PNNL-10855, Rev. 2

Pacific Northwest
National Laboratory
Operated by Battelle for the
U.S. Department of Energy

Assessment of Unabated Facility Emission Potentials for Evaluating Airborne Radionuclide Monitoring Requirements at Pacific Northwest National Laboratory - 2001

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Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RL01830

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Abstract

Assessments were performed to evaluate compliance with the airborne radionuclide emission monitoring requirements in the National Emission Standards for Hazardous Air Pollutants (NESHAP – U.S. Code of Federal Regulations, Title 40, Part 61, Subpart H) and Washington Administrative Code (WAC) 246-247: Radiation Protection – Air Emissions. In these assessments, potential unabated offsite doses were evaluated for emission locations at facilities owned by the U.S. Department of Energy and operated by Pacific Northwest National Laboratory (PNNL) on the Hanford Site. This report describes the inventory-based methods, and provides the results, for the assessment performed in 2001.

Summary

Assessments were performed to evaluate compliance with the airborne radionuclide emission monitoring requirements in the National Emission Standards for Hazardous Air Pollutants (NESHAP - U.S. Code of Federal Regulations, Title 40 Part 61, Subpart H). In these assessments, potential unabated offsite doses were evaluated for emission locations at facilities owned by the U.S. Department of Energy and operated by Pacific Northwest National Laboratory (PNNL) on the Hanford Site. One of the facilities evaluated, the 325 Building Radiochemical Processing Laboratory, met state and federal criteria for continuous sampling of airborne radionuclide emissions. Two other buildings, the 331 Building Life Sciences Laboratory and the 3720 Environmental Sciences Laboratory, were recognized as having missions with the potential for meeting the continuous sampling criteria.

The assessments were performed using building radionuclide inventory data obtained in 2001. The list of buildings that were evaluated is provided in Table S.1.

Table S.1. PNNL-Operated DOE Buildings with Radioactive Inventories in 2001

200E Environmental Monitoring Shed
305-B Hazardous Waste Storage Facility
306-W Materials Development Building
314 Engineering Development Laboratory
318 Radiological Calibrations Laboratory
320 Analytical and Nuclear Research Laboratory
323 Mechanical Properties Laboratory
325 Radiochemical Processing Laboratory
326 Materials Sciences Laboratory
329 Chemical Sciences Laboratory
331 Life Sciences Laboratory I
331-H Aerosol Wind Tunnel Research Facility
337 Technical Management Center
747A Whole Body Counter
3020 Environmental Molecular Sciences Laboratory
3720 Environmental Sciences Laboratory
3730 Gamma Irradiation Facility

Glossary

AMD	Aerodynamic Mean Diameter
AMSI	American National Standards Institute
CAP88PC	Clean Air Act Assessment Package -1988 for Personal Computers
CFR	Code of Federal Regulations
DOE	Department of Energy
DOE-RL	DOE-Richland Operations
DOT	Department of Transportation
EH	Environment, Safety and Health
EM	Effluent Management
EMSL	Environmental Molecular Sciences Laboratory
EPA	Environmental Protection Agency
FEMP	Facility Effluent Monitoring Plan
FH	Fluor Hanford
MBA	Material Balance Area
MPR	Maximum Public Receptor
NESHAP	National Emission Standards for Hazardous Air Pollutants
NW	Northwest
PNNL	Pacific Northwest National Laboratory
PTE	Potential-to-Emit
TEDE	Total Effective Dose Equivalent
WAC	Washington Administrative Code

Contents

Tables

1.0 Introduction

Requirements for sampling airborne radionuclide emissions are contained in the following regulations and guides:

- U.S. Code of Federal Regulations (CFR), Title 40, Subpart H: National Emission Standards for Hazardous Air Pollutants (NESHAP) (1989)
- Washington Administrative Code (WAC) 246-247: Radiation Protection - Air Emissions (1994)
- U.S. Department of Energy, DOE 5400.1: General Environmental Protection Program (1990)
- U.S. Department of Energy, DOE/EH-0173T, Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance (January 1991).

These documents require the performance of continuous sampling at emission points that have the potential to cause an offsite dose of 0.1 mrem/yr, if routine emissions were not mitigated by engineered pollution control systems. In addition, DOE 5400.1 specifies that a written plan be prepared for each facility that uses, generates, releases, or manages significant pollutants or hazardous materials. Thus, a Facility Effluent Monitoring Plan (FEMP) is prepared for facilities that require continuous sampling according to NESHAP.

In response to these requirements, the potential unmitigated offsite receptor dose from the facilities, operated for the U.S. Department of Energy (DOE) by Pacific Northwest National Laboratory[1] and containing radioactive materials or sources, is evaluated annually. These evaluations were performed initially in 1991 for the PNNL facilities on the Hanford Site. Based on the initial assessments, four PNNL buildings were identified as containing a sufficient inventory of radioactive material that unmitigated emissions could potentially result in an annual offsite maximum receptor dose of 0.1 mrem. These buildings were the 324 Waste Technology Engineering Laboratory, the 325 Applied Chemistry Laboratory, the 327 Postirradiation Testing Laboratory, and the 3720 Chemistry and Material Sciences Laboratory. In accordance with the NESHAP, qualifying emission points from these buildings were sampled continuously. Also, in accordance with DOE 5400.1, a FEMP was prepared for each of these buildings[2].

The original radionuclide assessments were updated annually. No changes were made in the facility emission NESHAP status until 1996 when the 324 and 327 Buildings were transitioned to other Hanford Site contractors. In 1997, proposed movement of the radionuclide inventory from the 3720 Building to the 331 Building upgraded the 331 Building to major stack status.

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[1] Operated by Battelle for the U.S. Department of Energy under Contract DE-AC0676RL01830.

[2] The FEMP have been updated over the years and are currently available for the 325, 331, 3720, and Balance-of-Plant Facilities (Pacific Northwest National Laboratory, 1999a, 1999b, 2001a, 2001b).

The move was accomplished in 1998 and 1999 with disposal of some materials resulting in the 3720 and the 331 Buildings Potential-To-Emit (PTE)[1] dropping to less than 0.1 mrem. The major stack for 3720 may be downgraded to minor in the future, depending on expected work activities, but continued work in the 331 Building may result in increased throughput. Thus, the 331 Building main stack is maintained as a major stack and continuously sampled. Results of the 1992-1993 assessment were documented by Sula and Jette (1994) with updates in 1995 and 1999. This report documents the most recent methods and assessments for 2001.

[1] Potential-to-Emit is defined as the rate of release of radionuclides from an emission unit based on the actual or potential discharge of the effluent stream that would result if all abatement control equipment did not exist, but operations are otherwise normal.

2.0 Assessment Methodology

Requirements for facility air emission sampling are promulgated by:

- U.S. Environmental Protection Agency (EPA) in 40 CFR 61, "National Emissions Standards for Hazardous Air Pollutants," Subpart H, "National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities"
- Washington State Department of Health in Washington Administrative Code 246-247, "Regulation of Radioactive Air Emissions"
- DOE in regulatory guide DOE/EH-0173T, "Environmental Regulatory Guide for Radiological Monitoring and Environmental Surveillance."

These regulations require evaluation of all emission units with the potential to emit radioactivity and that emission units be continuously sampled, if the potential exists for unmitigated releases to cause a dose of 0.1 mrem/yr to a maximum offsite receptor.

2.1 Projections of Annual Emission Quantities

Several methods for projecting potential unmitigated annual emission quantities are prescribed in the 1994 issuance of WAC 246-247:

- apply an annual release fraction to the radionuclide inventory in the facility
- multiply actual measured annual emissions by control system decontamination factors
- add actual measured annual emission quantities to actual measured quantities retained by control systems
- measure the annual discharge upstream from all control devices.

The inventory-based assessment method[1] has been used by PNNL since the initial facility assessment in 1991. Whereas the inventory method yields an assessment based on the current building status (or even the future status if projected future inventory quantities are used in the assessment), the other prescribed methods yield an assessment based on past facility measurements. Thus, the inventory method may be more appropriate for use at research and development facilities where types and quantities of radionuclides may change from year-to-year

[1] This method is described in WAC 246-247 as follows: Multiply the annual possession quantity of each radionuclide by the release fraction for that radionuclide, depending on its physical state. Use the following release fractions: (i) 1 for gases, (ii) 10^{-3} for liquids or particulate solids, and (iii) 10^{-6} for solids. Determine the physical state for each radionuclide by considering its chemical form and the highest temperature to which it is subjected. Use a release fraction of 1 if the radionuclide is subjected to temperatures at or above its boiling point; use a release fraction of 10^{-3} if the radionuclide is subjected to temperatures at or above its melting point but below its boiling point. If the chemical form is not known, use a release fraction of 1 for any radionuclide that is heated to a temperature of one hundred degrees Celsius or more, boils at a temperature of one hundred degrees Celsius or less, or is intentionally dispersed into the environment.

and where historical sampling data may not be a reliable predictor of future emissions.

At PNNL, radioactive source and material information is maintained using three separate inventory systems, as follows:

Nuclear Materials Inventory. This inventory includes most of the tritium, uranium, and transuranics in PNNL facilities. The inventory includes material in process, as well as residual contamination from historical operations in the facility. The Nuclear Materials Inventory is categorized as *Type 3 inventory*.

Composite Radioactive Materials Inventory. This inventory includes DOE-owned sealed radioactive sources above specific *de minimus* values or those values that need to be considered (based on the December 1998 revision to 10 CFR 835) and all radioactive material that is possessed by PNNL under a State of Washington Radioactive Materials License. Most of the radionuclides in this inventory are in *sealed source* form. The Composite Radioactive Materials Inventory is categorized as *Type 2 inventory*.

Facilities Management Radioactive Materials Inventory. This database was developed specifically to account for all radioactive material not included in either the Type 2 or Type 3 inventories. This category consists primarily of fission product radionuclides, including radionuclides in process, as well as residual contamination (for example, that in hot cells) from historical operations in the facility. The Facilities Management Radioactive Material Inventory is categorized as *Type 1 inventory*.

The PNNL Effluent Management Group annually requests Type 1 inventory information from the custodians of the radioactive inventory. This request is made through a central point of contact for each of the PNNL divisions that then request inventory information from custodians in their organization. The Effluent Management Group also requests Type 2 and Type 3 inventories from the custodians of the Composite Radioactive Materials Inventory and Nuclear Materials Inventory databases, respectively.

Although the type of information contained in each of the systems varies, after compiling the information and reformatting it, radioactive materials are identified by type, physical form, and quantity. Quantities are expressed either in terms of activity (Ci) or mass (grams). Radioactive material types may be expressed as specific radionuclides or as standard mixtures of radionuclides. For example, mixed radionuclides may be expressed as natural uranium, depleted uranium, or 6%(^{240}Pu) plutonium, as shown in Table 1. Appendix A provides the basis for these values. Individual radionuclides or mixtures of radionuclides in small quantities may also be reported as *alpha* or *beta activity* for simplification. These materials are assumed to be ^{241}Am (alpha) or ^{137}Cs (beta) for dose assessment purposes.

Table 1. Common Radionuclide Mixtures

Material	Unit Dose Value, mrem/Ci	Specific Activity (Ci/g)
Depleted Uranium	513 (^{238}U)	3.64E-07
Natural Uranium	513 (^{238}U)	6.93E-07
Hanford Uranium	513 (^{238}U)	8.99E-7
U-enriched (<20% ^{235}U)	550 (^{235}U)	9.34E-06
U-enriched (<90% ^{235}U)	550 (^{235}U)	6.21E-05
Pu (6% ^{240}Pu)	640	0.26
Pu (12% ^{240}Pu)	427	0.79
Pu (24% ^{240}Pu)	393	3.46

Radionuclides meeting any of the following criteria are excluded from the assessments:

- radionuclides present in commercially available building/construction materials
- radionuclides that can be purchased or possessed without a special radioactive materials license
- radionuclides <100 pCi/g alpha activity and <400 pCi/g beta activity.

Inventory data is entered into an ACCESS database that was developed specifically for these calculations. Appendix B provides a summary of the database features. The data are reviewed and revised, as needed, to eliminate duplicates, provide consistency in nuclide and unit identifications, and obtain additional information as required by the calculations. The review process is documented and filed with the assessment records.

Potential release fractions for radionuclides are based on the physical form of the radionuclide as shown in Table 2. Radionuclides present as sealed sources or in sealed, unvented Department of Transportation (DOT) shipping containers are assumed to be unavailable for release under normal circumstances.

