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CHAPTER 11 RADIOACTIVE WASTE MANAGEMENT

11.2.3 Liquid Radioactive Releases

This section describes the radiological impacts of liquid radioactive waste effluents from normal plant operation at the CRN Site on members of the public. Subsection 11.2.3.1 describes the exposure pathways by which radiation and radioactive effluents can be transmitted from the proposed nuclear units to individuals living near the site. Subsection 11.2.3.2 provides an estimate of the maximum doses to the public and evaluates the impacts of these doses by comparing them to applicable regulatory limits.

11.2.3.1 Exposure Pathways

Small quantities of radioactive liquids would be discharged to the Clinch River arm of the Watts Bar Reservoir, from the discharge structure at Clinch River Mile 15.5 shown in Figure 1.2-2, during normal operation of the nuclear units at the CRN Site. The impact of these releases on individuals and the general population in the vicinity of the site is evaluated by considering the major exposure pathways from the release point to the receptors of interest. The major exposure pathways are those that could yield the highest radiological doses for a given receptor. The relative importance of an exposure pathway is based on the type and amount of radioactivity released, the environmental transport mechanism, and the consumption or usage factors at the receptor.

The source term for the liquid radioactive waste effluents from normal plant operations at the CRN Site is provided in Table 2.0-6. As compliance is evaluated on a per-unit basis in some cases (i.e., 10 CFR 50, Appendix I) and on a per-site basis in others (i.e., 10 CFR 20, Appendix B, and 40 CFR 190), a determination of the source term with releases from one unit and for the site (all units) was required. In both cases, the source term for the surrogate plant is a composite of the four small modular reactor (SMR) technologies being considered. The source term associated with the release from one unit is a composite developed by selecting a representative activity for each of the radionuclides from the information for the four SMR technologies, consistent with the guidance provided in NEI 10-01 (Reference 11.2-4). The source term associated with the site was determined by selecting a representative per-radionuclide site activity of those calculated for each of the SMR technologies (determined by multiplying the per-radionuclide activity for a specific SMR unit by the maximum number of units being considered for that SMR technology). In some cases, based upon the maturity of the source term and the amount of conservatism, a lower activity for certain radionuclides was used. An evaluation was performed to ensure that the adjusted source terms utilized to evaluate the dose consequences are conservative compared to source terms for large light water reactors (scaled to a comparable power output) and are considered to be reasonable for use.

The exposure pathways considered and the analytical methods used to estimate doses to the maximally exposed individual (MEI) and to the general population surrounding the CRN Site are based on Regulatory Guide (RG) 1.109. The MEI is defined as a member of the general public at an assumed location that results in the maximum possible calculated dose. The MEI approach supports comparisons with established dose criteria for the public.

The NRC-endorsed LADTAP II computer program (Reference 11.2-1) is used to calculate liquid radioactive waste effluent doses, with parameters specific to the Clinch River arm of the Watts Bar Reservoir and downstream locations. LADTAP II implements the radiological exposure models described in RG 1.109 for radioactivity in liquid effluents, as well as exposure models for boating and swimming, as described in Reference 11.2-1.

The following exposure pathways are considered in LADTAP II in calculating doses to the MEI and the general population:

- internal exposure from ingestion of aquatic foods
- internal exposure from ingestion of drinking water
- internal exposure from ingestion of meat or milk from livestock consuming water and pasture feed from farms irrigated by contaminated water
- internal exposure from ingestion of vegetables and fruits from farms irrigated by contaminated water
- external exposure to shoreline sediments
- external exposure from boating and swimming

Population doses for the CRN Site are calculated for the year 2067, 40 years from the projected commencement of commercial operation of the last of potentially multiple units at the site. At that time, the affected population within 50 miles of the site (permanent and transient) is projected to be at its maximum during the period of plant operation. The total projected population (permanent and transient) for the year 2067 within 50 miles of the CRN site is provided in Table 11.2-2 and was calculated using the methodology presented in Subsection 2.1.3.

11.2.3.2 Liquid Pathway Doses

Based on the design inputs and assumptions shown in Table 11.2-1, the LADTAP II computer program is used to calculate doses to the MEI and the general population from the following activities:

- ingesting fish and invertebrates caught in Watts Bar Reservoir
- ingesting water from Watts Bar Reservoir
- ingesting meat, milk and vegetables irrigated by water from Watts Bar Reservoir
- using the shoreline of Watts Bar Reservoir
- boating and swimming in Watts Bar Reservoir

As shown in Table 11.2-4, the projected CRN Site liquid radioactive effluent concentrations in the Clinch River arm of the Watts Bar Reservoir are within the effluent concentration limits (ECLs) of 10 CFR 20, Appendix B, Table 2, Column 2.

The projected annual doses to the MEI from liquid radioactive effluents from each reactor and for the site are shown in Tables 11.2-5 and 11.2-6, respectively.

The projected total annual doses per reactor from both liquid and gaseous radioactive effluents are within the design objectives of 10 CFR 50, Appendix I, as shown in Table 11.2-7.

The projected total site doses due to liquid and gaseous radioactive effluents and direct radiation are within the environmental standards of 40 CFR 190, as shown in Table 11.2-8.

Because 40 CFR 190 is more restrictive than 10 CFR 20.1301, compliance with the limits of 40 CFR 190 demonstrates compliance with the 0.1 rem (100 mrem) limit of 10 CFR 20.1301.

Projected annual collective doses to the population within 50 miles of the CRN Site are shown in Table 11.2-9.

11.2.4 References

11.2-1. NUREG/CR-4013, LADTAP II Technical Reference and User Guide, U.S. Nuclear Regulatory Commission, 1986.

11.2-2. NCRP Report No. 160, Ionizing Radiation Exposure of the Population of the United States, National Council on Radiation Protection and Measurements, 2009.

11.2-3. Westinghouse Electric Corporation, Westinghouse AP1000 Design Control Document, Non-Proprietary, Revision 19, June 13, 2011.

11.2-4. NEI 10-01, “Industry Guidance for Developing a Plant Parameter Envelope in Support of an Early Site Permit,” Revision 1, May 2012.

