BSC	**Calculation/Analysis Change Notice** *Complete only applicable items.*	1. QA: QA 2. Page 1 of ~~18~~ 19 DOD 3/28/08

3. Document Identifier: 000-00C-MGR0-00900-000	4. Rev.: 00E	5. CACN: 001

6. Title:
Preclosure Consequence Analyses

7. Reason for Change:
This calculation determines the consequences from normal operations and event sequences from surface and subsurface facilities during the preclosure period. This CACN is needed because CR11900 identified two errors in calculation 000-PSA-MGR0-01200-000-00B, *GROA Airborne Release Dose Calculation* that provides onsite normal operation airborne release dose inputs to this calculation. The first error involves using an incorrect χ/Q value for five facilities; the second error involves using PWR results instead of BWR results in the summation of the doses. The overall effect is a slight increase in the resultant doses. Results from the *GROA Airborne Release Dose Calculation* are also used in calculation 000-PSA-MGR0-01400-000-00B, *GROA Worker Dose Calculation*, which is another input to this calculation. Both the *GROA Airborne Release Dose Calculation* and the *GROA Worker Dose Calculation* have been revised to correct the errors.

In addition, this CACN updates several references that were recently revised and updates Assumption 3.2.14, Tables 17, 18, 19, and Table 21 to clarify exposure periods used in dose calculations. Minor editorial changes are also implemented.

8. Supersedes Change Notice:	☐ Yes	If, Yes, CACN No.: ________	☒ No

9. Change Impact:

Inputs Changed:	☒ Yes	☐ No	Results Impacted:	☒ Yes	☐ No
Assumptions Changed:	☒ Yes	☐ No	Design Impacted:	☐ Yes	☒ No

10. Description of Change:

There is no change to the calculation method and conclusions of this calculation by this CACN001 due to the changes to inputs from the *GROA Airborne Release Dose Calculation* and from the *GROA Worker Dose Calculation.*

Affected calculation pages: 24, 26, 36–38, 40, 53, (DOD 3/28/08) 59, 73, 78–80, 82–84, 88, 133, 151

Added pages: none

The detailed changes to the calculation are presented in the following pages to be inserted into this calculation.

11. REVIEWS AND APPROVAL

Printed Name	Signature	Date
11a. Originator: J. Schulz	[signature] for J. Schulz	3/27/2008
11b. Checker: D. T. Dexheimer	[signature]	3/27/08
11c. EGS: S. S. Tsai	[signature]	3/27/2008
11d. DEM: D. Beckman M. FRANK FOR	[signature]	3/28/08
11e. Design Authority: B. Rusinko	[signature]	3/28/08

2.2.8 NRC (Nuclear Regulatory Commission) 2003. "Spent Fuel Project Office Interim Staff Guidance - 5, Revision 1. Confinement Evaluation." SFPO-ISG-5, Rev. 1. Washington, D.C.: U.S. Nuclear Regulatory Commission. Accessed January 24, 2003. ACC: MOL.20030124.0247. http://www.nrc.gov/reading-rm/doc-collections/isg/spent-fuel.html. [DIRS 160582]

2.2.9 NRC 2007. *Preclosure Safety Analysis - Dose Performance Objectives and Radiation Protection Program*. HLWRS-ISG-03. Washington, D.C.: Nuclear Regulatory Commission. Internet Accessible. [DIRS 182588]

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2.2.11 Slade, D.H., ed. 1968. *Meteorology and Atomic Energy 1968*. TID-24190. Washington, D.C.: Air Resources Laboratories. TIC: 243832. [DIRS 107697]

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2.2.13 BSC 2007. *Shielding Requirements and Dose Rate Calculations for WHF and LLW*. 050-00C-WH00-00300-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20071130.0017.

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2.2.15 DOE (U.S. Department of Energy) 2007. *Software Validation Report for: GENII Version 2.05*. Document ID: 11211-SVR-2.05-02-WinXP. Las Vegas, Nevada: U.S. Department of Energy, Office of Repository Development. ACC: MOL.20071009.0112. [DIRS 183404]

2.2.16 40 CFR 191. 2007. Protection of Environment: Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes. Internet Accessible. [DIRS 184252]

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2.2.18 Napier, B.A. 2007. *GENII Version 2 Users' Guide*. PNNL-14583, Rev. 2. Richland, Washington: Pacific Northwest National Laboratory. ACC: MOL.20070314.0029. [DIRS 179907]

2.2.19 NRC 2000. *Standard Review Plan for Spent Fuel Dry Storage Facilities*. NUREG-1567. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 247929. [DIRS 149756]

2.2.32 BSC 2007. *Release Fractions for Spent Nuclear Fuel and High-Level Waste.* 000-00C-MGR0-03400-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20071105.0010.

2.2.33 BSC 2007. *Source Terms for HLW Glass Canisters.* 000-00C-MGR0-03500-000-00B. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20080130.0002.