Table 2. Physical Forms and Potential Annual Release Fractions for Radionuclides

Form	Code	Description	Potential Release Fraction
Gas	G	Nuclide will exceed its boiling point when uncontained, except that nuclides in gaseous form in commercial gas cylinders that are not opened may be listed as L.	1
Liquid/Powder	L/P	Nuclide will exceed its melting point or be present in particulate form (Aerodynamic Mean Diameter [AMD] <100 microns) when uncontained, except liquid and powders in unopened containers may be listed as S.	10^{-3}
Solid	S	Nuclides not meeting conditions for the more dispersible classes.	10^{-6}
Contained	C	Sealed sources or material in sealed, DOT containers, except those meeting exempt criteria.	0
Exempt	E	Sealed sources engineered to pass the special form testing specified by the DOT in 40CFR173.469 or ANSI[(a)] N43.6, or sealed in Type B DOT shipping containers.	0

(a) American National Standards Institute

2.2 Maximum Receptor Unit Dose Calculation

For the unit dose calculations, the maximum offsite receptor is defined as an individual whose residence location, work location, and lifestyle maximize the dose from airborne pathways. In previous years, this maximum offsite receptor was considered to be a resident living at the nearest location across the Columbia River from the 300 Area. However, with the leasing of facilities in the 300 Area to private companies, the maximum offsite receptor is now considered an onsite worker. All potential environmental transport pathways associated with an airborne radionuclide release were included (that is, air inhalation, air submersion, exposure to deposited radionuclides, uptake of vegetation grown in contaminated soil). The onsite worker is conservatively assumed as continuously exposed (8766 hours per year). In addition, site-specific atmospheric dispersion and environmental transport and uptake parameters were used (see Appendix C).

Unit dose factors for the maximum offsite receptor were calculated for specific radionuclides using the EPA compliance code CAP88-PC (Parks 1992). Radionuclides that were not

represented in CAP88-PC were conservatively assigned default values equal to that of ^{241}Am for alpha emitters or ^{137}Cs for non-alpha emitters. The decay of the daughter products was also considered in assigning default values for short half-life radionuclides. The unit dose factor calculations were performed for a single source point in the 300 Area of the Hanford Site (Table 3).

For Building 331 and the Environmental Molecular Sciences Laboratory (EMSL), dose assessments were performed by applying a *location correction factor* to the 300 Area unit dose factor to correct for varying source-receptor distances and directions. The location correction factor was calculated by dividing the atmospheric dispersion values (Chi/Q) for these buildings by the atmospheric dispersion values for the 300 Area. The code CAP88-PC was used to calculate these dispersion values. Similar calculations were performed to obtain location correction factors for other PNNL-operated DOE facilities outside the 300 Area.

2.3 Potential Emission Dose Assessment

Doses from projected radionuclide emissions were calculated by multiplying the quantity of each radionuclide present in the facility by its associated potential release fraction, the 300 Area unit dose factor (see Appendix C), and the location correction factor. Doses from individual radionuclides were summed to derive the total potential annual emission dose for each facility.

The assessments were independently reviewed, then packets were prepared for each building containing the raw inventory information, any communications clarifying or correcting the inventory information, summarized inventory information, and a cover sheet showing the resulting dose and approval signatures. The packets were approved by the preparer, the reviewer, the divisional points of contact for the inventory custodians, and the building managers. After approval, assessment packets are maintained as records by the Effluent Management Group. A summary of the assessment results for 2001 and the primary contributing radionuclides for facilities that require continuous monitoring is provided in Table 4. The table also identifies the radionuclides that contribute 10% or more of the potential dose for facilities where continuous sampling is required.

Table 3. Unit Dose Factors for 300 Area Source Locations

Radionuclide	Total Effective Dose Equivalent (100 m NW)	Radionuclide	Total Effective Dose Equivalent (100 m NW)	Radionuclide	Total Effective Dose Equivalent (100 m NW)
H-3	5.89E-04	*SR-90*	9.80E-01	SB-125	5.11E+00
BE-7	3.50E-02	SR-90+D (b)	9.80E-01	SB-126	4.87E-01
C-11	2.84E-03	SR-91	9.92E-03	SB-126M	4.46E-03
C-14	4.94E-04	SR-92	8.13E-03	SB-127	6.18E-02
C-15 (a)	0.00E+00	Y-90	4.11E-02	TE-125M	4.72E-02
N-13	2.63E-03	Y-90M	2.71E-03	TE-127	1.91E-03
O-15	2.06E-03	Y-91	2.17E-01	TE-127M	1.04E-01
F-18	3.87E-03	Y-91M	1.76E-03	TE-129	7.64E-04
NA-22	2.27E+01	Y-92	6.44E-03	TE-129M	1.20E-01
NA-24	4.50E-02	Y-93	1.31E-02	TE-131	1.69E-03

Radionuclide	Total Effective Dose Equivalent (100 m NW)	Radionuclide	Total Effective Dose Equivalent (100 m NW)	Radionuclide	Total Effective Dose Equivalent (100 m NW)
P-32	2.68E-02	ZR-93	2.10E-01	TE-131M	4.62E-02
S-35	1.36E-03	*ZR-95*	6.46E-01	TE-132	4.55E-02
AR-41	3.40E-03	ZR-95+D	1.26E+00	TE-133	2.44E-03
K-40	1.35E+01	NB-93M	1.73E-01	TE-133M	6.92E-03
CA-41	2.03E-03	NB-94	1.57E+02	TE-134	2.55E-03
SC-46	2.11E+00	NB-95	3.60E-01	I-122	2.64E-03
CR-51	1.30E-02	NB-95M	1.40E-02	I-123	2.32E-02
MN-54	3.18E+00	NB-97	2.77E-03	I-125	4.20E-01
MN-56	9.17E-03	NB-97M	1.19E-03	I-129	3.83E+01
FE-55	8.37E-03	MO-93	5.61E-01	I-130	2.61E-01
FE-59	6.55E-01	*MO-99*	2.49E-02	I-131	8.46E-01
CO-57	4.93E-01	MO-99+D (b)	2.98E-02	I-132	5.54E-02
CO-58	9.00E-01	TC-99M	5.88E-03	I-133	1.43E-01
CO-60	4.75E+01	TC-97	6.26E-01	I-134	2.78E-02
NI-59	4.50E-02	TC-99	4.06E-02	I-135	9.70E-02
NI-63	1.00E-02	TC-101	8.85E-04	XE-122	1.74E-04
NI-65	3.67E-03	RU-97	1.15E-02	XE-123	1.63E-03
CU-64	3.32E-03	*RU-103*	2.80E-01	XE-125	6.39E-04
ZN-65	1.70E+00	RU-103+D (b)	2.80E-01	XE-127	6.71E-04
ZN-69	2.98E-04	RU-105	6.72E-03	XE-131M	2.45E-05
ZN-69M	8.64E-03	*RU-106*	2.09E+00	XE-133	9.00E-05
GA-67	9.45E-03	RU-106+D (b)	3.00E+00	XE-133M	7.85E-05
AS-76	2.67E-02	RH-105	6.48E-03	XE-135	6.37E-04
BR-82	5.91E-02	RH-105M	4.01E-05	XE-135M	1.06E-03
BR-83	2.84E-05	RH-106	2.22E-04	XE-137	4.34E-04
BR-84	5.57E-03	PD-107	5.55E-02	XE-138	3.10E-03
BR-85	1.50E-04	PD-109	7.19E-03	CS-134	1.39E+01
KR-83M	6.08E-07	AG-109M	5.98E-06	CS-134M	2.97E-04
KR-85	8.59E-06	AG-110	3.01E-05	CS-135	2.10E-02
KR-85M	4.11E-04	AG-110M	8.40E+00	CS-136	3.82E-01
KR-87	2.28E-03	AG-111	3.13E-02	*CS-137*	1.39E-01
KR-88	5.80E-03	CD-115	2.67E-02	CS-137+D (b)	4.24E+01
KR-89	4.43E-03	CD-115M	2.02E-01	CS-138	7.54E-03
KR-90 (a)	1.48E-03	IN-113M	1.12E-03	CS-139	8.28E-04
RB-86	5.69E-02	IN-115	4.48E+00	BA-133	1.48E+01
RB-87	3.37E-02	IN-115M	1.57E-03	BA-133M	4.32E-03
RB-88	2.36E-03	SN-113	7.03E-02	BA-137M	1.29E-03
RB-89	6.11E-03	SN-123	1.03E-02	BA-139	9.71E-04
RB-90	5.44E-03	SN-125	1.06E-01	BA-140	4.95E-02
RB-90M	8.53E-03	SN-126	6.28E+00	BA-140+D (b)	3.81E-01
SR-89	2.87E-02	SB-124	1.41E+00	BA-141	2.40E-03
BA-142	2.34E-03	PB-211	4.18E-02	U-233	5.84E+02
LA-140	7.39E-02	PB-212	7.45E-01	U-234	5.77E+02
LA-141	1.90E-04	PB-214	4.79E-03	U-235	5.50E+02
LA-142	1.00E-02	BI-210	8.56E-01	U-236	5.46E+02
CE-141	7.43E-02	BI-211	3.90E-03	U-237	2.98E-02
CE-143	2.17E-02	BI-212	1.5E-01	U-238	5.13E+02
CE-144	1.71E+00	BI-213	5.86E-03	U-240	1.10E-02

Radionuclide	Total Effective Dose Equivalent (100 m NW)	Radionuclide	Total Effective Dose Equivalent (100 m NW)	Radionuclide	Total Effective Dose Equivalent (100 m NW)
CE-144+D (b)	1.81E+00	BI-214	6.02E-03	NP-237	2.14E+03
PR-143	3.70E-02	PO-210	3.80E+01	NP-238	1.56E-01
PR-144	4.39E-04	PO-212 (a)	0.00E+00	NP-239	1.77E-02
PR-144M	1.57E-04	PO-213 (a)	0.00E+00	NP-240	4.23E-03
ND-147	5.06E-02	PO-214 (a)	0.00E+00	NP-240M	9.05E-04
PM-147	1.70E-01	PO-215 (a)	0.00E+00	PU-236	3.85E+02
PM-148	8.81E-02	PO-216 (a)	0.00E+00	PU-238	1.39E+03
PM-148M	1.26E+00	PO-218	1.99E-04	PU-239	1.49E+03
PM-149	1.48E-02	AT-217	0.00E+00	PU-240	1.49E+03
PM-151	6.00E-03	RN-219 (c)	1.09E-01	*PU-241*	2.27E+01
SM-147	3.28E+02	RN-220 (c)	1.04E-03	PU-241+D (b)	2.28E+01
SM-151	1.32E-01	RN-222	1.10E-02	PU-242	1.42E+03
SM-153	1.15E-02	FR-221	1.77E-02	PU-243	1.15E-03
EU-152	4.82E+01	FR-223	1.19E-02	PU-244	1.41E+03
EU-152M	2.32E-03	RA-223	3.64E+01	AM-241	2.37E+03
EU-154	3.89E+01	RA-224	1.55E+01	AM-242	2.64E-01
EU-155	1.53E+00	RA-225	1.84E+01	AM-242M	2.28E+03
EU-156	3.01E-01	RA-226	3.96E+01	AM-243	2.37E+03
TB-160	1.04E+00	RA-228	1.07E+01	CM-242	7.83E+01
HO-166	1.66E-02	AC-225	2.68E+01	CM-243	1.59E+03
HO-166M	1.59E+02	AC-227	2.80E+03	CM-244	1.25E+03
HF-181	3.55E-01	AC-228	3.84E-01	CM-245	2.45E+03
W-181	6.69E-02	TH-227	5.16E+01	CM-246	2.42E+03
W-185	3.48E-03	TH-228	1.11E+03	CM-247	2.25E+03
W-187	1.01E-02	TH-229	3.09E+03	CM-248	8.91E+03
RE-187	2.42E-04	TH-230	1.10E+03	CF-252	6.76E+02
IR-192	9.04E-01	TH-231	4.56E-03		
HG-203	1.66E-01	TH-232	1.58E+03		
TL-207	3.85E-05	TH-232 +D (b)	1.83E+03		
TL-208	8.64E-03	TH-234	1.60E-01		
TL-209	4.53E-03	PA-231	2.12E+03		
PB-209	4.47E-04	PA-233	1.20E-01		
PB-210	6.08E+01	PA-234	1.67E-02		
PB-210+D (b)	6.08E+01	PA-234M	3.09E-05		
PO-210	5.72E-04	U-232	2.10E+03		

(a) Very short-lived radionuclide. Dose is zero for onsite public worker.
(b) *+D* designation indicates the doses from grown-in progeny are included in the reported dose.
(c) Short-lived Rn isotopes were modeled based on the dose from their longer-lived progeny. For each Ci of Rn-219 released, 0.0018 Ci of Pb-210 is generated. Each Ci of Rn-220 produces 0.0014 Ci of Pb-212. Dose is based on the Pb progeny times the appropriate equilibrium factor (Hill and Rittman 1999).