Table 11.2-1 (Sheet 1 of 2)
Liquid Effluent Dose Calculation Parameters

Parameter	Value	Basis/Comment
Water Type	Freshwater	Clinch River arm of the Watts Bar Reservoir is fresh water.
Reactor Effluent Discharge Rate	4000 ft^3/s	This mean annual flow rate conservatively bounds flow data collected over a period of 47 years for Clinch River arm of the Watts Bar Reservoir.
Radionuclide Release Rates	Table 2.0-6	Values are shown per reactor and for all reactors on site.
Population Within 50 Miles	2,658,157	Table 11.2-2 shows the total projected population distribution (permanent and transient) within 50 miles of the Clinch River Nuclear (CRN) Site by sector and distance in 2067. Food production rates and population consumption and usage rates in 2067 are estimated using the ratio of 2067 to 2010 population.
Impoundment Reconcentration Model	None	This model does not apply to the river discharge scenario.
Shore-Width Factor	0.2	This is the appropriate value for a river (RG 1.109, Table A-2).
Dilution Factor for Receptors	1	No dilution is assumed beyond full mixing in the river flow rate.
Transit Time to Receptors	0	It is conservatively assumed that there is no decay beyond the distribution times built into LADTAP II.
Usage and Consumption Rates by Age Group		Annual usage and consumption rates for the average individual and the MEI are taken from Tables E-4 and E-5, respectively, of RG 1.109. Times spent boating and swimming are assumed to be identical to that spent on shoreline activities. LADTAP II utilizes the maximum rates in calculating individual doses and the average rates in calculating population doses.
Sport Fishing Harvest	1.87×10^6 kg/yr	These are projected values for 2067. It is assumed that the Watts Bar Reservoir is the source of 50 percent of the fish and invertebrate consumption by the population within 50 miles of the CRN Site. This is a conservative assumption because only the part of the river downstream from CRN Site is affected by liquid effluents, there are other bodies of water in the region, and some fish and invertebrate food is likely imported from outside the region. It is further assumed that for every individual who catches fish or invertebrates for sport, there are four individuals that consume the catch, reflecting a typical family of four for the purpose of calculating population doses.
Commercial Fishing Harvest	5.93×10^6 kg/yr	
Sport Invertebrate Harvest	2.71×10^5 kg/yr	
Commercial Invertebrate Harvest	8.61×10^5 kg/yr	
Population Supplied by Drinking Water	2.49×10^5	This is the projected value for 2067.
Population Shoreline, Swimming, and Boating Usage	3.40×10^7 hr/yr	This is the projected value for 2067. Times spent swimming and boating are assumed to be identical to that spent on shoreline activities.
Irrigation Rate	110 L/m^2 per month	This corresponds to a rate of 1 inch/week, which bounds the actual rate within 50 miles of the CRN Site.
Vegetable Production	Table 11.2-3	The table shows the values for 2067. Vegetable production rates within 50 miles of the CRN Site are assumed to be equal to the state-wide production rates for Tennessee, multiplied by the fraction of the harvested land area within Tennessee that falls within 50 miles of the site, as shown in Table 11.2-3. Furthermore, production rates for leafy vegetables are assumed to be the same as for non-leafy vegetables.

Table 11.2-1 (Sheet 2 of 2)
Liquid Effluent Dose Calculation Parameters

Parameter	Value	Basis/Comment
Milk and Meat Production	Table 11.2-3	Milk and meat production rates within 50 miles of the CRN Site are assumed to be equal to the state-wide production rates for Tennessee, multiplied by the respective fractions of the milk and meat animals within Tennessee that reside within 50 miles of the site, as shown in Table 11.2-3.

Table 11.2-2
Total Projected Population Distribution within 50 Miles of the Clinch River Nuclear Site in 2067

Direction	Distance (Miles)									
	0 – 1	**1 – 2**	**2 – 3**	**3 – 4**	**4 – 5**	**5 – 10**	**10 – 20**	**20 – 30**	**30 – 40**	**40 – 50**
S	13	29	38	150	213	2,446	14,716	24,197	19,100	10,242
SSW	14	31	41	150	147	1,242	5,357	26,006	49,143	21,631
SW	13	51	69	132	265	965	3,895	5,502	12,679	44,254
WSW	16	68	172	151	373	7,989	4,829	7,185	7,015	9,876
W	18	107	161	183	742	18,819	15,343	5,587	52,483	12,930
WNW	21	89	248	87	220	5,303	6,069	8,407	11,606	13,108
NW	20	25	50	14	84	1,771	7,498	4,907	3,914	24,543
NNW	0	1	0	0	156	2,077	8,465	840	11,546	35,117
N	0	0	0	0	110	2,850	2,594	570	5,499	12,272
NNE	0	0	0	0	0	8,678	10,509	12,234	35,396	11,082
NE	5	0	0	0	0	1,555	51,540	30,575	25,463	12,290
ENE	8	9	1	0	0	1,670	104,860	711,355	81,037	31,999
E	8	14	130	57	116	9,101	130,456	207,087	67,225	108,807
ESE	6	39	112	203	475	12,098	26,220	229,719	32,360	14,583
SE	8	42	85	307	357	22,492	11,132	21,153	4,038	10,641
SSE	7	59	67	234	396	3,916	35,921	17,961	2,693	707
Total	**157**	**564**	**1,174**	**1,668**	**3,654**	**102,972**	**439,404**	**1,313,285**	**421,197**	**374,082**
										Grand Total = 2,658,157

Notes:
Total projected population within 50 miles of the Clinch River Nuclear Site in 2067 (2,658,157) is an increase of 54% as compared to the total population in 2010 (1,723,327).

Table 11.2-3
Milk, Meat, and Vegetable and Fruit Production in Tennessee within 50 Miles of the Clinch River Nuclear Site

Food	Production in Tennessee (kg/yr)	Percent of Production in Tennessee within 50 Miles of CRN Site	Production within 50 Miles of the CRN Site (kg/yr)		
			Present	2067	Irrigation 2067
Milk	4.30×10^8	28.81%	1.24×10^8	1.91×10^8	3.08×10^4
Red Meat	3.06×10^8	12.75%	3.91×10^7	–	–
Broilers	4.62×10^8	14.39%	6.65×10^7	–	–
Meat (Total)	–	–	1.06×10^8	1.63×10^8	2.62×10^4
Vegetables and Fruits	5.17×10^9	8.79% (% Harvested Land)	4.54×10^8	7.00×10^8	1.13×10^5
Column	1	2	3	4	5

Notes:

Entries in Column 2 assume that the fraction of the land area of counties outside Tennessee within 50 miles of the Clinch River Nuclear (CRN) Site is negligible, pursuant to Table 11.2-2.

Entries in Column 3 are obtained by multiplying the values in Column 1 by those in Column 2.

Entries in Column 4 are obtained by multiplying the values in Column 3 by a population ratio of 1.54, from the footnote of Table 11.2-2.

Entries in Column 5 show production using irrigated water and are obtained by multiplying Column 4 by 2.41%, the percentage of state irrigation occurring within 50 miles of the CRN site, and by 0.67%, the percentage of irrigation occurring with water from Watts Bar Reservoir.

