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CHAPTER 11.0

RADIOACTIVE WASTE MANAGEMENT

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CHAPTER 11.0

RADIOACTIVE WASTE MANAGEMENT

11.1 SOURCE TERMS

This section presents the design bases for determining the source terms for radioactive releases from the plant, for shielding within the plant, and for accident analysis performed in Chapter 15.0. The source terms used for releases, shielding, and accident analyses are based on 0.12, 0.25, and 1.0 percent fuel defects, respectively.

11.1.1 RADIOACTIVE CONCENTRATIONS AND RELEASES

Reactor coolant and secondary coolant specific activities for an assumed 0.12-percent fuel defects and an assumed 100 pounds per day primary-to-secondary leakage are listed in Table 11.1-1. These activities are used for calculational purposes only and may not represent actual reactor coolant and secondary coolant specific activities. Actual concentrations vary depending on plant conditions at any particular time. The basis for calculating these sources is Regulatory Guide 1.112. Compliance with Regulatory Guide 1.112 is discussed in Table 11.1-3. Appendix 11.1A provides a comparison of the input used for the GALE Code with the generic input identified in the GALE Code.

The decontamination factors applied are based on Regulatory Guide 1.112. A description of liquid leakage rates, process paths, and associated component activity levels is contained in Section 11.2 and Appendix 11.1A. A description of gaseous leakage rates, process paths, and associated activity levels is contained in Appendix 11.1A and Sections 11.3 and 9.4. In-plant airborne activity concentrations and other data regarding the ventilation systems are provided in Sections 12.3 and 12.4.

Prior to the licensing and operation of a nuclear power plant, the applicant includes an estimate of the radioactive effluents and the resulting public doses in FSAR Chapter 11 per the requirements contained in 10 CFR 50.34(b)(3). This is provided to ensure the proposed radwaste treatment systems will be sufficient to ensure compliance with radioactive release criteria specified in 10 CFR 20 and 10 CFR 50 Appendix I (or RM 50-2 for Callaway). The assessments presented in Chapter 11.1 are based on nominal assumptions and generic models that were appropriate at the time the original FSAR was written. They represent assumptions chosen for the purpose of estimating public dose consequences. They do not represent design or operational requirements. Actual operational data or system usage is expected to vary from the chosen assumptions, and may be more or less conservative than the assumptions presented in Chapter 11.1.

During operation, compliance with effluent release limits is ensured and controlled by compliance with FSAR Chapter 16 and the Offsite Dose Calculation Manual (ODCM). Chapter 16 and the ODCM provide detailed controls on effluent limits (both concentration and dose limits), monitoring requirements and performance of dose calculations. They also require operation of radwaste treatment equipment, if the projected dose exceeds a small fraction of effluent ALARA guidelines. If effluent ALARA release guidelines are exceeded, or if treatment equipment is not operated when necessary, special reports to the NRC are required. These reports must provide the corrective actions being taken to ensure the guidelines are not exceeded in the future. Chapter 16 and the ODCM require the use of actual measured concentrations of radioactivity released to verify compliance with effluent limits. Compliance with effluent limits is verified frequently during the year. Assuming operation within the Chapter 16 limits on primary coolant activity, it would take a long enough time to approach the limits such that the routine verifications will provide sufficient advanced indication to allow for corrective actions. Such corrective actions would ensure all annual dose limits are met.

Therefore, compliance with effluent limits and regulations is controlled by Chapter 16 and the ODCM, not by meeting parameters or assumptions provided in Chapter 11.1. The assessments provided in Chapter 11.1 are a historical perspective of the basis behind the original radwaste system design. It was not the intent to operate within the bounds of each detailed assumption. As such, the parameters in Chapter 11.1 related to estimates of public dose from effluents are not updated, nor would it be useful to compare such parameters to actual plant operation. A more accurate and useful assessment of effluent levels and the public dose from effluents can be determined by referencing the Annual Radiological Effluent Report, Annual Radiological Environmental Monitoring Report and the routine estimates of dose required by the ODCM.

When there are proposed changes to plant design, the LIR required per APA-ZZ-00140 for the modification process requires an evaluation of the potential effects on normal radiological effluents. If the initial screening determines that there may be some effect, a more detailed Final Environmental Evaluation may look at the parameters in Chapter 11.1 for a historical basis, but the review primarily considers the effects of the change on the actual measured effluents and the ability to meet the requirements of Chapter 16 and the ODCM. Informaton describing the Radioactive Waste Handling Systems required by 10 CFR 50.34(b)(2)(i) is addressed in FSAR Sections 11.2 and 11.3. These FSAR sections are not designated "historical" and will be updated as system modifications are made.

Regulatory Guide 1.70, Revision 3, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants," Section 11.1 requires that certain information on the sources and releases of radioactivity that serve as design bases for the various radioactive waste treatment systems be included in the PSAR including, mathematical models and parameters used to calculate source terms. Regulatory Guide 1.70 further requires that the FSAR should provide additional information required to update the PSAR to the final design conditions. Further, AmerenUE is committed to Regulatory Guide 1.181 which endorses NEI 98-03, Revision 1 "Guidelines for Updating Final Safety Analysis Reports." Section A3 of NEI 98-03 states that "Historical information provided in the original FSAR may have become out-of-date and is not expected to be used to support current or future plant operations or regulatory activities. Accordingly, it may be appropriate to reformat such information to distinguish it from UFSAR information actively maintained by licensees to describe the updated plant design and operation."

While information regarding originally estimated source terms in FSAR Section 11.1 will remain in the FSAR, it will be designed as historical in accordance with NEI 98-03. Regulatory Guide 1.70 does not provide for the designation of FSAR information as historical. Therefore, an exception to Regulatory Guide 1.70 is taken in this regard and is noted in Table 3A-1.

11.1.2 SHIELDING

Reactor coolant and secondary coolant source terms used for shielding are based on 0.25-percent fuel defects. The source terms and the parameters used to calculate the source terms are given in Table 11.1-4 and Appendix 11.1A, respectively. Table 11.1-6 provides the isotopic composition of the contained sources for radioactive waste management systems and for large, potentially radioactive outside storage tanks.

11.1.3 ACCIDENT ANALYSIS SOURCE TERMS

Source terms used in accident analysis are based on assumptions presented in Section 15.0.9 and in the sections discussing individual analyses.

TABLE 11.1-1 REACTOR COOLANT AND SECONDARY COOLANT SPECIFIC ACTIVITIES 0.12-PERCENT FUEL DEFECTS[1]

	Reactor Coolant μCi/gm	Secondary Coolant[2] μCi/gm
Class 1		
Kr-83m	2.18E-2	5.70E-9
Kr-85m	1.08E-1	2.87E-8
Kr-85	8.04E-3	2.13E-9
Kr-87	6.32E-2	1.60E-8
Kr-88	2.03E-1	5.29E-8
Kr-89	5.43E-3	1.44E-9
Xe-131m	1.91E-2	5.09E-9
Xe-133	5.19E+0	1.36E-6
Xe-133m	1.04E-1	2.78E-8
Xe-135m	1.41E-2	3.68E-9
Xe-135	3.09E-1	8.10E-8
Xe-137	9.78E-3	2.57E-9
Xe-138	4.75E-2	1.23E-8
Total noble gas	6.10E+0	1.60E-6
Class 2		
Br-83	4.80E-3	5.13E-8
Br-84	2.60E-3	1.38E-8
Br-85	3.00E-4	2.12E-10
I-130	2.10E-3	2.91E-8
I-131	2.70E-1	4.06E-6
I-132	1.00E-1	1.42E-6
I-133	3.80E-1	5.50E-6
I-134	4.70E-2	3.27E-7
I-135	1.90E-1	2.51E-6
Total halogens	9.97E-1	1.39E-5
Class 3		
Rb-86	8.50E-5	1.96E-9
Rb-88	2.00E-1	7.26E-7
Cs-134	2.50E-2	5.75E-7
Cs-136	1.30E-2	2.99E-7
Cs-137	1.80E-2	4.16E-7
Total Cs, Rb	2.56E-1	2.02E-6

TABLE 11.1-1 (Sheet 2)

	Reactor Coolant µCi/gm	Secondary Coolant[2] µCi/gm
Class 4		
N-16	4.00E+1	1.08E-6
Water activation product		
Class 5		
H-3	1.00E+0	1.00E-3
Tritium		
Class 6		
Cr-51	1.90E-3	4.07E-8
Mn-54	3.10E-4	9.02E-9
Fe-55	1.60E-3	3.61E-8
Fe-59	1.00E-3	2.71E-8
Co-58	1.60E-2	3.61E-7
Co-60	2.00E-3	4.06E-8
Sr-89	3.50E-4	9.04E-9
Sr-90	1.00E-5	1.80E-10
Sr-91	6.50E-4	1.08E-8
Y-90	1.20E-6	2.72E-11
Y-91m	3.60E-4	8.61E-9
Y-91	6.40E-5	1.36E-9
Y-93	3.40E-5	5.34E-10
Zr-95	6.00E-5	1.81E-9
Nb-95	5.00E-5	1.81E-9
Mo-99	8.40E-2	1.86E-6
Tc-99m	4.80E-2	1.74E-6
Ru-103	4.50E-5	9.04E-10
Ru-106	1.00E-5	1.80E-10
Rh-103m	4.50E-5	1.68E-9
Rh-106	1.00E-5	4.31E-10
Te-125m	2.90E-5	4.52E-10
Te-127m	2.80E-4	4.51E-9
Te-127	8.50E-4	1.62E-8
Te-129m	1.40E-3	2.71E-8
Te-129	1.60E-3	4.88E-8
Te-131m	2.50E-3	4.82E-8
Te-131	1.10E-3	1.90E-8
Te-132	2.70E-2	4.63E-7
Ba-137m	1.60E-2	9.58E-7

TABLE 11.1-1 (Sheet 3)

	Reactor Coolant µCi/gm	Secondary Coolant[2] µCi/gm
Ba-140	2.20E-4	4.54E-9
La-140	1.50E-4	3.32E-9
Class 1		
Ce-141	7.00E-5	1.81E-9
Ce-143	4.00E-5	4.79E-10
Ce-144	3.30E-5	9.03E-10
Pr-143	5.00E-5	9.08E-10
Pr-144	3.30E-5	1.97E-9
	2.90E-1	5.78E-6[3]

(1) Refer to Table 11.1A-1 for assumptions.

(2) For the secondary side, the noble gas activities are for the steam phase; all other activities are for steam generator water activities.

(3) Lower blowdown rates result in higher secondary system activities. A 60-gpm blowdown will result in a total of 5.35E-5 µCi/gm (excluding noble gases, N-16, and tritium) in the steam generator. A maximum blowdown rate was used in this table.

TABLE 11.1-2 ANNUAL EFFLUENT RELEASES (1) (2)

LIQUID

Nuclide	Half-life (Days)	Boron RS (Curies)	Misc. Wastes (Curies)	Secondary (Curies)	Turb. Bldg. (Curies)	Total LWS (Curies)	Adjusted Total (3) (Ci/yr)	Detergent Wastes (Ci/yr)	Total (Ci/yr)
Corrosion & activation products									
Cr-51	2.78+01	.00001	.00000	.00000	.00000	.00001	.00019	.00000	.00019
Mn-54	3.30+02	.00000	.00000	.00000	.00000	.00000	.00004	.00010	.00014
Fe-55	9.50+02	.00001	.00000	.00000	.00000	.00001	.00020	.00000	.00020
FE-59	4.50+01	.00001	.00000	.00000	.00000	.00001	.00011	.00000	.00011
Co-58	7.13+01	.00009	.00002	.00000	.00000	.00012	.00182	.00040	.00220
Co-60	1.92+03	.00001	.00000	.00000	.00000	.00002	.00025	.00087	.00110
Np-239	2.35+00	.00000	.00000	.00000	.00000	.00000	.00002	.00000	.00002
Fission products									
Br-83	1.00-01	.00000	.00000	.00000	.00000	.00000	.00002	.00000	.00002
Rb-86	1.87+01	.00000	.00000	.00000	.00000	.00000	.00007	.00000	.00007
Sr-89	5.20+01	.00000	.00000	.00000	.00000	.00000	.00004	.00000	.00004
Mo-99	2.79+00	.00007	.00004	.00000	.00002	.00012	.00194	.00000	.00190
Tc-99m	2.50-01	.00006	.00004	.00000	.00002	.00012	.00184	.00000	.00180
Te-127m	1.09+02	.00000	.00000	.00000	.00000	.00000	.00003	.00000	.00003
Te-127	3.92-01	.00000	.00000	.00000	.00000	.00000	.00003	.00000	.00003
Te-129m	3.40+01	.00001	.00000	.00000	.00000	.00001	.00014	.00000	.00014
Te-129	4.79-02	.00000	.00000	.00000	.00000	.00001	.00009	.00000	.00009
I-130	5.17-01	.00000	.00000	.00000	.00000	.00000	.00006	.00000	.00006
Te-131m	1.25+00	.00000	.00000	.00000	.00000	.00000	.00002	.00000	.00002
I-131	8.05+00	.00007	.00229	.00000	.00040	.00276	.04302	.00001	.04300
Te-132	3.25+00	.00003	.00001	.00000	.00000	.00005	.00071	.00000	.00071
I-132	9.58-02	.00003	.00003	.00000	.00003	.00009	.00135	.00000	.00140
I-133	8.75-01	.00000	.00058	.00000	.00045	.00103	.01611	.00000	.01600
Cs-134	7.49+02	.00208	.00003	.00000	.00001	.00212	.03306	.00130	.03400
I-135	2.79-01	.00000	.00005	.00000	.00013	.00019	.00293	.00000	.00290
Cs-136	1.30+01	.00059	.00001	.00000	.00000	.00061	.00951	.00000	.00950
Cs-137	1.10+04	.00152	.00002	.00000	.00000	.00154	.02406	.00240	.02600
Ba-137m	1.77-03	.00142	.00002	.00000	.00000	.00144	.02250	.00000	.02200
Ba-140	1.28+01	.00000	.00000	.00000	.00000	.00000	.00002	.00000	.00002
La-140	1.67+00	.00000	.00000	.00000	.00000	.00000	.00002	.00000	.00002
All others		.00000	.00000	.00000	.00000	.00000	.00007	.00000	.00007
Total (Except tritium)		.00603	.00317	.00000	.00107	.01027	.16027	.00623	.16000

Tritium release 410 curies per year

(1) Releases are based on assumptions given in Appendix 11.1A.

(2) These values are based on the standard power block design. See Chapter 11.0 of each Site Addendum for any site-specific variations.

(3) Adjustment is 0.15 Ci/yr based on Regulatory Guide 1.112.

TABLE 11.1-2 (Sheet 2)

GASEOUS (Ci/yr) (1), (2)

	Unit Vent				Ground Level				
Nuclide	Fuel/Aux. Bldg	Air Ejector	Reactor Bldg.	Total	WGPS	Radwaste Bldg.	Turbine Bldg.	Total	PLANT TOTAL
Kr-83m	0	0	0	0	0	0	0	0	0
Kr-85m	1.0	1.0	2.0	4.0	0	1.0	0	1.0	5.0
Kr-85	0	0	6.0	6.0	2.54E+2	0	0	2.54E+2	2.6E+2
Kr-87	0.5	0	0	0.5	0	0.5	0	0.5	1.0
Kr-88	2.0	3.0	2.0	7.0	0	2.0	0	2.0	9.0
Kr-89	0	0	0	0	0	0	0	0	0
Xe-131m	0	0	1.0E+1	1.0E+1	3.0	0	0	3.0	1.3E+1
Xe-133m	1.0	1.0	1.9E+1	2.1E+1	0	1.0	0	1.0	2.2E+1
Xe-133	5.5E+1	6.9E+1	1.8E+3	1.92E+3	1.0	5.5E+1	0	5.6E+1	1.98E+3
Xe-135m	0	0	0	0	0	0	0	0	0
Xe-135	3.5	4.0	1.0E+1	1.75E+1	0	3.5	0	3.5	2.1E+1
Xe-137	0	0	0	0	0	0	0	0	0
Xe-138	0.5	0	0	0.5	0	0.5	0	0.5	1.0
Ar-41	0	0	2.5E+1	2.5E+1	0	0	0	0	2.5E+1
Total noble gases				2.01E+3				3.22E+2	2.34E+3
I-131	6.6E-3	8.3E-3	3.6E-2	5.09E-2	0	6.6E-3	2.4E-4	6.84E-3	5.77E-2
I-133	9.6E-3	1.2E-2	8.7E-3	3.03E-2	0	9.6E-3	3.3E-4	9.93E-3	4.02E-2
C-14	0	0	1.0	1.0	7.0	0	0	7.0	8.0
H-3	(3)	0	(3)	1.0E+3	0	0	0	0	1.0E+3
Mn-54	9.0E-5	0	2.2E-4	3.1E-4	4.5E-5	9.0E-5	0	1.35E-4	4.45E-4
Fe-59	3.0E-5	0	7.5E-5	1.05E-4	1.5E-5	3.0E-5	0	4.5E-5	1.5E-4
Co-58	3.0E-4	0	7.5E-4	1.05E-3	1.5E-4	3.0E-4	0	4.5E-4	1.5E-3
Co-60	1.35E-4	0	3.4E-4	4.75E-4	7.0E-5	1.35E-4	0	2.05E-4	6.8E-4
Sr-89	6.5E-4	0	1.7E-5	2.35E-5	3.3E-6	6.5E-6	0	9.8E-6	3.33E-5
Sr-90	1.2E-6	0	3.0E-6	4.2E-6	6.0E-7	1.2E-6	0	1.8E-6	6.0E-6
Cs-134	9.0E-5	0	2.2E-4	3.1E-4	4.5E-5	9.0E-5	0	1.35E-4	4.45E-4
Cs-137	1.5E-4	0	3.8E-4	5.3E-4	7.5E-5	1.5E-4	0	2.25E-4	7.55E-4

(1) 20 intermittent purges at power +4 shutdown purges are assumed for the reactor building

(2) Auxiliary building release outputs by GALE Code are evenly split between fuel/aux. building and radwaste building

(3) GALE Code calculates only total tritium releases.

TABLE 11.1-3 COMPARISON OF THE DESIGN TO REGULATORY POSITIONS OF REGULATORY GUIDE 1.112, REVISION 0, DATED APRIL, 1976, TITLED "CALCULATION OF RELEASES OF RADIOACTIVE MATERIALS IN GASEOUS AND LIQUID EFFLUENTS FROM LIGHT-WATER-COOLED POWER REACTORS"

Regulatory Guide 1.112 Position	Union Electric
1. Each application for a permit to construct a nuclear power reactor should include in-plant control measures to maintain releases of radioactive materials in liquid and gaseous effluents to the environment as low as is reasonably achievable in accordance with the requirements of Paragraph 20.1(c) of 10 CFR Part 20 and of Paragraph 50.34a, Paragraph 50.36a, and Appendix I of 10 CFR Part 50. For gaseous effluents, such measures could include storage for decay of noble gases removed from the primary coolant and charcoal adsorbers or HEPA filters to remove radioiodine and radioactive particulates released from building ventilation exhaust systems. For liquid effluents, such measures could include storage for decay, demineralization, reverse osmosis, and evaporation.	1. Inclusion of inplant control measures to maintain radioactive releases as low as is reasonably achievable has been incorporated in the design.
2. The method of calculation described in NUREG-0016 and NUREG-0017 and the parameters presented in Chapter 2 of each report should be used to calculate the quantities of radioactive materials in gaseous and liquid effluents from light-water-cooled nuclear power reactors.	2. Parameters of NUREG-0017 are used as discussed in Appendix 11.1A. The method of calculation described in NUREG-0017 has been generally followed.
3. If methods and parameters used in calculating source terms are different from those given in NUREG-0016 and NUREG-0017, they should be described in detail and in the Environmental Report the basis for the methods and parameters used should be provided.	3. Justification for use of assumptions other than those used in NUREG-0017 are provided in Appendix 11.1A.

