Result PM-10 Inhalation Loading (pCi/m^3)	(Ci/m^3)	Phase Duration (Hours)	FGR No. 11 Table 2.1 Inhalation Intakes (mrem/pCi)	Dose Based upon FGR No. 11 Table 2.1 (mrem)	% of 40 CFR61 Standard of 10 mrem/yr (%)
Radium-226	12.9	6.6E-06	8.5E-05	8.5E-17	465	8.57E-03 (6)	2.8E-04	0.003%
Strontium-90	0.9	6.6E-06	5.9E-06	5.9E-18	465	3.23E-03 (7)	7.4E-06	0.0001%
			Sludge Excavation Modeling Results PM-10 Inhalation Loading					
Strontium-90	18600	1.8E-04	3.3E+00	3.3E-12	10	3.23E-03 (7)	8.9E-02	0.8887%

Chemical Name	Max Soil Concentration[1] (pCi/g)	Resuspension Factor[3] (pCi/m^3) / (pCi/g)	Onsite Excavation Storage Piles Modeling Result PM-10 Inhalation Loading (pCi/m^3)	(Ci/m^3)	Phase Duration (Hours)	FGR No. 11 Table 2.1 Inhalation Intakes (mrem/pCi)	Dose Based upon FGR No. 11 Table 2.1 (mrem)	% of 40 CFR61 Standard of 10 mrem/yr (%)
Radium-226	12.9	2.1E-04	2.7E-03	2.7E-15	470	8.57E-03 (6)	8.9E-03	0.09%
Strontium-90	0.9	2.1E-04	1.9E-04	1.9E-16	470	3.23E-03 (7)	2.4E-04	0.00%

Chemical Name	Max Soil Concentration[1] (pCi/g)	Resuspension Factor[5] (pCi/m^3) / (pCi/g)	Excavation Soil Loading Modeling Result PM-10 Inhalation Loading (pCi/m^3)	(Ci/m^3)	Phase Duration (Hours)	FGR No. 11 Table 2.1 Inhalation Intakes (mrem/pCi)	Dose Based upon FGR No. 11 Table 2.1 (mrem)	% of 40 CFR61 Standard of 10 mrem/yr (%)
Radium-226	12.9	2.9E-05	3.7E-04	3.7E-16	470	8.57E-03 (6)	1.2E-03	0.01247%
Strontium-90	0.9	2.9E-05	2.6E-05	2.6E-17	470	3.23E-03 (7)	3.3E-05	0.00033%

Notes:

1 = Maximum Limited Field Investigation soil concentration for sr-90 and the 95% UCL of the LFI ra-226 soil concentrations for the Ra/Sr Treatment System Areas.

2 = PM-10 excavation particulate resuspension factor estimated using the Air/Superfund National Technical Guidance Series Volume III - Estimation of Air Emissions from Cleanup Activities at Superfund Sites (Jan, 1989), (Assuming emission rate of PM-15 particulates for "dragline" in Table 24 of reference)

3 = PM-10 storage pile particulate resuspension factor estimated using the Air/Superfund National Technical Guidance Series Volume III - Estimation of Air Emissions from Cleanup Activities at Superfund Sites (Jan, 1989), (Assuming emission rate of Total Suspended Particulates for short-term (24hr) active storage piles in Table 21 of reference. Adjustment made for particulate size distribution less than 30 mm from Table 25).

4 = PM-10 screening of radionuclide contaminated soil particulate resuspension factor estimated using the USEPA AP-42 Chapter 11, Section 11.19.2 Crushed Stone Processing. Table 11.19.2-1: Emission Factors for Crushed Stone Processing.

5 = PM-10 loading of radionuclide contaminated soil particulate resuspension factor based upon AP-42 Chapter 13 - Aggregate Handling and Storage Piles. Equation 1 - Quantity of particulate emissions generated by drop operations.