Dashes (–) = No Value

Table 11.2-4 (Sheet 1 of 3)
Projected Liquid Radioactive Effluent Concentrations in Watts Bar Reservoir

Nuclide	Release (Ci/yr)	Concentration (µCi/mL)		Fraction of ECL
		River	ECL	
H-3	8.85×10^{2}	2.48×10^{-7}	1×10^{-3}	2.5×10^{-4}
C-14	9.83×10^{-3}	2.75×10^{-12}	3×10^{-5}	9.2×10^{-8}
Na-24	8.40×10^{-3}	2.35×10^{-12}	5×10^{-5}	4.7×10^{-8}
P-32	3.03×10^{-4}	8.48×10^{-14}	9×10^{-6}	9.4×10^{-9}
Cr-51	1.28×10^{-1}	3.59×10^{-11}	5×10^{-4}	7.2×10^{-8}
Mn-54	6.53×10^{-2}	1.83×10^{-11}	3×10^{-5}	6.1×10^{-7}
Mn-56	1.09×10^{-3}	3.05×10^{-13}	7×10^{-5}	4.4×10^{-9}
Fe-55	4.87×10^{-2}	1.36×10^{-11}	1×10^{-4}	1.4×10^{-7}
Fe-59	1.19×10^{-2}	3.33×10^{-12}	1×10^{-5}	3.3×10^{-7}
Co-58	5.51×10^{-2}	1.54×10^{-11}	2×10^{-5}	7.7×10^{-7}
Co-60	8.21×10^{-3}	2.30×10^{-12}	3×10^{-6}	7.7×10^{-7}
Ni-63	1.84×10^{-1}	5.14×10^{-11}	1×10^{-4}	5.1×10^{-7}
Cu-64	6.72×10^{-3}	1.88×10^{-12}	2×10^{-4}	9.4×10^{-9}
Zn-65	2.11×10^{-2}	5.91×10^{-12}	5×10^{-6}	1.2×10^{-6}
Br-82	7.48×10^{-6}	2.09×10^{-15}	4×10^{-5}	5.2×10^{-11}
Br-83	1.41×10^{-5}	3.94×10^{-15}	9×10^{-4}	4.4×10^{-12}
Br-84	1.01×10^{-3}	2.82×10^{-13}	4×10^{-4}	7.0×10^{-10}
Br-85	9.68×10^{-9}	2.71×10^{-18}	–	–
Rb-86	7.48×10^{-5}	2.09×10^{-14}	7×10^{-6}	3.0×10^{-9}
Rb-88	1.49×10^{-2}	4.18×10^{-12}	4×10^{-4}	1.0×10^{-8}
Rb-89	6.18×10^{-4}	1.73×10^{-13}	9×10^{-4}	1.9×10^{-10}
Sr-89	1.67×10^{-4}	4.69×10^{-14}	8×10^{-6}	5.9×10^{-9}
Sr-90	1.43×10^{-5}	4.00×10^{-15}	5×10^{-7}	8.0×10^{-9}
Sr-91	6.67×10^{-4}	1.87×10^{-13}	2×10^{-5}	9.3×10^{-9}
Sr-92	2.36×10^{-4}	6.61×10^{-14}	4×10^{-5}	1.7×10^{-9}
Y-90	1.86×10^{-6}	5.21×10^{-16}	7×10^{-6}	7.4×10^{-11}
Y-91	1.25×10^{-4}	3.51×10^{-14}	8×10^{-6}	4.4×10^{-9}
Y-91m	2.67×10^{-5}	7.47×10^{-15}	2×10^{-3}	3.7×10^{-12}
Y-92	9.01×10^{-4}	2.52×10^{-13}	4×10^{-5}	6.3×10^{-9}
Y-93	7.25×10^{-4}	2.03×10^{-13}	2×10^{-5}	1.0×10^{-8}
Zr-95	2.20×10^{-3}	6.15×10^{-13}	2×10^{-5}	3.1×10^{-8}
Zr-97	4.40×10^{-7}	1.23×10^{-16}	9×10^{-6}	1.4×10^{-11}
Nb-95	1.07×10^{-3}	2.99×10^{-13}	3×10^{-5}	1.0×10^{-8}
Mo-99	4.52×10^{-2}	1.27×10^{-11}	2×10^{-5}	6.3×10^{-7}
Tc-99m	2.27×10^{-2}	6.35×10^{-12}	1×10^{-3}	6.3×10^{-9}
Tc-99	1.76×10^{-8}	4.93×10^{-18}	6×10^{-5}	8.2×10^{-14}
Ru-103	2.63×10^{-3}	7.36×10^{-13}	3×10^{-5}	2.5×10^{-8}
Ru-105	7.04×10^{-8}	1.97×10^{-17}	7×10^{-5}	2.8×10^{-13}

Table 11.2-4 (Sheet 2 of 3)
Projected Liquid Radioactive Effluent Concentrations in Watts Bar Reservoir

Nuclide	Release (Ci/yr)	Concentration (μCi/mL)		Fraction of ECL
		River	ECL	
Ru-106	3.92×10^{-2}	1.10×10^{-11}	3×10^{-6}	3.7×10^{-6}
Rh-103m	4.37×10^{-6}	1.22×10^{-15}	6×10^{-3}	2.0×10^{-13}
Rh-105	4.27×10^{-7}	1.19×10^{-16}	5×10^{-5}	2.4×10^{-12}
Rh-106	3.74×10^{-7}	1.05×10^{-16}	1.0×10^{-8}	1.0×10^{-8}
Ag-110m	2.66×10^{-2}	7.46×10^{-12}	6×10^{-6}	1.2×10^{-6}
Ag-110	3.48×10^{-8}	9.73×10^{-18}	–	–
Sb-124	2.29×10^{-4}	6.42×10^{-14}	7×10^{-6}	9.2×10^{-9}
Sb-125	7.92×10^{-9}	2.22×10^{-18}	3×10^{-5}	7.4×10^{-14}
Sb-127	4.40×10^{-8}	1.23×10^{-17}	1×10^{-5}	1.2×10^{-12}
Sb-129	1.76×10^{-8}	4.93×10^{-18}	4×10^{-5}	1.2×10^{-13}
Te-127m	5.72×10^{-6}	1.60×10^{-15}	9×10^{-6}	1.8×10^{-10}
Te-127	1.28×10^{-5}	3.57×10^{-15}	1×10^{-4}	3.6×10^{-11}
Te-129m	6.90×10^{-2}	1.93×10^{-11}	7×10^{-6}	2.8×10^{-6}
Te-129	1.65×10^{-4}	4.62×10^{-14}	4×10^{-4}	1.2×10^{-10}
Te-131m	1.98×10^{-3}	5.54×10^{-13}	8×10^{-6}	6.9×10^{-8}
Te-131	4.05×10^{-5}	1.13×10^{-14}	8×10^{-5}	1.4×10^{-10}
Te-132	1.32×10^{-1}	3.70×10^{-11}	9×10^{-6}	4.1×10^{-6}
Te-134	1.06×10^{-6}	2.96×10^{-16}	3×10^{-4}	9.9×10^{-13}
I-129	5.04×10^{-9}	1.41×10^{-18}	2×10^{-7}	7.1×10^{-12}
I-130	1.85×10^{-5}	5.17×10^{-15}	2×10^{-5}	2.6×10^{-10}
I-131	1.66×10^{-1}	4.64×10^{-11}	1×10^{-6}	4.6×10^{-5}
I-132	1.32×10^{-1}	3.70×10^{-11}	1×10^{-4}	3.7×10^{-7}
I-133	2.76×10^{-1}	7.73×10^{-11}	7×10^{-6}	1.1×10^{-5}
I-134	3.91×10^{-2}	1.10×10^{-11}	4×10^{-4}	2.7×10^{-8}
I-135	1.64×10^{-1}	4.60×10^{-11}	3×10^{-5}	1.5×10^{-6}
Cs-134	3.44×10^{-2}	9.64×10^{-12}	9×10^{-7}	1.1×10^{-5}
Cs-136	1.17×10^{-2}	3.28×10^{-12}	6×10^{-6}	5.5×10^{-7}
Cs-137	4.24×10^{-2}	1.19×10^{-11}	1×10^{-6}	1.2×10^{-5}
Cs-138	1.42×10^{-2}	3.96×10^{-12}	4×10^{-4}	9.9×10^{-9}
Ba-137m	2.07×10^{-3}	5.79×10^{-13}	–	–
Ba-139	6.16×10^{-8}	1.72×10^{-17}	2×10^{-4}	8.6×10^{-14}
Ba-140	4.80×10^{-2}	1.34×10^{-11}	8×10^{-6}	1.7×10^{-6}
La-140	4.27×10^{-3}	1.19×10^{-12}	9×10^{-6}	1.3×10^{-7}
La-141	8.80×10^{-8}	2.46×10^{-17}	5×10^{-5}	4.9×10^{-13}
La-142	1.19×10^{-8}	3.33×10^{-18}	1×10^{-4}	3.3×10^{-14}
Ce-141	1.58×10^{-4}	4.43×10^{-14}	3×10^{-5}	1.5×10^{-9}
Ce-143	3.25×10^{-4}	9.11×10^{-14}	2×10^{-5}	4.6×10^{-9}
Ce-144	2.99×10^{-3}	8.36×10^{-13}	3×10^{-6}	2.8×10^{-7}
Pr-143	6.93×10^{-5}	1.94×10^{-14}	2×10^{-5}	9.7×10^{-10}