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Table 4. Emission System Potential Dose Assessment Summary

Emission System	Emission Type[1]	System Description	Emission Measurement Required	Nuclides Contributing > 10% of Potential Dose	Comment
Systems Located in the Southeast Region (300 Area) of the Hanford Site					
305-B	Fugitive + Point	Hazardous Waste Storage Facility	Confirmatory	Cs-137	
306-W	Point	Materials Development Building	Confirmatory	U(20%)	
314	Fugitive + Point	Engineering Development Laboratory	None	U(natural)	Bldg vacated (Inventory based on holdup)
318	Point	Radiological Calibrations Laboratory	None	Eu-154, H-3	Primarily sealed sources
320	Point	Analytical and Nuclear Research Laboratory	Confirmatory	U-233	
323	Point	Mechanical Properties Laboratory	Confirmatory	Co-60, V-49	
325	Point	Radiochemical Processing Laboratory	Continuous	Am-241, Pu-238, Pu-239	
326	Point	Materials Sciences Laboratory	Confirmatory	U(natural), U(90%)	
329	Point	Chemical Sciences Laboratory	Confirmatory	Am-241	
331	Point	Life Sciences Laboratory I	Continuous (Based on mission)	Np-237, Pu-239, Pu-240	
331H	Point	Aerosol Wind Tunnel Research Facility	None	None	Sealed Sources Only
337	Fugitive	Technical Management Center	None	None	Sealed Sources (for Training Purposes Only)
3720	Point	Environmental Sciences Laboratory	Continuous (Based on mission)	Cs-137, Pu-239	
3730	Point	Gamma Irradiation Facility	Confirmatory	Co-60, V-49	
3020 EMSL	Point	Environmental Molecular Sciences Laboratory	None	Cm-248	Primarily Sealed Sources

Table 4. (contd)

Systems Located in the Central Region (200 Areas) of the Hanford Site					
200E	Fugitive	Environmental Monitoring Shed	None	None	Sealed Sources Only
Systems Located in Richland					
747A	Fugitive	Whole Body Counter	None	None	Primarily Sealed Sources

[a] *Fugitive emissions* are radioactive air emissions that do not and could not reasonably pass through a stack, vent, or other functionally equivalent structure, and that are not feasible to directly measure and quantify (WAC 1994).

3.0 References

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Appendix A

Common Radionuclide Mixtures

The reference for Pu and U mixes isotope weight percent in the following tables is: Sula, M.J., E.H. Carbaugh, and D.E. Bihl. 1991. Technical Basis for Internal Dosimetry at Hanford, PNL-6866, Rev. 1, Pacific Northwest Laboratory, Richland, Washington.

6% Pu-240	Isotope	Isotope	30 yr decay	Mixture	Mixture
Isotope	Ci/g	mrem/Ci	wt fraction	Ci/g	mrem/g
Pu-238	17.1	1390	0.000395	0.007	9.39
Pu-239	0.062	1490	0.93	0.058	85.91
Pu-240	0.226	1490	0.061	0.014	20.54
Pu-241	103	22.8	0.0016	0.165	3.76
Pu-242	0.0039	1420	0.0005	1.95E-06	2.77E-03
Am-241	3.24	2370	0.0064	2.07E-02	4.91E+01
Total			1	0.264	168.75
				mrem/Ci =	640
12% Pu-240	Isotope	Isotope	30 yr decay	Mixture	Mixture
Isotope	Ci/g	mrem/Ci	wt fraction	Ci/g	mrem/g
Pu-238	17.1	1390	0.00079	0.014	18.78
Pu-239	0.062	1490	0.844	0.052	77.97
Pu-240	0.226	1490	0.124	0.028	41.76
Pu-241	103	22.8	0.006	0.618	14.09
Pu-242	0.0039	1420	0.001	3.90E-06	5.54E-03
Am-241	3.24	2370	0.024	7.78E-02	1.84E+02
Total			1	0.790	336.89
				mrem/Ci =	427
24% Pu-240	Isotope	Isotope	30 yr decay	Mixture	Mixture
Isotope	Ci/g	mrem/Ci	wt fraction	Ci/g	mrem/g
Pu-238	17.1	1390	0.01422	0.243	338.00
Pu-239	0.062	1490	0.542	0.034	50.07
Pu-240	0.226	1490	0.238	0.054	80.14
Pu-241	103	22.8	0.027	2.781	63.41
Pu-242	0.0039	1420	0.064	2.50E-04	3.54E-01
Am-241	3.24	2370	0.108	3.50E-01	8.29E+02
Total			0.997	3.462	1361.28
				mrem/Ci =	393

Depleted U		Isotope	Mixture
Isotope	wt. Fraction	Ci/g	Ci/g
U-234	3.7E-06	6.25E-03	2.31E-08
U-235	0.0025	2.16E-06	5.40E-09
U-238	9.98E-01	3.36E-07	3.35E-07
	1.000004		3.64E-07
Natural U		Isotope	Mixture
Isotope	wt. Fraction	Ci/g	Ci/g
U-234	5.5E-05	6.25E-03	3.44E-07
U-235	0.0072	2.16E-06	1.56E-08
U-238	9.93E-01	3.36E-07	3.34E-07
	1		6.93E-07
U-enriched (Hanf UO3)		Isotope	Mixture
Isotope	wt. Fraction	Ci/g	Ci/g
U-234	8.00E-05	6.25E-03	5.00E-07
U-235	0.0083	2.16E-06	1.79E-08
U-236	0.00074	6.47E-05	4.79E-08
U-238	0.99088	3.36E-07	3.33E-07
	1		8.99E-07
U-enriched (< 20% U235)		Isotope	Mixture
Isotope	wt. Fraction	Ci/g	Ci/g
U-234	1.30E-03	6.25E-03	8.13E-06
U-235	0.2	2.16E-06	4.32E-07
U-236	0.008	6.47E-05	5.18E-07
U-238	0.7907	3.36E-07	2.66E-07
	1		9.34E-06
U-enriched (<90% U235)		Isotope	Mixture
Isotope	wt. Fraction	Ci/g	Ci/g
U-234	0.0095	6.25E-03	5.94E-05
U-235	0.9	2.16E-06	1.94E-06
U-236	0.011	6.47E-05	7.12E-07
U-238	0.0795	3.36E-07	2.67E-08
	1		6.21E-05

Appendix B

Radionuclide Inventory Database Features

The information obtained from the nuclear materials inventory, composite radioactive materials inventory, and facility management radioactive materials inventory is maintained by Effluent Management (EM) in an ACCESS database. The inventory information that is obtained and stored in the database is listed in Section 2.1.

Database Population

The nuclear materials and composite radioactive materials inventories currently are obtained in electronic formats. The general format of the electronic files is manipulated to allow electronic downloading of the information from these two sources into the database tables; the data in the electronic files is not changed.

The facility management radioactive materials inventory is obtained from individual research personnel who act as custodians of the material. This inventory data is provided in various forms (for instance, handwritten, electronic files, and e-mail messages). Electronic files are re-formatted to the database table format and downloaded directly into the database tables. Handwritten and e-mail information is manually input to the database tables by EM personnel. For accuracy, entries to the database are independently verified by other EM personnel.

The information entered into the database includes:

- Staff member acting as custodian of the material
- Research or support division of the custodian
- Form of the material – gas, liquid, powder, solid, contained, or exempt/sealed DOT
- Basis for the inventory – physical inventory records, estimated through process knowledge, estimated through transportation records, or estimated through other means (such as, procedures and documents)
- Nuclides
- Inventory in activity (Ci) or mass (grams)
- Building/room in which material is stored or used
- Identification number – numbers previously assigned by the custodian or by other databases (sealed source or material balance area identification numbers)
- Comments – any additional comments related to the material (for example, reference numbers on the material, whether or not the material is considered throughput, a description of the material).

The database assigns an identification number to each of the entries. For sealed source and Material Balance Area (MBA) data the identification number previously assigned to the material is used. For the research inventories, the database applies a sequential number to each of the entries. The database assigns the following designations to the identification number:

D - = Input provided by the research division
G - = Government sealed source
P - = Private radioactive material inventory (Non-DOE radioactive material under the State of Washington Radioactive Material License)
M - = Nuclear materials inventory.

Other Database Tables

Other database tables are used to store specific information about individual nuclides that are used in the NESHAP dose calculations:

Factors Table - Factors for the dose per curie (mrem/Ci) for different isotopes are listed in Table 3 and are entered as a separate table in the ACCESS database. The source for each of the nuclide factors is listed in the factors table.

Release Fraction Table - The release fractions for material forms (such as, solids, liquids, or powders) are listed in Table 2. These release fractions are entered as a separate table in the database.

Calculations

The ACCESS database uses queries and macros that are applied to the tables previously listed to calculate the potential dose for the different PNNL facilities.

Normalizing Inventory Data -- The database is designed to convert the reported mass and activity inventory units (such as, grams, mCi, μCi, mg, μg) to curie (Ci) units for use in subsequent calculations.

Potential Dose Calculations -- Potential dose calculations are determined on a facility-specific basis. The reported inventory is first converted to Ci and then is multiplied by the dose factor (mrem/Ci) for the specific nuclide, the location modification factor, and the release fraction to determine the potential dose for that nuclide inventory.

Example: 20 μCi of U-238 in powder form at the 305B facility
20 μCi * 1.0E-06 Ci/μCi * 1E-03 * 513 mrem/Ci * 1.0 = 1.03E-05 mrem/Ci

Where : 1E-03 = release fraction for powder
513 mrem/Ci = dose factor for U-238
1.0 = location modification factor (with relation to 300 Area).

The cumulative dose for the facility is determined by summing the potential doses of each inventory entry.

Reports

Three reports are generated using the database for the NESHAP assessment as part of the final packet:

- The first is a report of the raw data that was provided by the research personnel, the nuclear materials inventory, and the composite radioactive materials inventory.

- The second is a summary page listing the potential dose (mrem/Ci) of the facility inventory and sign-off blocks for the preparer, reviewer, facility safety representative, divisional representative(s), and the building manager.

- The third report is a listing of each radionuclide present in the building and the dose contribution in mrem/Ci and in percent of the total dose.

Appendix C

Unit Dose Factor Calculations

DOSE CALCULATIONS FOR UNIT CURIE RELEASE OF RADIONUCLIDES FROM 300 AREA FOR MAXIMUM PUBLIC RECEPTOR WITH REGIONAL INGESTION USING HANFORD-SPECIFIC PARAMETERS

L.H. Staven June 20, 2001

Introduction

A dose calculation for a chronic unit (1 Ci) radionuclide release was performed in support of efforts by Fluor Hanford, (FH) to satisfy requirements of Washington State Department of Health and the Department of Energy Facilities Effluent Monitoring Plan for facilities in the 300 Area of the Hanford Site. In the 300 Area, atmospheric releases from a generic facility were modeled as 10 m- (33-ft) or 40 m- (132-ft) releases. The CAP88PC computer code (Parks 1992) was used to model atmospheric releases with Hanford-specific parameters[1]. The maximum public receptor (MPR) was assumed to be a non-DOE worker who works within the Hanford Site boundary and who eats food grown regionally.

Methods

One Ci per year of each radionuclide was modeled in CAP88PC as a release from a 300 Area facility from heights of 10 m and 40 m. Hanford-specific CAP88PC, population and meteorological parameters were used for the calculations (Schreckhise et al 1993). Joint frequency meteorology data were collected from the 300 Area weather stations and represent the 14-year average of wind data collected between 1983 and 1996. Two public receptor locations are to be evaluated at this time, the 313 Building, and the WSU Laboratory. Sources within 500 m of either receptor should use the 100 m data. Sources greater than 500 m from either receptor should use the 500 m data in estimating doses. The dose was reported as the 50-year total effective dose equivalent (TEDE). Dose factors for grown-in progeny were included in the reported dose factor for the parent radionuclide. The worker was conservatively assumed to occupy the work site 8766 h/y.

Calculations of the regional food ingestion for an average individual were made by subtracting the population dose without ingestion from the population dose with local ingestion, then dividing the resulting population ingestion dose by the number of individuals in that population.

Results

The dose factors for chronic releases of radionuclides from the 300 Area are shown in Tables 1 and 2 for the worker MPR. To determine the potential dose (mrem per year) from the actual release from each building, multiply the released amount of each radionuclide in Ci per year by the appropriate dose factor and sum for all nuclides released from the facility.

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[1] Permission to use Hanford-specific parameters was granted in a letter from D.E. Hardesty of EPA to J.H. Hebdon at DOE-RL, dated March 22, 2001 : Subject: the third response of the U.S. EPA to the new definition of the maximally exposed individual.

Sample output from CAP88PC is included as Attachments 1 and 2 to Appendix C.

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Table C-1. CAP88PC 300 Area Dose Factors to Onsite Public Worker (a) per Unit Ci Released Using Hanford-specific Parameters with 10-m release (mrem/y per Ci/y released).