TABLE 11.1-4 REACTOR COOLANT AND SECONDARY COOLANT SHIELDING SOURCE TERMS - 0.25 PERCENT FUEL DEFECTS [1]

Isotope	Reactor Coolant μCi/gm	Secondary Coolant [2] μCi/gm
Class 1		
Kr-83m	4.54E-2	1.19E-8
Kr-85m	2.25E-1	5.98E-8
Kr-85	1.68E-2	4.44E-9
Kr-87	1.32E-1	3.33E-8
Kr-88	4.23E-1	1.10E-7
Kr-89	1.13E-2	3.00E-9
Xe-131m	3.98E-2	1.06E-8
Xe-133m	2.17E-1	5.79E-8
Xe-133	1.08E+1	2.83E-6
Xe-135m	2.94E-2	7.67E-9
Xe-135	6.44E-1	1.69E-7
Xe-137	2.04E-2	5.35E-9
Xe-138	9.90E-2	2.56E-8
Total noble gases	1.27E+1	3.33E-6
Class 2		
Br-83	1.00E-2	1.07E-7
Br-84	5.42E-3	2.88E-8
Br-85	6.25E-4	4.42E-10
I-130	4.38E-3	6.06E-8
I-131	5.63E-1	8.46E-6
I-132	2.08E-1	2.96E-6
I-133	7.92E-1	1.15E-5
I-134	9.79E-2	6.81E-7
I-135	3.96E-1	5.23E-6
Total halogens	2.08E+0	2.90E-5
Class 3		
Rb-86	1.77E-4	4.08E-9
Rb-88	4.17E-1	1.51E-6
Cs-134	5.21E-2	1.20E-6
Cs-136	2.71E-2	6.23E-7
Cs-137	3.75E-2	8.67E-7
Total Cs, Rb	5.34E-1	4.20E-6

TABLE 11.1-4 (Sheet 2)

Isotope	Reactor Coolant μCi/gm	Secondary Coolant [(2)] μCi/gm
Class 4		
N-16	4.00E+1	1.08E-6
Class 5		
H-3	1.00E+0	1.00E-3
Class 6		
Cr-51	1.90E-3	4.07E-8
Mn-54	3.10E-4	9.02E-9
Fe-55	1.60E-3	3.61E-8
Fe-59	1.00E-3	2.71E-8
Co-58	1.60E-2	3.61E-7
Co-60	2.00E-3	4.06E-8
Sr-89	7.29E-4	1.88E-8
Sr-90	2.08E-5	3.75E-10
Sr-91	1.35E-3	2.25E-8
Y-90	2.50E-6	7.77E-11
Y-91m	7.50E-4	1.79E-8
Y-91	1.33E-4	2.83E-9
Y-93	7.08E-5	1.11E-9
Zr-95	1.25E-4	3.77E-9
Nb-95	1.04E-4	3.77E-9
Mo-99	1.75E-1	3.63E-6
Tc-99	1.00E-1	3.88E-6
Ru-103	9.38E-5	1.88E-9
Ru-106	2.08E-5	3.75E-10
Rh-103m	9.38E-5	3.50E-9
Rh-106	2.08E-5	8.98E-10
Te-125m	6.04E-5	9.42E-10
Te-127m	5.83E-4	9.40E-9
Te-127	1.77E-3	3.38E-8
Te-129m	2.92E-3	5.65E-8
Te-129	3.33E-3	1.02E-7
Te-131m	5.21E-3	1.00E-7
Te-131	2.29E-3	3.96E-8
Te-132	5.63E-2	9.65E-7
Ba-137m	3.33E-2	2.00E-6
Ba-140	4.58E-4	9.46E-9
La-140	3.13E-4	6.92E-9

TABLE 11.1-4 (Sheet 3)

Isotope	Reactor Coolant μCi/gm	Secondary Coolant [(2)] μCi/gm
Ce-141	1.46E-4	3.77E-9
Ce-143	8.33E-5	9.98E-10
Ce-144	6.88E-5	1.88E-9
Pr-143	1.04E-4	1.89E-9
Pr-144	6.88E-5	4.10E-9
Total other isotopes	4.10E-1	1.15E-5 [(3)]

(1) Refer to Table 11.1A-1 for assumptions.

(2) For the secondary side, (primary to secondary leak) the noble gas activities are for the steam phase; all other activities are for steam generator water activities.

(3) Lower blowdown rates result in higher secondary system activities. A 60-gpm blowdown will result in a total of 1.11E-4 μCi/gm (excluding noble gases, N-16, and tritium) in the steam generator. A maximum blowdown rate was used in this table.

TABLE 11.1-5 REACTOR COOLANT SPECIFIC ACTIVITY ACCIDENT SOURCE TERMS - ONE PERCENT FUEL DEFECTS

Isotope	
Class 1	μCi/gm
Kr-83m	1.82E-1
Kr-85m	9.00E-1
Kr-85	6.70E-2
Kr-87	5.27E-1
Kr-88	1.69E+0
Kr-89	4.53E-2
Xe-131m	1.59E-1
Xe-133m	8.67E-1
Xe-133	4.33E+1
Xe-135m	1.18E-1
Xe-135	2.58E+0
Xe-137	8.15E-2
Xe-138	3.96E-1
Total noble gases	5.09E+1
Class 2	
Br-83	4.00E-2
Br-84	2.17E-2
Br-85	2.50E-3
I-130	1.75E-2
I-131	2.25E+0
I-132	8.33E-1
I-133	3.17E+0
I-134	3.92E-1
I-135	1.58E+0
Total halogens	8.31E+0

TABLE 11.1-5 (Sheet 2)

Class 3	µCi/gm
Rb-86	7.08E-4
Rb-88	1.67E+0
Cs-134	2.08E-1
Cs-136	1.08E-1
Cs-137	1.50E-1
Total Cs, Rb	2.14E+0
Class 4	
N-16	4.00E+1
Class 5	
H-3	1.00E+0
Class 6	
Cr-51	1.90E-3
Mn-54	3.10E-4
Fe-55	1.60E-3
Fe-59	1.00E-3
Co-58	1.60E-2
Co-60	2.00E-3
Sr-89	2.92E-3
Sr-90	8.33E-5
Sr-91	5.42E-3
Y-90	1.00E-5
Y-91m	3.00E-3
Y-91	5.33E-4
Y-93	2.83E-4
Zr-95	5.00E-4
Nb-95	4.17E-4
Mo-99	7.00E-1

TABLE 11.1-5 (Sheet 3)

	μCi/gm
Tc-99m	4.00E-1
Ru-103	3.75E-4
Ru-106	8.33E-5
Rh-103m	3.75E-4
Rh-106	8.33E-5
Te-125m	2.42E-4
Te-127m	2.33E-3
Te-127	7.08E-3
Te-129m	1.17E-2
Te-129	1.33E-2
Te-131m	2.08E-2
Te-131	9.17E-3
Te-132	2.25E-1
Ba-137m	1.33E-1
Ba-140	1.83E-3
La-140	1.25E-3
Ce-141	5.83E-4
Ce-143	3.33E-4
Ce-144	2.75E-4
Pr-143	4.17E-4
Pr-144	2.75E-4
Total other isotopes	1.57E+0

TABLE 11.1-6 CONTAINED SOURCES OF THE RADIOACTIVE WASTE MANAGEMENT SYSTEMS AND LARGE POTENTIALLY RADIOACTIVE OUTSIDE STORAGE TANKS

Component: Reactor Makeup Water Storage Tank — Diameter, ft: 27.5

Location: Outside — Height, ft: 34.5 — Source volume, gal (1): 133,600

	Inventory (2) Ci	Concentration (3) μCi/gm
Class 1		
Kr-83m	NEG	NEG
Kr-85m	NEG	NEG
Kr-85	NEG	NEG
Kr-87	NEG	NEG
Kr-88	NEG	NEG
Kr-89	NEG	NEG
Xe-131m	NEG	NEG
Xe-133m	NEG	NEG
Xe-133	NEG	NEG
Xe-135m	NEG	NEG
Xe-135	NEG	NEG
Xe-137	NEG	NEG
Xe-138	NEG	NEG
Total noble gas	NEG	NEG
Class 2		
Br-83	2.10E-08	2.98E-11
Br-84	1.58E-11	NEG
Br-85	NEG	NEG
I-130	2.29E-07	2.51E-10
I-131	6.59E-04	6.96E-07
I-132	6.78E-06	1.13E-08
I-133	8.49E-05	9.01E-08
I-134	4.84E-09	9.12E-12
I-135	8.09E-06	9.28E-09
Total halogens	7.59E-04	8.07E-07
Class 3		
Rb-86	1.96E-06	3.85E-09
Rb-88	NEG	NEG
Cs-134	1.21E-03	2.37E-06
Cs-136	2.30E-04	4.50E-07
Cs-137	8.86E-04	1.74E-06
Total Cs, Rb	2.33E-03	4.56E-06
Class 4		
N-16	NEG	NEG
Class 5		
H-3	1.284E+03	2.5E+00

	Inventory (2) Ci	Concentration (3) μCi/gm
Class 6		
Cr-51	2.56E-06	4.65E-09
Mn-54	6.57E-07	1.21E-09
Fe-55	3.50E-06	6.45E-09
Fe-59	1.61E-06	2.95E-09
Co-58	2.90E-05	5.32E-08
Co-60	4.41E-06	8.13E-09
Sr-89	1.25E-06	2.30E-09
Sr-90	4.63E-08	8.54E-11
Sr-91	6.03E-09	7.50E-12
Y-89m	NEG	NEG
Y-90	4.36E-08	8.07E-11
Y-91m	4.03E-09	5.01E-12
Y-91	2.46E-07	4.51E-10
Y-93	3.50E-10	NEG
Zr-95	1.07E-07	1.96E-10
Nb-95m	9.91E-08	1.83E-10
Nb-95	1.28E-07	2.36E-10
Mo-99	2.59E-05	4.45E-09
Tc-99m	NEG	NEG
Ru-103	7.00E-08	1.28E-10
Ru-106	2.13E-08	3.92E-11
Rh-103m	NEG	NEG
Rh-106	NEG	NEG
Te-125m	5.01E-08	9.18E-11
Te-127m	5.43E-07	9.98E-10
Te-127	5.45E-07	1.00E-09
Te-129m	2.06E-06	3.75E-09
Te-129	1.32E-06	2.40E-09
Te-131m	1.06E-07	1.70E-10
Te-131	1.92E-08	3.09E-11
Te-132	4.98E-06	8.61E-09
Ba-137m	8.35E-04	1.64E-06
Ba-140	3.80E-07	6.83E-10
La-140	4.22E-04	7.61E-10
Ce-141	2.11E-07	3.84E-10
Ce-143	4.16E-09	6.77E-12
Ce-144	1.45E-07	2.67E-10
Pr-143	9.83E-08	1.77E-10
Pr-144	1.45E-07	2.67E-10
Total other isotopes	9.16E-04	1.78E-06

Notes:

(1) For liquid vessels, this is based on at least 80 percent of vessel usable volume

(2) Tank inventory is based on restricting feed sources to ≤10^{-5}μCi/gm (excluding tritium) even when there is 1.0 percent fuel defects

(3) Source is based on 0.25 percent fuel defects; however, feed concentrations will not exceed 10^{-5}μCi/gm

NEG - negligible

HISTORICAL

TABLE 11.1-6 (Sheet 2)

Component: Refueling Water Storage Tank | Diameter, ft: 40.0

Location: Outside | Height, ft: 46.0 | Source volume, gal (1): 400,000

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 1		
Kr-83m	NEG	NEG
Kr-85m	NEG	NEG
Kr-85	NEG	NEG
Kr-87	NEG	NEG
Kr-88	NEG	NEG
Kr-89	NEG	NEG
Xe-131m	NEG	NEG
Xe-133m	NEG	NEG
Xe-133	NEG	NEG
Xe-135m	NEG	NEG
Xe-135	NEG	NEG
Xe-137	NEG	NEG
Xe-138	NEG	NEG
Total noble gas	NEG	NEG
Class 2		
Br-83	NEG	NEG
Br-84	NEG	NEG
Br-85	NEG	NEG
I-130	NEG	NEG
I-131	2.34E-02	3.87E-06
I-132	3.57E-04	5.89E-08
I-133	4.55E-05	7.52E-09
I-134	NEG	NEG
I-135	NEG	NEG
Total halogens	2.38E-02	3.94E-06
Class 3		
Rb-86	3.38E-05	5.59E-09
Rb-88	NEG	NEG
Cs-134	1.39E-02	2.30E-06
Cs-136	4.45E-03	7.35E-07
Cs-137	1.01E-02	1.67E-06
Total Cs, Rb	2.85E-02	4.71E-07
Class 4		
N-16	NEG	NEG
Class 5		
H-3	3.79E+03	2.5E+0

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 6		
Cr-51	3.47E-05	2.29E-08
Mn-54	6.99E-06	4.62E-09
Fe-55	3.66E-05	2.42E-08
Fe-59	1.99E-05	1.32E-08
Co-58	3.36E-04	2.22E-07
Co-60	4.58E-05	3.03E-08
Sr-89	5.92E-05	9.78E-09
Sr-90	1.92E-06	3.17E-10
Sr-91	NEG	NEG
Y-89m	5.33E-09	NEG
Y-90	1.76E-05	2.90E-10
Y-91m	NEG	NEG
Y-91	1.17E-05	1.93E-09
Y-93	NEG	NEG
Zr-95	1.25E-06	8.27E-10
Nb-95m	1.06E-06	7.01E-10
Nb-95	1.31E-06	8.65E-10
Mo-99	1.59E-03	2.62E-07
Tc-99m	NEG	NEG
Ru-103	8.81E-07	5.82E-10
Ru-106	2.26E-07	1.49E-10
Rh-103m	NEG	NEG
Rh-106	NEG	NEG
Te-125m	5.97E-07	3.95E-10
Te-127m	6.07E-06	4.01E-09
Te-127	6.09E-06	4.03E-09
Te-129m	2.67E-05	1.76E-08
Te-129	1.71E-05	1.13E-08
Te-131m	3.41E-08	2.25E-10
Te-131	6.22E-08	4.11E-11
Te-132	8.65E-05	5.72E-08
Ba-137m	9.55E-03	1.58E-06
Ba-140	2.56E-05	4.22E-09
La-140	2.90E-05	4.78E-09
Ce-141	1.10E-05	1.82E-09
Ce-143	7.26E-08	1.20E-11
Ce-144	6.19E-06	1.02E-09
Pr-143	6.52E-07	1.08E-09
Pr-144	6.20E-06	1.02E-09
Total other isotopes	1.19E-02	2.29E-06

Notes:

(1) For liquid vessels, this is based on at least 80 percent of vessel usable volume

(2) Source is based on 1.0-percent fuel defects

(3) Source is based on 0.25-percent fuel defects

NEG - negligible

TABLE 11.1-6 (Sheet 3)

Component: Condensate Storage Tank — Diameter, ft: 43.0

Location: Outside — Height, ft: 43.0 — Source volume, gal (1): 450,000

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 1		
Kr-83m	NEG	NEG
Kr-85m	NEG	NEG
Kr-85	NEG	NEG
Kr-87	NEG	NEG
Kr-88	NEG	NEG
Kr-89	NEG	NEG
Xe-131m	NEG	NEG
Xe-133m	NEG	NEG
Xe-133	NEG	NEG
Xe-135m	NEG	NEG
Xe-135	NEG	NEG
Xe-137	NEG	NEG
Xe-138	NEG	NEG
Total noble gas	NEG	NEG
Class 2		
Br-83	2.91E-06	4.27E-10
Br-84	7.84E-07	1.15E-10
Br-85	1.20E-08	1.77E-12
I-130	1.65E-06	2.42E-10
I-131	2.31E-04	3.38E-08
I-132	8.07E-05	1.18E-08
I-133	3.12E-04	4.58E-08
I-134	1.86E-05	2.72E-09
I-135	1.43E-04	2.09E-08
Total halogens	7.91E-04	1.16E-07
Class 3		
Rb-86	1.23E-08	1.80E-12
Rb-88	4.54E-06	6.66E-10
Cs-134	3.49E-07	5.27E-10
Cs-136	1.87E-06	2.74E-10
Cs-137	2.60E-06	3.81E-10
Total Cs, Rb	1.26E-05	1.85E-09
Class 4		
N-16	NEG	NEG
Class 5		
H-3	2.38E+0	1.40E-3

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 6		
Cr-51	2.77E-08	1.63E-11
Mn-54	6.14E-09	3.61E-12
Fe-55	2.46E-08	1.44E-11
Fe-59	1.85E-08	1.08E-11
Co-58	2.46E-07	1.44E-10
Co-60	2.76E-08	1.62E-11
Sr-89	5.13E-08	7.53E-12
Sr-90	1.02E-09	1.50E-13
Sr-91	6.13E-08	9.00E-12
Y-89m	NEG	NEG
Y-90	2.12E-10	NEG
Y-91m	4.89E-08	7.17E-12
Y-91	7.72E-09	1.13E-12
Y-93	3.03E-09	4.45E-13
Zr-95	1.23E-09	7.24E-13
Nb-95m	NEG	NEG
Nb-95	1.23E-09	7.24E-13
Mo-99	1.06E-05	1.55E-09
Tc-99m	NEG	NEG
Ru-103	6.16E-10	3.62E-13
Ru-106	1.23E-10	NEG
Rh-103m	NEG	NEG
Rh-106	NEG	NEG
Te-125m	3.08E-10	1.81E-13
Te-127m	3.07E-09	1.80E-12
Te-127	1.10E-08	6.48E-12
Te-129m	1.85E-08	1.08E-11
Te-129	3.32E-08	1.95E-11
Te-131m	3.28E-08	1.93E-11
Te-131	1.29E-08	7.60E-12
Te-132	3.15E-07	1.85E-10
Ba-137m	5.44E-06	7.98E-10
Ba-140	2.58E-08	3.78E-12
La-140	1.89E-08	2.77E-12
Ce-141	1.03E-08	1.51E-12
Ce-143	2.72E-09	3.99E-13
Ce-144	5.13E-09	7.52E-13
Pr-143	5.16E-09	7.56E-13
Pr-144	1.12E-08	1.64E-12
Total other isotopes	1.70E-05	2.85E-09