Table 11.2-4 (Sheet 3 of 3)
Projected Liquid Radioactive Effluent Concentrations in Watts Bar Reservoir

Nuclide	Release (Ci/yr)	Concentration (μCi/mL)		Fraction of ECL
		River	ECL	
Pr-144	1.69×10^{-3}	4.73×10^{-13}	6×10^{-4}	7.9×10^{-10}
Nd-147	1.07×10^{-6}	2.99×10^{-16}	2×10^{-5}	1.5×10^{-11}
W-187	6.30×10^{-4}	1.76×10^{-13}	3×10^{-5}	5.9×10^{-9}
Np-239	2.99×10^{-2}	8.37×10^{-12}	2×10^{-5}	4.2×10^{-7}
Pu-238	2.64×10^{-9}	7.39×10^{-19}	2×10^{-8}	3.7×10^{-11}
Pu-239	3.39×10^{-10}	9.48×10^{-20}	2×10^{-8}	4.7×10^{-12}
Pu-240	4.27×10^{-10}	1.19×10^{-19}	2×10^{-8}	6.0×10^{-12}
Pu-241	1.28×10^{-7}	3.57×10^{-17}	1×10^{-6}	3.6×10^{-11}
Am-241	1.85×10^{-10}	5.17×10^{-20}	2×10^{-8}	2.6×10^{-12}
Cm-242	3.78×10^{-8}	1.06×10^{-17}	7×10^{-7}	1.5×10^{-11}
Cm-244	1.76×10^{-9}	4.93×10^{-19}	3×10^{-8}	1.6×10^{-11}
Totals	**8.87×10^{2}**			**3.5×10^{-4}**

Notes:
ECL = Effluent Concentration Limit
Ci = Curies
Dashes (–) = No Value

Table 11.2-5
Radioactive Liquid Effluent Doses per Reactor for the Maximally Exposed Individual

Pathway	Dose per Reactor (mrem/yr)							
	Total Body	Other Organ						
		GI-LLI[(a)]	Bone	Liver	Kidney	Thyroid	Lung	Skin
Fish	8.5×10^{-3}	1.3×10^{-2}	2.2×10^{-2}	1.1×10^{-2}	7.0×10^{-3}	3.0×10^{-3}	1.1×10^{-3}	0
Invertebrate	2.6×10^{-3}	4.6×10^{-2}	6.5×10^{-3}	5.4×10^{-3}	1.5×10^{-2}	1.9×10^{-3}	1.8×10^{-4}	0
Drinking	2.9×10^{-3}	4.3×10^{-3}	2.0×10^{-3}	4.2×10^{-3}	4.6×10^{-3}	1.8×10^{-2}	3.7×10^{-3}	0
Shoreline	1.2×10^{-5}	1.2×10^{-5}	1.4×10^{-5}	1.4×10^{-5}	1.4×10^{-5}	1.4×10^{-5}	1.4×10^{-5}	7.9×10^{-5}
Swimming	1.4×10^{-6}	1.4×10^{-6}	1.7×10^{-6}	1.7×10^{-6}	1.7×10^{-6}	1.7×10^{-6}	1.7×10^{-6}	0
Boating	7.2×10^{-7}	7.2×10^{-7}	8.4×10^{-7}	8.4×10^{-7}	8.4×10^{-7}	8.4×10^{-7}	8.4×10^{-7}	0
Irrigated Vegetables	3.4×10^{-3}	7.2×10^{-3}	1.9×10^{-2}	8.5×10^{-3}	8.3×10^{-3}	1.8×10^{-2}	4.5×10^{-3}	0
Irrigated Milk	2.0×10^{-3}	2.1×10^{-3}	9.1×10^{-3}	6.0×10^{-3}	4.0×10^{-3}	2.3×10^{-2}	2.8×10^{-3}	0
Irrigated Meat	6.5×10^{-4}	2.5×10^{-2}	2.0×10^{-3}	6.8×10^{-4}	2.9×10^{-3}	7.6×10^{-4}	3.4×10^{-4}	0
Total	2.0×10^{-2}	9.7×10^{-2}	6.0×10^{-2}	3.5×10^{-2}	4.2×10^{-2}	6.4×10^{-2}	1.3×10^{-2}	7.9×10^{-5}
Maximum Dose Age Group	Adult	Adult	Child	Child	Child	Child	Child	Teen

(a) GI-LLI = Gastrointestinal Tract – Lower Large Intestine

Table 11.2-6
Radioactive Liquid Effluent Doses for the Site for the Maximally Exposed Individual