Radio-nuclide	Inhalation and External (100 m NW)	Inhalation and External (500 m NW)	Average Individual Ingestion	Total Effective Dose Equivalent (100 m NW)	Total Effective Dose Equivalent (500 m NW)
H-3	5.83E-04	2.84E-04	6.30E-06	5.89E-04	2.90E-04
BE-7	3.50E-02	1.63E-02	7.10E-07	3.50E-02	1.63E-02
BE-10 (b)	(Sr-90)	(Sr-90)	(Sr-90)	(Sr-90)	(Sr-90)
C-11	2.84E-03	1.23E-03	0.00E+00	2.84E-03	1.23E-03
C-14	5.34E-05	2.61E-05	4.40E-04	4.94E-04	4.66E-04
C-15 (c)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
N-13	2.63E-03	1.02E-03	0.00E+00	2.63E-03	1.02E-03
O-15	2.06E-03	3.98E-04	0.00E+00	2.06E-03	3.98E-04
F-18	3.87E-03	1.81E-03	0.00E+00	3.87E-03	1.81E-03
NA-22	2.27E+01	1.06E+01	2.66E-03	2.27E+01	1.06E+01
NA-24	4.50E-02	2.13E-02	1.17E-06	4.50E-02	2.13E-02
P-32	2.65E-02	1.28E-02	3.26E-04	2.68E-02	1.31E-02
S-35	1.30E-03	6.27E-04	6.34E-05	1.36E-03	6.90E-04
AR-41	3.40E-03	1.62E-03	0.00E+00	3.40E-03	1.62E-03
K-40	1.35E+01	6.26E+00	7.14E-03	1.35E+01	6.27E+00
CA-41	2.03E-03	9.43E-04	0.00E+00	2.03E-03	9.43E-04
SC-46	2.11E+00	9.85E-01	1.14E-04	2.11E+00	9.85E-01
CR-51	1.30E-02	6.07E-03	1.35E-06	1.30E-02	6.07E-03
MN-54	3.18E+00	1.48E+00	2.49E-05	3.18E+00	1.48E+00
MN-56	9.17E-03	4.31E-03	0.00E+00	9.17E-03	4.31E-03
FE-55	8.35E-03	3.99E-03	2.04E-05	8.37E-03	4.01E-03
FE-59	6.55E-01	3.06E-01	1.10E-04	6.55E-01	3.06E-01
CO-57	4.93E-01	2.30E-01	4.08E-05	4.93E-01	2.30E-01
CO-58	9.00E-01	4.20E-01	9.23E-05	9.00E-01	4.20E-01
CO-60	4.75E+01	2.21E+01	1.07E-03	4.75E+01	2.21E+01
NI-59	4.50E-02	2.10E-02	5.82E-06	4.50E-02	2.10E-02
NI-63	1.00E-02	4.83E-03	1.53E-05	1.00E-02	4.85E-03
NI-65	3.67E-03	1.73E-03	0.00E+00	3.67E-03	1.73E-03
CU-64	3.32E-03	1.58E-03	7.10E-09	3.32E-03	1.58E-03
ZN-65	1.70E+00	7.92E-01	2.70E-03	1.70E+00	7.95E-01
ZN-69	2.98E-04	1.38E-04	0.00E+00	2.98E-04	1.38E-04
ZN-69M	8.64E-03	4.12E-03	1.78E-07	8.64E-03	4.12E-03
GA-67	9.45E-03	4.45E-03	1.07E-07	9.45E-03	4.45E-03
AS-76	2.67E-02	1.28E-02	3.55E-08	2.67E-02	1.28E-02
SE-79 (b)	(Pu-241)	(Pu-241)	(Pu-241)	(Pu-241)	(Pu-241)

Table C-1. CAP88PC 300 Area Dose Factors to Onsite Public Worker (a) per Unit Ci Released Using Hanford-specific Parameters with 10-m release (mrem/y per Ci/y released).

Radio-nuclide	Inhalation and External (100 m NW)	Inhalation and External (500 m NW)	Average Individual Ingestion	Total Effective Dose Equivalent (100 m NW)	Total Effective Dose Equivalent (500 m NW)
BR-82	5.91E-02	2.77E-02	6.04E-06	5.91E-02	2.77E-02
BR-83	2.84E-05	1.33E-05	0.00E+00	2.84E-05	1.33E-05
BR-84	5.57E-03	2.50E-03	0.00E+00	5.57E-03	2.50E-03
BR-85	1.50E-04	3.65E-05	0.00E+00	1.50E-04	3.65E-05
KR-83M	6.08E-07	2.91E-07	0.00E+00	6.08E-07	2.91E-07
KR-85	8.59E-06	4.22E-06	0.00E+00	8.59E-06	4.22E-06
KR-85M	4.11E-04	2.00E-04	0.00E+00	4.11E-04	2.00E-04
KR-87	2.28E-03	1.08E-03	0.00E+00	2.28E-03	1.08E-03
KR-88	5.80E-03	2.80E-03	0.00E+00	5.80E-03	2.80E-03
KR-89	4.43E-03	1.15E-03	0.00E+00	4.43E-03	1.15E-03
KR-90 (c)	1.48E-03	5.05E-05	0.00E+00	1.48E-03	5.05E-05
RB-86	5.66E-02	2.70E-02	2.95E-04	5.69E-02	2.73E-02
RB-87	3.24E-02	1.56E-02	1.32E-03	3.37E-02	1.69E-02
RB-88	2.36E-03	1.00E-03	0.00E+00	2.36E-03	1.00E-03
RB-89	6.11E-03	2.55E-03	0.00E+00	6.11E-03	2.55E-03
RB-90	5.44E-03	1.25E-03	0.00E+00	5.44E-03	1.25E-03
RB-90M	8.53E-03	2.55E-03	0.00E+00	8.53E-03	2.55E-03
SR-89	2.86E-02	1.38E-02	9.13E-05	2.87E-02	1.39E-02
SR-90	9.70E-01	4.68E-01	1.04E-02	9.80E-01	4.78E-01
SR-90+D	9.70E-01	4.69E-01	1.04E-02	9.80E-01	4.79E-01
SR-91	9.92E-03	4.73E-03	3.55E-08	9.92E-03	4.73E-03
SR-92	8.13E-03	3.83E-03	0.00E+00	8.13E-03	3.83E-03
Y-90	4.11E-02	1.98E-02	3.55E-07	4.11E-02	1.98E-02
Y-90M	2.71E-03	1.27E-03	0.00E+00	2.71E-03	1.27E-03
Y-91	2.17E-01	1.05E-01	5.33E-05	2.17E-01	1.05E-01
Y-91M	1.76E-03	8.08E-04	0.00E+00	1.76E-03	8.08E-04
Y-92	6.44E-03	3.06E-03	0.00E+00	6.44E-03	3.06E-03
Y-93	1.31E-02	6.31E-03	0.00E+00	1.31E-02	6.31E-03
ZR-93	2.10E-01	1.01E-01	1.63E-05	2.10E-01	1.01E-01
ZR-95	6.46E-01	3.02E-01	3.55E-05	6.46E-01	3.02E-01
ZR-95+D	1.26E+00	5.88E-01	3.55E-05	1.26E+00	5.88E-01
NB-93M	1.73E-01	8.28E-02	2.34E-04	1.73E-01	8.30E-02
NB-94	1.57E+02	7.32E+01	3.91E-03	1.57E+02	7.32E+01
NB-95	3.60E-01	1.68E-01	4.29E-04	3.60E-01	1.68E-01
NB-95M	1.40E-02	6.71E-03	2.88E-05	1.40E-02	6.74E-03
NB-97	2.77E-03	1.29E-03	0.00E+00	2.77E-03	1.29E-03

Table C-1. CAP88PC 300 Area Dose Factors to Onsite Public Worker (a) per Unit Ci Released Using Hanford-specific Parameters with 10-m release (mrem/y per Ci/y released).

Radio-nuclide	Inhalation and External (100 m NW)	Inhalation and External (500 m NW)	Average Individual Ingestion	Total Effective Dose Equivalent (100 m NW)	Total Effective Dose Equivalent (500 m NW)
NB-97M	1.19E-03	1.11E-04	0.00E+00	1.19E-03	1.11E-04
MO-93	5.61E-01	2.61E-01	0.00E+00	5.61E-01	2.61E-01
MO-99	2.49E-02	1.19E-02	2.13E-06	2.49E-02	1.19E-02
MO-99+D	2.98E-02	1.42E-02	2.13E-06	2.98E-02	1.42E-02
TC-99M	5.88E-03	2.74E-03	0.00E+00	5.88E-03	2.74E-03
TC-97	6.26E-01	2.91E-01	4.51E-04	6.26E-01	2.91E-01
TC-99	3.67E-02	1.77E-02	3.86E-03	4.06E-02	2.16E-02
TC-101	8.85E-04	3.65E-04	0.00E+00	8.85E-04	3.65E-04
RU-97	1.15E-02	5.38E-03	3.55E-08	1.15E-02	5.38E-03
RU-103	2.80E-01	1.31E-01	1.67E-05	2.80E-01	1.31E-01
RU-103+D	2.80E-01	1.31E-01	1.70E-05	2.80E-01	1.31E-01
RU-105	6.72E-03	3.18E-03	0.00E+00	6.72E-03	3.18E-03
RU-106	2.09E+00	1.01E+00	2.56E-04	2.09E+00	1.01E+00
RU-106+D	3.00E+00	1.44E+00	2.56E-04	3.00E+00	1.44E+00
RH-105	6.48E-03	3.11E-03	2.45E-06	6.48E-03	3.11E-03
RH-105M	4.01E-05	2.44E-06	0.00E+00	4.01E-05	2.44E-06
RH-106	2.22E-04	6.45E-06	0.00E+00	2.22E-04	6.45E-06
PD-107	5.55E-02	2.68E-02	1.39E-05	5.55E-02	2.68E-02
PD-109	7.19E-03	3.48E-03	3.55E-07	7.19E-03	3.48E-03
AG-109M	5.98E-06	2.94E-07	0.00E+00	5.98E-06	2.94E-07
AG-110	3.01E-05	5.83E-07	0.00E+00	3.01E-05	5.83E-07
AG-110M	8.40E+00	3.91E+00	9.59E-04	8.40E+00	3.91E+00
AG-111	3.12E-02	1.51E-02	1.27E-04	3.13E-02	1.52E-02
CD-113 (b)	(Pu-241)	(Pu-241)	(Pu-241)	(Pu-241)	(Pu-241)
CD-113M (b)	(Pu-241)	(Pu-241)	(Pu-241)	(Pu-241)	(Pu-241)
CD-115	2.67E-02	1.28E-02	1.95E-06	2.67E-02	1.28E-02
CD-115M	2.02E-01	9.75E-02	1.27E-04	2.02E-01	9.76E-02
IN-113M	1.12E-03	5.24E-04	0.00E+00	1.12E-03	5.24E-04
IN-115	4.48E+00	2.16E+00	2.95E-03	4.48E+00	2.16E+00
IN-115M	1.57E-03	7.45E-04	0.00E+00	1.57E-03	7.45E-04
SN-113	7.00E-02	3.34E-02	2.67E-04	7.03E-02	3.37E-02
SN-123	1.03E-02	4.77E-03	0.00E+00	1.03E-02	4.77E-03

Table C-1. CAP88PC 300 Area Dose Factors to Onsite Public Worker (a) per Unit Ci Released Using Hanford-specific Parameters with 10-m release (mrem/y per Ci/y released).