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2.2.35 Baum, E.M.; Knox, H.D.; and Miller, T.R. 2002. *Nuclides and Isotopes.* 16th edition. [Schenectady, New York]: Knolls Atomic Power Laboratory. TIC: 255130. [DIRS 175238]

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2.2.39 BSC 2008. *GROA Worker Dose Calculation.* 000-PSA-MGR0-01400-000-00C. Las Vegas, Nevada: Bechtel SAIC Company.

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2.2.41 BSC 2007. *Aging Facility General Arrangement Aging Pad Area Plan.* 170-P10-AP00-00101-000-00C. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20071126.0018.

2.2.42 Regulatory Guide 1.183. 2000. *Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors.* Washington, D.C.: U.S. Nuclear Regulatory Commission. ACC: MOL.20050518.0242. [DIRS 173584]

2.2.43 ICRP (International Commission on Radiological Protection) 1996. *Age-Dependent Doses to Members of the Public from Intake of Radionuclides: Part 5 Compilation of Ingestion and Inhalation Dose Coefficients.* Volume 26, No. 1 of Annals of the ICRP. Smith, H., ed. ICRP Publication 72. New York, New York: Pergamon Press. TIC: 235870. [DIRS 152446]

3.2.11 Ingestion Doses

Offsite members of the public in the general environment receive a dose due to the ingestion of contaminated food and soil. Onsite radiation workers, onsite members of the public, and offsite members of the public not in the general environment do not receive a dose through the ingestion pathway.

Rationale: Radionuclides from an airborne release are depleted as the plume travels and is dispersed. The radionuclides are deposited on the soil, and on the vegetation, which can then be ingested by animals and people. Ground vegetation can also absorb the radionuclides from the soil and water as it grows, after which animals and people may ingest it. The ingestion dose is calculated from this ingestion intake of food crops and animal products containing nuclide concentrations as a result of an airborne release. No ingestion of contaminated food is expected for onsite radiation workers, onsite members of the public and offsite members of the public not in the general environment. Thus, ingestion dose is only calculated for offsite public in the general environment.

3.2.12 Bounding Fire Event Sequence

The bounding Category 2 fire event consists of a fire in the LLWF that consumes the entire combustible LLW inventory in the LLWF and damages the HEPA filters staged in B-25 boxes.

Rationale: The LLWF inventory includes combustible dry active waste (DAW) in bags and drums; WHF pool filters in HICs; WHF spent resins in HICs; and non-combustible waste including empty dual-purpose canisters (DPCs); the contents of the liquid waste collection tanks, and HEPA filters in B-25 boxes. Including the entire combustible inventory in the fire is conservative. It is unlikely that an actual fire could consume all the combustible material because (1) some of it is in non-flammable containers, (2) internal walls and building structure may prevent the spread of the fire to some of the waste, and (3) some waste containers may be stored in such a way that enough oxygen to support combustion cannot reach all of the containers.

3.2.13 Breathing Rates for Onsite Public and Public not in the General Environment

The breathing rate for the onsite public and the public located beyond the site boundary but not in the general environment, which is the acute breathing rate determined in Reference 2.2.10 and shown in Table 16, is used for normal releases and Category 1 and Category 2 event sequences.

Rationale: Because no one can live onsite or offsite not in the general environment (i.e. in the Nevada Test Site or in the Nevada Test and Training Range) individuals in these locations are workers or visitors that are performing various activities. Therefore, it is appropriate to use the higher breathing rate considered for the calculation of doses from acute releases.

3.2.14 Fraction of a Day Outdoor Inhalation and Air Submersion Occurs for Event Sequences

For evaluating event sequence dose consequences involving inhalation and air submersion, the fraction of the day that outdoor inhalation and air submersion occurs is 1.0 for short duration events, such as burst or drop events. For long duration release events such as oxidation, a fraction of a day value of 0.35 is used for receptors with exposure periods based on a normal work schedule.

Rationale: The exposure period applies to inhalation and outdoor air submersion. For short duration events it is appropriate and conservative to consider that the affected individuals will be exposed outdoors for the entire exposure period. For long duration exposures, such as oxidation events, it is bounding to have a member of the public in the general environment spend the entire exposure period outdoors because it maximizes the exposure to contaminated outdoor air. For other receptors in which individuals are in a work environment, the exposure period is based on a normal work schedule of 8.5 hours per day (i.e. 0.35 fraction of a day).

3.2.15 Fall Season for Event Sequence Release Timing

In modeling the dose consequences from an event sequence, a fall season event is assumed and the input to the GENII model (Section 4.3.3) is September 1, at 0 hour.

Rationale: Ingestion exposure pathways include local farm products, local animal products, and inadvertent soil intake. As the radioactive plume passes, radionuclides deposit on the ground and directly contaminate soil and vegetation. Vegetation can also become contaminated indirectly by uptake of radionuclides from the soil during the growing season, during which radioactive decay occurs. The Category 2 event sequence exposure time is 30 days (Assumption 3.2.3), which is shorter than the growing season for most farm produce. A fall season event is modeled in the GENII code (Reference 2.2.12) because it occurs immediately before the harvest of the farm produce contaminated by the plume passage. This modeling approach yields the shortest time for radioactive decay, which maximizes the amount of radioactive material available for ingestion and thereby results in the highest calculated ingestion dose. Thus, this assumption is conservative.