Pathway	Site Dose (mrem/yr)							
	Total Body	Other Organ						
		GI-LLI[a]	Bone	Liver	Kidney	Thyroid	Lung	Skin
Fish	9.2×10^{-2}	4.5×10^{-2}	1.6×10^{-1}	1.1×10^{-1}	4.8×10^{-2}	3.2×10^{-2}	1.2×10^{-2}	0
Invertebrate	2.3×10^{-2}	2.3×10^{-1}	3.4×10^{-2}	5.2×10^{-2}	5.6×10^{-2}	7.7×10^{-3}	2.0×10^{-3}	0
Drinking	1.3×10^{-2}	1.7×10^{-2}	1.9×10^{-2}	2.1×10^{-2}	1.9×10^{-2}	1.8×10^{-1}	1.5×10^{-2}	0
Shoreline	1.1×10^{-4}	1.1×10^{-4}	1.3×10^{-4}	1.3×10^{-4}	1.3×10^{-4}	1.3×10^{-4}	1.3×10^{-4}	7.0×10^{-4}
Swimming	8.8×10^{-6}	8.8×10^{-6}	1.0×10^{-5}	1.0×10^{-5}	1.0×10^{-5}	1.0×10^{-5}	1.0×10^{-5}	0
Boating	4.4×10^{-6}	4.4×10^{-6}	5.1×10^{-6}	5.1×10^{-6}	5.1×10^{-6}	5.1×10^{-6}	5.1×10^{-6}	0
Irrigated Vegetables	2.2×10^{-2}	3.2×10^{-2}	2.1×10^{-1}	6.8×10^{-2}	4.1×10^{-2}	1.8×10^{-1}	2.2×10^{-2}	0
Irrigated Milk	1.4×10^{-2}	1.5×10^{-2}	1.1×10^{-1}	5.1×10^{-2}	2.5×10^{-2}	2.5×10^{-1}	1.4×10^{-2}	0
Irrigated Meat	3.5×10^{-3}	9.9×10^{-2}	1.4×10^{-2}	4.2×10^{-3}	1.0×10^{-2}	5.0×10^{-3}	1.7×10^{-3}	0
Total	1.7×10^{-1}	4.4×10^{-1}	5.4×10^{-1}	3.1×10^{-1}	2.0×10^{-1}	6.6×10^{-1}	6.8×10^{-2}	7.0×10^{-4}
Maximum Dose Age Group	Adult	Adult	Child	Child	Child	Child	Child	Teen

(a) GI-LLI = Gastrointestinal Tract – Lower Large Intestine

Table 11.2-7
Comparison of Doses to the Maximally Exposed Individual from Liquid and Gaseous Radioactive Effluents with 10 CFR 50, Appendix I, Criteria

Type of Dose	Location	Annual Dose per Reactor	
		Site	Limit
Liquid Effluents			
Total Body (mrem)	Watts Bar Reservoir	0.020	3
Maximum Organ = GI-LLI (mrem)	Watts Bar Reservoir	0.097	10
Gaseous Effluents			
Gamma Air (mrad)	Site Boundary	9.5	10
Beta Air (mrad)	Site Boundary	12	20
Total Body (mrem)	Residence	0.9	5
Skin (mrem)	Residence	1.9	15
Iodines and Particulates			
Maximum Organ = Thyroid (mrem)	Residence/Garden/ Beef Animal	4.5	15

Table 11.2-8
Comparison of Doses to the Maximally Exposed Individual from All Sources with 40 CFR 190 Criteria

Type of Dose	Site Dose (mrem/yr)				
	Liquid[(a)]	Gaseous[(b)]	Direct[(c)]	Total	Limit
Total Body	0.17	10	1.0	11	25
Thyroid	0.66	24	0.0	25	75
Other Organ (Bone)	0.54	23	0.0	24	25

(a) From Table 11.2-6.
(b) From Table 11.3-5.
(c) It is conservatively assumed that the total direct radiation from all reactors at the Clinch River Nuclear (CRN) Site is 1 mrem/yr at the Site Boundary. Direct radiation dose from the pressurized water reactor (PWR) designs under consideration for the CRN Site is expected to be negligible, similar to doses from large PWRs – for example, AP1000 (Reference 11.2-3, Section 12.4.2.1).

Table 11.2-9
Collective Doses per Reactor to the Population within 50 Miles of the Clinch River Nuclear Site from Liquid and Gaseous Effluents

Pathway	Dose per Reactor (person-rem/yr)	
	Total Body	Thyroid
Liquid Effluents	2.4	1.8
Gaseous Effluents		
Noble Gases	0.8	0.8
Iodines	0.020	9.9
Particulates	0.72	0.57
C-14	10	10
H-3	3.3	3.3
Total for Gaseous Effluents	15	25
Total for Liquid and Gaseous Effluents	17	26
Natural Background[a]	8.3×10^5	

(a) Obtained by multiplying the natural background dose of 311 mrem/yr (Reference 11.2-2) by the 2067 population of 2,658,157 persons (Table 11.2-2).

11.3.3 Gaseous Radioactive Releases

This section describes the radiological impacts of gaseous radioactive waste effluents from normal plant operation at the Clinch River Nuclear (CRN) Site on members of the public. Subsection 11.3.3.1 describes the exposure pathways by which radiation and radioactive effluents can be transmitted from the proposed nuclear units to individuals living near the site. Subsection 11.3.3.2 provides an estimate of the maximum doses to the public and evaluates the impacts of these doses by comparing them to applicable regulatory limits.

11.3.3.1 Exposure Pathways

Small quantities of radioactive gases would be discharged to the environment during normal operation of nuclear units at the CRN Site. The impact of these releases on individuals and the general population in the vicinity of the site is evaluated by considering the most important pathways from the release to the receptors of interest. The major pathways are those that could yield the highest radiological doses for a given receptor. The relative importance of a pathway is based on the type and amount of radioactivity released, the environmental transport mechanism, and the consumption or usage factors at the receptor.

The source term for the gaseous radioactive waste effluents from normal plant operations at the CRN Site is provided in Table 2.0-4. As compliance is evaluated on a per-unit basis in some cases (i.e., 10 CFR 50, Appendix I) and on a per-site basis in others (i.e., 10 CFR 20, Appendix B, and 40 CFR 190), a determination of the source term with releases from one unit and for the site (all units) was required. In both cases, the source term for the surrogate plant is a composite of the four small modular reactor (SMR) technologies being considered. The source term associated with the release from one unit is a composite developed by selecting a representative activity for each of the radionuclides from the information for the four SMR technologies, consistent with the guidance provided in NEI 10-01 (Reference 11.3-2). The source term associated with the site was determined by selecting a representative per-radionuclide site activity of those calculated for each of the SMR technologies (determined by multiplying the per-radionuclide activity for a specific SMR unit by the maximum number of units being considered for that SMR technology). In some cases, the maturity of the source term resulted in an excessive amount of conservatism. In these instances, a lower activity for certain radionuclides was used. An evaluation was performed to ensure that the source terms utilized to evaluate the dose consequences are conservative compared to source terms for large light water reactors (scaled to a comparable power output) and are considered to be reasonable for use.

The exposure pathways considered and the analytical methods used to estimate doses to the maximally exposed individual (MEI) and to the general population surrounding the CRN Site are based on Regulatory Guide (RG) 1.109 and RG 1.111. The MEI is defined as a member of the general public located to receive the maximum possible calculated dose; and the MEI approach supports dose comparisons with established criteria for the public.

The NRC-endorsed GASPAR II computer code (Reference 11.3-1) is used to calculate the doses to offsite receptors from the proposed nuclear units at the CRN Site. This program implements the radiological exposure models described in RG 1.109 to estimate the doses resulting from radioactive releases in gaseous effluents. The atmospheric dispersion component of the analysis is calculated with the NRC-endorsed XOQDOQ computer program, and its development (including assumed release points) is discussed in Subsection 2.3.5.