Radio-nuclide	Inhalation and External (100 m NW)	Inhalation and External (500 m NW)	Average Individual Ingestion	Total Effective Dose Equivalent (100 m NW)	Total Effective Dose Equivalent (500 m NW)
SN-125	1.06E-01	5.06E-02	8.27E-05	1.06E-01	5.07E-02
SN-126	6.28E+00	2.93E+00	2.59E-03	6.28E+00	2.93E+00
SB-124	1.41E+00	6.58E-01	6.04E-05	1.41E+00	6.58E-01
SB-125	5.11E+00	2.38E+00	2.84E-05	5.11E+00	2.38E+00
SB-126	4.87E-01	2.27E-01	2.02E-05	4.87E-01	2.27E-01
SB-126M	4.46E-03	1.91E-03	0.00E+00	4.46E-03	1.91E-03
SB-127	6.18E-02	2.93E-02	1.42E-06	6.18E-02	2.93E-02
TE-125M	4.71E-02	2.25E-02	5.90E-05	4.72E-02	2.26E-02
TE-127	1.91E-03	9.24E-04	0.00E+00	1.91E-03	9.24E-04
TE-127M	1.04E-01	4.99E-02	1.71E-04	1.04E-01	5.01E-02
TE-129	7.64E-04	3.56E-04	0.00E+00	7.64E-04	3.56E-04
TE-129M	1.20E-01	5.77E-02	1.19E-04	1.20E-01	5.78E-02
TE-131	1.69E-03	7.44E-04	0.00E+00	1.69E-03	7.44E-04
TE-131M	4.62E-02	2.19E-02	0.00E+00	4.62E-02	2.19E-02
TE-132	4.55E-02	2.18E-02	1.78E-06	4.55E-02	2.18E-02
TE-133	2.44E-03	9.86E-04	0.00E+00	2.44E-03	9.86E-04
TE-133M	6.92E-03	3.19E-03	0.00E+00	6.92E-03	3.19E-03
TE-134	2.55E-03	1.16E-03	0.00E+00	2.55E-03	1.16E-03
I-122	2.64E-03	6.07E-04	0.00E+00	2.64E-03	6.07E-04
I-123	2.32E-02	9.30E-03	6.04E-08	2.32E-02	9.30E-03
I-125	4.19E-01	1.68E-01	1.29E-03	4.20E-01	1.69E-01
I-129	3.83E+01	1.54E+01	2.33E-02	3.83E+01	1.54E+01
I-130	2.61E-01	1.05E-01	4.62E-07	2.61E-01	1.05E-01
I-131	8.45E-01	3.39E-01	6.40E-04	8.46E-01	3.40E-01
I-132	5.54E-02	2.18E-02	0.00E+00	5.54E-02	2.18E-02
I-133	1.43E-01	5.74E-02	4.83E-06	1.43E-01	5.74E-02
I-134	2.78E-02	1.07E-02	0.00E+00	2.78E-02	1.07E-02
I-135	9.70E-02	3.87E-02	1.07E-08	9.70E-02	3.87E-02
XE-122	1.74E-04	8.47E-05	0.00E+00	1.74E-04	8.47E-05
XE-123	1.63E-03	7.77E-04	0.00E+00	1.63E-03	7.77E-04
XE-125	6.39E-04	3.11E-04	0.00E+00	6.39E-04	3.11E-04
XE-127	6.71E-04	3.27E-04	0.00E+00	6.71E-04	3.27E-04
XE-131M	2.45E-05	1.19E-05	0.00E+00	2.45E-05	1.19E-05
XE-133	9.00E-05	4.38E-05	0.00E+00	9.00E-05	4.38E-05
XE-133M	7.85E-05	3.83E-05	0.00E+00	7.85E-05	3.83E-05
XE-135	6.37E-04	3.10E-04	0.00E+00	6.37E-04	3.10E-04

Table C-1. CAP88PC 300 Area Dose Factors to Onsite Public Worker (a) per Unit Ci Released Using Hanford-specific Parameters with 10-m release (mrem/y per Ci/y released).

Radio-nuclide	Inhalation and External (100 m NW)	Inhalation and External (500 m NW)	Average Individual Ingestion	Total Effective Dose Equivalent (100 m NW)	Total Effective Dose Equivalent (500 m NW)
XE-135M	1.06E-03	4.48E-04	0.00E+00	1.06E-03	4.48E-04
XE-137	4.34E-04	1.25E-04	0.00E+00	4.34E-04	1.25E-04
XE-138	3.10E-03	1.29E-03	0.00E+00	3.10E-03	1.29E-03
CS-134	1.39E+01	6.47E+00	4.19E-03	1.39E+01	6.47E+00
CS-134M	2.97E-04	1.41E-04	0.00E+00	2.97E-04	1.41E-04
CS-135	2.04E-02	9.87E-03	6.07E-04	2.10E-02	1.05E-02
CS-136	3.82E-01	1.78E-01	1.72E-04	3.82E-01	1.78E-01
CS-137	1.35E-01	6.54E-02	3.63E-03	1.39E-01	6.90E-02
CS-137+D	4.24E+01	1.98E+01	3.63E-03	4.24E+01	1.98E+01
CS-138	7.54E-03	3.38E-03	0.00E+00	7.54E-03	3.38E-03
CS-139	8.28E-04	3.17E-04	0.00E+00	8.28E-04	3.17E-04
BA-133	1.48E+01	6.87E+00	3.55E-05	1.48E+01	6.87E+00
BA-133M	4.32E-03	2.06E-03	1.42E-07	4.32E-03	2.06E-03
BA-137M	1.29E-03	2.92E-04	0.00E+00	1.29E-03	2.92E-04
BA-139	9.71E-04	4.53E-04	0.00E+00	9.71E-04	4.53E-04
BA-140	4.95E-02	2.34E-02	2.41E-05	4.95E-02	2.34E-02
BA-140+D	3.81E-01	1.78E-01	2.41E-05	3.81E-01	1.78E-01
BA-141	2.40E-03	1.03E-03	0.00E+00	2.40E-03	1.03E-03
BA-142	2.34E-03	9.21E-04	0.00E+00	2.34E-03	9.21E-04
LA-140	7.39E-02	3.49E-02	0.00E+00	7.39E-02	3.49E-02
LA-141	1.90E-04	8.93E-05	0.00E+00	1.90E-04	8.93E-05
LA-142	1.00E-02	4.66E-03	0.00E+00	1.00E-02	4.66E-03
CE-141	7.43E-02	3.53E-02	1.31E-05	7.43E-02	3.53E-02
CE-143	2.17E-02	1.04E-02	0.00E+00	2.17E-02	1.04E-02
CE-144	1.71E+00	8.25E-01	1.63E-04	1.71E+00	8.25E-01
CE-144+D	1.81E+00	8.71E-01	1.67E-04	1.81E+00	8.71E-01
PR-143	3.70E-02	1.79E-02	1.03E-05	3.70E-02	1.79E-02
PR-144	4.39E-04	1.86E-04	0.00E+00	4.39E-04	1.86E-04
PR-144M	1.57E-04	5.61E-05	0.00E+00	1.57E-04	5.61E-05
ND-147	5.06E-02	2.41E-02	7.10E-06	5.06E-02	2.41E-02
PM-147	1.70E-01	8.23E-02	1.46E-05	1.70E-01	8.23E-02
PM-148	8.81E-02	4.19E-02	5.33E-06	8.81E-02	4.19E-02
PM-148M	1.26E+00	5.91E-01	7.10E-05	1.26E+00	5.91E-01
PM-149	1.48E-02	7.13E-03	7.10E-08	1.48E-02	7.13E-03

Table C-1. CAP88PC 300 Area Dose Factors to Onsite Public Worker (a) per Unit Ci Released Using Hanford-specific Parameters with 10-m release (mrem/y per Ci/y released).

Radio-nuclide	Inhalation and External (100 m NW)	Inhalation and External (500 m NW)	Average Individual Ingestion	Total Effective Dose Equivalent (100 m NW)	Total Effective Dose Equivalent (500 m NW)
PM-151	6.00E-03	2.81E-03	0.00E+00	6.00E-03	2.81E-03
SM-147	3.28E+02	1.58E+02	3.55E-03	3.28E+02	1.58E+02
SM-151	1.32E-01	6.40E-02	5.68E-06	1.32E-01	6.40E-02
SM-153	1.15E-02	5.51E-03	3.55E-08	1.15E-02	5.51E-03
EU-152	4.82E+01	2.24E+01	7.10E-05	4.82E+01	2.24E+01
EU-152M	2.32E-03	1.09E-03	0.00E+00	2.32E-03	1.09E-03
EU-154	3.89E+01	1.81E+01	1.42E-04	3.89E+01	1.81E+01
EU-155	1.53E+00	7.13E-01	2.13E-05	1.53E+00	7.13E-01
EU-156	3.01E-01	1.41E-01	2.88E-05	3.01E-01	1.41E-01
GD-152 (b)	(Pu-239)	(Pu-239)	(Pu-239)	(Pu-239)	(Pu-239)
TB-160	1.04E+00	4.88E-01	6.39E-05	1.04E+00	4.88E-01
HO-166	1.66E-02	8.00E-03	0.00E+00	1.66E-02	8.00E-03
HO-166M	1.59E+02	7.38E+01	0.00E+00	1.59E+02	7.38E+01
HF-181	3.55E-01	1.66E-01	2.45E-05	3.55E-01	1.66E-01
W-181	6.69E-02	3.11E-02	1.46E-05	6.69E-02	3.11E-02
W-185	3.41E-03	1.65E-03	6.68E-05	3.48E-03	1.72E-03
W-187	1.01E-02	4.77E-03	3.55E-08	1.01E-02	4.77E-03
RE-187	2.40E-04	1.16E-04	1.75E-06	2.42E-04	1.18E-04
IR-192	9.04E-01	4.23E-01	3.91E-05	9.04E-01	4.23E-01
HG-203	1.66E-01	7.79E-02	3.57E-04	1.66E-01	7.83E-02
TL-207	3.85E-05	1.20E-05	0.00E+00	3.85E-05	1.20E-05
TL-208	8.64E-03	2.18E-03	0.00E+00	8.64E-03	2.18E-03
TL-209	4.53E-03	9.26E-04	0.00E+00	4.53E-03	9.26E-04
PB-209	4.47E-04	2.13E-04	0.00E+00	4.47E-04	2.13E-04
PB-210	6.07E+01	2.93E+01	5.08E-02	6.08E+01	2.94E+01
PB-210+D	6.07E+01	2.93E+01	5.05E-02	6.08E+01	2.94E+01
PO-210	5.13E-04	2.39E-04	5.93E-05	5.72E-04	2.98E-04
PB-211	4.18E-02	1.90E-02	0.00E+00	4.18E-02	1.90E-02
PB-212	7.45E-01	3.60E-01	0.00E+00	7.45E-01	3.60E-01
PB-214	4.79E-03	2.13E-03	0.00E+00	4.79E-03	2.13E-03
BI-210	8.56E-01	4.14E-01	3.55E-06	8.56E-01	4.14E-01
BI-211	3.90E-03	7.79E-04	0.00E+00	3.90E-03	7.79E-04
BI-212	1.50E-01	6.97E-02	0.00E+00	1.50E-01	6.97E-02
BI-213	5.86E-03	2.69E-03	0.00E+00	5.86E-03	2.69E-03
BI-214	6.02E-03	2.60E-03	0.00E+00	6.02E-03	2.60E-03

Table C-1. CAP88PC 300 Area Dose Factors to Onsite Public Worker (a) per Unit Ci Released Using Hanford-specific Parameters with 10-m release (mrem/y per Ci/y released).

Radio-nuclide	Inhalation and External (100 m NW)	Inhalation and External (500 m NW)	Average Individual Ingestion	Total Effective Dose Equivalent (100 m NW)	Total Effective Dose Equivalent (500 m NW)
PO-210	3.80E+01	1.84E+01	1.46E-02	3.80E+01	1.84E+01
PO-212 (c)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PO-213 (c)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PO-214 (c)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PO-215 (c)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PO-216 (c)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PO-218	1.99E-04	5.03E-05	0.00E+00	1.99E-04	5.03E-05
AT-217	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RN-219 (e)	1.09E-01	5.27E-02	9.09E-05	1.09E-01	5.28E-02
RN-220 (e)	1.04E-03	5.04E-04	0.00E+00	1.04E-03	5.04E-04
RN-222	1.10E-02	5.37E-03	0.00E+00	1.10E-02	5.37E-03
FR-221	1.77E-02	5.53E-03	0.00E+00	1.77E-02	5.53E-03
FR-223	1.19E-02	5.18E-03	0.00E+00	1.19E-02	5.18E-03
RA-223	3.64E+01	1.76E+01	1.78E-03	3.64E+01	1.76E+01
RA-224	1.55E+01	7.47E+00	1.42E-04	1.55E+01	7.47E+00
RA-225	1.84E+01	8.90E+00	1.88E-03	1.84E+01	8.90E+00
RA-226	3.96E+01	1.91E+01	1.28E-02	3.96E+01	1.91E+01
RA-228	1.07E+01	5.18E+00	6.61E-03	1.07E+01	5.19E+00
AC-225	2.68E+01	1.30E+01	1.42E-04	2.68E+01	1.30E+01
AC-227	2.80E+03	1.35E+03	3.20E-02	2.80E+03	1.35E+03
AC-228	3.84E-01	1.84E-01	0.00E+00	3.84E-01	1.84E-01
TH-227	5.16E+01	2.49E+01	0.00E+00	5.16E+01	2.49E+01
TH-228	1.11E+03	5.37E+02	3.55E-03	1.11E+03	5.37E+02
TH-229	3.09E+03	1.49E+03	0.00E+00	3.09E+03	1.49E+03
TH-230	1.10E+03	5.31E+02	3.55E-03	1.10E+03	5.31E+02
TH-231	4.56E-03	2.20E-03	0.00E+00	4.56E-03	2.20E-03
TH-232	1.58E+03	7.65E+02	3.55E-03	1.58E+03	7.65E+02
TH-232 +D	1.83E+03	8.82E+02	3.83E-03	1.83E+03	8.82E+02

Table C-1. CAP88PC 300 Area Dose Factors to Onsite Public Worker (a) per Unit Ci Released Using Hanford-specific Parameters with 10-m release (mrem/y per Ci/y released).