6 = Committed effective dose equivalent per unit intake ($h_{E,50}$) for Ra-226 (Class=W; f_1=2.0e-01), computed using w_T from ICRP-26. From "Federal Guidance Report No. 11" : Table 2.1. Inhalation Intakes (EPA-5201/1-88-020).

7= Committed effective dose equivalent per unit intake (hE,50) for Sr-90 (Class=Y; f1=1.0e-02), computed using wT from ICRP-26. From "Federal Guidance Report No. 11" : Table 2.1. Inhalation Intakes (EPA-5201/1-88-020).

Table 3 - Ra/Sr Treatment System Areas - Resuspension Factors Resulting From Radionuclide-Contaminated Soil Remediation

Box model assuming emission rates estimated on "Excavation", "Storage" and "Loading" spreadsheets, and ASTM RBCA 1996 box model, adjusted for site specific data.

Excavation Emission Rate =	1.24E-02	(g/m^2-hr)	=	3.45E-06	(g/m^2-sec)
Storage pile Emission Rate =	3.90E-01	(g/m^2-hr)	=	1.08E-04	(g/m^2-sec)
Loading Emission Rate =	5.44E-02	(g/m^2-hr)	=	1.51E-05	(g/m^2-sec)
Total PM-10 Emission Rate =	4.57E-01	(g/m^2-hr)	=	1.27E-04	(g/m^2-sec)

Uw = 3 95% UCL of mean annual windspeed at 7 m (m/s)

Hb = 1.6 Height of breathing zone (m)

Excavation Modeling Result

L = 30 Downwind length of area source (ft)

= 9.1 Downwind length of area source (m)

PM-10 Exposure point concentration = 6.6E-06 g/m^3

6.58 $\mu g/m^3$

Excavation Resuspension Factor = 6.58E-06 (ug/m^3) / (mg/kg)

Onsite Excavation Storage Piles Modeling Result

L = 30 Downwind length of area source (ft)

= 9.1 Downwind length of area source (m)

PM-10 Exposure point concentration = 2.1E-04 g/m^3

206.57 $\mu g/m^3$

Storage Pile Resuspension Factor = 2.07E-04 ($\mu g/m^3$) / (mg/kg)

Excavated Soil Loading Modeling Result

L = 30 Downwind length of area source (ft)

= 9.1 Downwind length of area source (m)

PM-10 Exposure point concentration = 2.9E-05 g/m^3

28.81 $\mu g/m^3$

Soil Loading Resuspension Factor = 2.88E-05 ($\mu g/m^3$) / (mg/kg)

Table 4 - Ra/Sr Treatment System Areas - Resuspension Factors Resulting From Radionuclide-Contaminated Soil Remediation

Excavation PM-10 emissions model based upon Air/Superfund National Technical Guidance Series
Volume III - Estimation of Air Emissions from Cleanup Activities at Superfund Sites
(Assuming emission rate of PM-15 particulates for "dragline" in Table 24 of reference)

Excavation Volume =	37,665	ft^3	(1395 cu-yd)
=	1,066.5	m^3	
Moisture Content (M)=	10	wt. %	(model developed assuming range of 0.2 to 16.3%)
Drop Height (d) =	10	ft	(model developed assuming range of 5-100 ft)
=	3.05	m	(Low value for Dragline in Table 29 of reference)
Backhoe Excavation Emissions Factor (E_{15}) =	3.17E-03	kg/m^3	$E_{15} = 0.0029 \times d^{0.7} \times M^{-0.3}$
Excavation Time =	465	hours (30 Yd^3/10 hr-day)	
Backhoe Emission rate=	7.27	g/hr	
			PM-10 Inhalation Loading
Excavation area =	6,300	ft^2	(105' x 60')
=	585.3	m^2	
PM-10 Emission Rate =	1.24E-02	(g/m^2-hr)	= 3.45E-06 (g/m^2-sec)

Note:

1 = Assume only 1395 yd^3 of low-level radioactive soil and concrete will be excavated during the remediation.