The following exposure pathways are considered in GASPAR II:

- external exposure to an airborne plume

- external exposure to contaminated ground
- internal exposure from inhalation of airborne activity
- internal exposure from ingestion of contaminated vegetables, milk, and meat

Population doses for the CRN Site are calculated for the year 2067, 40 years from the projected commencement of commercial operation of the last of potentially multiple units at the site. At that time, the affected population within 50 miles of the site (permanent and transient) is projected to be at its maximum during the period of plant operation. The total projected population (permanent and transient) for the year 2067 within 50 miles of the CRN site is provided in Table 11.2-2 and was calculated using the methodology presented in Subsection 2.1.3.

11.3.3.2 Gaseous Pathway Doses

Based on the design inputs and assumptions shown in Table 11.3-1, the GASPAR II computer program is used to calculate doses to the MEI from gaseous radioactive effluents at the following locations:

- nearest site boundary
- nearest residence
- nearest vegetable garden
- nearest meat animal

As shown in Table 11.3-3, projected gaseous radioactive effluent concentrations at the CRN Site exclusion area boundary (EAB) are within the ECLs of 10 CFR 20, Appendix B, Table 2, Column 1.

The projected annual doses to the MEI from gaseous radioactive effluents from each reactor and from the site are shown in Tables 11.3-4 and 11.3-5, respectively.

The projected total annual doses per reactor from both liquid and gaseous radioactive effluents are within the design objectives of 10 CFR 50, Appendix I, as shown in Table 11.2-7.

The projected total site doses due to liquid and gaseous radioactive effluents and direct radiation are within the environmental standards of 40 CFR 190, as shown in Table 11.2-8.

Because 40 CFR 190 is more restrictive than 10 CFR 20.1301, compliance with the limits of 40 CFR 190 demonstrates compliance with the 0.1 rem (100 mrem) limit of 10 CFR 20.1301.

Projected annual collective doses to the population within 50 miles of the CRN Site are shown in Table 11.2-9.

11.3.4 References

11.3-1. NUREG/CR-4653, GASPAR II – Technical Reference and User Guide, 1987.

11.3-2. NEI 10-01, “Industry Guidance for Developing a Plant Parameter Envelope in Support of an Early Site Permit,” Revision 1, May 2012.

Table 11.3-1
Gaseous Effluent Dose Calculation Parameters

Parameter	Value	Basis/Comment
Atmospheric Dispersion and Deposition Factors	Table 11.3-2	Site atmospheric dispersion factors (X/Q values) and ground deposition factors (D/Q values) are shown in Subsection 2.3.5. The maximum X/Q and D/Q values at the Site Boundary and at the nearest residence, beef animal, vegetable garden and biota are shown in Table 11.3-2.
Fraction of Year Leafy Vegetables Grown	1	Most conservative value.
Fraction of Year Milk Cows on Pasture	1	Most conservative value.
Fraction of Maximum Individual's Vegetable Intake from own Garden	0.76	Default value from RG 1.109, Table E-15.
Fraction of Milk-Cow Feed from Pasture	1	Most conservative value.
Average Absolute Humidity for Growing Season	8 g/m^3	Default value in GASPAR II (Reference 11.3-1, Table 2.3), used when a value of zero is input.
Average Temperature over Growing Season	0	Not used if absolute humidity is specified.
Fraction of Year Goats at Pasture	1	Most conservative value.
Fraction of Goat Feed from Pasture	1	Most conservative value.
Fraction of Year Beef Cattle at Pasture	1	Most conservative value.
Fraction of Beef Cattle Feed from Pasture	1	Most conservative value.
Population Within 50 Miles	Table 11.2-2	The table shows the total projected population distribution within 50 miles of the Clinch River Nuclear Site by sector and distance in 2067.
Milk Production Within 50 Miles	1.91×10^8 L/yr	Projected values for 2067 from Table 11.2-3.
Meat Production Within 50 Miles	1.63×10^8 kg/yr	
Vegetable Production Within 50 Miles	7.00×10^8 kg/yr	
Radionuclide Release Rates	Table 2.0-4	Values are shown per reactor and for all reactors on site.

Table 11.3-2
Maximum Atmospheric Dispersion and Ground Deposition Factors by Location

Location	Direction	Distance (mi)	Atmospheric Dispersion (X/Q – s/m^3)			Ground Deposition (D/Q – m^{-2})
			Undecayed Undepleted	2.26-Day Decay Undepleted	8-Day Decay Depleted	
Site Boundary	WNW	0.21	2.0×10^{-4}	2.0×10^{-4}	1.9×10^{-4}	7.9×10^{-8}
Residence	WNW	0.66	2.5×10^{-5}	2.5×10^{-5}	2.3×10^{-5}	1.2×10^{-8}
Beef Animal	WNW	0.70	2.3×10^{-5}	2.3×10^{-5}	2.1×10^{-5}	7.8×10^{-9}
Vegetable Garden	WNW	1.15	1.0×10^{-5}	9.9×10^{-6}	8.7×10^{-6}	7.3×10^{-9}
Biota	WNW	0.25	1.5×10^{-4}	1.5×10^{-4}	1.4×10^{-4}	6.0×10^{-8}

Table 11.3-3 (Sheet 1 of 2)
Projected Gaseous Radioactive Effluent Concentrations at the Site Exclusion Area Boundary