Notes:

(1) For liquid vessels, this is based on at least 80 percent of vessel usable volume

(2) Source is based on 1.0 percent fuel defects

(3) Source is based on 0.25 percent fuel defects

NEG - negligible

TABLE 11.1-6 (Sheet 4)

Component: Steam Generator Blowdown Flash Tank — Diameter, ft: 6

Location: Turbine Building — Height, ft: 12 — Source volume, gal (1): 1880

	Inventory (2) Ci	Concentration (3) μCi/gm
Class 1		
Kr-83m	NEG	NEG
Kr-85m	NEG	NEG
Kr-85	NEG	NEG
Kr-87	NEG	NEG
Kr-88	NEG	NEG
Kr-89	NEG	NEG
Xe-131m	NEG	NEG
Xe-133m	NEG	NEG
Xe-133	NEG	NEG
Xe-135m	NEG	NEG
Xe-135	NEG	NEG
Xe-137	NEG	NEG
Xe-138	NEG	NEG
Total noble gas	NEG	NEG
Class 2		
Br-83	3.57E-06	1.42E-07
Br-84	9.58E-07	3.82E-08
Br-85	1.47E-08	5.87E-10
I-130	2.02E-06	8.06E-08
I-131	2.82E-04	1.12E-05
I-132	9.86E-05	3.93E-06
I-133	3.82E-04	1.52E-05
I-134	2.27E-05	9.06E-07
I-135	1.74E-04	6.95E-06
Total halogens	9.66E-04	3.84E-05
Class 3		
Rb-86	1.36E-07	5.43E-09
Rb-88	5.04E-05	2.01E-06
Cs-134	4.00E-05	1.59E-06
Cs-136	2.08E-05	8.28E-07
Cs-137	2.90E-05	1.15E-06
Total Cs, Rb	1.40E-04	5.58E-06
Class 4		
N-16	NEG	NEG
Class 5		
H-3	2.19E-02	3.5E-3

	Inventory (2) Ci	Concentration (3) μCi/gm
Class 6		
Cr-51	3.39E-07	5.41E-08
Mn-54	7.52E-08	1.20E-08
Fe-55	3.01E-07	4.80E-08
Fe-59	2.26E-07	3.60E-08
Co-58	3.01E-06	4.80E-07
Co-60	3.39E-07	5.40E-08
Sr-89	6.27E-07	2.50E-08
Sr-90	1.25E-08	4.99E-10
Sr-91	7.50E-07	2.99E-08
Y-89m	NEG	NEG
Y-90	2.59E-09	1.03E-10
Y-91m	5.98E-07	2.38E-08
Y-91	9.44E-08	3.77E-09
Y-93	3.71E-08	1.48E-09
Zr-95	1.51E-08	2.41E-09
Nb-95m	NEG	NEG
Nb-95	1.51E-08	2.41E-09
Mo-99	1.29E-04	5.15E-06
Tc-99m	NEG	NEG
Ru-103	7.54E-09	1.20E-09
Ru-106	1.51E-09	2.39E-10
Rh-103m	NEG	NEG
Rh-106	NEG	NEG
Te-125m	3.76E-09	6.01E-10
Te-127m	3.76E-08	6.00E-09
Te-127	1.35E-07	2.15E-08
Te-129m	2.26E-07	3.60E-08
Te-129	4.06E-07	6.49E-08
Te-131m	4.02E-07	6.41E-08
Te-131	1.58E-07	2.53E-08
Te-132	3.86E-06	6.16E-07
Ba-137m	6.66E-05	2.65E-06
Ba-140	3.15E-07	1.26E-08
La-140	2.34E-07	9.20E-09
Ce-141	1.26E-07	5.01E-09
Ce-143	3.33E-08	1.33E-09
Ce-144	6.27E-08	2.50E-09
Pr-143	6.30E-08	2.52E-09
Pr-144	1.37E-07	5.46E-09
Total other isotopes	2.08E-04	9.45E-06

Notes:
(1) For liquid vessels, this is based on 80 percent of vessel usable volume
(2) Source is based on 1.0 percent fuel defects
(3) Source is based on 0.25 percent fuel defects
NEG - negligible

TABLE 11.1-6 (Sheet 5)

Component: Waste Holdup Tank Diameter, ft: 12

Location: Radwaste Building Height, ft: 12 Source volume, gal (1): 8,000

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 1		
Kr-83m	NEG	NEG
Kr-85m	NEG	NEG
Kr-85	NEG	NEG
Kr-87	NEG	NEG
Kr-88	NEG	NEG
Kr-89	NEG	NEG
Xe-131m	NEG	NEG
Xe-133m	NEG	NEG
Xe-133	NEG	NEG
Xe-135m	NEG	NEG
Xe-135	NEG	NEG
Xe-137	NEG	NEG
Xe-138	NEG	NEG
Total noble gas	NEG	NEG
Class 2		
Br-83	4.38E-03	7.23E-05
Br-84	5.22E-04	8.62E-06
Br-85	5.71E-06	9.43E-08
I-130	9.88E-03	1.63E-04
I-131	1.63E+01	1.89E-01
I-132	1.81E-01	6.99E-03
I-133	3.00E+00	4.96E-02
I-134	1.55E-02	2.56E-04
I-135	4.84E-01	7.99E-03
Total halogens	2.00E+01	2.54E-01
Class 3		
Rb-86	7.56E-03	7.39E-05
Rb-88	2.23E-02	3.69E-04
Cs-134	3.12E+00	2.59E-02
Cs-136	1.01E+00	1.05E-02
Cs-137	2.27E+00	1.87E-02
Total Cs, Rb	6.43E+00	5.55E-02
Class 4		
N-16	NEG	NEG
Class 5		
H-3	5.29E+01	1.75E+0

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 6		
Cr-51	2.26E-02	8.41E-04
Mn-54	4.58E-03	1.53E-04
Fe-55	2.40E-02	7.97E-04
Fe-59	1.30E-02	4.63E-04
Co-58	2.20E-01	7.62E-03
Co-60	3.01E-02	9.98E-04
Sr-89	3.86E-02	3.41E-04
Sr-90	1.26E-03	1.04E-05
Sr-91	2.39E-03	3.95E-05
Y-89m	3.48E-06	3.07E-08
Y-90	1.04E-03	7.11E-06
Y-91m	1.57E-03	2.60E-05
Y-91	7.62E-03	6.65E-05
Y-93	1.32E-04	2.18E-06
Zr-95	8.18E-04	2.85E-05
Nb-95m	6.13E-04	1.57E-05
Nb-95	7.15E-04	2.38E-05
Mo-99	2.10E+00	3.21E-02
Tc-99m	NEG	NEG
Ru-103	5.74E-04	2.06E-05
Ru-106	1.48E-04	4.95E-06
Rh-103m	NEG	NEG
Rh-106	NEG	NEG
Te-125m	3.90E-04	1.37E-05
Te-127m	3.98E-03	1.36E-04
Te-127	4.23E-03	1.52E-04
Te-129m	1.74E-02	6.33E-04
Te-129	1.12E-02	4.08E-04
Te-131m	3.41E-03	2.24E-04
Te-131	6.34E-04	4.18E-05
Te-132	9.44E-02	5.58E-03
Ba-137m	2.15E+00	1.77E-02
Ba-140	1.69E-02	1.77E-04
La-140	1.79E-02	1.78E-04
Ce-141	7.19E-03	6.56E-05
Ce-143	5.00E-04	8.21E-06
Ce-144	4.06E-03	3.39E-05
Pr-143	4.25E-03	4.35E-05
Pr-144	4.06E-03	3.39E-05
Total other isotopes	4.81E+00	6.90E-02

Notes:

(1) For liquid vessels, this is based on 80 percent of vessel usable volume

(2) Source is based on 1.0 percent fuel defects

(3) Source is based on 0.25 percent fuel defects

NEG - negligible

TABLE 11.1-6 (Sheet 6)

Component: Floor Drain Tank A or B — Diameter, ft: 12

Location: Radwaste Building — Height, ft: 12 — Source volume, gal (1): 8,000

	Inventory (2) Ci	Concentration (3) μCi/gm
Class 1		
Kr-83m	NEG	NEG
Kr-85m	NEG	NEG
Kr-85	NEG	NEG
Kr-87	NEG	NEG
Kr-88	NEG	NEG
Kr-89	NEG	NEG
Xe-131m	NEG	NEG
Xe-133m	NEG	NEG
Xe-133	NEG	NEG
Xe-135m	NEG	NEG
Xe-135	NEG	NEG
Xe-137	NEG	NEG
Xe-138	NEG	NEG
Total noble gas	NEG	NEG
Class 2		
Br-83	1.45E-03	1.19E-05
Br-84	1.73E-04	1.42E-06
Br-85	1.89E-06	1.56E-08
I-130	3.27E-03	2.69E-05
I-131	2.96E+00	2.44E-02
I-132	5.30E-02	1.04E-03
I-133	9.90E-01	8.16E-03
I-134	5.12E-03	4.22E-05
I-135	1.60E-01	1.32E-03
Total halogens	4.17E+0	3.50E-02
Class 3		
Rb-86	1.09E-03	9.01E-06
Rb-88	7.39E-03	6.09E-05
Cs-134	3.64E-01	3.00E-03
Cs-136	1.58E-01	1.31E-03
Cs-137	2.63E-01	2.17E-03
Total Cs, Rb	7.93E-01	6.55E-03
Class 4		
N-16	NEG	NEG
Class 5		
H-3	6.13E+00	2.03E-01

	Inventory (2) Ci	Concentration (3) μCi/gm
Class 6		
Cr-51	3.05E-03	1.01E-04
Mn-54	5.39E-04	1.78E-05
Fe-55	2.80E-03	9.24E-05
Fe-59	1.66E-03	5.49E-05
Co-58	2.71E-02	8.96E-04
Co-60	3.50E-03	1.16E-04
Sr-89	4.87E-03	4.02E-05
Sr-90	1.46E-04	1.20E-06
Sr-91	7.91E-04	6.52E-06
Y-89m	4.39E-07	3.62E-09
Y-90	8.64E-05	7.13E-07
Y-91m	5.20E-04	4.29E-06
Y-91	9.48E-04	7.82E-06
Y-93	4.36E-05	3.59E-07
Zr-95	1.01E-04	3.35E-06
Nb-95m	4.48E-05	1.48E-06
Nb-95	8.40E-05	2.78E-06
Mo-99	5.78E-01	4.77E-03
Tc-99m	NEG	NEG
Ru-103	7.42E-05	2.45E-06
Ru-106	1.74E-05	5.75E-07
Rh-103m	NEG	NEG
Rh-106	NEG	NEG
Te-125m	4.87E-05	1.61E-06
Te-127m	4.80E-04	1.59E-05
Te-127	5.61E-04	1.86E-05
Te-129m	2.29E-03	7.56E-05
Te-129	1.48E-03	4.88E-05
Te-131m	1.10E-03	3.65E-05
Te-131	2.06E-04	6.80E-06
Te-132	2.46E-02	8.12E-04
Ba-137m	2.48E-01	2.05E-03
Ba-140	2.67E-03	2.20E-05
La-140	2.58E-03	2.13E-05
Ce-141	9.49E-04	7.83E-06
Ce-143	1.61E-04	1.33E-06
Ce-144	4.78E-04	3.94E-06
Pr-143	6.51E-04	5.37E-06
Pr-144	4.78E-04	3.94E-06
Total other isotopes	9.12E-01	9.25E-03

Notes:

(1) For liquid vessels, this is based on 80 percent of vessel usable volume

(2) Source is based on 1.0 percent fuel defects

(3) Source is based on 0.25 percent fuel defects

NEG - negligible

HISTORICAL

TABLE 11.1-6 (Sheet 7)

Component: Waste Evaporator Condensate Tank — Diameter, ft: 8

Location: Radwaste Building — Height, ft: 15 — Source volume, gal (1): 4,000

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 1		
Kr-83m	NEG	NEG
Kr-85m	NEG	NEG
Kr-85	NEG	NEG
Kr-87	NEG	NEG
Kr-88	NEG	NEG
Kr-89	NEG	NEG
Xe-131m	NEG	NEG
Xe-133m	NEG	NEG
Xe-133	NEG	NEG
Xe-135m	NEG	NEG
Xe-135	NEG	NEG
Xe-137	NEG	NEG
Xe-138	NEG	NEG
Total noble gas	NEG	NEG
Class 2		
Br-83	8.73E-07	2.01E-09
Br-84	1.25E-09	2.58E-12
Br-85	NEG	NEG
I-130	6.18E-06	1.27E-08
I-131	9.00E-03	1.86E-05
I-132	2.05E-04	2.22E-07
I-133	2.08E-03	4.28E-06
I-134	3.58E-07	7.36E-10
I-135	2.45E-04	5.05E-07
Total halogens	1.15E-02	2.36E-05
Class 3		
Rb-86	3.57E-07	7.34E-10
Rb-88	NEG	NEG
Cs-134	1.26E-04	2.59E-07
Cs-136	5.05E-05	1.04E-07
Cs-137	9.16E-05	1.87E-07
Total Cs, Rb	2.68E-04	5.51E-07
Class 4		
N-16	NEG	NEG
Class 5		
H-3	2.20E+02	1.75E+0

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 6		
Cr-51	1.27E-07	8.37E-09
Mn-54	2.33E-08	1.53E-09
Fe-55	1.21E-07	7.97E-09
Fe-59	7.01E-08	4.62E-09
Co-58	1.15E-06	7.61E-08
Co-60	1.51E-07	9.98E-09
Sr-89	1.65E-06	3.40E-09
Sr-90	5.06E-08	1.04E-10
Sr-91	1.40E-07	2.88E-10
Y-90	3.52E-08	7.27E-11
Y-91m	9.33E-08	1.92E-10
Y-91	3.22E-07	6.65E-10
Y-93	7.80E-09	1.61E-11
Zr-95	3.59E-08	2.84E-10
Nb-95m	2.03E-08	1.61E-10
Nb-95	3.02E-08	2.39E-10
Mo-99	1.48E-04	3.06E-07
Tc-99m	NEG	NEG
Ru-103	2.60E-08	2.06E-10
Ru-106	6.26E-09	4.95E-11
Rh-103m	NEG	NEG
Rh-106	NEG	NEG
Te-125m	1.72E-08	1.36E-10
Te-127m	1.72E-07	1.35E-09
Te-127	1.87E-07	1.47E-09
Te-129m	7.98E-07	6.31E-09
Te-129	5.11E-07	4.04E-09
Te-131m	2.57E-07	2.03E-09
Te-131	4.67E-08	3.70E-10
Te-132	6.78E-06	5.36E-08
Ba-137m	8.58E-05	1.77E-07
Ba-140	8.50E-07	1.75E-09
La-140	8.66E-07	1.78E-09
Ce-141	3.17E-07	6.54E-10
Ce-143	3.63E-08	7.48E-11
Ce-144	1.65E-07	3.39E-10
Pr-143	2.10E-07	4.32E-10
Pr-144	1.65E-07	3.39E-10
Total other isotopes	2.49E-04	6.72E-07

Notes:

(1) For liquid vessels, this is based on 80 percent of vessel usable volume

(2) Source is based on 1.0 percent fuel defects

(3) Source is based on 0.25 percent fuel defects

NEG - negligible

TABLE 11.1-6 (Sheet 8)

Component: Waste Evaporator | Diameter, ft: 3.5

Location: Radwaste Building | Height, ft: 11 | Source volume, gal (1): 500

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 1		
Kr-83m	NEG	NEG
Kr-85m	NEG	NEG
Kr-85	NEG	NEG
Kr-87	NEG	NEG
Kr-88	NEG	NEG
Kr-89	NEG	NEG
Xe-131m	NEG	NEG
Xe-133m	NEG	NEG
Xe-133	NEG	NEG
Xe-135m	NEG	NEG
Xe-135	NEG	NEG
Xe-137	NEG	NEG
Xe-138	NEG	NEG
Total noble gas	NEG	NEG
Class 2		
Br-83	1.60E-04	1.69E-04
Br-84	1.87E-07	1.98E-07
Br-85	NEG	NEG
I-130	1.16E-03	1.23E-03
I-131	3.11E+00	3.29E+00
I-132	6.27E-02	6.63E-02
I-133	4.00E-01	4.23E-01
I-134	5.41E-05	5.72E-05
I-135	4.44E-02	4.70E-02
Total halogens	3.62E+00	3.83E+00
Class 3		
Rb-86	2.15E-03	2.28E-03
Rb-88	NEG	NEG
Cs-134	1.89E+00	2.00E+00
Cs-136	2.39E-01	2.53E-01
Cs-137	1.40E+00	1.48E+00
Total Cs, Rb	3.53E+00	3.74E+00
Class 4		
N-16	NEG	NEG
Class 5		
H-3	2.72E+0	1.38E+0

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 6		
Cr-51	6.52E-02	3.31E-02
Mn-54	2.23E-02	1.13E-02
Fe-55	1.22E-01	6.18E-02
Fe-59	4.55E-02	2.31E-02
Co-58	8.77E-01	4.45E-01
Co-60	1.54E-01	7.83E-02
Sr-89	1.68E-02	1.78E-02
Sr-90	7.80E-04	8.25E-04
Sr-91	2.59E-04	2.74E-04
Y-89m	1.50E-06	1.59E-06
Y-90	7.44E-04	7.87E-04
Y-91m	1.74E-04	1.84E-04
Y-91	3.48E-03	3.68E-03
Y-93	1.46E-05	1.54E-05
Zr-95	1.53E-03	1.62E-03
Nb-95m	1.46E-03	1.55E-03
Nb-95	2.48E-03	2.62E-03
Mo-99	3.19E-01	3.38E-01
Tc-99m	NEG	NEG
Tc-99	2.23E-07	2.36E-07
Ru-103	9.21E-04	9.75E-04
Ru-106	3.50E-04	3.70E-04
Rh-103m	NEG	NEG
Rh-106	NEG	NEG
Te-125m	7.08E-04	7.49E-04
Te-127m	8.28E-03	8.76E-03
Te-127	8.41E-03	8.90E-03
Te-129m	2.63E-02	2.78E-02
Te-129	1.68E-02	1.78E-02
Te-131m	1.93E-03	2.04E-03
Te-131	3.51E-04	3.71E-04
Te-132	5.85E-02	6.19E-02
Ba-137m	1.33E+00	1.41E+00
Ba-140	3.98E-03	4.21E-03
La-140	4.35E-03	4.60E-03
Ce-141	2.66E-03	2.82E-03
Ce-143	7.13E-05	7.54E-05
Ce-144	2.34E-03	2.48E-03
Pr-143	1.04E-03	1.10E-03
Pr-144	2.34E-03	2.48E-03
Total other isotopes	3.11E+00	2.58E+00

Notes:

(1) For liquid vessels, this is based on 100 percent of vessel usable volume

(2) Source is based on 0.12 percent due to the total collection time of 70 days to obtain a full source volume

(3) Source is based on 0.25 percent fuel defects

NEG - negligible

HISTORICAL

TABLE 11.1-6 (Sheet 9)