Table 5 - Ra/Sr Treatment System Areas - Resuspension Factors Resulting From Radionuclide-Contaminated Soil Remediation

Storage pile particulate emissions model based upon Air/Superfund National Technical Guidance Series Volume III - Estimation of Air Emissions from Cleanup Activities at Superfund Sites (Assuming emission rate of Total Suspended Particulates for short-term (24hr) active storage piles in Table 21 of reference. Adjustment made for particulate size distribution less than 30 um from Table 25)

Storage pile area =	100	ft^2 (10' x 10' storage pile)	
=	9.3	m^2	
=	9.29E-04	hectare	
Uw =	1.86	Mean windspeed for 1995-1997 between May and August (m/s)	
Uv =	2.24	Vehicle speed assumed to be 5 mph (m/s)	
u=	4.09	Sum of Uw + Uv	
Storage Pile Emission factor =	7.37	kg/hectare/hr	$E_{TSP} = 1.8 \times u$
TSP Emission Rate =	6.84	g/hr	
PM-30 Emission Rate =	3.63	g/hr	$E_{30} = 1.8 \times u \times 0.53$
PM-30 Emission Rate =	3.90E-01	(g/m^2-hr) =	1.08E-04 (g/m^2-sec) PM-10 Inhalation Loading

Note:

1 = Assume soil will be temporarily stockpiled during excavation.

Table 6 - Ra/Sr Treatment System Areas - Resuspension Factors Resulting From Radionuclide-Contaminated Concrete Demolition

PM-10 emissions model based upon AP-42 Chapter 11, Section 11.19.2 Crushed Stone Processing.

Table 11.19.2-1: Emission Factors for Crushed Stone Processing

Storage pile volume =	0	ft^3	(0 cu-yd)
=	0.00	m^3	
Storage pile area =	0	ft^2	(0 stockpile)
=	0.0	m^2	
Soil Bulk Density =	1.7	g/cm^3	
Soil Mass =	0.0	Mg	
Fines Screening emission Factor =	3.60E-02	kg/Mg	
Screening Time =	0	hours (0 Yd^3/10 hr-day)	
Soil screening emission rate=	0.0	g/hr	PM-10 Inhalation Loading
PM-10 Emission Rate =	0.00E+00	(g/m^2-hr) =	0.00E+00 (g/m^2-sec)

Note:

1 = Assume no activity for crushed stone processing.

Table 7 - Ra/Sr Treatment System Areas - Resuspension Factors Resulting From Radionuclide-Contaminated Soil Remediation

PM-10 emissions model based upon AP-42 Chapter 13 - Aggregate Handling and Storage Piles

Equation 1 - Quantity of particulate emissions generated by drop operations.

Storage pile volume =	675	ft^3 (25 cu-yd)	
=	19.11	m^3	
Storage pile area =	100	ft^2 (1 stockpile)	
=	9.3	m^2	
Soil Bulk Density =	1.7	g/cm^3	(model developed assuming silt content range of 0.44 to 19%)
Soil Mass =	32.5	Mg	
PM-10 Particle Size Multiplier (k) =	0.35		
Moisture Content (M)=	5	wt. %	(model developed assuming range of 0.25 to 4.8%)
Mean annual windspeed (U) =	1.86	(m/s)	(model developed assuming range of 0.6- to 6.7 m/s)
Waste container loading emission Factor (E) =	1.25E-04	kg/Mg	
Loading Time =	8	hours (30 Yd^3/10 hr-day)	
Waste container loading emission rate=	5.06E-01	g/hr	
PM-10 Emission Rate =	5.44E-02	(g/m^2-hr) =	1.51E-05 (g/m^2-sec)

PM-10 Inhalation Loading

$$E = k(0.0016)\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}(kg/Mg)$$

Note:

Table 8 - Ra/Sr Treatment System Areas - Resuspension Factors Resulting From Radionuclide-Contaminated Tank Sludge

Excavation PM-10 emissions model based upon Air/Superfund National Technical Guidance Series
Volume III - Estimation of Air Emissions from Cleanup Activities at Superfund Sites
(Assuming emission rate of PM-15 particulates for "dragline" in Table 24 of reference)