3.2.16 HEPA Filter Replacement Schedule

It is assumed that the HEPA filters are replaced every 18 months.

Rationale: Radionuclide buildup occurs on the HEPA filters in the WHF during normal operations. Reference 2.2.13, Sections 3.1.9 and 6.1.6.7 gives a replacement schedule of 10 months in order to maintain the filters as Class C low-level waste. By assuming that the filters are replaced on an 18-month schedule, additional filter loading occurs resulting in higher concentrations of radionuclides and higher doses from accidents involving these filters.

3.3 ASSUMPTIONS NOT REQUIRING VERIFICATION THAT RESULT IN DESIGN OR OPERATIONAL REQUIREMENTS

3.3.1 Maximum Annual Receipt Rate

The nominal annual receipt rate of commercial SNF and HLW of 3,000 metric tons of heavy metal (MTHM) (Reference 2.2.14, Section 2.2.1.2) is conservatively increased by a factor of 20%.

Rationale: For the purposes of this calculation a maximum annual receipt rate of 3,600 MTHM of commercial SNF provides additional margin in the calculation of doses from normal operation releases. Therefore, this is a conservative assumption.

3.3.2 Primary Confinement Ventilation and Filtration Availability

The ventilation system and HEPA filters for all facilities except the IHF and Subsurface must be available for the duration of the event (30 days for Category 2 event sequences).

Rationale: The doses calculated in Sections 6.6 and 6.8 are based on HEPA filtration for the duration of the event. Per Assumption 3.2.3 the exposure duration for Category 2 event sequences is 30 days; therefore, the ventilation system and HEPA filtration must be available for at least 30 days from the onset of the event.

3.3.3 Doses to Onsite Public and Workers from Ground Contamination

Doses to onsite public and workers from ground contamination are not considered.

Rationale: The surface and subsurface facilities are under the control of the licensee and are monitored for potential radiation contamination. If elevated radiation levels are found, appropriate remedial steps will be taken to reduce the radiation levels.

Title: Excel
Version/Revision Number: Microsoft® Excel 2003, SP2 or SP3
This version is installed on Dell Optiplex GX620 and 745 personal computers running Microsoft® Windows XP with CPU numbers YMP004480 and YMP005050, respectively.

User-defined formulas, inputs, and results are documented in sufficient detail in Sections 4 and 6 to allow an independent checker to reproduce or verify the results without recourse to the originator. This information was verified by checks using hand calculations.

The Excel files used to perform the calculations are included in Appendix XI (Appendix X gives the file information for Appendix XI).

4.3 COMPUTATIONAL METHOD

Radiation doses from normal operations are conservatively estimated and include exposures due to releases of radioactive gases, volatile species, and particulates from surface and subsurface facility operations, as well as direct exposure from contained radiation sources within transportation casks, aging overpacks, shielded transfer casks, waste packages, and surface facilities and buildings. Preclosure dose analyses for airborne releases do not include ^{222}Rn and its daughter products that are part of the normal background radiation environment. The potential contribution to dose from ^{222}Rn and its daughter products is excluded by 10 CFR 20.1101(d) (Reference 2.2.2) for air emissions. The potential contribution to dose from offsite transportation is also not included, because it is excluded from the definition of management in 40 CFR 191.2 (Reference 2.2.16) as cited by 10 CFR 63.204 (Reference 2.2.1). This exclusion also applies to the rail transportation support facilities planned to be in the immediate vicinity of the site.

10 CFR Part 20, 10 CFR 63.111(a), 10 CFR 63.111(b), and 10 CFR 63.204 (References 2.2.1 and 2.2.2) establish preclosure performance objectives applicable to radiation workers and members of the public; numerical guides for design objectives are provided for:

- Total effective dose equivalent (TEDE)
- Total organ dose equivalent (TODE), which is the sum of the committed dose equivalent (CDE) plus the deep dose equivalent (DDE)
- Shallow dose equivalent to skin (SDE)
- Lens dose equivalent (LDE).

Two categories of individuals are relevant for the application of performance objectives and operational dose constraints: (1) radiation workers, who are individuals receiving occupational doses and (2) members of the public. Radiation workers are personnel who are assigned duties that involve exposure to radiation and/or to radioactive material. Members of the public include any individual not receiving an occupational dose. The members of the public are further divided into three subcategories: (1) members of the public in the general environment, (2) members of the public offsite but not in the general environment, and (3) onsite members of the public including construction workers.

4.4 NORMAL OPERATIONS AND EVENT SEQUENCES

This section discusses radionuclide releases from normal operations and event sequences. Waste forms involved in normal operations and in event sequences include pressurized water reactor (PWR) or boiling water reactor (BWR) SNF, LLW, and HLW.