Component: Laundry and Hot Shower Tank B   Diameter, ft: 12

Location: Radwaste Building   Height, ft: 12   Source volume, gal (1): 8000

	Inventory (2) Ci	Concentration (3) μCi/gm
Class 1		
Kr-83m	ND	ND
Kr-85m	ND	ND
Kr-85	ND	ND
Kr-87	ND	ND
Kr-88	ND	ND
Kr-89	ND	ND
Xe-131m	ND	ND
Xe-133m	ND	ND
Xe-133	ND	ND
Xe-135m	ND	ND
Xe-135	ND	ND
Xe-137	ND	ND
Xe-138	ND	ND
Total noble gas	ND	ND
Class 2		
Br-83	ND	ND
Br-84	ND	ND
Br-85	ND	ND
I-130	ND	ND
I-131	2.93E-5	9.66E-7
I-132	ND	ND
I-133	ND	ND
I-134	ND	ND
I-135	ND	ND
Total halogens	2.93E-5	9.66E-7
Class 3		
Rb-86	ND	ND
Rb-88	ND	ND
Cs-134	6.34E-4	2.09E-5
Cs-136	ND	ND
Cs-137	1.17E-3	3.86E-5
Total Cs, Rb	1.80E-3	5.95E-5
Class 4		
N-16	ND	ND
Class 5		
H-3	ND	ND

	Inventory (2) Ci	Concentration (3) μCi/gm
Class 6		
Cr-51	ND	ND
Mn-54	4.86E-5	1.61E-6
Fe-55	ND	ND
Fe-59	ND	ND
Co-58	1.95E-4	6.44E-6
Co-60	4.38E-4	1.45E-5
Sr-89	ND	ND
Sr-90	ND	ND
Sr-91	ND	ND
Y-89m	ND	ND
Y-90	ND	ND
Y-91m	ND	ND
Y-91	ND	ND
Y-93	ND	ND
Zr-95	6.82E-5	2.25E-6
Nb-95m	9.74E-5	3.22E-6
Nb-95	ND	ND
Mo-99	ND	ND
Tc-99m	6.82E-6	2.25E-7
Ru-103	1.17E-4	3.86E-6
Ru-106	ND	ND
Rh-103m	ND	ND
Rh-106	2.14E-5	7.08E-7
Te-125m	ND	ND
Te-127m	ND	ND
Te-127	ND	ND
Te-129m	ND	ND
Te-129	ND	ND
Te-131m	ND	ND
Te-131	ND	ND
Te-132	ND	ND
Ba-137m	ND	ND
Ba-140	ND	ND
La-140	ND	ND
Ce-141	ND	ND
Ce-143	ND	ND
Ce-144	2.43E-4	8.05E-6
Pr-143	ND	ND
Pr-144	ND	ND
Total other isotopes	1.24E-3	4.09E-5

Notes:

(1) For liquid vessels, this is based on 80 percent of vessel usable volume

(2) Source is based on Table 2-20 of NUREG-0017, April 1976

(3) Source is based on 0.25 percent fuel defects

ND - indicates no data available

TABLE 11.1-6 (Sheet 10)

Component: Laundry and Hot Shower Tank A | Diameter, ft: 12

Location: Radwaste Building | Height, ft: 12 | Source volume, gal (1): 8000

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 1		
Kr-83m	ND	ND
Kr-85m	ND	ND
Kr-85	ND	ND
Kr-87	ND	ND
Kr-88	ND	ND
Kr-89	ND	ND
Xe-131m	ND	ND
Xe-133m	ND	ND
Xe-133	ND	ND
Xe-135m	ND	ND
Xe-135	ND	ND
Xe-137	ND	ND
Xe-138	ND	ND
Total noble gas	ND	ND
Class 2		
Br-83	ND	ND
Br-84	ND	ND
Br-85	ND	ND
I-130	ND	ND
I-131	2.93E-5	9.66E-7
I-132	ND	ND
I-133	ND	ND
I-134	ND	ND
I-135	ND	ND
Total halogens	2.93E-5	9.66E-7
Class 3		
Rb-86	ND	ND
Rb-88	ND	ND
Cs-134	6.34E-4	2.09E-5
Cs-136	ND	ND
Cs-137	1.17E-3	3.86E-5
Total Cs, Rb	1.80E-3	5.59E-5
Class 4		
N-16	ND	ND
Class 5		
H-3	ND	ND

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 6		
Cr-51	ND	ND
Mn-54	4.86E-5	1.61E-6
Fe-55	ND	ND
Fe-59	ND	ND
Co-58	1.95E-4	6.44E-6
Co-60	4.38E-4	1.45E-5
Sr-89	ND	ND
Sr-90	ND	ND
Sr-91	ND	ND
Y-89m	ND	ND
Y-90	ND	ND
Y-91m	ND	ND
Y-91	ND	ND
Y-93	6.82E-5	2.25E-6
Zr-95	9.74E-5	3.22E-6
Nb-95m	ND	ND
Nb-95	ND	ND
Mo-99	6.82E-6	2.25E-7
Tc-99m	1.17E-4	3.86E-6
Ru-103	ND	ND
Ru-106	ND	ND
Rh-103m	2.14E-5	7.08E-7
Rh-106	ND	ND
Te-125m	ND	ND
Te-127m	ND	ND
Te-127	ND	ND
Te-129m	ND	ND
Te-129	ND	ND
Te-131m	ND	ND
Te-131	ND	ND
Te-132	ND	ND
Ba-137m	ND	ND
Ba-140	ND	ND
La-140	ND	ND
Ce-141	ND	ND
Ce-143	2.43E-4	8.05E-6
Ce-144	ND	ND
Pr-143	ND	ND
Pr-144	1.24E-3	4.09E-5
Total other isotopes	ND	ND

Notes:

(1) For liquid vessels, this is based on 80 percent of vessel usable volume

(2) Source is based on Table 2-20 of NUREG-0017, April 1976

(3) Source is based on 0.25 percent fuel defects

ND - indicates no data available

HISTORICAL

TABLE 11.1-6 (Sheet 11)

Component: Waste Monitor Tank "B" Diameter, ft: 7.3

Location: Radwaste Building Height, ft: 8 Source volume, gal (1): 4000

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 1		
Kr-83m	ND	ND
Kr-85m	ND	ND
Kr-85	ND	ND
Kr-87	ND	ND
Kr-88	ND	ND
Kr-89	ND	ND
Xe-131m	ND	ND
Xe-133m	ND	ND
Xe-133	ND	ND
Xe-135m	ND	ND
Xe-135	ND	ND
Xe-137	ND	ND
Xe-138	ND	ND
Total noble gas	ND	ND
Class 2		
Br-83	ND	ND
Br-84	ND	ND
Br-85	ND	ND
I-130	ND	ND
I-131	1.46E-6	9.66E-8
I-132	ND	ND
I-133	ND	ND
I-134	ND	ND
I-135	ND	ND
Total halogens	1.46E-6	9.66E-8
Class 3		
Rb-86	ND	ND
Rb-88	ND	ND
Cs-134	3.17E-5	2.09E-6
Cs-136	ND	ND
Cs-137	5.85E-5	3.86E-6
Total Cs, Rb	9.02E-5	5.95E-6
Class 4		
N-16	ND	ND
Class 5		
H-3	ND	ND

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 6		
Cr-51	ND	ND
Mn-54	2.43E-6	1.61E-7
Fe-55	ND	ND
Fe-59	ND	ND
Co-58	9.76E-6	6.44E-7
Co-60	2.19E-5	1.45E-6
Sr-89	ND	ND
Sr-90	ND	ND
Sr-91	ND	ND
Y-90	ND	ND
Y-91m	ND	ND
Y-91	ND	ND
Y-93	ND	ND
Zr-95	3.41E-6	2.25E-7
Nb-95m	4.87E-6	3.22E-7
Nb-95	ND	ND
Mo-99	ND	ND
Tc-99m	3.41E-7	2.25E-8
Ru-103	5.85E-6	3.86E-7
Ru-106	ND	ND
Rh-103m	ND	ND
Rh-106	1.07E-6	7.08E-8
Te-125m	ND	ND
Te-127m	ND	ND
Te-127	ND	ND
Te-129m	ND	ND
Te-129	ND	ND
Te-131m	ND	ND
Te-131	ND	ND
Te-132	ND	ND
Ba-137m	ND	ND
Ba-140	ND	ND
La-140	ND	ND
Ce-141	ND	ND
Ce-143	ND	ND
Ce-144	1.22E-5	8.05E-7
Pr-143	ND	ND
Pr-144	ND	ND
Total other isotopes	6.18E-5	4.09E-6

Notes:

(1) For liquid vessels, this is based on 80 percent of vessel usable volume

(2) Source is based on Table 2-20 of NUREG-0017, April 1976

(3) Source is based on 0.25 percent fuel defects

ND - indicates no data available

TABLE 11.1-6 (Sheet 12)

Component: Boron Recycle Holdup Tank A or B   Diameter, ft: 20

Location: Radwaste Building   Height, ft: 31   Source volume, gal (1): 44,800

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 1		
Kr-83m	NEG	NEG
Kr-85m	NEG	NEG
Kr-85	NEG	NEG
Kr-87	NEG	NEG
Kr-88	NEG	NEG
Kr-89	NEG	NEG
Xe-131m	NEG	NEG
Xe-133m	NEG	NEG
Xe-133	NEG	NEG
Xe-135m	NEG	NEG
Xe-135	NEG	NEG
Xe-137	NEG	NEG
Xe-138	NEG	NEG
Total noble gas	NEG	NEG
Class 2		
Br-83	1.06E-03	1.56E-06
Br-84	1.26E-04	1.86E-07
Br-85	1.38E-06	2.03E-09
I-130	2.39E-03	3.52E-06
I-131	3.99E+00	5.89E-03
I-132	4.30E-02	1.61E-04
I-133	7.25E-01	1.07E-03
I-134	3.74E-03	5.51E-06
I-135	1.17E-01	1.72E-04
Total halogens	4.88E+00	7.30E-03
Class 3		
Rb-86	2.22E-02	3.27E-05
Rb-88	2.35E+00	3.48E-03
Rb-89	1.16E-03	1.72E-06
Cs-134	9.29E+00	1.37E-02
Cs-136	2.94E+00	4.33E-03
Cs-137	6.75E+00	9.95E-03
Cs-138	4.54E-02	6.71E-05
Total Cs, Rb	2.14E+01	3.16E-02
Class 4		
N-16	NEG	NEG

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 5		
H-3	5.92E+02	3.50E+0
Class 6		
Cr-51	5.48E-03	3.22E-05
Mn-54	1.12E-03	6.59E-06
Fe-55	5.88E-03	3.45E-05
Fe-59	3.16E-03	1.86E-05
Co-58	5.36E-02	3.15E-04
Co-60	7.37E-03	4.33E-05
Sr-89	9.67E-03	1.43E-05
Sr-90	3.08E-04	4.54E-07
Sr-91	5.58E-04	8.23E-07
Y-89m	8.44E-07	1.24E-09
Y-90	2.57E-04	3.79E-07
Y-91m	3.67E-04	5.41E-07
Y-91	1.85E-03	2.73E-06
Y-93	3.08E-05	4.53E-08
Zr-95	1.99E-04	1.17E-06
Nb-95m	1.52E-04	8.91E-07
Nb-95	1.75E-04	1.03E-06
Mo-99	4.91E-01	7.24E-04
Tc-99m	NEG	NEG
Ru-103	1.40E-04	8.20E-07
Ru-106	3.63E-05	2.13E-07
Rh-103m	NEG	NEG
Rh-106	NEG	NEG
Te-125m	9.49E-05	5.58E-07
Te-127m	9.70E-04	5.70E-06
Te-127	1.03E-03	6.05E-06
Te-129m	4.22E-03	2.48E-05
Te-129	2.71E-03	1.60E-05
Te-131m	7.97E-04	4.69E-06
Te-131	1.48E-04	8.72E-07
Te-132	2.21E-02	1.30E-04
Ba-137m	6.39E+00	9.41E-03
Ba-140	4.05E-03	5.97E-06
La-140	4.29E-03	6.33E-06
Ce-141	1.74E-03	2.57E-06
Ce-143	1.17E-04	1.72E-07
Ce-144	9.91E-04	1.46E-06
Pr-143	1.02E-03	1.50E-06
Pr-144	9.92E-04	1.46E-06
Total other isotopes	7.01E+00	1.08E-02

Notes:

(1) For liquid vessels, this is based on 80 percent of vessel usable volume

(2) Source is based on 1.0 percent fuel defects

(3) Source is based on 0.25 percent fuel defects

NEG - negligible

HISTORICAL

TABLE 11.1-6 (Sheet 13)

Component: Boron Recycle Evaporator   Diameter, ft: 3.5

Location: Radwaste Building   Height, ft: 11   Source volume, gal (1): 500

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 1		
Kr-83m	NEG	NEG
Kr-85m	NEG	NEG
Kr-85	NEG	NEG
Kr-87	NEG	NEG
Kr-88	NEG	NEG
Kr-89	NEG	NEG
Xe-131m	NEG	NEG
Xe-133m	NEG	NEG
Xe-133	NEG	NEG
Xe-135m	NEG	NEG
Xe-135	NEG	NEG
Xe-137	NEG	NEG
Xe-138	NEG	NEG
Total noble gas	NEG	NEG
Class 2		
Br-83	1.92E-05	2.54E-06
Br-84	NEG	NEG
Br-85	NEG	NEG
I-130	2.32E-04	3.06E-05
I-131	5.65E-01	7.46E-02
I-132	2.61E-02	1.67E-03
I-133	8.28E-02	1.09E-02
I-134	1.71E-06	2.26E-07
I-135	8.05E-03	1.06E-03
Total halogens	6.82E-01	8.83E-02
Class 3		
Rb-86	3.18E-03	4.20E-04
Rb-88	NEG	NEG
Cs-134	1.35E+00	1.78E-01
Cs-135	NEG	NEG
Cs-136	4.20E-01	5.53E-02
Cs-137	9.82E-01	1.29E-01
Cs-138	5.99E-07	NEG
Total Cs, Rb	2.76E+00	3.63E-01
Class 4		
N-16	NEG	NEG

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 5		
H-3	5.51E+01	3.50E+0
Class 6		
Cr-51	7.88E-04	4.16E-04
Mn-54	1.62E-04	8.56E-05
Fe-55	8.52E-04	4.49E-04
Fe-59	4.56E-04	2.41E-04
Co-58	7.75E-03	4.08E-03
Co-60	1.07E-03	5.63E-04
Sr-89	1.40E-03	1.85E-04
Sr-90	4.46E-05	5.90E-06
Sr-91	4.84E-05	6.39E-06
Y-89m	1.26E-07	1.66E-08
Y-90	3.78E-05	5.00E-06
Y-91m	3.23E-05	4.27E-06
Y-91	2.68E-04	3.54E-05
Y-93	2.73E-06	3.61E-07
Zr-95	2.40E-04	1.52E-05
Nb-95m	1.86E-04	1.18E-05
Nb-95	2.13E-04	1.35E-05
Mo-99	6.61E-02	8.72E-03
Tc-99m	NEG	NEG
Ru-103	1.67E-04	1.06E-05
Ru-106	4.38E-05	2.77E-06
Rh-103m	NEG	NEG
Rh-106	NEG	NEG
Te-125m	1.14E-04	7.23E-06
Te-127m	1.17E-03	7.40E-05
Te-127	1.22E-03	7.68E-05
Te-129m	5.06E-03	3.21E-04
Te-129	3.25E-03	2.05E-04
Te-131m	8.15E-04	5.16E-05
Te-131	1.49E-04	9.41E-06
Te-132	2.51E-02	1.59E-03
Ba-137m	9.25E-01	1.22E-01
Ba-140	5.78E-04	7.64E-05
La-140	6.18E-04	8.17E-05
Ce-141	2.51E-04	3.31E-05
Ce-143	1.46E-05	1.92E-06
Ce-144	1.43E-04	1.90E-05
Pr-143	1.46E-04	1.93E-05
Pr-144	1.43E-04	1.90E-05
Total other isotopes	1.04E+00	1.40E-01

Notes:

(1) For liquid vessels, this is based on 80 percent of vessel usable volume

(2) Source is based on 1.0 percent fuel defects

(3) Source is based on 0.25 percent fuel defects

NEG - negligible

HISTORICAL

TABLE 11.1-6 (Sheet 14)

Component: Water Monitor Tank A   Diameter, ft: 7.3

Location: Radwaste Building   Height, ft: 8   Source volume, gal (1): 4000

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 1		
Kr-83m	NEG	NEG
Kr-85m	NEG	NEG
Kr-85	NEG	NEG
Kr-87	NEG	NEG
Kr-88	NEG	NEG
Kr-89	NEG	NEG
Xe-131m	NEG	NEG
Xe-133m	NEG	NEG
Xe-133	NEG	NEG
Xe-135m	NEG	NEG
Xe-135	NEG	NEG
Xe-137	NEG	NEG
Xe-138	NEG	NEG
Total noble gas	NEG	NEG
Class 2		
Br-83	2.09E-10	1.38E-11
Br-84	3.58E-12	2.37E-13
Br-85	NEG	NEG
I-130	7.32E-10	4.85E-11
I-131	7.33E-07	4.86E-08
I-132	2.83E-08	1.88E-09
I-133	2.31E-07	1.53E-08
I-134	2.80E-10	1.85E-11
I-135	3.28E-08	2.17E-09
Total halogens	1.03E-06	6.80E-08
Class 3		
Rb-86	1.36E-08	8.99E-10
Rb-88	1.05E-09	6.98E-11
Cs-134	4.53E-06	3.00E-07
Cs-136	1.96E-06	1.30E-07
Cs-137	3.27E-06	2.17E-07
Total Cs, Rb	9.77E-06	6.48E-07
Class 4		
N-16	NEG	NEG
Class 5		
H-3	3.07E+00	2.03E-01

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 6		
Cr-51	3.04E-09	2.02E-10
Mn-54	5.38E-10	3.56E-11
Fe-55	2.79E-09	1.85E-10
Fe-59	1.66E-09	1.10E-10
Co-58	2.70E-08	1.79E-09
Co-60	3.49E-09	2.31E-10
Sr-89	1.21E-09	8.03E-11
Sr-90	3.64E-11	2.41E-12
Sr-91	1.72E-10	1.14E-11
Y-90	2.18E-11	1.44E-12
Y-91m	1.14E-10	7.58E-12
Y-91	2.36E-10	1.56E-11
Y-93	9.54E-12	6.32E-13
Zr-95	1.01E-10	6.69E-12
Nb-95m	4.56E-11	3.02E-12
Nb-95	8.40E-11	5.56E-12
Mo-99	1.41E-07	9.35E-09
Tc-99m	NEG	NEG
Ru-103	7.40E-11	4.90E-12
Ru-106	1.74E-11	1.15E-12
Rh-103m	NEG	NEG
Rh-106	NEG	NEG
Te-125m	4.86E-11	3.22E-12
Te-127m	4.79E-10	3.17E-11
Te-127	5.50E-10	3.64E-11
Te-129m	2.28E-09	1.51E-10
Te-129	1.46E-09	9.70E-11
Te-131m	1.06E-09	6.99E-11
Te-131	1.93E-10	1.28E-11
Te-132	2.41E-08	1.60E-09
Ba-137m	3.10E-06	2.05E-07
Ba-140	6.63E-10	4.39E-11
La-140	6.44E-10	4.27E-11
Ce-141	2.36E-10	1.56E-11
Ce-143	3.85E-11	2.55E-12
Ce-144	1.19E-10	7.88E-12
Pr-143	1.62E-10	1.07E-11
Pr-144	1.19E-10	7.88E-12
Total other isotopes	3.32E-06	2.19E-07