Radio-nuclide	Inhalation and External (100 m NW)	Inhalation and External (500 m NW)	Average Individual Ingestion	Total Effective Dose Equivalent (100 m NW)	Total Effective Dose Equivalent (500 m NW)
TH-234	1.60E-01	7.72E-02	4.76E-05	1.60E-01	7.72E-02
PA-231	2.12E+03	1.02E+03	3.55E-02	2.12E+03	1.02E+03
PA-233	1.20E-01	5.64E-02	1.35E-05	1.20E-01	5.64E-02
PA-234	1.67E-02	7.89E-03	0.00E+00	1.67E-02	7.89E-03
PA-234M	3.09E-05	3.49E-06	0.00E+00	3.09E-05	3.49E-06
U-232	2.10E+03	1.01E+03	2.84E-02	2.10E+03	1.01E+03
U-233	5.84E+02	2.82E+02	1.42E-02	5.84E+02	2.82E+02
U-234	5.77E+02	2.79E+02	1.07E-02	5.77E+02	2.79E+02
U-235	5.50E+02	2.66E+02	1.07E-02	5.50E+02	2.66E+02
U-236	5.46E+02	2.64E+02	1.07E-02	5.46E+02	2.64E+02
U-237	2.98E-02	1.42E-02	4.26E-06	2.98E-02	1.42E-02
U-238	5.13E+02	2.48E+02	7.10E-03	5.13E+02	2.48E+02
U-240	1.10E-02	5.31E-03	3.55E-08	1.10E-02	5.31E-03
NP-237	2.14E+03	1.04E+03	3.55E-02	2.14E+03	1.04E+03
NP-238	1.56E-01	7.51E-02	0.00E+00	1.56E-01	7.51E-02
NP-239	1.77E-02	8.45E-03	7.10E-08	1.77E-02	8.45E-03
NP-240	4.23E-03	1.96E-03	0.00E+00	4.23E-03	1.96E-03
NP-240M	9.05E-04	3.27E-04	0.00E+00	9.05E-04	3.27E-04
PU-236	3.85E+02	1.86E+02	3.55E-03	3.85E+02	1.86E+02
PU-238	1.39E+03	6.70E+02	2.84E-02	1.39E+03	6.70E+02
PU-239	1.49E+03	7.21E+02	3.20E-02	1.49E+03	7.21E+02
PU-240	1.49E+03	7.20E+02	3.20E-02	1.49E+03	7.20E+02
PU-241	2.27E+01	1.10E+01	6.39E-04	2.27E+01	1.10E+01
PU-241+D	2.28E+01	1.10E+01	6.41E-04	2.28E+01	1.10E+01
PU-242	1.42E+03	6.85E+02	2.84E-02	1.42E+03	6.85E+02
PU-243	1.15E-03	5.47E-04	0.00E+00	1.15E-03	5.47E-04
PU-244	1.41E+03	6.81E+02	2.84E-02	1.41E+03	6.81E+02
AM-241	2.37E+03	1.15E+03	3.20E-02	2.37E+03	1.15E+03
AM-242	2.64E-01	1.27E-01	0.00E+00	2.64E-01	1.27E-01
AM-242M	2.28E+03	1.10E+03	2.84E-02	2.28E+03	1.10E+03
AM-243	2.37E+03	1.15E+03	3.20E-02	2.37E+03	1.15E+03
CM-242	7.83E+01	3.78E+01	7.10E-04	7.83E+01	3.78E+01
CM-243	1.59E+03	7.70E+02	2.13E-02	1.59E+03	7.70E+02
CM-244	1.25E+03	6.05E+02	1.78E-02	1.25E+03	6.05E+02
CM-245	2.45E+03	1.19E+03	3.55E-02	2.45E+03	1.19E+03

Table C-1. CAP88PC 300 Area Dose Factors to Onsite Public Worker (a) per Unit Ci Released Using Hanford-specific Parameters with 10-m release (mrem/y per Ci/y released).

Radio-nuclide	Inhalation and External (100 m NW)	Inhalation and External (500 m NW)	Average Individual Ingestion	Total Effective Dose Equivalent (100 m NW)	Total Effective Dose Equivalent (500 m NW)
CM-246	2.42E+03	1.17E+03	3.20E-02	2.42E+03	1.17E+03
CM-247	2.25E+03	1.09E+03	3.20E-02	2.25E+03	1.09E+03
CM-248	8.91E+03	4.31E+03	1.07E-01	8.91E+03	4.31E+03
CF-252	6.76E+02	3.27E+02	7.10E-03	6.76E+02	3.27E+02

(a) Worker assumed to work full 8766 h/y.
(b) Dose factors not included in the CAP88PC library. Suggest using unit dose from radionuclide in parentheses.
(c) Very short-lived radionuclide. Dose is zero for onsite public worker.
(d) "+D" designation indicates the doses from grown-in progeny are included in the reported dose.
(e) Short-lived Rn isotopes were modeled based on the dose from their longer-lived progeny. For each Ci of Rn-219 released, 0.0018 Ci of Pb-210 is generated. Each Ci of Rn-220 produces 0.0014 Ci of Pb-212. Dose is based on the Pb progeny times the appropriate equilibrium factor (Hill and Rittman 1999).

Table C-2. CAP88PC 300 Area Dose Factors to Onsite Public Worker[a] per Unit Ci Released using Hanford-Specific Parameters with 40 m release (mrem/y per Ci/y released)

Radionuclide	Inhalation and External (500 m NW)	Average Individual Ingestion	Total Effective Dose Equivalent (500 m NW)
H-3	2.52E-05	3.50E-06	2.87E-05
BE-7	1.85E-03	5.33E-07	1.85E-03
BE-10 (b)	(Sr-90)	(Sr-90)	(Sr-90)
C-11	1.12E-04	0.00E+00	1.12E-04
C-14	2.31E-06	2.46E-04	2.48E-04
C-15 (c)	0.00E+00	0.00E+00	0.00E+00
N-13	9.36E-05	0.00E+00	9.36E-05
O-15	3.88E-05	0.00E+00	3.88E-05
F-18	1.73E-04	0.00E+00	1.73E-04
NA-22	1.21E+00	1.92E-03	1.21E+00
NA-24	2.22E-03	8.17E-07	2.22E-03
P-32	1.14E-03	2.39E-04	1.38E-03
S-35	5.61E-05	4.68E-05	1.03E-04
AR-41	1.43E-04	0.00E+00	1.43E-04
K-40	7.15E-01	5.26E-03	7.20E-01
CA-41	1.08E-04	0.00E+00	1.08E-04
SC-46	1.11E-01	8.52E-05	1.11E-01
CR-51	6.75E-04	9.94E-07	6.76E-04
MN-54	1.68E-01	1.78E-05	1.68E-01
MN-56	4.10E-04	0.00E+00	4.10E-04
FE-55	3.85E-04	1.50E-05	4.00E-04
FE-59	3.42E-02	8.13E-05	3.43E-02
CO-57	2.58E-02	3.13E-05	2.58E-02
CO-58	4.73E-02	6.75E-05	4.74E-02
CO-60	2.51E+00	7.81E-04	2.51E+00
NI-59	2.35E-03	4.33E-06	2.35E-03
NI-63	4.32E-04	1.13E-05	4.43E-04
NI-65	1.62E-04	0.00E+00	1.62E-04
CU-64	1.56E-04	7.10E-09	1.56E-04
ZN-65	8.94E-02	1.98E-03	9.14E-02
ZN-69	1.24E-05	0.00E+00	1.24E-05
ZN-69M	4.03E-04	1.42E-07	4.03E-04
GA-67	4.72E-04	7.10E-08	4.72E-04
AS-76	1.21E-03	3.55E-08	1.21E-03
SE-79 (b)	(Pu-241)	(Pu-241)	(Pu-241)
BR-82	3.02E-03	4.26E-06	3.02E-03
BR-83	1.29E-06	0.00E+00	1.29E-06
BR-84	2.29E-04	0.00E+00	2.29E-04

Table C-2. CAP88PC 300 Area Dose Factors to Onsite Public Worker[(a)] per Unit Ci Released using Hanford-Specific Parameters with 40 m release (mrem/y per Ci/y released)

Radionuclide	Inhalation and External (500 m NW)	Average Individual Ingestion	Total Effective Dose Equivalent (500 m NW)
BR-85	3.48E-06	0.00E+00	3.48E-06
KR-83M	2.58E-08	0.00E+00	2.58E-08
KR-85	3.73E-07	0.00E+00	3.73E-07
KR-85M	1.77E-05	0.00E+00	1.77E-05
KR-87	9.57E-05	0.00E+00	9.57E-05
KR-88	2.48E-04	0.00E+00	2.48E-04
KR-89	1.08E-04	0.00E+00	1.08E-04
KR-90 (c)	5.57E-06	0.00E+00	5.57E-06
RB-86	2.65E-03	2.17E-04	2.87E-03
RB-87	1.40E-03	9.70E-04	2.37E-03
RB-88	9.13E-05	0.00E+00	9.13E-05
RB-89	2.33E-04	0.00E+00	2.33E-04
RB-90	1.20E-04	0.00E+00	1.20E-04
RB-90M	2.38E-04	0.00E+00	2.38E-04
SR-89	1.23E-03	6.70E-05	1.30E-03
SR-90	4.19E-02	7.67E-03	4.96E-02
SR-90+D	4.19E-02	7.64E-03	4.95E-02
SR-91	4.61E-04	0.00E+00	4.61E-04
SR-92	3.62E-04	0.00E+00	3.62E-04
Y-90	1.77E-03	3.91E-07	1.77E-03
Y-90M	1.26E-04	0.00E+00	1.26E-04
Y-91	9.40E-03	3.94E-05	9.44E-03
Y-91M	7.50E-05	0.00E+00	7.50E-05
Y-92	2.79E-04	0.00E+00	2.79E-04
Y-93	5.69E-04	0.00E+00	5.69E-04
ZR-93	9.05E-03	1.21E-05	9.06E-03
ZR-95	3.37E-02	2.45E-05	3.37E-02
ZR-95+D	6.57E-02	2.66E-05	6.57E-02
NB-93M	7.93E-03	1.72E-04	8.10E-03
NB-94	8.35E+00	2.49E-03	8.35E+00
NB-95	1.88E-02	3.17E-04	1.91E-02
NB-95M	6.35E-04	2.12E-05	6.56E-04
NB-97	1.20E-04	0.00E+00	1.20E-04
NB-97M	1.16E-05	0.00E+00	1.16E-05
MO-93	2.98E-02	0.00E+00	2.98E-02
MO-99	1.13E-03	1.56E-06	1.13E-03
MO-99+D	1.39E-03	1.57E-06	1.39E-03
TC-99M	3.07E-04	0.00E+00	3.07E-04
TC-97	3.32E-02	3.32E-04	3.35E-02

Table C-2. CAP88PC 300 Area Dose Factors to Onsite Public Worker[(a)] per Unit Ci Released using Hanford-Specific Parameters with 40 m release (mrem/y per Ci/y released)

Radionuclide	Inhalation and External (500 m NW)	Average Individual Ingestion	Total Effective Dose Equivalent (500 m NW)
TC-99	1.58E-03	2.84E-03	4.42E-03
TC-101	3.34E-05	0.00E+00	3.34E-05
RU-97	5.82E-04	3.55E-08	5.82E-04
RU-103	1.45E-02	1.28E-05	1.45E-02
RU-103+D	1.43E-02	1.24E-05	1.43E-02
RU-105	3.05E-04	0.00E+00	3.05E-04
RU-106	9.00E-02	1.92E-04	9.02E-02
RU-106+D	1.38E-01	1.88E-04	1.38E-01
RH-105	2.95E-04	1.81E-06	2.97E-04
RH-105M	2.64E-07	0.00E+00	2.64E-07
RH-106	7.21E-07	0.00E+00	7.21E-07
PD-107	2.40E-03	9.94E-06	2.41E-03
PD-109	3.11E-04	2.49E-07	3.11E-04
AG-109M	3.23E-08	0.00E+00	3.23E-08
AG-110	6.52E-08	0.00E+00	6.52E-08
AG-110M	4.43E-01	7.10E-04	4.44E-01
AG-111	1.37E-03	9.37E-05	1.46E-03
CD-113 (b)	(Pu-241)	(Pu-241)	(Pu-241)
CD-113M (b)	(Pu-241)	(Pu-241)	(Pu-241)
CD-115	1.21E-03	1.46E-06	1.21E-03
CD-115M	8.84E-03	9.48E-05	8.93E-03
IN-113M	4.94E-05	0.00E+00	4.94E-05
IN-115	1.93E-01	2.20E-03	1.95E-01
IN-115M	7.10E-05	0.00E+00	7.10E-05
SN-113	3.23E-03	1.96E-04	3.43E-03
SN-123	5.45E-04	0.00E+00	5.45E-04
SN-125	4.92E-03	6.07E-05	4.98E-03
SN-126	3.30E-01	1.92E-03	3.32E-01
SB-124	7.38E-02	4.62E-05	7.38E-02
SB-125	2.71E-01	1.78E-05	2.71E-01
SB-126	2.53E-02	1.56E-05	2.53E-02
SB-126M	1.75E-04	0.00E+00	1.75E-04
SB-127	2.99E-03	1.07E-06	2.99E-03
TE-125M	2.18E-03	4.35E-05	2.22E-03
TE-127	8.28E-05	0.00E+00	8.28E-05
TE-127M	4.56E-03	1.26E-04	4.69E-03
TE-129	3.23E-05	0.00E+00	3.23E-05
TE-129M	5.33E-03	8.74E-05	5.42E-03