Airborne release radiological dose consequences to the public are calculated for several offsite and onsite locations: offsite public in the general environment, offsite public not in the general environment, onsite construction worker locations, and other onsite public areas. The highest onsite public doses are reported in Section 7 and compared after aggregation with Category 1 event sequence doses to the dose performance objectives in Table 1. Additionally, onsite public doses are calculated at 60 m (Reference 2.2.23, Section 3.2.7) from the surface facilities and 100 m (Reference 2.2.23, Section 3.2.7) from the subsurface exhaust shafts.

4.4.1 Normal Operations

Normal operations include surface operations and subsurface operations. Potential radiation doses from normal operations result from airborne releases of radioactive gases, volatile species, and particulates; resuspension of radioactive contamination remaining on the external surfaces of contained sources; neutron activation of air and silica dust inside the emplacement drifts that could become airborne, resuspension of waste package surface contamination during normal operations; as well as direct exposure from contained waste forms (calculated in other analyses). There are no liquid releases from the facilities to the environment. The maximum annual average χ/Q values at each of the four locations are used for determining the dose from normal operations.

4.4.1.1 Normal Surface Operations

Waste handling operations are performed in the GROA near the North Portal where the surface facilities are located. Radiation doses from normal surface operations can result from resuspension of radioactive contamination from external surfaces of contained sources, airborne releases from opening contained sources, and direct exposure from contained sources.

All naval SNF and approximately 98% of the Department of Energy (DOE) HLW are received in sealed canisters inside transportation casks. Approximately 90% of the commercial SNF is received in sealed canisters inside transportation casks. These canisters are placed inside waste packages for emplacement or aging overpacks for aging or transferring between buildings (Reference 2.2.14, Section 1.2.2 and Design Input 6.1.1.4). No airborne releases occur from these contained sources during normal operations. Radiation surveys of the external surfaces of aging overpacks and transportation casks are performed. Decontamination of these external surfaces is performed, if necessary. Surface contamination, however small, can be resuspended and contribute to normal operational doses. Resuspension of surface contamination of contained sources is discussed in Design Input 6.1.2.5 and in Section 6.7.3.

Direct radiation dose is a result of exposure to contained sources. Exposure of the public to the canisters that contain SNF and HLW is precluded by the shielding design of the facilities and the use of remote operations within facilities. There is potential for direct exposures to onsite individuals for operations involving shielded casks and overpacks. Due to the distance from the

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Table 9. Annual Releases from Subsurface Facility Normal Operation

Normal Operations Release (Ci/yr)	
Waste Package Surface Contamination[a]	
^{241}Am	4.9×10^{-5}
^{243}Am	5.5×10^{-7}
^{243}Cm	2.6×10^{-7}
^{244}Cm	3.4×10^{-5}
^{60}Co (crud)	2.9×10^{-3}
^{60}Co	7.8×10^{-6}
^{137}Cs	6.8×10^{-3}
^{154}Eu	1.7×10^{-5}
^{63}Ni	6.3×10^{-6}
^{147}Pm	3.0×10^{-6}
^{238}Pu	5.7×10^{-5}
^{239}Pu	4.4×10^{-6}
^{240}Pu	7.9×10^{-6}
^{241}Pu	6.2×10^{-4}
^{151}Sm	5.3×10^{-6}
^{90}Sr	6.8×10^{-4}
^{90}Y	6.8×10^{-4}
Activated Air[b]	
^{41}Ar	1.5×10^{1}
^{16}N	5.8
Activated Dust[c]	
^{28}Al	4.0×10^{-3}
^{55}Fe	8.2×10^{-5}
^{42}K	8.0×10^{-4}
^{16}N	2.1×10^{-5}
^{24}Na	3.7×10^{-3}
^{31}Si	5.2×10^{-4}

Source: Reference 2.2.34, [a]Table II-2, [b]Table III-1 (as modified by CACN001 to Reference 2.2.34), and [c]Table III-4 (as modified by CACN001 to Reference 2.2.34)

6.1.2.5 Potential Aging Facility Releases

Airborne effluents from the Aging Facility under normal operations are the surface contamination resuspended from TAD canisters and DPCs inside aging overpacks. The nonfixed (removable) radioactive surface contamination is based on 1×10^{-4} μCi/cm^2 for beta-gamma emitters and low-toxicity alpha emitters and 1×10^{-5} μCi/cm^2 for all other alpha emitters. To simplify the calculation, ^{60}Co is used to bound the dose contribution of beta-gamma emitters and low-toxicity alpha emitters and ^{241}Am is used to bound the dose contribution of all other alpha emitters. The release rate for ^{60}Co is 2.89×10^{-2} Ci/yr and the release rate for ^{241}Am is 2.89×10^{-3} Ci/yr (Reference 2.2.36, Section 3.2.1 and Table 10).

6.1.5 Potential Radiation Worker Dose Results

6.1.5.1 Radiation Worker Doses from Airborne Releases

Doses to radiation workers from airborne releases were determined for the releases from the WHF, subsurface releases due to activation of air and silica dust and resuspension of waste package surface contamination, and resuspension of surface contamination from aging casks on the aging pads to workers located throughout the site. Radiation workers located at the WHF received the highest dose from airborne releases, which are shown in Table 13 (Reference 2.2.36, Table 15).