Excavation Volume =	810	ft^3	(30 cu-yd)
=	22.9	m^3	
Moisture Content (M)=	50	wt. %	(model developed assuming range of 0.2 to 16.3%)
Drop Height (d) =	10	ft	(model developed assuming range of 5-100 ft)
=	3.05	m	(Low value for Dragline in Table 29 of reference)
Backhoe Excavation Emissions Factor (E_{15}) =	1.96E-03	kg/m^3	$E_{15} = 0.0029 \times d^{0.7} \times M^{-0.3}$
Excavation Time =	10	hours (30 Yd^3/10 hr-day)	
Backhoe Emission rate=	4.49	g/hr	
			PM-10 Inhalation Loading
Excavation area =	144	ft^2	(24' x 6')
=	13.4	m^2	
PM-10 Emission Rate =	3.35E-01	(g/m^2-hr)	= 9.32E-05 (g/m^2-sec)

Note:

1 = Assume only 30 yd^3 of low-level radioactive sludge will be excavated during the remediation.

Table 9 - Ra/Sr Treatment System Areas - Resuspension Factors Resulting From Radionuclide-Contaminated Sludge Removal

Box model assuming emission rates estimated on "Excavation", "Storage" and "Loading" spreadsheets, and ASTM RBCA 1996 box model, adjusted for site specific data.

Excavation Emission Rate =	3.35E-01	(g/m^2-hr)	=	9.32E-05	(g/m^2-sec)
Storage pile Emission Rate =		(g/m^2-hr)	=	0.00E+00	(g/m^2-sec)
Loading Emission Rate =		(g/m^2-hr)	=	0.00E+00	(g/m^2-sec)
Total PM-10 Emission Rate =	3.35E-01	(g/m^2-hr)	=	9.32E-05	(g/m^2-sec)

Uw =	3	95% UCL of mean annual windspeed at 7 m (m/s)
Hb =	1.6	Height of breathing zone (m)

Excavation Modeling Result

L =	30	Downwind length of area source (ft)
=	9.1	Downwind length of area source (m)
PM-10 Exposure point concentration =	1.8E-04	g/m^3
	177.52	$\mu g/m^3$
Excavation Resuspension Factor =	1.78E-04	(ug/m^3) / (mg/kg)

Onsite Excavation Storage Piles Modeling Result

L =	30	Downwind length of area source (ft)
=	9.1	Downwind length of area source (m)
PM-10 Exposure point concentration =	0.0E+00	g/m^3
	0.00	$\mu g/m^3$
Storage Pile Resuspension Factor =	0.00E+00	($\mu g/m^3$) / (mg/kg)

Excavated Soil Loading Modeling Result

L =	30	Downwind length of area source (ft)
=	9.1	Downwind length of area source (m)
PM-10 Exposure point concentration =	0.0E+00	g/m^3
	0.00	$\mu g/m^3$
Soil Loading Resuspension Factor =	0.00E+00	($\mu g/m^3$) / (mg/kg)

Ra/Sr Treatment System Areas - PM-10 Emission Rate

Excavation PM-10 emissions (EX-10) model based on Air/Superfund National Technical Guidance Series
Fugitive dust PM-10 emissions (E10) from exposed Ra/Sr Area II excavation based on Cowherd

A_{rasr} =	585.3	m^2	
EX-10=	1.24E-02	g/m^2-hr	Excavation
EX-10=	3.89E-01	g/m^2-hr	Stockpile
EX-10=	5.44E-02	g/m^2-hr	Loading
E_{10}=	1.21E-05	g/m^2-hr	