Table C-2. CAP88PC 300 Area Dose Factors to Onsite Public Worker[(a)] per Unit Ci Released using Hanford-Specific Parameters with 40 m release (mrem/y per Ci/y released)

Radionuclide	Inhalation and External (500 m NW)	Average Individual Ingestion	Total Effective Dose Equivalent (500 m NW)
TE-131	6.79E-05	0.00E+00	6.79E-05
TE-131M	2.21E-03	1.07E-07	2.21E-03
TE-132	2.06E-03	1.31E-06	2.06E-03
TE-133	9.02E-05	0.00E+00	9.02E-05
TE-133M	2.98E-04	0.00E+00	2.98E-04
TE-134	1.08E-04	0.00E+00	1.08E-04
I-122	6.81E-05	0.00E+00	6.81E-05
I-123	1.00E-03	1.42E-07	1.00E-03
I-125	1.81E-02	2.96E-03	2.11E-02
I-129	1.66E+00	5.32E-02	1.71E+00
I-130	1.13E-02	9.94E-07	1.13E-02
I-131	3.66E-02	1.46E-03	3.81E-02
I-132	2.36E-03	0.00E+00	2.36E-03
I-133	6.19E-03	1.10E-05	6.20E-03
I-134	1.16E-03	0.00E+00	1.16E-03
I-135	4.18E-03	3.55E-08	4.18E-03
XE-122	7.49E-06	0.00E+00	7.49E-06
XE-123	6.88E-05	0.00E+00	6.88E-05
XE-125	2.75E-05	0.00E+00	2.75E-05
XE-127	2.89E-05	0.00E+00	2.89E-05
XE-131M	1.06E-06	0.00E+00	1.06E-06
XE-133	3.88E-06	0.00E+00	3.88E-06
XE-133M	3.39E-06	0.00E+00	3.39E-06
XE-135	2.75E-05	0.00E+00	2.75E-05
XE-135M	4.00E-05	0.00E+00	4.00E-05
XE-137	1.16E-05	0.00E+00	1.16E-05
XE-138	1.16E-04	0.00E+00	1.16E-04
CS-134	7.38E-01	3.09E-03	7.41E-01
CS-134M	1.31E-05	0.00E+00	1.31E-05
CS-135	8.82E-04	4.47E-04	1.33E-03
CS-136	1.99E-02	1.26E-04	2.00E-02
CS-137	5.84E-03	2.68E-03	8.52E-03
CS-137+D	2.24E+00	2.67E-03	2.24E+00
CS-138	3.10E-04	0.00E+00	3.10E-04
CS-139	2.90E-05	0.00E+00	2.90E-05
BA-133	7.85E-01	3.55E-05	7.85E-01
BA-133M	2.00E-04	1.10E-07	2.00E-04
BA-137M	2.80E-05	0.00E+00	2.80E-05
BA-139	4.09E-05	0.00E+00	4.09E-05

Table C-2. CAP88PC 300 Area Dose Factors to Onsite Public Worker[(a)] per Unit Ci Released using Hanford-Specific Parameters with 40 m release (mrem/y per Ci/y released)

Radionuclide	Inhalation and External (500 m NW)	Average Individual Ingestion	Total Effective Dose Equivalent (500 m NW)
BA-140	2.45E-03	1.77E-05	2.47E-03
BA-140+D	1.99E-02	1.77E-05	1.99E-02
BA-141	9.39E-05	0.00E+00	9.39E-05
BA-142	8.44E-05	0.00E+00	8.44E-05
LA-140	3.63E-03	0.00E+00	3.63E-03
LA-141	8.86E-06	0.00E+00	8.86E-06
LA-142	4.39E-04	0.00E+00	4.39E-04
CE-141	3.55E-03	9.59E-06	3.56E-03
CE-143	9.83E-04	3.55E-08	9.83E-04
CE-144	7.45E-02	1.21E-04	7.46E-02
CE-144+D	7.98E-02	1.21E-04	7.99E-02
PR-143	1.60E-03	7.28E-06	1.61E-03
PR-144	1.69E-05	0.00E+00	1.69E-05
PR-144M	5.14E-06	0.00E+00	5.14E-06
ND-147	2.38E-03	5.33E-06	2.39E-03
PM-147	7.36E-03	1.07E-05	7.37E-03
PM-148	4.15E-03	3.55E-06	4.15E-03
PM-148M	6.46E-02	5.33E-05	6.47E-02
PM-149	6.41E-04	7.10E-08	6.41E-04
PM-151	3.11E-04	0.00E+00	3.11E-04
SM-147	1.42E+01	2.13E-03	1.42E+01
SM-151	5.72E-03	4.26E-06	5.72E-03
SM-153	5.11E-04	0.00E+00	5.11E-04
EU-152	2.55E+00	7.10E-05	2.55E+00
EU-152M	1.15E-04	0.00E+00	1.15E-04
EU-154	2.05E+00	1.07E-04	2.05E+00
EU-155	7.93E-02	1.78E-05	7.93E-02
EU-156	1.53E-02	2.10E-05	1.53E-02
GD-152 (b)	(Pu-239)	(Pu-239)	(Pu-239)
TB-160	5.44E-02	4.62E-05	5.44E-02
HO-166	7.20E-04	0.00E+00	7.20E-04
HO-166M	8.44E+00	0.00E+00	8.44E+00
HF-181	1.83E-02	1.85E-05	1.83E-02
W-181	3.55E-03	1.08E-05	3.56E-03
W-185	1.47E-04	4.92E-05	1.96E-04
W-187	4.96E-04	3.55E-08	4.96E-04
RE-187	1.03E-05	1.29E-06	1.16E-05
IR-192	4.68E-02	2.84E-05	4.68E-02
HG-203	8.59E-03	2.63E-04	8.85E-03
TL-207	1.12E-06	0.00E+00	1.12E-06

Table C-2. CAP88PC 300 Area Dose Factors to Onsite Public Worker[(a)] per Unit Ci Released using Hanford-Specific Parameters with 40 m release (mrem/y per Ci/y released)

Radionuclide	Inhalation and External (500 m NW)	Average Individual Ingestion	Total Effective Dose Equivalent (500 m NW)
TL-208	2.07E-04	0.00E+00	2.07E-04
TL-209	8.98E-05	0.00E+00	8.98E-05
PB-209	1.90E-05	0.00E+00	1.90E-05
PB-210	2.62E+00	3.73E-02	2.66E+00
PB-210+D	2.62E+00	3.73E-02	2.66E+00
PO-210	2.73E-05	4.38E-05	7.11E-05
PB-211	1.70E-03	0.00E+00	1.70E-03
PB-212	3.22E-02	0.00E+00	3.22E-02
PB-214	1.92E-04	0.00E+00	1.92E-04
BI-210	3.70E-02	3.55E-06	3.70E-02
BI-211	7.56E-05	0.00E+00	7.56E-05
BI-212	6.25E-03	0.00E+00	6.25E-03
BI-213	2.42E-04	0.00E+00	2.42E-04
BI-214	2.36E-04	0.00E+00	2.36E-04
PO-210	1.64E+00	1.07E-02	1.65E+00
PO-212 (c)	0.00E+00	0.00E+00	0.00E+00
PO-213 (c)	0.00E+00	0.00E+00	0.00E+00
PO-214 (c)	0.00E+00	0.00E+00	0.00E+00
PO-215 (c)	0.00E+00	0.00E+00	0.00E+00
PO-216 (c)	0.00E+00	0.00E+00	0.00E+00
PO-218	4.76E-06	0.00E+00	4.76E-06
AT-217	0.00E+00	0.00E+00	0.00E+00
RN-219 (e)	4.72E-03	6.72E-05	4.78E-03
RN-220 (e)	4.51E-05	0.00E+00	4.51E-05
RN-222	4.75E-04	0.00E+00	4.75E-04
FR-221	5.13E-04	0.00E+00	5.13E-04
FR-223	4.67E-04	0.00E+00	4.67E-04
RA-223	1.57E+00	1.28E-03	1.57E+00
RA-224	6.67E-01	1.42E-04	6.67E-01
RA-225	7.95E-01	1.39E-03	7.96E-01
RA-226	1.72E+00	9.62E-03	1.73E+00
RA-228	4.63E-01	4.83E-03	4.68E-01
AC-225	1.16E+00	1.07E-04	1.16E+00
AC-227	1.21E+02	2.49E-02	1.21E+02
AC-228	1.65E-02	0.00E+00	1.65E-02
TH-227	2.23E+00	0.00E+00	2.23E+00
TH-228	4.80E+01	3.55E-03	4.80E+01
TH-229	1.34E+02	7.10E-03	1.34E+02
TH-230	4.74E+01	3.55E-03	4.74E+01

Table C-2. CAP88PC 300 Area Dose Factors to Onsite Public Worker[(a)] per Unit Ci Released using Hanford-Specific Parameters with 40 m release (mrem/y per Ci/y released)

Radionuclide	Inhalation and External (500 m NW)	Average Individual Ingestion	Total Effective Dose Equivalent (500 m NW)
TH-231	1.99E-04	0.00E+00	1.99E-04
TH-232	6.84E+01	0.00E+00	6.84E+01
TH-232 +D	8.16E+01	3.75E-03	8.16E+01
TH-234	6.93E-03	3.52E-05	6.97E-03
PA-231	9.15E+01	2.84E-02	9.15E+01
PA-233	5.93E-03	9.94E-06	5.94E-03
PA-234	7.83E-04	0.00E+00	7.83E-04
PA-234M	3.59E-07	0.00E+00	3.59E-07
U-232	9.06E+01	2.13E-02	9.06E+01
U-233	2.52E+01	7.10E-03	2.52E+01
U-234	2.49E+01	1.07E-02	2.49E+01
U-235	2.39E+01	7.10E-03	2.39E+01
U-236	2.36E+01	7.10E-03	2.36E+01
U-237	1.42E-03	3.13E-06	1.42E-03
U-238	2.22E+01	7.10E-03	2.22E+01
U-240	4.74E-04	0.00E+00	4.74E-04
NP-237	9.26E+01	2.49E-02	9.26E+01
NP-238	6.87E-03	0.00E+00	6.87E-03
NP-239	8.18E-04	3.55E-08	8.18E-04
NP-240	1.83E-04	0.00E+00	1.83E-04
NP-240M	3.01E-05	0.00E+00	3.01E-05
PU-236	1.66E+01	2.49E-03	1.66E+01
PU-238	5.99E+01	2.13E-02	5.99E+01
PU-239	6.44E+01	2.49E-02	6.44E+01
PU-240	6.43E+01	2.13E-02	6.43E+01
PU-241	9.80E-01	4.62E-04	9.80E-01
PU-241+D	9.83E-01	4.63E-04	9.83E-01
PU-242	6.12E+01	2.13E-02	6.12E+01
PU-243	4.97E-05	0.00E+00	4.97E-05
PU-244	6.08E+01	2.49E-02	6.08E+01
AM-241	1.02E+02	2.49E-02	1.02E+02
AM-242	1.14E-02	0.00E+00	1.14E-02
AM-242M	9.86E+01	2.49E-02	9.86E+01
AM-243	1.03E+02	2.13E-02	1.03E+02
CM-242	3.38E+00	7.10E-04	3.38E+00
CM-243	6.89E+01	1.78E-02	6.89E+01
CM-244	5.41E+01	1.42E-02	5.41E+01
CM-245	1.06E+02	2.84E-02	1.06E+02
CM-246	1.05E+02	2.49E-02	1.05E+02

Table C-2. CAP88PC 300 Area Dose Factors to Onsite Public Worker[(a)] per Unit Ci Released using Hanford-Specific Parameters with 40 m release (mrem/y per Ci/y released)

Radionuclide	Inhalation and External (500 m NW)	Average Individual Ingestion	Total Effective Dose Equivalent (500 m NW)
CM-247	9.76E+01	2.49E-02	9.76E+01
CM-248	3.85E+02	7.10E-02	3.85E+02
CF-252	2.92E+01	3.55E-03	2.92E+01

(a) Worker assumed to work full 8766 h/y.
(c) Dose factors not included in the CAP88PC library. Suggest using unit dose from radionuclide in parentheses.
(c) Very short-lived radionuclide. Dose is zero for onsite public worker.
(d) "+D" designation indicates the doses from grown-in progeny are included in the reported dose.
(e) Short-lived Rn isotopes were modeled based on the dose from their longer-lived progeny. For each Ci of Rn-219 released, 0.0018 Ci of Pb-210 is generated. Each Ci of Rn-220 produces 0.0014 Ci of Pb-212. Dose is based on the Pb progeny times the appropriate equilibrium factor (Hill and Rittman 1999).