Table 13. Airborne Release Radiation Worker Dose Results

Facility Number	Facility Name	Total Effective Dose Equivalent (mrem/yr)	Total Organ Dose Equivalent[a] (mrem/yr)	Skin (mrem/yr)	Lens (mrem/yr)
60	Canister Receipt and Closure Facility-1	2.88×10^{-1}	6.37	1.63	1.92
70	Canister Receipt and Closure Facility-2	2.07×10^{-1}	6.63	5.08×10^{-1}	7.15×10^{-1}
80	Canister Receipt and Closure Facility-3	1.98×10^{-1}	6.77	3.50×10^{-1}	5.48×10^{-1}
200	Receipt Facility	2.54×10^{-1}	6.46	1.16	1.41
50	Wet Handling Facility	1.53×10^{1}	1.86×10^{2}	1.37×10^{2}	1.53×10^{2}
51A	Initial Handling Facility	1.34×10^{-1}	2.85	7.49×10^{-1}	8.83×10^{-1}
160	Low-Level Waste Facility	2.66×10^{-1}	4.99	1.77	2.04
17RE	Aging Pad R – East	2.75×10^{-1}	9.37	5.21×10^{-1}	7.96×10^{-1}
17RW	Aging Pad R - West	1.47×10^{-1}	4.10	5.28×10^{-1}	6.75×10^{-1}
17PN	Aging Pad P – North	1.97×10^{-1}	6.69	3.53×10^{-1}	5.49×10^{-1}
17PS	Aging Pad P – South	2.83×10^{-1}	1.00×10^{1}	4.24×10^{-1}	7.08×10^{-1}
IS2	Intake Shaft 2	2.48×10^{-2}	5.52×10^{-1}	1.60×10^{-2}	4.08×10^{-2}
IS3	Intake Shaft 3	3.50×10^{-2}	7.52×10^{-1}	2.34×10^{-2}	5.84×10^{-2}
IS4	Intake Shaft 4	4.40×10^{-2}	8.82×10^{-1}	2.91×10^{-2}	7.31×10^{-2}
NC	North Construction Portal	3.56×10^{-2}	9.05×10^{-1}	1.21×10^{-1}	1.57×10^{-1}
NP	North Portal	1.27×10^{-1}	2.54	7.60×10^{-1}	8.87×10^{-1}
SP	South Portal	8.22×10^{-2}	1.44	5.25×10^{-1}	6.07×10^{-1}
220	Heavy Equipment Maintenance Facility	1.55×10^{-1}	3.02	9.71×10^{-1}	1.13
240	Central Communications Control Facility	1.23×10^{-1}	3.14	5.16×10^{-1}	6.39×10^{-1}
230	Warehouse and Non-Nuclear Receipt Facility	1.12×10^{-1}	3.05	4.04×10^{-1}	5.16×10^{-1}
25A	Utilities Facility	1.03×10^{-1}	3.68	9.61×10^{-2}	1.99×10^{-1}
620	Administration Facility	1.13×10^{-1}	4.06	1.09×10^{-1}	2.22×10^{-1}
71A	Craft Shops	1.26×10^{-1}	4.53	1.27×10^{-1}	2.54×10^{-1}
30A	Central Security Station	1.06×10^{-1}	3.79	1.01×10^{-1}	2.07×10^{-1}
30B	Cask Receipt Security Station	9.96×10^{-2}	2.51	4.17×10^{-1}	5.17×10^{-1}
30C	North Perimeter Security Station	8.41×10^{-2}	2.25	3.02×10^{-1}	3.86×10^{-1}
27A	Switchyard	1.78×10^{-1}	3.24	1.19	1.37
780	Lower Muck Yard	8.45×10^{-2}	2.73	1.58×10^{-1}	2.43×10^{-1}
33A	Rail Buffer Area	1.07×10^{-1}	2.75	4.41×10^{-1}	5.48×10^{-1}
33B	Truck Buffer Area	1.01×10^{-1}	2.59	4.08×10^{-1}	5.08×10^{-1}

NOTE: [a]Highest organ dose is to the bone surface.

Source: Reference 2.2.36, Table 15.

6.1.5.2 Radiation Worker Dose from Direct Radiation from Sources within Facilities

Table 14 summarizes the nominal radiation worker dose from direct radiation while performing their duties in each of the facilities based on the expected nominal throughputs during normal operations (Reference 2.2.39, Section 3.1.1).

Table 14. Nominal Radiation Worker Dose from Direct Radiation

Facility	Worker Group	Individual Worker Dose (mrem/yr)
Receipt Facility	Operator	1,300
	Health Physics Technician	800

Sources: Reference 2.2.39, Table 1

6.1.5.3 Dose from Direct Radiation and Airborne Releases at Facility Locations in the GROA

The direct radiation from contained sources external to facilities is from the TAD canisters and DPCs in aging overpacks located at the Aging Facility and from transportation casks located at the rail car and truck buffer areas. Airborne releases are the total from all surface and subsurface facility normal operation releases. Radiation dose to onsite workers or public due to direct radiation from contained sources and airborne releases is calculated in Reference 2.2.39. Table 6 of Reference 2.2.39 is duplicated herein (Table 15) and shows the annual dose for locations throughout the GROA. Per Reference 2.2.39, doses during movement of waste outside facilities are excluded.