Nuclide	Release (Ci/yr)	Concentration (µCi/ml)		Fraction of ECL
		EAB	ECL	
H-3	1.01×10^{3}	6.41×10^{-9}	1×10^{-7}	6.4×10^{-2}
C-14	1.00×10^{1}	6.34×10^{-11}	3×10^{-9}	2.1×10^{-2}
Na-24	2.50×10^{-3}	1.59×10^{-14}	7×10^{-9}	2.3×10^{-6}
P-32	5.68×10^{-4}	3.60×10^{-15}	5×10^{-10}	7.2×10^{-6}
Ar-41	5.44×10^{2}	3.45×10^{-9}	1×10^{-8}	3.5×10^{-1}
Cr-51	2.17×10^{-2}	1.37×10^{-13}	3×10^{-8}	4.6×10^{-6}
Mn-54	5.22×10^{-3}	3.31×10^{-14}	1×10^{-9}	3.3×10^{-5}
Mn-56	2.17×10^{-3}	1.37×10^{-14}	2×10^{-8}	6.9×10^{-7}
Fe-55	4.01×10^{-3}	2.54×10^{-14}	3×10^{-9}	8.5×10^{-6}
Fe-59	9.55×10^{-4}	6.06×10^{-15}	5×10^{-10}	1.2×10^{-5}
Co-57	1.10×10^{-4}	6.98×10^{-16}	9×10^{-10}	7.8×10^{-7}
Co-58	6.90×10^{-2}	4.38×10^{-13}	1×10^{-9}	4.4×10^{-4}
Co-60	2.64×10^{-2}	1.67×10^{-13}	5×10^{-11}	3.3×10^{-3}
Ni-63	1.46×10^{-2}	9.26×10^{-14}	1×10^{-9}	9.3×10^{-5}
Cu-64	6.18×10^{-3}	3.92×10^{-14}	3×10^{-8}	1.3×10^{-6}
Zn-65	6.86×10^{-3}	4.35×10^{-14}	4×10^{-10}	1.1×10^{-4}
Br-84	1.28×10^{-5}	8.14×10^{-17}	8×10^{-8}	1.0×10^{-9}
Kr-83m	1.28×10^{-2}	8.14×10^{-14}	5×10^{-5}	1.6×10^{-9}
Kr-85m	3.39×10^{2}	2.15×10^{-9}	1×10^{-7}	2.1×10^{-2}
Kr-85	7.20×10^{2}	4.57×10^{-9}	7×10^{-7}	6.5×10^{-3}
Kr-87	3.27×10^{1}	2.08×10^{-10}	2×10^{-8}	1.0×10^{-2}
Kr-88	1.45×10^{2}	9.21×10^{-10}	9×10^{-9}	1.0×10^{-1}
Kr-89	5.00×10^{-7}	3.17×10^{-18}	1×10^{-9}	3.2×10^{-9}
Rb-88	9.80×10^{-6}	6.22×10^{-17}	9×10^{-8}	6.9×10^{-10}
Rb-89	2.67×10^{-5}	1.69×10^{-16}	2×10^{-7}	8.5×10^{-10}
Sr-89	9.00×10^{-3}	5.71×10^{-14}	2×10^{-10}	2.9×10^{-4}
Sr-90	3.60×10^{-3}	2.28×10^{-14}	6×10^{-12}	3.8×10^{-3}
Sr-91	6.18×10^{-4}	3.92×10^{-15}	5×10^{-9}	7.8×10^{-7}
Sr-92	4.84×10^{-4}	3.07×10^{-15}	9×10^{-9}	3.4×10^{-7}
Y-90	2.84×10^{-5}	1.80×10^{-16}	9×10^{-10}	2.0×10^{-7}
Y-91	1.49×10^{-4}	9.44×10^{-16}	2×10^{-10}	4.7×10^{-6}
Y-92	3.84×10^{-4}	2.44×10^{-15}	1×10^{-8}	2.4×10^{-7}
Y-93	6.86×10^{-4}	4.35×10^{-15}	3×10^{-9}	1.4×10^{-6}
Zr-95	3.00×10^{-3}	1.90×10^{-14}	4×10^{-10}	4.8×10^{-5}
Nb-95	7.50×10^{-3}	4.76×10^{-14}	2×10^{-9}	2.4×10^{-5}
Mo-99	3.68×10^{-2}	2.33×10^{-13}	2×10^{-9}	1.2×10^{-4}
Tc-99m	1.83×10^{-4}	1.16×10^{-15}	2×10^{-7}	5.8×10^{-9}
Ru-103	2.17×10^{-3}	1.37×10^{-14}	9×10^{-10}	1.5×10^{-5}
Ru-106	2.34×10^{-4}	1.48×10^{-15}	2×10^{-11}	7.4×10^{-5}

Table 11.3-3 (Sheet 2 of 2)
Projected Gaseous Radioactive Effluent Concentrations at the Site Exclusion Area Boundary

Nuclide	Release (Ci/yr)	Concentration (µCi/ml)		Fraction of ECL
		EAB	ECL	
Rh-103m	1.48×10^{-8}	9.36×10^{-20}	2×10^{-6}	4.7×10^{-14}
Rh-106	4.57×10^{-11}	2.90×10^{-22}	1×10^{-12}	2.9×10^{-10}
Ag-110m	2.14×10^{-3}	1.35×10^{-14}	1×10^{-10}	1.4×10^{-4}
Sb-124	1.12×10^{-4}	7.09×10^{-16}	3×10^{-10}	2.4×10^{-6}
Sb-125	3.77×10^{-5}	2.39×10^{-16}	7×10^{-10}	3.4×10^{-7}
Te-129m	1.35×10^{-4}	8.58×10^{-16}	3×10^{-10}	2.9×10^{-6}
Te-131m	4.68×10^{-5}	2.97×10^{-16}	1×10^{-9}	3.0×10^{-7}
Te-132	7.13×10^{-5}	4.52×10^{-16}	9×10^{-10}	5.0×10^{-7}
I-129	8.02×10^{-11}	5.08×10^{-22}	4×10^{-11}	1.3×10^{-11}
I-131	2.31×10^{-1}	1.46×10^{-12}	2×10^{-10}	7.3×10^{-3}
I-132	1.35×10^{0}	8.58×10^{-12}	2×10^{-8}	4.3×10^{-4}
I-133	1.05×10^{0}	6.66×10^{-12}	1×10^{-9}	6.7×10^{-3}
I-134	2.33×10^{0}	1.48×10^{-11}	6×10^{-8}	2.5×10^{-4}
I-135	1.49×10^{0}	9.44×10^{-12}	6×10^{-9}	1.6×10^{-3}
Xe-131m	1.67×10^{3}	1.06×10^{-8}	2×10^{-6}	5.3×10^{-3}
Xe-133m	1.05×10^{2}	6.66×10^{-10}	6×10^{-7}	1.1×10^{-3}
Xe-133	2.24×10^{3}	1.42×10^{-8}	5×10^{-7}	2.8×10^{-2}
Xe-135m	1.28×10^{1}	8.12×10^{-11}	4×10^{-8}	2.0×10^{-3}
Xe-135	2.82×10^{2}	1.79×10^{-9}	7×10^{-8}	2.6×10^{-2}
Xe-137	3.00×10^{0}	1.90×10^{-11}	1×10^{-9}	1.9×10^{-2}
Xe-138	1.14×10^{1}	7.23×10^{-11}	2×10^{-8}	3.6×10^{-3}
Cs-134	6.90×10^{-3}	4.38×10^{-14}	2×10^{-10}	2.2×10^{-4}
Cs-136	3.68×10^{-4}	2.33×10^{-15}	9×10^{-10}	2.6×10^{-6}
Cs-137	3.26×10^{-2}	2.06×10^{-13}	2×10^{-10}	1.0×10^{-3}
Cs-138	1.05×10^{-4}	6.66×10^{-16}	8×10^{-8}	8.3×10^{-9}
Ba-140	1.67×10^{-2}	1.06×10^{-13}	2×10^{-9}	5.3×10^{-5}
La-140	1.12×10^{-3}	7.09×10^{-15}	2×10^{-9}	3.5×10^{-6}
Ce-141	5.68×10^{-3}	3.60×10^{-14}	8×10^{-10}	4.5×10^{-5}
Ce-143	1.16×10^{-7}	7.33×10^{-19}	2×10^{-9}	3.7×10^{-10}
Ce-144	1.17×10^{-5}	7.40×10^{-17}	2×10^{-11}	3.7×10^{-6}
Pr-144	1.17×10^{-5}	7.40×10^{-17}	2×10^{-7}	3.7×10^{-10}
W-187	1.17×10^{-4}	7.40×10^{-16}	1×10^{-8}	7.4×10^{-8}
Np-239	7.35×10^{-3}	4.66×10^{-14}	3×10^{-9}	1.6×10^{-5}
Totals	**7.13×10^{3}**			**6.8×10^{-1}**