ATTACHMENT 1

CAP88PC OUTPUT
for
MPR run to show input parameters

Note: The document has been changed from the original.
It has been annotated and reformatted to fit on fewer sheets.
Do not use doses in this attachment for compliance purposes.

C A P 8 8 - P C

Version 1.00

Clean Air Act Assessment Package - 1988

S Y N O P S I S R E P O R T

Non-Radon Individual Assessment
Mar 30, 2001 1:31 pm

Facility: WORKER 300 10 mat 100 m DATASET3
Address: BATTELLE PNL
POB 999
City: RICHLAND
State: WA Zip: 99352

Effective Dose Equivalent
(mrem/year)

1.75E+02 - this includes doses from other radionuclides and should not be used for compliance.

At This Location: 100 Meters Northwest

Source Category: 10.0M STACK UNIT CI AIRBORNE RELEASE
Source Type: Stack
Emission Year:

Comments: WORKER MI use NW

Dataset Name: b1324 10m set3
Dataset Date: Mar 30, 2001 11:32 am
Wind File: WNDFILES\HS30010.WND

C A U T I O N: Defaults Have Been Changed

C A U T I O N !

The Following DEFAULT VALUES Have Been Changed By The User.

These changes CANNOT BE USED to demonstrate compliance per 40 CFR 61.93(a) unless specifically approved by EPA[1].

Inhalation Rate of Man

Changed From: 9.1670E+05
To: 9.7000E+05

Fraction Radioactivity on Veg. & Prod. after Washing

Changed From: 0.5000
To: 1.000

Ingestion Rate of Meat by Man

Changed From: 85.00
To: 98.00

Ingestion Rate of Leafy Veg. by Man

Changed From: 18.00
To: 30.00

Ingestion Rate of Milk by Man

Changed From: 112.0
To: 270.0

Ingestion Rate of Produce by Man

Changed From: 176.0
To: 220.0

Fraction Time Spent Swimming

Changed From: 0.0000
To: 1.0000E-02

Fraction Year Animals Graze on Pasture

Changed From: 0.4000
To: 0.7500

Fraction Animals Daily Feed is Pasture Grass

Changed From: 0.4300
To: 1.000

[1] Permission to use Hanford-specific parameters granted in letter from DE Hardesty, EPA, to JH Hebdon, DOE-RL, dated March 22, 2001, Subject: U.S. Environmental Protection Agency's third response to the new maximally exposed individual definition.

The Following DEFAULT VALUES Have Been Changed By The User (Continued):

Removal Rate Constant - Physical Loss by Weathering

Changed From: 2.9000E-03
To: 3.0000E-03

Effec. Surface Density of Soil, Dry Weight

Changed From: 215.0
To: 224.0

Fallout interception Fraction-Pasture

Changed From: 0.5700
To: 0.2500

Fallout Interception Fraction-Vegetable

Changed From: 0.2000
To: 0.2500

Period Exposure - Growing Season - Crops/Leafy Veg.

Changed From: 1440.
To: 2160.

Time Delay - Ingestion Stored Feed

Changed From: 2160.
To: 2400.

Time Delay - Ingestion Leafy Veg. - Man

Changed From: 336.0
To: 24.00

Time Delay - Ingestion Produce - Man

Changed From: 336.0
To: 120.0

Avg. Time - Slaughter to Consumption

Changed From: 20.00
To: 15.00

The Following DEFAULT VALUES Have Been Changed By The User (Continued):

Agr. Productivity by Unit Area - Milk

Changed From: 0.2800
To: 0.3000

Agr. Productivity by Unit Area - Prod/Leafy Veg.

Changed From: 0.7160
To: 2.000

Period Long-term Buildup in Soil

Changed From: 100.0
To: 50.00

Direction Single Location - Individual Calculation

Changed From: 0
To: 3

Distance Single Location - Individual Calculation

Changed From: 0
To: 1

Ground Surface Correction Factor

Changed From: 0.5000
To: 1.000

MAXIMALLY EXPOSED INDIVIDUAL

NOTE: This page is for information only, and includes data from other radionuclides than those used in this calculation. This should not be used for compliance.

Location Of The Individual: 100 Meters Northwest
Lifetime Fatal Cancer Risk: 4.26E-03

ORGAN DOSE EQUIVALENT SUMMARY

Organ	Dose Equivalent (mrem/y)
GONADS	1.96E+02
BREAST	1.80E+02
R MAR	1.65E+02
LUNGS	1.82E+02
THYROID	1.85E+02
ENDOST	1.71E+02
RMNDR	1.55E+02
EFFEC	1.75E+02

RADIONUCLIDE EMISSIONS DURING THE YEAR

Nuclide	Class	Size	Source #1 Ci/y	TOTAL Ci/y
.				
.				
.				
TC-99	W	1.00	1.0E+00	1.0E+00
.				
.				
.				

SITE INFORMATION

Temperature: 12 degrees C
Precipitation: 16 cm/y
Mixing Height: 1000 m

SOURCE INFORMATION

Source Number: 1

Stack Height (m): 10.00
Diameter (m): 0.00

Plume Rise Pasquill Cat:	A	B	C	D	E	F	G
Fixed (m): (Fixed Rise)	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

AGRICULTURAL DATA

	Vegetable	Milk	Meat
Fraction Home Produced:	0.000	0.000	0.000
Fraction From Assessment Area:	0.000	0.000	0.000
Fraction Imported:	1.000	1.000	1.000

Food Arrays were not generated for this run.
Default Values used.

DISTANCES USED FOR MAXIMUM INDIVIDUAL ASSESSMENT
100

ATTACHMENT 2

CAP88PC OUTPUT
for
Population run to show input parameters

Note: The document has been changed from the original.
It has been annotated and reformatted to fit on fewer sheets.
Do not use doses in this attachment for compliance purposes.

C A P 8 8 - P C

Version 1.00

Clean Air Act Assessment Package - 1988

S Y N O P S I S R E P O R T

Non-Radon Population Assessment

Mar 30, 2001 4:19 pm

Facility: pop w/ 300 10 m DATASET3

Address: BATTELLE PNL

POB 999

City: RICHLAND

State: WA Zip: 99352

Effective Dose Equivalent (mrem/year)
1.86E+01

At This Location: 800 Meters Northeast

Source Category: 10.0M STACK UNIT CI AIRBORNE RELEASE

Source Type: Stack

```
  Emission Year:


Comments:  pop w/  use defaultp.han


   Dataset Name:  p 324 10m set3
   Dataset Date:  May 16, 2000   2:24 pm
      Wind File:  WNDFILES\HS30010.WND
Population File:  POPFILES\HAN30090.POP


        C A U T I O N:  Defaults Have Been Changed
            (Changes Detailed on Next Page)
```

C A U T I O N !

The Following DEFAULT VALUES Have Been Changed By The User.

These changes CANNOT BE USED to demonstrate compliance per 40 CFR 61.93(a) unless specifically approved by EPA.

Inhalation Rate of Man

Changed From: 9.1670E+05
To: 9.7000E+05

Fraction Radioactivity on Veg. & Prod. after Washing

Changed From: 0.5000
To: 1.000

Ingestion Rate of Meat by Man

Changed From: 85.00
To: 79.00

Ingestion Rate of Leafy Veg. by Man

Changed From: 18.00
To: 15.00

Ingestion Rate of Milk by Man

Changed From: 112.0
To: 230.0

Ingestion Rate of Produce by Man

Changed From: 176.0
To: 140.0

Fraction Time Spent Swimming

Changed From: 0.0000
To: 1.0000E-02

Fraction Produce Ingested From Garden of Interest

Changed From: 1.000
To: 0.2500

Fraction Leafy Veg. From Garden of Interest

Changed From: 1.000
To: 0.2500

The Following DEFAULT VALUES Have Been Changed By The User (Continued):

Fraction Year Animals Graze on Pasture

Changed From: 0.4000
To: 0.7500

Fraction Animals Daily Feed is Pasture Grass

Changed From: 0.4300
To: 1.000

Removal Rate Constant - Physical Loss by Weathering

Changed From: 2.9000E-03
To: 3.0000E-03

Effec. Surface Density of Soil, Dry Weight

Changed From: 215.0
To: 224.0

Fallout interception Fraction-Pasture

Changed From: 0.5700
To: 0.2500

Fallout Interception Fraction-Vegetable

Changed From: 0.2000
To: 0.2500

Period Exposure - Growing Season - Crops/Leafy Veg.

Changed From: 1440.
To: 2160.

Time Delay - Ingestion Stored Feed

Changed From: 2160.
To: 2400.

Avg. Time - Slaughter to Consumption

Changed From: 20.00
To: 34.00

The Following DEFAULT VALUES Have Been Changed By The User
(Continued):

Agr. Productivity by Unit Area - Milk

Changed From: 0.2800
To: 0.3000

Agr. Productivity by Unit Area - Prod/Leafy Veg.

Changed From: 0.7160
To: 2.000

Period Long-term Buildup in Soil

Changed From: 100.0
To: 50.00

MAXIMALLY EXPOSED INDIVIDUAL

Location Of The Individual: 800 Meters Northeast
NOT USED IN THIS ASSESSMENT
Lifetime Fatal Cancer Risk: 4.55E-04

ORGAN DOSE EQUIVALENT SUMMARY

Organ	Selected Individual (mrem/y)	Collective Population (person-rem/y)
GONADS	1.86E+01	3.70E+01
BREAST	1.67E+01	3.32E+01
R MAR	1.85E+01	3.64E+01
LUNGS	2.02E+01	3.93E+01
THYROID	1.95E+01	3.86E+01
ENDOST	1.87E+01	3.69E+01
RMNDR	1.89E+01	3.73E+01
EFFEC	1.86E+01	3.67E+01

FREQUENCY DISTRIBUTION OF LIFETIME FATAL CANCER RISKS

Risk Range	Number of People	Number of People In This Risk Range Or Higher	Deaths/Year In This Risk Range	Deaths/Year In This Risk Range Or Higher
1.0E+00 TO 1.0E-01	0	0	0.00E+00	0.00E+00
1.0E-01 TO 1.0E-02	0	0	0.00E+00	0.00E+00
1.0E-02 TO 1.0E-03	0	0	0.00E+00	0.00E+00
1.0E-03 TO 1.0E-04	28	28	7.75E-05	7.75E-05
1.0E-04 TO 1.0E-05	21532	21560	4.23E-03	4.30E-03
1.0E-05 TO 1.0E-06	145448	167008	7.62E-03	1.19E-02
LESS THAN 1.0E-06	114578	281586	7.40E-04	1.27E-02

RADIONUCLIDE EMISSIONS DURING THE YEAR

Nuclide	Class	Size	Source #1 Ci/y	TOTAL Ci/y
.				
.				
.				
TC-99	W	1.00	1.0E+00	1.0E+00
.				
.				
.				

SITE INFORMATION

Temperature: 12 degrees C
Precipitation: 16 cm/y
Mixing Height: 1000 m

SOURCE INFORMATION

Source Number: 1

Stack Height (m): 10.00
Diameter (m): 0.00

Plume Rise Pasquill Cat:	A	B	C	D	E	F	G
Fixed (m): (Fixed Rise)	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

AGRICULTURAL DATA

	Vegetable	Milk	Meat
Fraction Home Produced:	1.000	1.000	1.000
Fraction From Assessment Area:	0.000	0.000	0.000
Fraction Imported:	0.000	0.000	0.000

Beef Cattle Density: 5.62E-02
Milk Cattle Density: 1.50E-02
Land Fraction Cultivated for Vegetable Crops: 5.20E-02

POPULATION DATA

Direction	Distance (m) 800	2400	4000	5600	7200	12000	24000
N	0	0	0	2	6	85	602
NNW	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0
W	0	0	0	0	0	0	730
WSW	0	0	0	0	0	967	3238
SW	0	0	0	0	59	2364	2916
SSW	0	0	0	0	297	3518	3788
S	0	0	3	198	2231	17726	12449
SSE	0	7	18	25	121	616	57047
SE	2	11	18	25	33	277	15318
ESE	2	11	18	25	33	264	117
E	3	11	18	25	33	276	170
ENE	2	11	18	25	33	277	754
NE	1	11	18	25	33	277	827
NNE	0	3	16	25	33	277	678

Direction	Distance (m) 40000	56000	72000
N	4203	2894	9998
NNW	273	1277	1153
NW	181	1279	1428
WNW	417	1703	2120
W	1669	16968	12843
WSW	5812	13516	713
SW	1619	311	763
SSW	288	651	1859
S	123	13473	10913
SSE	4098	3779	4785
SE	3337	1322	3257
ESE	454	878	10548
E	255	761	1001
ENE	741	480	535
NE	1094	590	306
NNE	2242	2411	1218