Table 15. Normal Operation Direct and Airborne Doses At Facility Locations in the GROA

Area No.[a]	GROA Location	Direct Radiation TEDE[b, d] (mrem/yr)	Airborne Release TEDE[c, d] (mrem/yr)	Total TEDE (direct + airborne) (mrem/yr)
17P	Aging Pad 17P	1.0×10^1	2.8×10^{-1}	1.0×10^1
51A	Initial Handling Facility	3.7	1.3×10^{-1}	3.8
160	Low-Level Waste Facility	4.2×10^{-1}	2.7×10^{-1}	6.9×10^{-1}
050	Wet Handling Facility	4.0×10^{-1}	1.5×10^1	1.5×10^1
200	Receipt Facility	4.7×10^{-1}	2.5×10^{-1}	7.2×10^{-1}
060	Canister Receipt and Closure Facility 1	1.2×10^{-1}	2.9×10^{-1}	4.1×10^{-1}
070	Canister Receipt and Closure Facility 2	1.5	2.1×10^{-1}	1.7
080	Canister Receipt and Closure Facility 3	1.8	2.0×10^{-1}	2.0
220	Heavy Equipment Maintenance Facility	1.5	1.6×10^{-1}	1.7
240	Central Communication Control Facility	7.0	1.2×10^{-1}	7.1
230	Warehouse and Non-Nuclear Receipt Facility	1.7×10^1	1.1×10^{-1}	1.7×10^1
25A	Utility Facility	5.3×10^{-1}	1.0×10^{-1}	6.3×10^{-1}
620	Administration Facility	6.9×10^{-2}	1.1×10^{-1}	1.8×10^{-1}
71A	Craft Shop	1.1×10^{-1}	1.3×10^{-1}	2.4×10^{-1}
30A	Central Security Station	8.2×10^{-2}	1.1×10^{-1}	1.9×10^{-1}
30B	Cask Receipt Security Station	2.2	1.0×10^{-1}	2.3
30C	North Perimeter Security Station	9.7	8.4×10^{-2}	9.8
27A	Switchyard	3.6×10^1	1.8×10^{-1}	3.6×10^1
780	Lower Muck Yard	7.8×10^1	8.5×10^{-2}	7.8×10^1
33A	Railcar Buffer Area	NA	1.1×10^{-1}	NA
33B	Truck Buffer Area	NA	1.0×10^{-1}	NA

NOTES: [a]Areas are shown in References 2.2.40 and 2.2.41
[b]Direct radiation doses are the total external doses from aging overpacks on the aging pads (17P and 17R), and transportation casks in 33A (rail buffer area) and 33B (truck buffer area)
[c]Airborne release doses are the total from all surface and subsurface facility normal operation releases
[d]Doses are based on 2,000 hr/yr occupancy.

Source: Reference 2.2.39, Table 6.

6.1.6.3 Summary Inhalation, Submersion and Groundshine Exposure Period Inputs

Table 17 provides a summary of the inhalation and submersion exposure period inputs, which are taken from Reference 2.2.10 (Tables 89 and 94) and which also reflect Assumptions 3.2.3, 3.2.4, and 3.2.5. In Table 17, the 22-hr daily exposure period for members of the offsite public in the general environment reflects that such individuals spend an average of two hours per day away from the area. The 8.5-hr daily exposure period for members of the public not in the general environment recognizes that these individuals are workers at the Nevada Test Site or the Nellis Test and Training Range and therefore are only present for a portion of the day.

Table 17. Inhalation and Submersion Exposure Periods

Individual	Condition	Exposure Period Category	Inhalation and Submersion Exposure Period (Mean Value)	Inhalation and Submersion Exposure Period (Distribution and Value)
Offsite Public in the General Environment	Normal operations	Yearly	365 (days/yr)	None
	Category 1 event sequences	Event	Duration of release (days)	None
	Category 2 event sequences	Event	Duration of release up to 30 (days)	None
	All	Daily	22 (hr/day)	Normal distribution: Mean = 22.0 Standard Deviation = 0.4, Min = 20.7, Max = 22.8
Offsite Public Not within the General Environment	Normal operations	Yearly	250 (days/yr)	Uniform distribution: Min = 225 and Max = 275
	Category 1 event sequences	Event	Duration of release (days)	None
	Category 2 event sequences	Event	Duration of release up to 30 (days)	None
	All	Daily	8.5 (hr/day)	Uniform distribution: Min = 8.0 and Max = 9.0
Onsite Public or Radiation Worker	Normal operations	Yearly	250 (days/yr)	Uniform distribution: Min = 225 and Max = 275
	Category 1 event sequences	Event	Duration of release (days)	None
	All	Daily	8.5 (hr/day)	Uniform distribution: Min = 8.0 and Max = 9.0

Sources: Reference 2.2.10, Tables 89 and 94 and Assumptions 3.2.3, 3.2.4, and 3.2.5.