Notes:
ECL = Effluent Concentration Limit
EAB = Exclusion Area Boundary
Ci = Curies

Table 11.3-4 (Sheet 1 of 2)
Gaseous Radioactive Effluent Doses per Reactor for the Maximally Exposed Individual

Location	Pathway	Dose per Reactor (mrem/yr)							
		Total Body	GI-Tract	Bone	Liver	Kidney	Thyroid	Lung	Skin
Site Boundary (0.21 mi WNW)	External								
	• Plume	6.2	6.2	6.2	6.2	6.2	6.2	6.3	14
	• Ground	0.85	0.85	0.85	0.85	0.85	0.85	0.85	1.0
	• Total	7.1	7.1	7.1	7.1	7.1	7.1	7.2	15
	Inhalation								
	• Adult	1.5	1.5	0.29	1.5	1.5	12	2.0	0
	• Teen	1.5	1.5	0.35	1.6	1.6	15	2.4	0
	• Child	1.3	1.3	0.43	1.4	1.4	18	2.1	0
	• Infant	0.76	0.75	0.21	0.85	0.83	16	1.3	0
	All								
	• Adult	8.5	8.6	7.3	8.6	8.6	19	9.2	15
	• Teen	8.5	8.6	7.4	8.6	8.7	22	9.5	15
	• Child	8.4	8.4	7.5	8.5	8.5	25	9.2	15
	• Infant	7.8	7.8	7.3	7.9	7.9	23	8.5	15
Residence (0.66 mi WNW)	External								
	• Plume	0.78	0.78	0.78	0.78	0.78	0.78	0.79	1.8
	• Ground	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.15
	• Total	0.90	0.90	0.90	0.90	0.90	0.90	0.92	1.9
	Inhalation								
	• Adult	0.18	0.19	0.035	0.19	0.19	1.5	0.25	0
	• Teen	0.19	0.19	0.042	0.20	0.20	1.8	0.29	0
	• Child	0.16	0.16	0.052	0.18	0.18	2.2	0.25	0
	• Infant	0.095	0.094	0.026	0.11	0.10	1.9	0.16	0
Vegetable Garden (1.15 mi WNW)	Vegetables								
	• Adult	0.57	0.57	2.3	0.58	0.56	1.5	0.55	0
	• Teen	0.85	0.85	3.7	0.87	0.85	2.1	0.83	0
	• Child	1.9	1.9	8.9	1.9	1.9	4.2	1.9	0

Table 11.3-4 (Sheet 2 of 2)
Gaseous Radioactive Effluent Doses per Reactor for the Maximally Exposed Individual

Location	Pathway	Dose per Reactor (mrem/yr)							
		Total Body	GI-Tract	Bone	Liver	Kidney	Thyroid	Lung	Skin
Meat Animal	Meat								
(0.70 mi WNW)	• Adult	0.44	0.46	2.0	0.44	0.44	0.51	0.44	0
	• Teen	0.36	0.37	1.6	0.36	0.36	0.41	0.36	0
	• Child	0.65	0.66	3.1	0.66	0.65	0.73	0.65	0
MEI	All								
	• Adult	2.1	2.1	5.2	2.1	2.1	4.4	2.2	1.9
	• Teen	2.3	2.3	6.3	2.3	2.3	5.2	2.4	1.9
	• Child	3.6	3.6	13	3.7	3.6	8.0	3.7	1.9
	• Infant	1.0	1.0	0.93	1.0	1.0	2.8	1.1	1.9
	Maximum Group	3.6 Child	3.6 Child	13 Child	3.7 Child	3.6 Child	8.0 Child	3.7 Child	1.9 All

Table 11.3-5 (Sheet 1 of 2)
Gaseous Radioactive Effluent Doses for the Site for the Maximally Exposed Individual

Location	Pathway	Site Dose (mrem/yr)							
		Total Body	GI-Tract	Bone	Liver	Kidney	Thyroid	Lung	Skin
Site Boundary	External								
(0.21 mi WNW)	• Plume	40	40	40	40	40	40	41	84
	• Ground	2.9	2.9	2.9	2.9	2.9	2.9	2.9	3.3
	• Total	43	43	43	43	43	43	43	88
	Inhalation								
	• Adult	4.8	5.0	0.94	5.0	5.1	41	6.6	0
	• Teen	4.9	5.0	1.2	5.2	5.3	52	7.7	0
	• Child	4.3	4.3	1.4	4.7	4.7	62	6.7	0
	• Infant	2.5	2.5	0.73	2.8	2.8	55	4.2	0
	All								
	• Adult	48	48	44	48	48	84	50	88
	• Teen	48	48	44	48	48	95	51	88
	• Child	47	47	44	48	48	100	50	88
	• Infant	45	45	44	46	46	98	48	88
Residence	External								
(0.66 mi WNW)	• Plume	5.0	5.0	5.0	5.0	5.0	5.0	5.1	11
	• Ground	0.43	0.43	0.43	0.43	0.43	0.43	0.43	0.51
	• Total	5.4	5.4	5.4	5.4	5.4	5.4	5.5	11
	Inhalation								
	• Adult	0.60	0.62	0.11	0.63	0.64	5.1	0.82	0
	• Teen	0.61	0.63	0.14	0.65	0.66	6.4	0.96	0
	• Child	0.54	0.54	0.17	0.58	0.59	7.6	0.82	0
	• Infant	0.31	0.31	0.089	0.35	0.34	6.8	0.52	0
Vegetable Garden	Vegetables								
(1.15 mi WNW)	• Adult	1.1	1.1	3.7	1.1	1.0	4.0	1.0	0
	• Teen	1.5	1.5	5.8	1.6	1.5	5.2	1.4	0
	• Child	3.1	3.0	14	3.2	3.1	10	3.0	0

Table 11.3-5 (Sheet 2 of 2)
Gaseous Radioactive Effluent Doses for the Site for the Maximally Exposed Individual

Location	Pathway	Site Dose (mrem/yr)							
		Total Body	GI-Tract	Bone	Liver	Kidney	Thyroid	Lung	Skin
Meat Animal	Meat								
(0.70 mi WNW)	• Adult	0.70	0.75	2.7	0.70	0.69	0.90	0.68	0
	• Teen	0.55	0.58	2.3	0.56	0.55	0.70	0.54	0
	• Child	0.96	0.98	4.3	0.98	0.96	1.2	0.96	0
MEI	All								
	• Adult	7.8	7.9	12	7.9	7.8	15	8.0	11
	• Teen	8.1	8.1	14	8.2	8.1	18	8.4	11
	• Child	10	10	23	10	10	24	10	11
	• Infant	5.8	5.8	5.5	5.8	5.8	12	6.0	11
	Maximum Group	10 Child	10 Child	23 Child	10 Child	10 Child	24 Child	10 Child	11 All