Contaminant of Concern	Concentration [pCi/g]	E_{area} (EX-10) [Ci/yr]	E_{area} (E10) [Ci/yr]		# hrs
Radium-226	12.9	4.35E-08		Excavation	465
Radium-226	12.9	2.19E-08		Stockpile	470
Radium-226	12.9	3.07E-09		Loading	470
Radium-226	Total	6.85E-08	1.37E-12		
Strontium-90	0.9	3.04E-09		Excavation	465
Strontium-90	0.9	1.53E-09		Stockpile	470
Strontium-90	0.9	2.14E-10		Loading	470
Strontium-90	0.9	8.35E-07			
		8.40E-07	9.54E-14		

Ra/Sr Treatment System Areas - PM-10 Emission Rate

Excavation PM-10 emissions (EX-10) model based on Air/Superfund National Technical Guidance Series

A_{rasr} =	92	m^2	
EX-10=	4.88E-02	g/m^2-hr	Excavation

Strontium-90	18600	8.35E-07		Excavation	10
		8.35E-07			

Only three samples were taken in 1997, this is the maximum concentration

LEHR-S-384	1.61	WDP	EDP
LEHR-S-385	0.76	1.50E-04	1.10E-06
LEHR-S-386	0.86	8.80E-06	2.20E-07
LEHR-S-389	0.59	8.30E-06	8.50E-08
LEHR-S-390	0.45	9.50E-06	1.40E-07
LEHR-S-407	0.91	5.30E-05	7.10E-07
LEHR-S-409	0.59	1.50E-04	9.60E-07
LEHR-S-410	0.65	5.30E-05	1.40E-07
LEHR-S-412	0.47	6.80E-05	8.00E-07
LEHR-S-397	0.78	5.01E-04	4.16E-06
LEHR-S-396	0.6		
LEHR-S-399	0.63		

n= 12
Mean(conc)= 0.741667
Std Dev(conc)= 0.308068
Z 1.782
95% UCL (pCi/g)= 0.900143

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Version 1.00

Clean Air Act Assessment Package - 1988

D O S E A N D R I S K E Q U I V A L E N T S U M M A R I E S

Non-Radon Individual Assessment
Jul 11, 2000 10:58 am

Facility: LEHR
Address: Old Davis Road
MS ITEH
City: Davis
State: CA Zip: 95616

Source Category: Non-point source
Source Type: Area
Emission Year: 2000

Comments:

Dataset Name: Ra/SR II
Dataset Date: Jul 11, 2000 10:57 am
Wind File: WNDFILES\SAC0320.WND

ORGAN DOSE EQUIVALENT SUMMARY

Organ	Selected Individual (mrem/y)
GONADS	3.42E-03
BREAST	3.43E-03
R MAR	1.61E-01

	D.sum
LUNGS	4.85E-02
THYROID	3.41E-03
ENDOST	4.72E-01
RMNDR	7.23E-03
EFFEC	4.29E-02

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY

Pathway	Selected Individual (mrem/y)
INGESTION	3.41E-02
INHALATION	8.70E-03
AIR IMMERSION	3.11E-09
GROUND SURFACE	8.35E-05
INTERNAL	4.28E-02
EXTERNAL	8.35E-05
TOTAL	4.29E-02

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY

Nuclide	Selected Individual (mrem/y)
RA-226	1.32E-02
SR-90	2.97E-02
TOTAL	4.29E-02

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk
LEUKEMIA	4.28E-07
BONE	5.41E-08
THYROID	9.43E-10

	D.sum
BREAST	8.04E-09
LUNG	1.52E-07
STOMACH	5.26E-09
BOWEL	1.48E-08
LIVER	7.11E-09
PANCREAS	4.89E-09
URINARY	2.59E-09
OTHER	5.98E-09
TOTAL	6.83E-07

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk
INGESTION	4.98E-07
INHALATION	1.83E-07
AIR IMMERSION	7.28E-14
GROUND SURFACE	1.95E-09
INTERNAL	6.81E-07
EXTERNAL	1.95E-09
TOTAL	6.83E-07

NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk
RA-226	1.83E-07
SR-90	5.00E-07
TOTAL	6.83E-07