Notes:

(1) For liquid vessels, this is based on 80 percent of vessel usable volume

(2) Source is based on a total concentration of $1x10^{-5}$ Ci/cc in the floor drain tank, except that the tritium concentration is based on a floor drain tank concentration of $2.0x10^{-}$ µCi/gm

(3) Source is based on 0.25 percent fuel defects

NEG - negligible

HISTORICAL

TABLE 11.1-6 (Sheet 15)

Component: Evaporator Bottoms Tank (Primary) Diameter, ft: 5

Location: Radwaste Building Height, ft: 8.83 Source volume, gal (1): 800

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 1		
Kr-83m	NEG	NEG
Kr-85m	NEG	NEG
Kr-85	NEG	NEG
Kr-87	NEG	NEG
Kr-88	NEG	NEG
Kr-89	NEG	NEG
Xe-131m	NEG	NEG
Xe-133m	NEG	NEG
Xe-133	NEG	NEG
Xe-135m	NEG	NEG
Xe-135	NEG	NEG
Xe-137	NEG	NEG
Xe-138	NEG	NEG
Total noble gas	NEG	NEG
Class 2		
Br-83	1.60E-04	1.69E-04
Br-84	1.87E-07	1.98E-07
Br-85	NEG	NEG
I-130	1.16E-03	1.23E-03
I-131	3.11E+00	3.29E+00
I-132	6.27E-02	6.63E-02
I-133	4.00E-01	4.23E-01
I-134	5.41E-05	5.72E-05
I-135	4.44E-02	4.70E-02
Total halogens	3.62E+00	3.83E+00
Class 3		
Rb-86	2.24E-03	2.28E-03
Rb-88	NEG	NEG
Cs-134	2.85E+00	2.00E+00
Cs-136	2.42E-01	2.53E-01
Cs-137	2.15E+00	1.48E+00
Total Cs, Rb	5.24E+00	3.74E+00
Class 4		
N-16	NEG	NEG
Class 5		
H-3	4.19E+00	1.38E+00

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 6		
Cr-51	7.14E-02	3.31E-02
Mn-54	3.26E-02	1.13E-02
Fe-55	1.85E-01	6.18E-02
Fe-59	5.39E-02	2.31E-02
Co-58	1.12E+00	4.45E-01
Co-60	2.35E-01	7.83E-02
Sr-89	2.03E-02	1.78E-02
Sr-90	1.20E-03	8.25E-04
Sr-91	2.59E-04	2.74E-04
Y-89m	1.81E-06	1.59E-06
Y-90	1.16E-03	7.87E-04
Y-91m	1.74E-04	1.84E-04
Y-91	4.30E-03	3.68E-03
Y-93	1.46E-05	1.54E-05
Zr-95	1.92E-03	1.62E-03
Nb-95m	1.88E-03	1.55E-03
Nb-95	3.67E-03	2.62E-03
Mo-99	3.19E-01	3.38E-01
Tc-99m	NEG	NEG
Ru-103	9.36E-04	9.75E-04
Ru-106	5.16E-04	3.70E-04
Rh-103m	NEG	NEG
Rh-106	NEG	NEG
Te-125m	8.74E-04	7.49E-04
Te-127m	1.12E-02	8.76E-03
Te-127	1.13E-02	8.90E-03
Te-129m	2.97E-02	2.78E-02
Te-129	1.90E-02	1.78E-02
Te-131m	1.93E-03	2.04E-03
Te-131	3.51E-04	3.71E-04
Te-132	5.85E-02	6.19E-02
Ba-137m	2.04E+00	1.41E+00
Ba-140	4.03E-03	4.21E-03
La-140	4.41E-03	4.60E-03
Ce-141	2.98E-03	2.82E-03
Ce-143	7.13E-05	7.54E-05
Ce-144	3.41E-03	2.48E-03
Pr-143	1.06E-03	1.10E-03
Pr-144	3.41E-03	2.48E-03
Total other isotopes	4.25E+00	2.58E+00

Notes:

(1) For liquid vessels, this is based on 80 percent of vessel usable volume

(2) Source is based on 0.12 percent fuel defects due to the collection time of 70 days for the waste evaporator

(3) Source is based on 0.25 percent fuel defects

NEG - negligible

TABLE 11.1-6 (Sheet 16)

Component: Spent Resin Storage Tank (Primary) Diameter, ft: 7

Location: Radwaste Building Height, ft: 10.7 Source volume, ft^3 (1): 280

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 1		
Kr-83m	NEG	NEG
Kr-85m	NEG	NEG
Kr-85	NEG	NEG
Kr-87	NEG	NEG
Kr-88	NEG	NEG
Kr-89	NEG	NEG
Xe-131m	NEG	NEG
Xe-133m	NEG	NEG
Xe-133	NEG	NEG
Xe-135m	NEG	NEG
Xe-135	NEG	NEG
Xe-137	NEG	NEG
Xe-138	NEG	NEG
Total noble gas	NEG	NEG
Class 2		
Br-83	NEG	NEG
Br-84	NEG	NEG
Br-85	NEG	NEG
I-130	5.80E-01	1.57E-01
I-131	1.17E+03	3.16E+02
I-132	5.20E+01	7.51E+00
I-133	1.76E+02	4.80E+01
I-134	9.08E-01	2.47E-01
I-135	2.83E+01	7.73E+00
Total halogens	1.43E+03	3.80E+02
Class 3		
Rb-86	7.91E-01	2.15E-01
Rb-88	1.39E+00	3.80E-01
Cs-134	1.78E+03	4.85E+02
Cs-136	8.91E+01	2.43E+01
Cs-137	1.48E+03	4.03E+02
Total Cs, Rb	3.35E+03	9.13E+02
Class 4		
N-16	NEG	NEG
Class 5		
H-3	NEG	NEG

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 6		
Cr-51	2.99E+01	3.90E+00
Mn-54	2.91E+01	3.80E+00
Fe-55	1.93E+02	2.52E+01
Fe-59	2.49E+01	3.26E+00
Co-58	6.10E+02	7.98E+01
Co-60	2.56E+02	3.34E+01
Sr-89	9.80E+00	2.67E+00
Sr-90	1.35E+00	3.67E-01
Sr-91	NEG	NEG
Y-90	1.33E+00	3.62E-01
Y-91m	NEG	NEG
Y-91	2.18E+00	5.93E-01
Y-93	NEG	NEG
Zr-95	2.12E+00	2.77E-01
Nb-95m	2.11E+00	2.76E-01
Nb-95	3.00E+00	3.92E-01
Mo-99	1.36E+02	3.71E+01
Tc-99m	NEG	NEG
Ru-103	9.98E-01	1.31E-01
Ru-106	9.89E-01	1.29E-01
Rh-103m	NEG	NEG
Rh-106	NEG	NEG
Te-125m	9.18E-01	1.20E-01
Te-127m	1.50E+01	1.96E+00
Te-127	1.52E+01	1.99E+00
Te-129m	2.69E+01	3.51E+00
Te-129	1.72E+01	2.25E+00
Te-131m	1.83E+00	2.39E-01
Te-131	NEG	NEG
Te-132	5.15E+01	6.74E+00
Ba-137m	1.40E+03	3.81E+02
Ba-140	1.63E+00	4.44E-01
La-140	1.77E+00	4.82E-01
Ce-141	1.28E+00	3.48E-01
Ce-143	NEG	NEG
Ce-144	3.00E+00	8.15E-01
Pr-143	4.25E-01	1.16E-01
Pr-144	3.00E+00	8.15E-01
Total other isotopes	2.89E+03	5.93E+02

Notes:

(1) For liquid vessels, this is based on 80 percent of vessel usable volume

(2) Source is based on 0.12 percent fuel defects and 1 year accumulated activity collection for demineralizers

(3) Source is based on 0.25 percent fuel defects

(4) Liquid activities are obtained by multiplying inventory and concentration by .001

NEG - negligible

TABLE 11.1-6 (Sheet 17)

Component: Chemical Drain Tank

Location: Radwaste Building

Diameter, ft: 4

Height, ft: 6.7

Source volume, ft^3 (1): 66.8

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 1		
Kr-83m	NEG	NEG
Kr-85m	NEG	NEG
Kr-85	NEG	NEG
Kr-87	NEG	NEG
Kr-88	NEG	NEG
Kr-89	NEG	NEG
Xe-131m	NEG	NEG
Xe-133m	NEG	NEG
Xe-133	NEG	NEG
Xe-135m	NEG	NEG
Xe-135	NEG	NEG
Xe-137	NEG	NEG
Xe-138	NEG	NEG
Total noble gas	NEG	NEG
Class 2		
Br-83	1.08E-06	2.38E-06
Br-84	1.29E-07	2.84E-07
Br-85	1.41E-09	3.10E-09
I-130	2.43E-06	5.37E-06
I-131	4.88E-03	1.08E-02
I-132	2.18E-04	2.55E-04
I-133	7.40E-04	1.63E-03
I-134	3.81E-06	8.41E-06
I-135	1.19E-04	2.63E-04
Total halogens	5.96E-03	1.30E-02
Class 3		
Rb-86	3.55E-06	7.57E-06
Rb-88	5.50E-06	1.21E-05
Cs-134	6.52E-03	7.49E-03
Cs-136	3.78E-04	8.27E-04
Cs-137	5.07E-03	5.61E-03
Total Cs, Rb	1.20E-02	1.39E-02
Class 4		
N-16	NEG	NEG
Class 5		
H-3	9.86E-01	5.21E-01

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 6		
Cr-51	1.17E-04	1.12E-04
Mn-54	7.22E-05	4.21E-05
Fe-55	4.26E-04	2.33E-04
Fe-59	9.47E-05	8.06E-05
Co-58	2.12E-03	1.59E-03
Co-60	5.48E-04	2.95E-04
Sr-89	3.65E-05	6.26E-05
Sr-90	2.82E-06	3.12E-06
Sr-91	5.89E-07	1.30E-06
Y-89m	3.29E-09	5.63E-09
Y-90	2.75E-06	2.99E-06
Y-91m	3.87E-07	8.55E-07
Y-91	7.92E-06	1.30E-05
Y-93	3.24E-08	7.16E-08
Zr-95	7.53E-06	5.77E-06
Nb-95m	7.45E-06	5.56E-06
Nb-95	1.00E-05	6.67E-06
Mo-99	5.21E-04	1.15E-03
Tc-99m	NEG	NEG
Ru-103	3.84E-06	3.38E-06
Ru-106	2.40E-06	1.38E-06
Rh-103m	NEG	NEG
Rh-106	NEG	NEG
Te-125m	3.34E-06	2.65E-06
Te-127m	4.70E-05	3.19E-05
Te-127	4.76E-05	3.25E-05
Te-129m	1.04E-04	9.56E-05
Te-129	6.70E-05	6.13E-05
Te-131m	7.00E-06	7.41E-06
Te-131	1.30E-06	1.38E-06
Te-132	1.97E-04	2.08E-04
Ba-137m	4.80E-03	5.31E-03
Ba-140	6.29E-06	1.38E-05
La-140	6.85E-06	1.50E-05
Ce-141	5.00E-06	9.64E-06
Ce-143	1.23E-07	2.72E-07
Ce-144	7.55E-06	9.25E-06
Pr-143	1.65E-06	3.60E-06
Pr-144	7.55E-06	9.25E-06
Total other isotopes	9.29E-03	9.42E-03

Notes:

(1) For liquid vessels, this is based on 80 percent of vessel usable volume

(2) Source is based on 0.12 percent fuel defects

(3) Source is based on 0.25 percent fuel defects

NEG - negligible

TABLE 11.1-6 (Sheet 18)

Component: Evaporator Bottoms Tank (Secondary) Diameter, ft: 7.5

Location: Radwaste Building Height, ft: 10.6 Source volume, gal (1): 2000

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 1		
Kr-83m	NEG	NEG
Kr-85m	NEG	NEG
Kr-85	NEG	NEG
Kr-87	NEG	NEG
Kr-88	NEG	NEG
Kr-89	NEG	NEG
Xe-131m	NEG	NEG
Xe-133m	NEG	NEG
Xe-133	NEG	NEG
Xe-135m	NEG	NEG
Xe-135	NEG	NEG
Xe-137	NEG	NEG
Xe-138	NEG	NEG
Total noble gas	NEG	NEG
Class 2		
Br-83	1.59E-07	1.15E-07
Br-84	NEG	NEG
Br-85	NEG	NEG
I-130	3.24E-06	2.32E-06
I-131	1.69E-02	6.08E-03
I-132	7.73E-05	1.92E-05
I-133	1.31E-03	8.91E-04
I-134	5.20E-09	3.78E-09
I-135	1.01E-04	7.31E-05
Total halogens	1.84E-02	7.07E-03
Class 3		
Rb-86	1.19E-06	3.82E-07
Rb-88	NEG	NEG
Cs-134	1.31E-03	1.53E-04
Cs-136	1.54E-04	5.12E-05
Cs-137	1.85E-03	1.12E-04
Total Cs, Rb	3.32E-03	3.17E-04
Class 4		
N-16	NEG	NEG
Class 5		
H-3	3.33E-04	4.62E-05

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 6		
Cr-51	3.16E-05	4.68E-06
Mn-54	6.93E-05	1.27E-06
Fe-55	3.69E-05	5.14E-06
Fe-59	2.34E-05	3.38E-06
Co-58	5.64E-04	4.74E-05
Co-60	5.91E-04	5.80E-06
Sr-89	7.94E-06	2.39E-06
Sr-90	1.85E-07	5.37E-08
Sr-91	8.21E-08	5.94E-08
Y-89m	7.15E-10	2.15E-10
Y-90	1.67E-07	4.50E-08
Y-91m	5.48E-08	3.97E-08
Y-91	1.28E-06	3.83E-07
Y-93	4.40E-09	3.18E-09
Zr-95	8.22E-05	2.36E-07
Nb-95m	1.38E-06	1.73E-07
Nb-95	1.12E-04	2.42E-07
Mo-99	2.38E-04	1.15E-04
Tc-99m	NEG	NEG
Ru-103	8.52E-06	1.11E-07
Ru-106	1.45E-04	2.53E-08
Rh-103m	NEG	NEG
Rh-106	NEG	NEG
Te-125m	4.05E-07	5.82E-08
Te-127m	4.32E-06	6.10E-07
Te-127	4.40E-06	6.41E-07
Te-129m	2.21E-05	3.24E-06
Te-129	1.42E-05	2.08E-06
Te-131m	1.95E-06	5.87E-07
Te-131	3.55E-07	1.07E-07
Te-132	7.36E-05	1.61E-05
Ba-137m	1.74E-03	1.06E-04
Ba-140	1.58E-06	8.58E-07
La-140	2.84E-06	9.20E-07
Ce-141	1.46E-06	4.48E-07
Ce-143	2.23E-08	1.36E-08
Ce-144	3.01E-04	2.64E-07
Pr-143	5.61E-07	7.85E-07
Pr-144	3.01E-04	2.64E-07
Total other isotopes	4.39E-03	3.19E-04

Notes:

(1) For liquid vessels, this is based on 80 percent of vessel usable volume

(2) Source is based on 0.12 percent fuel defects due to collection time

(3) Source is based on 0.25 percent fuel defects

NEG - negligible

TABLE 11.1-6 (Sheet 19)

Component: Secondary Liquid Waste Evaporator   Diameter, ft: 7.5

Location: Radwaste Building   Height, ft: 13.5   Source volume, ft^3 (1): 760

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 1		
Kr-83m	NEG	NEG
Kr-85m	NEG	NEG
Kr-85	NEG	NEG
Kr-87	NEG	NEG
Kr-88	NEG	NEG
Kr-89	NEG	NEG
Xe-131m	NEG	NEG
Xe-133m	NEG	NEG
Xe-133	NEG	NEG
Xe-135m	NEG	NEG
Xe-135	NEG	NEG
Xe-137	NEG	NEG
Xe-138	NEG	NEG
Total noble gas	NEG	NEG
Class 2		
Br-83	1.32E-06	1.15E-07
Br-84	NEG	NEG
Br-85	NEG	NEG
I-130	2.67E-05	2.32E-06
I-131	7.00E-02	6.08E-03
I-132	9.00E-05	1.92E-05
I-133	1.03E-02	8.91E-04
I-134	4.33E-08	3.78E-09
I-135	8.41E-04	7.31E-05
Total halogens	8.13E-02	7.07E-03
Class 3		
Rb-86	4.40E-06	3.82E-07
Rb-88	NEG	NEG
Cs-134	1.76E-03	1.53E-04
Cs-136	5.89E-04	5.12E-05
Cs-137	1.28E-03	1.12E-04
Total Cs, Rb	3.63E-03	3.17E-04
Class 4		
N-16	NEG	NEG
Class 5		
H-3	1.33E-04	4.62E-05

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 6		
Cr-51	1.35E-05	4.68E-06
Mn-54	3.64E-06	1.27E-06
Fe-55	1.48E-05	5.14E-06
Fe-59	9.74E-06	3.38E-06
Co-58	1.36E-04	4.74E-05
Co-60	1.67E-05	5.80E-06
Sr-89	2.75E-05	2.39E-06
Sr-90	6.18E-07	5.37E-08
Sr-91	6.82E-07	5.94E-08
Y-89m	2.47E-07	2.15E-10
Y-90	5.18E-07	4.50E-08
Y-91m	4.55E-07	3.97E-08
Y-91	4.41E-06	3.83E-07
Y-93	3.66E-08	3.18E-09
Zr-95	6.79E-07	2.36E-07
Nb-95m	4.99E-07	1.73E-07
Nb-95	6.97E-07	2.42E-07
Mo-99	1.32E-03	1.15E-04
Tc-99m	NEG	NEG
Ru-103	3.19E-07	1.11E-07
Ru-106	7.29E-08	2.53E-08
Rh-103m	NEG	NEG
Rh-106	NEG	NEG
Te-125m	1.67E-07	5.82E-08
Te-127m	1.76E-06	6.10E-07
Te-127	1.84E-06	6.41E-07
Te-129m	9.34E-06	3.24E-06
Te-129	5.98E-06	2.08E-06
Te-131m	1.69E-06	5.87E-07
Te-131	3.08E-07	1.07E-07
Te-132	4.64E-05	1.61E-05
Ba-137m	1.22E-03	1.06E-04
Ba-140	9.87E-06	8.58E-07
La-140	1.06E-05	9.20E-07
Ce-141	5.15E-06	4.48E-07
Ce-143	1.57E-07	1.36E-08
Ce-144	3.03E-06	2.64E-07
Pr-143	2.13E-06	1.85E-07
Pr-144	3.03E-06	2.64E-07
Total other isotopes	2.89E-03	3.19E-04