Table 18 provides a summary of the external groundshine exposure period inputs, which are taken from Reference 2.2.10 (Table 89) and which also reflect Assumptions 3.2.3, 3.2.4, and 3.2.5. In Table 18, the daily exposure period for members of the offsite public in the general environment is different than in Table 17 because GENII handles groundshine exposures differently than inhalation/submersion exposures. As in Table 17, the 8.5-hr daily exposure period for members of the public not in the general environment recognizes that these individuals are workers at the Nevada Test Site or the Nellis Test and Training Range and therefore are only present for a portion of the day.

Table 18. External Groundshine Exposure Periods

Individual	Condition	Exposure Period Category	External Groundshine Exposure Period (Mean Value)	External Groundshine Exposure Period (Distribution and Value)
Offsite Public in the General Environment	Normal operations and Category 1 event sequences	Yearly	365 (days/yr)	None
	Category 2 event sequences	Event	30 (days)	None
	All	Daily	24 (hr/day)	None
Offsite Public Not within the General Environment	Normal operations and Category 1 event sequences	Yearly	250 (days/yr)	Uniform distribution: Min = 225 and Max = 275
	Category 2 event sequences	Event	30 (days)	None
	All	Daily	8.5 (hr/day)	Uniform distribution: Min = 8.0 and Max = 9.0

Sources: Reference 2.2.10, Table 89 and Assumptions 3.2.3, 3.2.4, and 3.2.5.

Table 19 summarizes the inputs used for the fraction of a day inhalation and submersion occurs.

Table 19. Fraction of a Day for Inhalation and Submersion

Individual	Condition	Exposure Category	Fraction of a Day Outdoor Exposure Occurs (Mean Value)	Fraction of a Day Outdoor Exposure Occurs (Distribution and Value)
Offsite Public in the General Environment	Normal operations	Air inhalation and submersion	0.92	Normal distribution: Mean = 0.92 Standard Deviation = 0.02, Min = 0.86, Max = 0.95
	Category 1 and Category 2 event sequences	Air inhalation and submersion	1.0	None
	All	Resuspended soil inhalation	0.31	Normal distribution: Mean = 0.31 Standard Deviation = 0.014, Min = 0.27, Max = 0.35
Offsite Public Not within the General Environment	Normal operations	Air inhalation and submersion	0.35	Uniform distribution: Min = 0.33 and Max = 0.38
	Category 1 and Category 2 event sequences	Air inhalation and submersion	1.0[a]	None
	All	Resuspended soil inhalation	0.35	Uniform distribution: Min = 0.33 and Max = 0.38
Onsite Public or Radiation Worker	Normal operations	Air inhalation and submersion	0.35	Uniform distribution: Min = 0.33 and Max = 0.38
	Category 1 event sequences	Air inhalation and submersion	1.0[a]	None

Note: [a] For long duration release events such as oxidation, a fraction of a day value of 0.35 is used based on a normal work schedule.

Source: Reference 2.2.10, Table 95 and Assumption 3.2.14.

Table 21. Changes to GENII Default Files

		Chronic Default Files Values			Acute Default Files Values			
		Offsite	Offsite	Onsite	Offsite	Offsite	Onsite	
GENII Parameter	Description (units)	General Environment	Non- General Environment	Worker or Public	General Environment	Non- General Environment	Worker or Public	
Resuspended Soil Inhalation								
UINHR	Inhalation rate for resuspended air (m^3/day)	21.7[a]	30.2	30.2	21.7	30.2	30.2	Table 16
TINHR	Annual resuspension intake factor (day/yr)	365[a]	250	250	30 (365 in run)	30 (365 in run)	30 (365 in run)	Table 17 adjusted in spreadsheet
FRINHR	Fraction of day that resuspension inhalation occurs (dimensionless)	0.31[a]	0.35	0.35	0.31	0.35	0.35	Table 19
Parameter Change to Default File Values in *GNDFLcud.GE* and *GNDFLaud.GE*								
Exposure Pathway Module								
LEACHOPTION[b]	Type of leach rate constant	2	2	2	2	2	2	Section 6.2.1
Parameter Change to Default Value within Heath Impacts Module								
Health Impacts Module								
SOILT[c]	Thickness of contaminated soil layer (m)	0.25	0.25	0.25	0.25	0.25	0.25	Design Input 6.1.1.11
Parameter Changes to Default File Values for Acute Oxidation Release								
Acute Oxidation Release (30 day)								
ABSHUM	Absolute humidity (kg/m^3)	-	-	-	1.30×10^{-4}	1.57×10^{-4}	NA	Section 6.2.3
JHOUR	Date/hour of release				1-Sep/0 hour	1-Sep/0 hour	1-Sep/0 hour	Assumption 3.2.15

NOTES: [a]Default value in *GNDFLiud.pop* from Reference 2.2.10.
[b]LEACHOPTION default value is 0 in both *GNDFLcud.GE* and *GNDFLaud.GE.*
[c]SOILT is not in a default file and must be entered directly into the Health Impacts module screen.