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

	Distance (m)						
Direction	1	3	5	7	9	11	20

D.sum

N	6.8E-07	6.8E-07	6.8E-07	6.6E-07	5.8E-07	5.0E-07	2.1E-07
NNW	6.8E-07	6.8E-07	6.8E-07	6.5E-07	5.8E-07	5.2E-07	2.2E-07
NW	6.8E-07	6.8E-07	6.8E-07	6.7E-07	5.7E-07	5.0E-07	2.1E-07
WNW	6.8E-07	6.8E-07	6.8E-07	6.8E-07	5.4E-07	4.3E-07	1.9E-07
W	6.8E-07	6.8E-07	6.8E-07	6.7E-07	5.1E-07	3.6E-07	1.6E-07
WSW	6.8E-07	6.8E-07	6.8E-07	6.7E-07	4.6E-07	3.1E-07	1.3E-07
SW	6.8E-07	6.8E-07	6.8E-07	6.5E-07	4.2E-07	2.7E-07	1.2E-07
SSW	6.8E-07	6.8E-07	6.8E-07	6.4E-07	3.5E-07	2.5E-07	1.2E-07
S	6.8E-07	6.8E-07	6.8E-07	6.2E-07	3.1E-07	2.4E-07	1.4E-07
SSE	6.8E-07	6.8E-07	6.8E-07	6.4E-07	2.9E-07	2.4E-07	1.5E-07
SE	6.8E-07	6.8E-07	6.8E-07	6.3E-07	3.2E-07	2.5E-07	1.4E-07
ESE	6.8E-07	6.8E-07	6.8E-07	6.4E-07	3.7E-07	2.7E-07	1.2E-07
E	6.8E-07	6.8E-07	6.8E-07	6.6E-07	4.5E-07	2.8E-07	1.2E-07
ENE	6.8E-07	6.8E-07	6.8E-07	6.8E-07	4.9E-07	3.3E-07	1.4E-07
NE	6.8E-07	6.8E-07	6.8E-07	6.8E-07	5.2E-07	3.9E-07	1.6E-07
NNE	6.8E-07	6.8E-07	6.8E-07	6.8E-07	5.5E-07	4.5E-07	2.0E-07

Distance (m)

Direction	30	40	50	100	200	300
N	1.5E-07	1.3E-07	1.2E-07	1.0E-07	9.6E-08	9.5E-08
NNW	1.5E-07	1.3E-07	1.1E-07	9.9E-08	9.5E-08	9.5E-08
NW	1.5E-07	1.3E-07	1.2E-07	1.0E-07	9.6E-08	9.5E-08
WNW	1.4E-07	1.2E-07	1.1E-07	9.9E-08	9.5E-08	9.4E-08
W	1.3E-07	1.1E-07	1.1E-07	9.7E-08	9.5E-08	9.4E-08
WSW	1.1E-07	1.0E-07	1.0E-07	9.5E-08	9.4E-08	9.4E-08
SW	1.0E-07	1.0E-07	9.7E-08	9.5E-08	9.4E-08	9.4E-08
SSW	1.1E-07	1.0E-07	9.8E-08	9.5E-08	9.4E-08	9.4E-08
S	1.2E-07	1.1E-07	1.0E-07	9.6E-08	9.5E-08	9.4E-08
SSE	1.2E-07	1.1E-07	1.1E-07	9.7E-08	9.5E-08	9.4E-08
SE	1.1E-07	1.1E-07	1.0E-07	9.6E-08	9.4E-08	9.4E-08
ESE	1.1E-07	1.0E-07	9.8E-08	9.5E-08	9.4E-08	9.4E-08
E	1.1E-07	1.0E-07	9.9E-08	9.5E-08	9.4E-08	9.4E-08
ENE	1.1E-07	1.0E-07	1.0E-07	9.5E-08	9.4E-08	9.4E-08
NE	1.3E-07	1.1E-07	1.1E-07	9.8E-08	9.5E-08	9.4E-08
NNE	1.4E-07	1.2E-07	1.1E-07	9.8E-08	9.5E-08	9.4E-08