Notes:

(1) For liquid vessels, this is based on 80 percent of vessel usable volume

(2) Source is based on 1.0 percent fuel defects

(3) Source is based on 0.25 percent fuel defects

NEG - negligible

TABLE 11.1-6 (Sheet 20)

Component: Spent Resin Storage Tank (Secondary) Diameter, ft: 8

Location: Radwaste Building Height, ft: 12.5 Source volume, ft^3 (1):450

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 1		
Kr-83m	NEG	NEG
Kr-85m	NEG	NEG
Kr-85	NEG	NEG
Kr-87	NEG	NEG
Kr-88	NEG	NEG
Kr-89	NEG	NEG
Xe-131m	NEG	NEG
Xe-133m	NEG	NEG
Xe-133	NEG	NEG
Xe-135m	NEG	NEG
Xe-135	NEG	NEG
Xe-137	NEG	NEG
Xe-138	NEG	NEG
Total noble gas	NEG	NEG
Class 2		
Br-83	1.42E-05	2.32E-06
Br-84	8.45E-07	1.38E-07
Br-85	NEG	NEG
I-130	4.16E-05	6.80E-06
I-131	9.00E-02	1.47E-02
I-132	2.37E-03	3.88E-04
I-133	1.32E-02	2.16E-03
I-134	3.27E-05	5.35E-06
I-135	1.94E-03	3.17E-04
Total halogens	1.08E-01	1.76E-02
Class 3		
Rb-86	9.00E-05	1.47E-05
Rb-88	2.47E-05	4.03E-06
Cs-134	6.43E-02	1.05E-02
Cs-136	1.03E-02	1.68E-03
Cs-137	4.78E-02	7.81E-03
Total Cs, Rb	1.23E-01	2.00E-02
Class 4		
N-16	NEG	NEG
Class 5		
H-3	NEG	NEG

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 6		
Cr-51	2.41E-03	1.90E-04
Mn-54	9.66E-04	7.61E-05
Fe-55	4.05E-03	3.19E-04
Fe-59	2.02E-03	1.59E-04
Co-58	3.14E-02	2.47E-03
Co-60	4.60E-03	3.62E-04
Sr-89	7.10E-04	1.16E-04
Sr-90	2.07E-05	3.38E-06
Sr-91	1.21E-05	1.97E-06
Y-89m	6.36E-08	1.04E-08
Y-90	1.95E-05	3.19E-06
Y-91m	8.20E-06	1.34E-06
Y-91	1.18E-04	1.92E-05
Y-93	6.30E-07	1.03E-07
Zr-95	7.41E-05	1.21E-05
Nb-95m	6.92E-05	1.13E-05
Nb-95	1.05E-04	1.71E-05
Mo-99	1.42E-02	2.32E-03
Tc-99m	NEG	NEG
Ru-103	3.09E-05	5.05E-06
Ru-106	9.42E-06	1.54E-06
Rh-103m	NEG	NEG
Rh-106	NEG	NEG
Te-125m	1.78E-05	2.91E-06
Te-127m	2.07E-04	3.38E-05
Te-127	2.14E-04	3.50E-05
Te-129m	8.63E-04	1.41E-04
Te-129	5.56E-04	9.09E-05
Te-131m	8.02E-05	1.31E-05
Te-131	1.48E-05	2.42E-06
Te-132	2.00E-03	3.27E-04
Ba-137m	4.52E-02	7.38E-03
Ba-140	1.54E-04	2.52E-05
La-140	1.69E-04	2.76E-05
Ce-141	1.18E-04	1.92E-05
Ce-143	1.82E-06	2.98E-07
Ce-144	9.67E-05	1.58E-05
Pr-143	3.43E-05	5.60E-06
Pr-144	9.67E-05	1.58E-05
Total other isotopes	1.11E-01	1.43E-02

Notes:

(1) For liquid vessels, this is based on 80 percent of vessel usable volume

(2) Source is based on 0.12 percent fuel defects

(3) Source is based on 0.25 percent fuel defects

NEG - negligible

HISTORICAL

TABLE 11.1-6 (Sheet 21)

Component: Solid Radwaste System Decant Tank | Diameter, ft: 4.5

Location: Radwaste Building | Height, ft: 6 | Source volume, gal (1): 400

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 1		
Kr-83m	NEG	NEG
Kr-85m	NEG	NEG
Kr-85	NEG	NEG
Kr-87	NEG	NEG
Kr-88	NEG	NEG
Kr-89	NEG	NEG
Xe-131m	NEG	NEG
Xe-133m	NEG	NEG
Xe-133	NEG	NEG
Xe-135m	NEG	NEG
Xe-135	NEG	NEG
Xe-137	NEG	NEG
Xe-138	NEG	NEG
Total noble gas	NEG	NEG
Class 2		
Br-83	NEG	NEG
Br-84	NEG	NEG
Br-85	NEG	NEG
I-130	1.16E-01	1.57E-01
I-131	2.34E+02	3.16E+02
I-132	1.04E+01	7.51E+00
I-133	3.52E+01	4.80E+01
I-134	1.82E-01	2.47E-01
I-135	5.66E+00	7.73E+00
Total halogens	2.86E+02	3.80E+02
Class 3		
Rb-86	1.58E-01	2.15E-01
Rb-88	2.78E-01	3.80E-01
Cs-134	3.56E+02	4.85E+02
Cs-136	1.78E+01	2.43E+01
Cs-137	2.96E+02	4.03E+02
Total Cs, Rb	6.70E+02	9.13E+02
Class 4		
N-16	NEG	NEG
Class 5		
H-3	NEG	NEG

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 6		
Cr-51	5.98E+00	3.90E+00
Mn-54	5.82E+00	3.80E+00
Fe-55	3.86E+01	2.52E+01
Fe-59	4.98E+00	3.26E+00
Co-58	1.22E+02	7.98E+01
Co-60	5.12E+01	3.34E+01
Sr-89	1.96E+00	2.67E+00
Sr-90	2.70E-01	3.67E-01
Sr-91	NEG	NEG
Y-90	2.66E-01	3.62E-01
Y-91m	NEG	NEG
Y-91	4.36E-01	5.93E-01
Y-93	NEG	NEG
Zr-95	4.24E-01	2.77E-01
Nb-95m	4.22E-01	2.76E-01
Nb-95	6.00E-01	3.92E-01
Mo-99	2.72E+01	3.71E+01
Tc-99m	NEG	NEG
Ru-103	2.00E-01	1.31E-01
Ru-106	1.98E-01	1.29E-01
Rh-103m	NEG	NEG
Rh-106	NEG	NEG
Te-125m	1.84E-01	1.20E-01
Te-127m	3.00E+00	1.96E+00
Te-127	3.04E+00	1.99E+00
Te-129m	5.38E+00	3.51E+00
Te-129	3.44E+00	2.25E+00
Te-131m	3.66E-01	2.39E-01
Te-131	NEG	NEG
Te-132	1.03E+01	6.74E+00
Ba-137m	2.80E+02	3.81E+02
Ba-140	3.26E-01	4.44E-01
La-140	3.54E-01	4.82E-01
Ce-141	2.56E-01	3.48E-01
Ce-143	NEG	NEG
Ce-144	6.00E-01	8.15E-01
Pr-143	8.50E-02	1.16E-01
Pr-144	6.00E-01	8.15E-01
Total other isotopes	5.69E+02	5.93E+02

Notes:

(1) For liquid vessels, this is based on 80 percent of vessel usable volume

(2) Source is based on 1.0 percent fuel defects

(3) Source is based on 0.25 percent fuel defects

NEG - negligible

TABLE 11.1-6 (Sheet 22)

Component: Secondary Liquid Waste System Drain Collector Tank A or B — Diameter, ft: 12

Location: Turbine Building — Height, ft: 22.75 — Source volume, gal (1): 12,600

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 1		
Kr-83m	NEG	NEG
Kr-85m	NEG	NEG
Kr-85	NEG	NEG
Kr-87	NEG	NEG
Kr-88	NEG	NEG
Kr-89	NEG	NEG
Xe-131m	NEG	NEG
Xe-133m	NEG	NEG
Xe-133	NEG	NEG
Xe-135m	NEG	NEG
Xe-135	NEG	NEG
Xe-137	NEG	NEG
Xe-138	NEG	NEG
Total noble gas	NEG	NEG
Class 2		
Br-83	1.68E-08	8.83E-11
Br-84	9.95E-10	5.23E-12
Br-85	NEG	NEG
I-130	4.44E-08	2.34E-10
I-131	1.49E-05	7.85E-08
I-132	4.58E-07	2.68E-09
I-133	1.17E-05	6.17E-08
I-134	3.87E-08	2.03E-10
I-135	2.26E-06	1.19E-08
Total halogens	2.94E-05	1.55E-07
Class 3		
Rb-86	7.52E-10	3.95E-12
Rb-88	2.91E-09	1.53E-11
Cs-134	2.28E-07	1.20E-09
Cs-136	1.13E-07	5.94E-10
Cs-137	1.65E-07	8.66E-10
Total Cs, Rb	5.10E-07	2.68E-09
Class 4		
N-16	NEG	NEG
Class 5		
H-3	1.66E-01	3.49E-03

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 6		
Cr-51	1.89E-09	3.98E-11
Mn-54	4.28E-10	8.99E-12
Fe-55	1.72E-09	3.60E-11
Fe-59	1.27E-09	2.67E-11
Co-58	1.70E-08	3.57E-10
Co-60	1.93E-09	4.05E-11
Sr-89	3.54E-09	1.86E-11
Sr-90	7.13E-11	3.75E-13
Sr-91	1.36E-09	7.13E-12
Y-90	2.58E-11	1.36E-13
Y-91m	9.21E-10	4.84E-12
Y-91	5.51E-10	2.90E-12
Y-93	7.00E-11	3.68E-13
Zr-95	8.53E-11	1.79E-12
Nb-95m	1.24E-11	2.61E-13
Nb-95	8.47E-11	1.78E-12
Mo-99	5.97E-07	3.14E-09
Tc-99m	NEG	NEG
Ru-103	4.23E-11	8.89E-13
Ru-106	8.54E-12	1.79E-13
Rh-103m	NEG	NEG
Rh-106	NEG	NEG
Te-125m	2.13E-11	4.47E-13
Te-127m	2.13E-10	4.48E-12
Te-127	3.84E-10	8.06E-12
Te-129m	1.27E-09	2.66E-11
Te-129	8.71E-10	1.83E-11
Te-131m	1.47E-09	3.08E-11
Te-131	2.75E-10	5.77E-12
Te-132	1.84E-08	3.86E-10
Ba-137m	1.56E-07	8.21E-10
Ba-140	1.72E-09	9.02E-12
La-140	1.44E-09	7.56E-12
Ce-141	7.04E-10	3.70E-12
Ce-143	1.26E-10	6.63E-13
Ce-144	3.57E-10	1.88E-12
Pr-143	3.50E-10	1.84E-12
Pr-144	3.61E-10	1.90E-12
Total other isotopes	8.12E-07	5.01E-09

Notes:

(1) For liquid vessels, this is based on 84 percent of vessel usable volume

(2) Source is based on 1.0 percent fuel defects

(3) Source is based on 0.25 percent fuel defects

NEG - negligible

TABLE 11.1-6 (Sheet 23)

Component: High TDS Collector Tank — Diameter, ft: 12

Location: Turbine Building — Height, ft: 20 — Source volume, gal (1): 15,000

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 1		
Kr-83m	NEG	NEG
Kr-85m	NEG	NEG
Kr-85	NEG	NEG
Kr-87	NEG	NEG
Kr-88	NEG	NEG
Kr-89	NEG	NEG
Xe-131m	NEG	NEG
Xe-133m	NEG	NEG
Xe-133	NEG	NEG
Xe-135m	NEG	NEG
Xe-135	NEG	NEG
Xe-137	NEG	NEG
Xe-138	NEG	NEG
Total noble gas	NEG	NEG
Class 2		
Br-83	1.46E-05	6.43E-08
Br-84	8.63E-07	3.81E-09
Br-85	1.26E-09	5.54E-12
I-130	4.26E-05	1.88E-07
I-131	7.21E-02	3.18E-04
I-132	4.33E-04	2.57E-06
I-133	1.35E-02	5.97E-05
I-134	3.35E-05	1.48E-07
I-135	1.99E-03	8.77E-06
Total halogens	8.81E-02	3.89E-04
Class 3		
Rb-86	4.49E-06	1.96E-08
Rb-88	2.29E-06	1.00E-08
Cs-134	1.78E-03	7.78E-06
Cs-136	6.05E-04	2.65E-06
Cs-137	1.30E-03	5.67E-06
Total Cs, Rb	3.69E-03	1.61E-05
Class 4		
N-16	NEG	NEG
Class 5		
H-3	NEG	NEG

	Inventory (2) Ci	Concentration (3) µCi/gm
Class 6		
Cr-51	1.36E-05	2.40E-07
Mn-54	3.65E-06	6.43E-08
Fe-55	1.48E-05	2.61E-07
Fe-59	9.80E-06	1.73E-07
Co-58	1.37E-04	2.41E-06
Co-60	1.67E-05	2.94E-07
Sr-89	2.76E-05	1.22E-07
Sr-90	6.18E-07	2.73E-09
Sr-91	1.24E-06	5.46E-09
Y-89m	2.49E-09	1.10E-11
Y-90	5.09E-07	2.25E-09
Y-91m	8.40E-07	3.70E-09
Y-91	4.42E-06	1.95E-08
Y-93	6.44E-08	2.84E-10
Zr-95	6.82E-07	1.20E-08
Nb-95m	4.88E-07	8.59E-09
Nb-95	6.95E-07	1.22E-08
Mo-99	1.44E-03	6.35E-06
Tc-99m	NEG	NEG
Ru-103	3.22E-07	5.66E-09
Ru-106	7.31E-08	1.29E-09
Rh-103m	NEG	NEG
Rh-106	NEG	NEG
Te-125m	1.68E-07	2.96E-09
Te-127m	1.76E-06	3.10E-08
Te-127	1.92E-06	3.39E-08
Te-129m	9.41E-06	1.66E-07
Te-129	6.08E-06	1.07E-07
Te-131m	2.05E-06	3.61E-08
Te-131	3.80E-07	6.70E-09
Te-132	5.00E-05	8.81E-07
Ba-137m	1.23E-03	5.36E-06
Ba-140	1.01E-05	4.44E-08
La-140	1.07E-05	4.71E-08
Ce-141	5.19E-06	2.29E-08
Ce-143	1.87E-07	8.23E-10
Ce-144	3.04E-06	1.34E-08
Pr-143	2.17E-06	9.55E-09
Pr-144	3.04E-06	1.34E-08
Total other isotopes	3.10E-03	1.69E-05

Notes:

(1) For liquid vessels, this is based on 100 percent of vessel usable volume

(2) Source is based on 1.0 percent fuel defects

(3) Source is based on 0.25 percent fuel defects

NEG - negligible

HISTORICAL

TABLE 11.1-6 (Sheet 24)

Component: Secondary Liquid Waste Monitor Tank — Diameter, ft: 12

Location: Radwaste Building — Height, ft: 22.75 — Source volume, gal (1): 15,000

	Inventory (2) Ci	Concentration (3) μCi/gm
Class 1		
Kr-83m	NEG	NEG
Kr-85m	NEG	NEG
Kr-85	NEG	NEG
Kr-87	NEG	NEG
Kr-88	NEG	NEG
Kr-89	NEG	NEG
Xe-131m	NEG	NEG
Xe-133m	NEG	NEG
Xe-133	NEG	NEG
Xe-135m	NEG	NEG
Xe-135	NEG	NEG
Xe-137	NEG	NEG
Xe-138	NEG	NEG
Total noble gas	NEG	NEG
Class 2		
Br-83	1.32E-10	5.83E-13
Br-84	NEG	NEG
Br-85	NEG	NEG
I-130	2.67E-09	1.18E-11
I-131	7.01E-06	3.09E-08
I-132	1.00E-08	2.82E-11
I-133	1.02E-06	4.52E-09
I-134	4.34E-12	1.91E-14
I-135	8.41E-08	3.71E-10
Total halogens	8.13E-06	3.58E-08
Class 3		
Rb-86	4.41E-11	1.94E-13
Rb-88	NEG	NEG
Cs-134	1.77E-08	7.77E-11
Cs-136	5.92E-09	2.60E-11
Cs-137	1.29E-08	5.67E-11
Total Cs, Rb	3.66E-08	1.61E-10
Class 4		
N-16	NEG	NEG
Class 5		
H-3	NEG	NEG

	Inventory (2) Ci	Concentration (3) μCi/gm
Class 6		
Cr-51	1.12E-09	2.38E-12
Mn-54	3.04E-10	6.43E-13
Fe-55	1.23E-09	2.61E-12
Fe-59	8.12E-10	1.72E-12
Co-58	1.14E-08	2.41E-11
Co-60	1.39E-09	2.94E-12
Sr-89	2.75E-10	1.21E-12
Sr-90	6.18E-12	2.73E-14
Sr-91	6.83E-12	3.01E-14
Y-89m	2.47E-14	1.09E-16
Y-90	5.19E-12	2.29E-14
Y-91m	4.56E-12	2.01E-14
Y-91	4.41E-11	1.94E-13
Y-93	3.67E-13	1.61E-15
Zr-95	5.66E-11	1.20E-13
Nb-95m	4.17E-11	8.80E-14
Nb-95	5.81E-11	1.23E-13
Mo-99	1.32E-08	5.82E-11
Tc-99m	NEG	NEG
Ru-103	2.67E-11	5.63E-14
Ru-106	6.08E-12	1.29E-14
Rh-103m	NEG	NEG
Rh-106	NEG	NEG
Te-125m	1.40E-11	2.95E-14
Te-127m	1.47E-10	3.10E-13
Te-127	1.54E-10	3.25E-13
Te-129m	7.79E-10	1.65E-12
Te-129	4.99E-10	1.06E-12
Te-131m	1.41E-10	2.98E-13
Te-131	2.57E-11	5.44E-14
Te-132	3.87E-09	8.18E-12
Ba-137m	1.22E-08	5.36E-11
Ba-140	9.91E-11	4.36E-13
La-140	1.06E-10	4.67E-13
Ce-141	5.16E-11	2.27E-13
Ce-143	1.57E-12	6.91E-15
Ce-144	3.04E-11	1.34E-13
Pr-143	2.13E-11	9.40E-14
Pr-144	3.04E-11	1.34E-13
Total other isotopes	4.81E-08	1.61E-10

Notes:

(1) For liquid vessels, this is based on 100 percent of vessel usable volume

(2) Source is based on 1.0 percent fuel defects

(3) Source is based on 0.25 percent fuel defects

NEG - negligible

APPENDIX 11.1A - PARAMETERS FOR CALCULATION OF SOURCE TERMS FOR EXPECTED RADIOACTIVE CONCENTRATIONS AND RELEASES

11.1A.1 Regulatory Guide 1.112 provides guidelines for developing radioactive source terms. The following parameters and models are used to calculate radioactive source terms for the evaluation of radioactive waste treatment systems in determining the impact of radioactive effluents on the environment. Except where indicated and justified, the source terms are calculated using the PWR-GALE Code. Figure 11.1A-1 shows a block diagram of liquid releases, and Table 11.1A-2 and Figure 11.1A-2 provide the volume, radioactivity level, and decontamination factors (DF) for each liquid path. The values shown are for the standard power block design with an anion bed recycle evaporator condensate demineralizer. A mixed bed demineralizer is optional. See Chapter 11.0 of the Site Addendum for the type used and any associated variations in the radioactive release values. Figure 11.1A-3 shows a block diagram of gaseous releases, and Tables 11.1A-3 and 11.1A-4 provide the volume, radioactivity level, and DF for each gaseous path.