Table 47. Potential Onsite Public Doses from Normal Operation

Area No.[a]	GROA Location	Direct Radiation TEDE[b, d] (mrem/yr)	Airborne Release TEDE[c, d] (mrem/yr)	Total TEDE (direct + airborne) (mrem/yr)
Construction Worker Locations				
17P	Aging Pad 17P	1.0×10^{1}	2.8×10^{-1}	1.0×10^{1}
200	Receipt Facility	4.7×10^{-1}	2.5×10^{-1}	7.2×10^{-1}
070	Canister Receipt and Closure Facility 2	1.5	2.1×10^{-1}	1.7
080	Canister Receipt and Closure Facility 3	1.8	2.0×10^{-1}	2.0
620	Administration Facility	6.9×10^{-2}	1.1×10^{-1}	1.8×10^{-1}
71A	Craft Shop	1.1×10^{-1}	1.3×10^{-1}	2.4×10^{-1}
30C	North Perimeter Security Station	9.7	8.4×10^{-2}	9.8
Other Onsite Areas				
220	Heavy Equipment Maintenance Facility	1.5	1.6×10^{-1}	1.7
240	Central Communication Control Facility	7.0	1.2×10^{-1}	7.1
230	Warehouse and Non-Nuclear Receipt Facility	1.7×10^{1}	1.1×10^{-1}	1.7×10^{1}
25A	Utility Facility	5.3×10^{-1}	1.0×10^{-1}	6.3×10^{-1}
30A	Central Security Station	8.2×10^{-2}	1.1×10^{-1}	1.9×10^{-1}
27A	Switchyard	3.6×10^{1}	1.8×10^{-1}	3.6×10^{1}
780	Lower Muck Yard	7.8×10^{1}	8.5×10^{-2}	7.8×10^{1}

NOTES: [a]Areas are shown in References 2.2.40 and 2.2.41
[b]Direct radiation doses are the total external doses from aging overpacks on the aging pads (17P and 17R), and transportation casks in 33A (rail buffer area) and 33B (truck buffer area)
[c]Airborne release doses are the total from all surface and subsurface facility normal operation releases
[d]Doses are based on 2,000 hr/yr occupancy.
GROA = geologic repository operations area; TEDE = total effective dose equivalent.

Source: Table 15

As stated in Section 4.4, in addition to the construction worker and other onsite public occupied areas, the normal operation onsite public doses from airborne releases from surface facilities are also determined at 60 m from surface facilities, the WHF and the Aging Facility, and 100 m from the subsurface exhaust shafts. These are restricted area boundary doses, not continuously occupied area doses. Results are given in Table 43, Table 44, and Table 45. The total onsite public normal operations dose for the maximum dose locations in occupied areas from Table 47 for construction workers and other onsite public are shown in Table 48.

Table 65. Worker Dose from Normal Operations and Category 1 Event Sequences

Dose Contributions	Total Effective Dose Equivalent (mrem/yr)	Highest Total Organ Dose Equivalent (mrem/yr)	Shallow Dose Equivalent to Skin (mrem/yr)	Lens Dose Equivalent (mrem/yr)
Normal operations airborne releases to Receipt Facility	0.25	6.5	1.2	1.5
Direct radiation during operations within the Receipt Facility	1,300	-	-	-
Direct radiation from external contained sources at Receipt Facility	0.47	-	-	-

Source: Table 13, Table 14, and Table 15.

6.10 PUBLIC NORMAL OPERATIONS AND CATEGORY 1 EVENT SEQUENCE DOSE SUMMARY

In compliance with 10 CFR 63.111(b)(1) (Reference 2.2.1), doses from normal operations and Category 1 event sequences are aggregated. However, per Assumption 3.1.1, there are no Category 1 event sequences. Therefore, Table 66 summarizes the public doses from normal operations only.

Table 66. Public Dose from Normal Operations and Category 1 Event Sequences

Event Sequence Type	Category of Individual	Site (Preclosure Controlled Area) (mrem/yr)	General Environment (Unrestricted Area) (mrem/yr)	Offsite, but not within the General Environment (Unrestricted Area) (mrem/yr)
Aggregate of Normal Operation and Category 1 Event Sequence Dose	Public	7.8×10^{1}	5.5×10^{-2}	1.1×10^{-1}
Aggregate of Normal Operation and Category 1 Event Sequence Dose	Construction Worker	1.0×10^{1}	-	-

Source: Table 46 and Table 47.

6.11 CATEGORY 2 EVENT SEQUENCE DOSE SUMMARY

The Category 2 event sequence dose results are tabulated in Section 6.8 with a subsection for each Category 2 event sequence. The results summarized in Table 67 and Table 68, can be found in the individual subsections in Section 6.8. Dose locations are shown in Figure 1.