11.1A.2 The basic plant data for the source term calculations are provided in Table 11.1A-1.

Table 11.1A-5 provides summary GALE Code input data.

The following sections discuss the detailed design of waste systems:

a. Chemical and volume control 9.3.4

b. Gaseous radwaste 11.3

c. Liquid radwaste 11.2

d. Boron recycle 9.3.6

e. Secondary liquid waste 10.4.10

f. Steam generator blowdown 10.4.8

The plant ventilation systems are discussed in Section 9.4.

TABLE 11.1A-1 PLANT DATA FOR SOURCE TERM CALCULATIONS

A.	General	
1.	Core power evaluated for safety considerations in the SAR MW(t)	3,636
2.	Plant capacity factor, percent	80
3.	Core properties	
(a)	The total mass of uranium in an equilibrium core, lb	196,000
(b)	Enrichment of uranium in reload fuel (max.), percent	3.10
(c)	Fissile plutonium in reload fuel (max.), percent	0.0
(d)	Fuel cladding defects number of rods, percent	0.12
(e)	Cladding material	Zircaloy-4/Zirlo
(f)	Escape rate coefficients	Same as R.G. 1.112
B.	Reactor Coolant System Properties	
1.	Mass of primary coolant, x 10^5 lb(1)	5.3
2.	Mass of primary coolant less pressurizer volume, x 10^5 lb	5.04
3.	Mass of primary coolant in reactor, x 10^5 lb	2.1
4.	Primary coolant flowrate, x 10^6 lb/hr	142
5.	Number of loops	4
6.	Average primary letdown rate to CVCS, gpm	75
7.	Average primary letdown rate to CVCS cation demineralizer, gpm	7.5
8.	Average shim bleed flowrate, gpm	1.3
9.	Chemical and volume control system parameter	See Figure 11.1A-2 (Sheet 1) and Table 11.1A-2.
10.	Boron recycle system parameters	See Figure 11.1A-2 (Sheet 2) and Table 11.1A-2.

TABLE 11.1A-1 (Sheet 2)

11. Reactor coolant degassing	Continuous in VCT (CVCS) or recycle evaporator (BRS)
12. Reactor coolant leakage to containment, percent of inventory per day	
Noble gases	1.0
Iodine	0.001
C. Secondary System	
1. Steam Generator	
Number	4
Type	Recirculation U-tube
Carryover, percent	0.25
Iodine partition factor	0.01
Nonvolatile partition factor	0.001
Type of chemistry	AVT
Operating temperature, °F	554.6
Operating pressure, psia	1000
Mass of steam each, (2) lb	8000
Mass of liquid each, (2) lb	104,000
2. Total steam flow, x 10^6 lb/hr	15.96
3. Total mass of coolant secondary cycle (3), x 10^6 lb	3.57
4. Condensate storage tank mass, x 10^6 lb	2.54
5. Hotwell mass, x 10^6 lb	1.33
6. Primary to secondary leakage rate, lb/day	100
7. Total blowdown rate	
Maximum, lb/hr	176,000
Minimum, lb/hr	30,000
8. Blowdown system process parameters	See Figure 11.1A-2 (Sheet 6)

TABLE 11.1A-1 (Sheet 3)

9. Condensate demineralizers	
Type (regenerative)	Mixed deep bed
Fraction of condensate passing through	.68
Number	6 (1 spare)
Flow Loading, gal/ft^2	50
Regeneration frequency, maximum	1 bed/2 days
Regeneration frequency, average	1 bed/3.5 days
Regeneration volume	
High TDS, gallons	15,000
Low TDS, gallons	45,000
D. Liquid Waste Processing Systems	
1. Liquid radwaste system design parameters	See Figure 11.1A-2 (Sheets 3,4,5) and Table 11.1A-2
2. Secondary liquid waste system design parameters	See Figure 11.1A-2 (Sheet 7) and Table 11.1A-2
E. Gaseous Waste Processing System	
Gaseous radwaste system design parameters	See Figure 11.3-2 and Tables 11.1A-3 & 4
F. Ventilation and Exhaust Systems	
HVAC system design parameters	See Figure 11.3-2 and Tables 11.1A-3 & 4

NOTES:

(1) Full power temperature and pressure

(2) Full power operation conditions

(3) Excluding condensate tank

TABLE 11.1A-2 PARAMETERS USED IN THE CALCULATION OF ESTIMATED ACTIVITY IN LIQUID WASTES

Collector Tank With Sources	Volume of Liquid Wastes	Specific Activity	Basis	Collection Period Assumed Before Processing	Comments
A. Reactor coolant drain tank	300 gal/day	1.0 PCA(1)	0.05 gpm/R.C. pump #2 seal leak and other miscellaneous leakage	Feed and bleed	10 percent assumed discharged. Balance recycled to BRS.
B. Letdown shim-bleed	1,840 gal/day	1.0 PCA(1)	CVCS inventory control	Feed and bleed	10 percent assumed discharged. Balance recycled to BRS.
C. Waste holdup tank	400 gal/day	0.5 PCA(1)		10 days	Recycle to RMWST
1. Equipment drains			Tank drains, filter drains, heat exchanger drains, demineralizer drains		
2. Excess samples			Miscellaneous prepurges sample		
D. Floor drain tank	1,140 gal/day	0.06 PCA(1)		7 days	Recycled to RMWST or discharged
1. Decontamination water			Fuel cask, vessel head system component flushing, floor washdown, etc.		Nominal discharge will be 5,000 gallons at 35 gpm, approximately twice a week.
2. Laboratory equipment			Washing and rinsing of laboratory equipment. Reactor grade drains which are aerated. Maintenance drains for filters, H. Ex., demineralizers, etc.		
E. Chemical drain tanks	7,000 gal/yr	0.15 PCA(1)	Samples plus sample rinse water	90 days	Drummed
F. Laundry and hot shower tanks	800 gal/day	N/A	Laundry operation waste 600 gal/day with remainder from abnormal refueling operation.	7 days	Normally Discharged. Nominal discharge will be 8,000 gallons at 35 gpm, approximately once per week.
G. Steam generator	86,400-518,400 gal/day	1.0 SCA(2)	Continuous blowdown of 60-360 gpm	None	Normally recycled to condensate/ feedwater water system
H. Secondary liquid waste drain collector tank	7,200 gal/day	(3)	Floor drains and equipment drains	None	Discharged or recycled to condensate storage tank.

TABLE 11.1A-2 (Sheet 2)

Collector Tank With Sources	Volume of Liquid Wastes	Specific Activity	Basis	Collection Period Assumed Before Processing	Comments
I. Condensate demineralizer regeneration waste	4,286 gal/day	(3)	15,000 gal/high TDS regeneration waste - per regeneration	None	Processing options are: 1. Neutralize and discharge 2. Process and recycle to condenser 3. Evaporate and discharge
	12,857 gal/day	(3)	45,000 gal/low TDS regeneration waste - per regeneration		Normally recycled to condensate/ feedwater water system

(1) PCA - Primary coolant specific activity

(2) SCA - Secondary coolant specific activity

(3) Fraction of SCA internally calculated by GALE Code.

TABLE 11.1A-3 DESCRIPTION OF MAJOR SOURCES OF GASEOUS RELEASES

		Factors Which Mitigate Radioactive Releases			
	Basis (per unit), 0.12% Failed Fuel,	Partition Factors (1)			
Source	80% Plant Factor	Noble Gas	Iodines	Holdup	Filters (2)
Containment building	1%/day, 0.001%/day of noble gas and iodine inventory in the reactor coolant, respectively	1	1	24 purges year	Internal: P-H-C-H (3) Exhaust: P-H-C-H
Auxiliary/fuel/radwaste buildings	Noble gas and volatile iodine in 160 lbs/day or reactor coolant (4)	1	0.15	No	Exhaust: P-H-C-H
Turbine building	1700 lbs/hr of secondary steam (5)	1	1	No	No
Condenser air removal system	Noble gas and volatile iodine in 100 lbs of primary coolant/day (4)	1	0.15	No	Exhaust: P-H-C-H
Gaseous radwaste system	Continuous stripping of gases during power operation and degassing of reactor coolant during 2 cold shutdowns/year	-	-	90 days	Exhaust: P-H-C-H

Notes:

(1) Partition factors here mean either the partition on a mass basis between the liquid and vapor phases or the fraction of the leak that is airborne.

(2) P - prefilter or roughing filter; H - HEPA filter; C - charcoal adsorber efficiencies of 99 percent for particulates and 70 percent for radioiodines.

(3) No credit has been taken for the internal recirculation clean-up.

(4) 5 percent of the iodine in the primary coolant is assumed to be in the volatile form.

(5) Secondary steam activities are based on 100 lbs./day primary-secondary leakage and a partition factor of 0.01 between liquid and vapor phases in the steam generator for iodines.

TABLE 11.1A-4 CHARACTERISTICS OF RELEASE POINTS AND RELEASES

	Source	Building Free Volume (cu. ft.)	Point of Release (1)	Filters (2)	Shape of Exhaust Vent	Type	Physical Characteristics of Effluent Streams: Flow rate (cfm)	Temperature (F)	Velocity (fpm)
A.	Reactor building	2,500,000	Unit vent	Internal: P-H-C-H Exhaust: P-H-C-H	-	Intermittent 4 shutdown purges/yr 20 purges/yr at power	20,000 4,000	120 max.	-
B.	Auxiliary building/fuel building	1,210,000/ 824,000	Unit vent	Exhaust: P-H-C-H	-	Continuous	32,000	104 max.	-
C.	Unit vent point of release for sources A, B, G, H, and I	-	Top of containment (Base El. 2208' Release El. 2218')	-	Rectangular 7'6" x 5'0"	Continuous	66,000/ 82,000	110 max.	1,800/2,200
D.	Vent collection header	-	Radwaste bldg. vent	Exhaust: P-H-C-H	-	Continuous	250	Ambient	-
E.	Radwaste building point of release for sources D, E gaseous radwaste system releases	477,400	Roof of radwaste building (Base El. 2055'-6" Release El. 2065'-6")	Exhaust: P-H-C-H	Square 34" x 34"	Continuous	12,000	104 max.	1,600
F.	Turbine building	4,400,000	Roof of turbine building (Base El. 2137' Release El. 2147')	None	Roof exhaust fans	Continuous	800,000 (summer) 80,000 (winter)	110 max.	-
G.	Condenser air removal filtration system	-	Unit vent P-H-C-H	Exhaust:	-	Continuous	1,000	120 max.	-
H.	Access control area	208,000	Unit vent	Exhaust: P-H-C-H	-	Continuous	6,000	104 max.	-
I.	Main steam enclosure	166,000	Unit vent	None	-	Continuous	23,000	120 max.	-
J.	Laundry Dryers	-	Laundry Decon Facility Dryer Exhaust	Exhaust P-H	Rectangular	Intermittent	5500-9000	180 max.	-

(1) Grade elevation is 2000'-0".

(2) P = prefilter or roughing filter, H = HEPA filter, C = charcoal adsorber

TABLE 11.1A-5 GALE CODE INPUT DATA (1)

Callaway Parameters	PWR Value
Thermal power level (megawatts)	3565.000
Plant capacity factor	0.800
Mass of primary coolant (thousands lbs)	530.000
Percent fuel with cladding defects	0.120
Primary system letdown rate (gpm)	75.000
Letdown cation demineralizer flow (gpm)	7.500
Number of steam generators	4.000
Total steam flow (millions lbs/hr)	15.850
Mass of steam in each steam generator (thousands lbs)	8.000
Mass of liquid in each steam generator (thousands lbs)	104.000
Mass of water in steam generators (thousands lbs)	416.000
Total mass of secondary coolant (thousands lbs)	3570.000
Steam generator blowdown rate (thousands lbs/hr)	176.000
Primary to secondary leak rate (lbs/day)	100.000
Condensate demineralizer regeneration time (days)	17.500
Fission product carry-over fraction	0.001
Halogen carry-over fraction	0.010
Condensate demineralizer flow fraction	0.684
Radwaste dilution flow (thousands gpm)	5.000

Liquid Waste Inputs

						Decontamination Factors		
Steam	Flow Rate (gal/day)	Fraction of PCA	Fraction Discharged	Collection Time (days)	Decay Time (days)	I	CS	Others
Shimbleed rate	1.84+03	1.000	.1	20.9	2.000	1.00+05	2.00+03	1.00+04
Equipment drains	3.00+02	1.000	.1	20.9	2.000	1.00+05	2.00+03	1.00+04
Clean waste input	4.00+02	.500	.1	10.0	.185	1.00+04	1.00+05	1.00+05
Dirty waste input	1.14+03	.058	1.0	7.0	.370	1.00+04	1.00+05	1.00+05
S.G. blowdown	3.80+05	(2)	.0	.0	.000	1.00+03	1.00+02	1.00+03
Untreated blowdown	1.27+05	(2)	1.0	0.0	.000	1.00+00	1.00+00	1.00+00
Regenerant sols	1.71+04	(2)	.0	.0	.350	1.33+02	2.67+00	1.33+02

(1) These values are based on the standard power block design.

(2) Fraction of SCA internally calculated by Gale Code

TABLE 11.1A-5 (Sheet 2)

Gaseous Waste Inputs

There is continuous low vol. purge of vol. control tk

Holdup time for xenon (days)	9.0E+1
Holdup time for krypton (days)	9.0E+1
Fill time of decay tanks for the gas stripper (days)	0.0E+0
Gas waste system: particulate release fraction	1.0E-2
Primary leakage to buildings outside containment (lb/day)	1.6E+2
Noncontainment: iodine release fraction	1.0E-1
Particulate release fraction	1.0E-2
Containment volume (million cu ft)	2.5E+0
Containment atmosphere cleanup rate (thousand cfm)	0.0E+0
Frequency of containment bldg. high vol. purge (times/yr.)	2.4E+1
Containment - shutdown purge iodine release fraction	1.0E-1
particulate release fraction	1.0E-2
Containment - normal purge rate (cfm)	4.0E+3
Containment - normal purge iodine release fraction	1.0E-1
particulate release fraction	1.0E-2
Steam leak to turbine bldg. (lbs/hr)	1.7E+3
Fraction iodine released from blowdown tank vent	0.0E+0
air ejector	3.0E-1

There is no cryogenic offgas system

11.2 LIQUID WASTE MANAGEMENT SYSTEMS

Several systems within the plant serve to control, collect, process, handle, store, recycle, and dispose of liquid radioactive waste generated as a result of normal plant operation, including anticipated operational occurrences. This section discusses the design and operating features and performance of the liquid radwaste system and the performance of other liquid waste management systems which are discussed in other sections.

11.2.1 DESIGN BASES

11.2.1.1 Safety Design Basis

Except for two containment penetrations and the component cooling water side of the reactor coolant drain tank heat exchanger, the liquid radwaste system (LRWS) is not a safety-related system.

SAFETY DESIGN BASIS ONE - The containment isolation valves in the LRWS are selected, tested, and located in accordance with the requirements of 10 CFR 50, Appendix A, GDC-56, and 10 CFR 50, Appendix J, Type C testing.

11.2.1.2 Power Generation Design Bases

POWER GENERATION BASIS ONE - The LRWS, in conjunction with other liquid waste management systems, is designed to meet the requirements of the discharge concentration limits of 10 CFR 20 and the ALARA dose objective of 10 CFR 50, Appendix I.

POWER GENERATION DESIGN BASIS TWO - The LRWS uses design and fabrication codes consistent with quality group D (augmented), as assigned by Regulatory Guide 1.143, for radioactive waste management systems.

POWER GENERATION DESIGN BASIS THREE - Liquid effluent discharge paths are monitored for radioactivity.

11.2.2 SYSTEM DESCRIPTION

11.2.2.1 General Description

This section describes the design and operating features of the LRWS. The performance of the LRWS, in conjunction with other liquid waste management systems, is discussed in Section 11.2.3. Detailed descriptions of other liquid waste management systems are provided in the following sections:

a. Boron recycle 9.3.6

b. Steam generator blowdown 10.4.8

c. CVCS boron thermal regeneration and purification 9.3.4

d. Secondary liquid waste 10.4.10

The piping and instrumentation diagram for the LRWS is shown in Figure 11.2-1.

The LRWS collects, processes, and discharges water entering the system. Equipment drains and waste streams are normally segregated to prevent the intermixing of the liquid wastes. The LRWS is capable of processing plant effluent for recycling reactor grade water, however, normally no tritiated water is transferred to the Reactor Makeup Water Storage Tank (RMWST). This method of operation prevents the contamination of Secondary systems due to deoxygenating the Reactor Makeup Water System (BL) water using the Demineralized Water Makeup Storage and Transfer System (AN).

The LRWS consists of five waste collection subsystems and three waste processing subsystems:

a. tritiated waste (CRW) drain subsystem

b. potentially radioactive nontritiated waste (DRW) drain subsystem

c. the Reactor Coolant Drain Tank subsystem (RCDT)

d. the Chemical Waste subsystem

e. the Laundry Waste subsystem

f. the Liquid Radwaste Treatment subsystem (LRWTS)

g. the Alternate Liquid Radwaste Treatment subsystem

h. the Discharge Monitor Tank subsystem

Tritiated wastes (CRW), potentially radioactive nontritiated waste (DRW) and laundry waste drainage are discussed in Section 9.3.3.

The various waste streams are processed as follows:

CRW SUBSYSTEM INFLUENTS - The CRW system processes all water that can be recycled. The CRW influents consist of reactor coolant which has been exposed to the atmosphere and has become aerated. This waste consists of equipment drains, leakoffs, and overflows from tritiated systems (e.g., CVCS and reactor coolant samples which have not been chemically contaminated).

This waste is typically collected in the floor and equipment drain system and then transferred to the waste holdup tank. CRW influents are normally processed using the LRWTS and discharged from the plant.

DRW SUBSYSTEM INFLUENTS - DRW influents are miscellaneous liquid wastes collected by the floor drain system within the radiologically controlled areas of the plant. The controlled access areas are radiation zones B through E and include the containment, auxiliary building, fuel building, radwaste building, and the access control areas of the control building.

Floor drainage consists of miscellaneous leakage from systems within the above areas. Generally, the amount of highly radioactive reactor coolant leakage into the drain system is very small. The bulk of the water originates as leakage from nonradioactive or slightly radioactive systems, such as the service water and component cooling water systems. In addition to system leakage, the floor drain systems will collect decontamination water used for area washdowns, spent fuel cask decontamination, and laboratory equipment decontamination and rinses. Highly chemically contaminated decontamination solutions are normally not allowed to enter the floor drain system. During maintenance, equipment drains from nontritiated systems will normally be directed to the floor drain system. Large volumes of component cooling water will not normally be drained to the floor drain system to prevent contamination of the LRWS by corrosion inhibitors. DRW influents are collected in two floor drain tanks and are normally processed using the LRWTS and discharged from the plant.

REACTOR COOLANT DRAIN TANK WASTE (RCDT) - Sources of water entering the reactor coolant drain tank include the reactor vessel flange leakoff, valve leakoffs, reactor coolant pump number two seal leakoffs, and the excess letdown heat exchanger flow. No continuous leakage is expected from the reactor vessel flange during operation. The tank is provided with a hydrogen cover gas to minimize dissolved air or nitrogen buildup in the GRWS. This water may be transferred to the Recycle Holdup Tanks and processed with the Boron Recycle System or transferred to the Waste Holdup tank for processing and discharge.

HIGH LEVEL CHEMICAL WASTE - High level chemical waste consists of plant samples which have been chemically contaminated. These wastes are collected in the chemical drain tank where pH adjustment is possible. These wastes are normally drained to the floor drain system for processing.

LAUNDRY AND PERSONNEL DECONTAMINATION WASTE - Laundry waste is generated by the washing of radioactively contaminated protective clothing and gear for reuse. The personnel decontamination waste contains detergents (inorganics) and/or soaps (organics) used by personnel to remove low level radioactive contamination. The hot showers (Men's shower and Decon shower) in the access control area are used occasionally for personal use and for personnel decontamination when needed.

Personnel decontamination wastes are collected in the detergent waste subsystem's detergent drain tank and then transferred to the laundry and hot shower tanks. Laundry waste is collected in the sump located in the Laundry Decontamination Facility and then transferred over to the laundry and hot shower tanks. The waste is then processed and discharged.

The various radwaste processing systems are described as follows:

LIQUID RADWASTE TREATMENT SYSTEM (LRWTS) - The liquid radwaste treatment system consists of a vendor supplied skid containing a chemical injection system along with a series of demineralizer vessels. The vessels may be operated in any combination or with any treatment media required to process the waste water effectively. Waste water from the CRW and DRW is processed through the components of the LRWTS on an as needed basis to remove the contaminants of concern. Influents to the boron recycle system and RCDT system may be processed with the LRWTS if the recycling of reactor coolant is not desired. Also waste water collected in the laundry and hot shower tanks may be processed through this equipment. The secondary liquid waste monitor tanks normally provide a holdup capacity and the ability to recirculate and sample process stream effluent prior to transferring the processed water to the Discharge Monitor Tanks for discharge.

ALTERNATE LIQUID RADWASTE TREATMENT SYSTEM - During situations when the LRWTS is not available, the floor drain tanks and waste holdup tank may be processed by a backup means. The alternate liquid radwaste treatment system consists of a series of filters, demineralizers, charcoal adsorbers and monitor tanks. Waste water from the CRW and DRW system can be processed through these components on an as need basis to remove contaminates of concern. Intermediate monitoring tanks provide a holdup capacity and the ability to recirculate and sample process steam effluent prior to transferring the processed water to the Discharge Monitor Tanks.

DISCHARGE MONITOR TANKS - The Discharge Monitor Tanks receive effluents from the LRWTS, Alternate Liquid Radwaste Treatment system, Laundry Waste system and the Secondary Liquid Waste system. The DMT's provide for a final holdup and processing to ensure the effluent quality of the waste water is acceptable for discharge to the environment.

Modifications to the Radwaste Systems such as the addition of the LRWS have resulted in the obsolescence of various radwaste equipment and components that are currently installed and pending formal retirement. Operating procedures that govern this equipment have been updated to ensure operation of the obsolete equipment does not occur. Obsolete radwaste equipment/components, along with the equipment identification numbers, system status, and associated FSAR figures, are listed below.

a. Recycle evaporator package (SHE02) - pending retirement - FSAR Figure 9.3-11 Sheet 3

b. Secondary liquid waste evaporator (SHF01 through SHF17) - pending retirement - FSAR Figure 10.4-12 Sheet 4

c. Recycle evaporator reagent tank (THE01) - pending retirement - FSAR Figure 9.3-11 Sheet 3

d. Waste evaporator package (SHB01) - pending retirement - FSAR Figure 11.2-1 Sheet 2

e. Waste evaporator reagent tank (THB08) - pending retirement - FSAR Figure 11.2-1 Sheet 2

f. Primary Evaporator bottoms tank (THC01) - pending retirement - FSAR Figure 11.4-1 Sheet 1

g. Secondary Evaporator bottoms tank (THC09) - pending retirement - FSAR Figure 11.4-1 Sheet 1

h. Primary and Secondary Evaporator bottoms tank pumps (PHC01 and PHC06) - pending retirement - FSAR Figure 11.4-1 Sheet 1

11.2.2.2 Component Description

Codes and standards applicable to the LRWS are listed in Tables 3.2-1 and 11.2-1. The LRWS is designed and constructed in accordance with quality group D (augmented). The LRWS is housed within a seismically designed building. Regulatory Guide 1.143 is complied with to the extent specified in Table 3.2-5. All tanks which contain or may contain concentrations of radioactivity have provisions to prevent the uncontrolled release of the fluid. Table 11.2-2 indicates the provisions made for each tank.

REACTOR COOLANT DRAIN TANK PUMPS - Due to the relative inaccessibility of the containment and the loop drain requirements, two pumps are provided. One pump provides sufficient flow for normal tank operation with one pump for standby.

WASTE EVAPORATOR FEED PUMP - One standard pump is used. The waste evaporator feed pump transfers water from the waste holdup tank to the LRWTS or the alternate LRWTS for processing. The pump is shut off when low level is reached in the waste holdup tank.

WASTE EVAPORATOR CONDENSATE TANK PUMP - The waste evaporator condensate tank pump is a transfer pump. One standard pump is used to transfer the contents of the waste condensate tank.

CHEMICAL DRAIN TANK PUMP - One standard pump can be used to recirculate the liquid in the chemical drain tank.

LAUNDRY AND HOT SHOWER TANK PUMP - One standard pump will be used to transfer contents of each L&HST.

FLOOR DRAIN TANK PUMPS - Two standard pumps transfer water from the floor drain tanks to the LRWTS or the alternate LRWTS for processing. The pumps are cross-connected to the pump from either floor drain tank.

WASTE MONITOR TANK PUMPS - One standard pump is to be used for each tank to transfer water. The pump may also be used for circulating the water in the waste monitor tank in order to obtain uniform tank contents and hence a representative sample before discharge. The pump can be throttled to achieve the desired discharge rate.

ACID METERING PUMP - One positive displacement chemical feed pump used to inject sulfuric acid into the discharge monitor tank discharge for pH control.

CAUSTIC METERING PUMP - One positive displacement chemical feed pump used to inject sodium hypochlorite into the discharge monitor tank discharge for pH control.

REACTOR COOLANT DRAIN TANK HEAT EXCHANGER - The reactor coolant drain tank heat exchanger is a U-tube type with one shell pass and two tube passes. Although the heat exchanger is normally used in conjunction with the reactor coolant drain tank, it can also cool the pressurizer relief tank from 200 to 120°F in less than 8 hours.

REACTOR COOLANT DRAIN TANK - One tank is provided to collect leakoff type drains inside the containment at a central collection point for further disposition through a single penetration via the reactor coolant drain tank pumps.

Only water which can be directed to the recycle holdup tanks enters the reactor coolant drain tank. The tank is provided with a hydrogen cover gas. The water must be compatible with reactor coolant, and it must not contain dissolved air or nitrogen to minimize buildup in the GRWS.

Sources of water entering the reactor coolant drain tank include the reactor vessel flange leakoff, valve leakoffs, reactor coolant pump number two seal leakoffs, and the excess letdown heat exchanger flow. No continuous leakage is expected from the reactor vessel flange during operation.

WASTE HOLDUP TANK - One atmospheric pressure tank is provided outside the containment to collect equipment drainage, valve and pump seal leakoffs, recycle holdup tank overflows, and other water from tritiated, aerated sources.

WASTE EVAPORATOR CONDENSATE TANK - One tank is provided to collect processed waste water from the LRWTS or the Alternate LRWTS.

CHEMICAL DRAIN TANK - One tank is provided to collect chemically contaminated tritiated water from the laboratories.

LAUNDRY AND HOT SHOWER TANK - Two atmospheric tanks are used to collect laundry and hot shower drainage.

FLOOR DRAIN TANKS - Two atmospheric pressure tanks are used to collect floor drainage from the reactor plant operations.

WASTE MONITOR TANKS - The two atmospheric waste monitor tanks are provided to aid in processing or storing waste water from the LRWTS or the Alternate LRWTS.

DISCHARGE MONITOR TANKS - The two atmospheric discharge monitor tanks are provided for collecting, storing, and monitoring liquid discharges from the plant site.

WASTE EVAPORATOR CONDENSATE DEMINERALIZER - One demineralizer is provided to remove ionic contaminants from the waste being processed.

LIQUID WASTE CHARCOAL ADSORBER - One charcoal adsorber is provided to remove organics from the waste being processed. The charcoal adsorber also has the capability of being loaded with a specific resin to aid in processing.

WASTE MONITOR TANK DEMINERALIZER - One demineralizer is provided to remove trace ionic contaminants from the waste being processed.

FILTERS - Most of the filters provided are of a disposable-type cartridge. However, four filters used for processing laundry and hot shower waste are of the disposable bag filter type.

The methods employed to change filters and screens are dependent on activity levels. Filters are valved out of service, drained to the appropriate tank, and vented locally. If the radiation level of the filter is low enough, it is changed manually.

STRAINERS - Strainers are provided in the discharge of the floor drain tank pumps to remove large particulate matter and thus prevent clogging of the downstream lines and filters.

System Operation

The LRWS operation is manually initiated, except for some functions of the reactor coolant drain subsystem. The system includes adequate control equipment to protect the system components and instrumentation and alarm functions to provide operator information to ensure proper system operation. All pumps in the system have low level shutoffs, and all filters, strainers, and demineralizers have differential pressure indication to indicate fouling.

Operation of the LRWS is essentially the same during all phases of normal reactor plant operation; the only differences are in the load on the system. The following sections discuss the operation of the system in performing its various functions. In this discussion, the term "normal operation" should be taken to mean all phases of operation, except operation under emergency or accident conditions. The LRWS is not regarded as a safety-related system.

CRW SUBSYSTEM OPERATION - Waste is accumulated in the waste holdup tank until a sufficient quantity exists to process. Normally the waste holdup tank is recirculated and sampled prior to being processed. Chemistry of the tank may be adjusted to ensure optimum system performance. Normally the waste holdup tank is processed utilizing the LRWTS. If the LRWTS is not available, the capability exists to process the waste holdup tank with the alternate liquid radwaste treatment system. If necessary, caustic or acid solution may be added to the waste water by caustic or acid metering pumps to bring the pH into allowable discharge specifications.

DRW SUBSYSTEM OPERATION - Normally one floor drain tank is aligned to receive the discharge from the floor drain system while the other tank is being used to supply waste to the processing system. This procedure allows the waste to be sampled and pH adjusted, if desired, prior to processing, to ensure optimum system performance. The second floor drain tank also provides additional system storage capacity during periods of abnormal waste generation or equipment outages. The floor drain tanks are normally processed through the floor drain tank filter to the LRWTS. If the LRWTS is not available, the capability exists to process the floor drain tanks with the alternate liquid radwaste treatment system.

REACTOR COOLANT DRAIN TANK SUBSYSTEM OPERATION - Normal operation of the reactor coolant drain subsystem is in the manual mode. Due to the small amount of leakage into the system, less wear and tear on the equipment is experienced by maintaining it in the manual mode. The tank level is monitored by the radwaste operators and pumped out when necessary. The leakage rate of reactor coolant pump No. 2 seal leakoffs, reactor vessel flange leakoffs, valve stem leakoffs and discharges from the excess letdown heat exchanger into the reactor coolant drain tank (RCDT) can be estimated by leaving the system in manual mode and watching the rate of level change. This will measure the identified leakage. The reactor coolant drain tank pumps normally discharge to the boron recycle system. These drains can also be aligned to the waste holdup tank. When in the automatic mode, the level in the RCDT is maintained by running one RCDT pump continuously and using a proportional control valve (LCV-1003) in the discharge line. This valve operates on a signal from the RCDT level controller to limit the flow out of the subsystem. The remainder of the flow is recirculated to the RCDT. The RCDT heat exchanger is sized to maintain the RCDT contents at or below 170°F, assuming an in-leakage of 10 gpm at 600°F.

A venting system is provided to prevent wide pressure variations in the RCDT. Normally, the pressure in the RCDT is manually controlled by raising/lowering level in the tank. If too much pressure has built up in the RCDT and cannot be controlled by lowering the tank level, manual valves can be opened to the gaseous radwaste system to lower the pressure in the RCDT. The manual valves may also be operated to raise the tank's gaseous overpressure as needed. Hydrogen cover gas is supplied from the service gas system and can be automatically maintained between 2 and 6 psig by pressure-regulating valves. PCV-7155 maintains a minimum tank pressure by admitting hydrogen, while PCV-7152 maintains maximum tank pressure by venting the RCDT to the gaseous radwaste system. The hydrogen is supplied from no more than two 194 SCF bottles, to limit the amount of hydrogen gas which might be accidentally released to the containment atmosphere. The RCDT vents to the gaseous radwaste system to limit any releases of radioactive gases. The reactor coolant drain subsystem may also be used in the pressurizer relief tank (PRT) cooling mode of operation. In this mode, the level control valve in the discharge line to the recycle evaporator feed demineralizers (LCV-1003), the isolation valve at the discharge of the reactor coolant drain tank (HV-7127), and the isolation valve in the reactor coolant drain tank recirculation line (HV-7144) are all closed. The PRT contents are circulated through the reactor coolant drain tank heat exchanger, via valve BB-HV-8031 and the reactor coolant drain tank pumps, prior to returning to the PRT via valve BB-HV-7141. In this mode of operation, the RCDT heat exchanger is capable of cooling the PRT contents from 200°F to 120°F in less than 8 hours. As an alternative to returning the cooled fluid to the PRT, the fluid may be directly transferred to the recycle holdup tanks in the boron recycle system. In any and all cases of PRT cooling, the PRT is vented to less than 50 psig to prevent overpressurization of the RCDT subsystem.

The reactor coolant drain subsystem may be used to drain the reactor coolant loops by first venting the reactor coolant system, then connecting the spool piece in the RCDT pump suction piping. The design objective of this mode of operation is to drain the RCS to the midpoint of the reactor vessel nozzles in less than 8 hours with both RCDT pumps running. In this mode, valve HV-7144 is closed and, in order to maximize flow capability, the RCDT discharge level control valve (LCV-1003) should be bypassed during RCS draining operations.

The reactor coolant drain subsystem may be used to drain down portions of the refueling pool which cannot be drained by the residual heat removal pumps. In this mode of operation, the RCDT heat exchanger may be bypassed and the RCDT level control valve (LCV-1003) may be bypassed to maximize flow through the fuel pool cooling and cleanup system to the refueling water storage tank. An alternate drain line is provided from the refueling pool to the containment sump to route decontamination chemicals away from the RCDT subsystem and minimize the possibility of contaminating any systems downstream of the RCDT pumps.

CHEMICAL WASTE - The chemical drain tank (CDT) receives chemically contaminated tritiated water from the plant sample stations. Contents of the tank are sampled, and normally drained to the floor drain system. Operation is intermittent and manually controlled. A high level alarm is provided from the CDT for operator information.

LAUNDRY SUBSYSTEM OPERATION - Waste water from the Deep sinks, a washing machine, Men's shower and the personnel decontamination shower are directed by gravity drain to the detergent drain tank located in the basement of the control building and then is pumped to the laundry and hot shower tanks (L&HST's). Laundry waste from the washers and the dryers located in the Laundry Decontamination Facility are collected in the building sump and also pumped over to the L&HST's. The L&HST fluid is low in radioactivity and is normally processed by the L&HST bag filters. The waste may be directed to waste monitor tank "B" and subsequently to the discharge monitor tanks for discharge or directly to the discharge monitor tanks.

The laundry system requires makeup water that is normally from a radiologically "clean" source (i.e., Potable water) because water is taken from the system in wet clothes, evaporated in the dryers, and vented from the plant. Potable water will be connected to an OZONE generator, which will provide the bulk of the cleaning agent for the washing machines. Ozone cleans by breaking down the organic molecules in the water and is more effective than chlorine in killing bacteria and reduces or eliminates the need for detergents. Since Ozone requires little or no detergent, there are less residual chemicals in the fabrics after the rinse cycle and fewer rinse cycles are needed. The laundry water is then pumped, on demand of the washing machines, to the laundry equipment in operation. Although the ozone works best in cold water, one washing machine will be equipped with a steam heating system if hot water might be needed. In all phases of laundry operation, the operator must take care to use detergents, soaps, and additives that are compatible with waste processing equipment.

DISCHARGE MONITOR TANKS - Normally one discharge monitor tank is aligned to receive plant waste while the other tank is being prepared for discharge. Waste is accumulated until a sufficient quantity exists for processing. The tank is isolated, recirculated, sampled and permitted prior to discharge. The capability exists to reprocess or adjust tank chemistry as necessary to ensure environmental effluent requirements are met. The second discharge monitor tank also provides additional system storage capacity during periods of abnormal waste generation.

The LRW system is designed to handle the occurrence of equipment faults of moderate frequency such as:

a. Malfunction in the LWRS

Malfunction in this system could include such things as pump or valve failures. Because of pump standardization throughout the system, a spare pump can be used to replace most pumps in the system. There is sufficient surge capacity in the system to accommodate waste until the failures can be fixed and normal plant operation resumed.

b. Excessive leakage in reactor coolant system equipment

The system is designed to handle a 1-gpm reactor coolant leak in addition to the expected leakage of 50 lb/day (Ref. 1) during normal operation, which is discussed in Section 5.2.5. Operation of the system is almost the same for normal operation, except that the load on the system is increased. A 1-gpm leak into the reactor coolant drain tank is handled automatically but will increase the load factor of the recycle system. If the gpm leak enters the waste holdup tank, operation is the same as normal, except for the increased load on the system. Abnormal liquid volumes of reactor coolant resulting from excessive reactor coolant or auxiliary building equipment leakage (in excess of 1 gpm) can also be accommodated by the floor drain tank and processed by the LRWTS. Valve and pump leakoffs containing recyclable water are recycled through the waste holdup tank.

c. Excessive leakage in the auxiliary system equipment

Leakage of this type could include water from steam side leaks and fan cooler leaks inside the containment which are collected in the containment sump and sent to the floor drain tank. Other sources could be component cooling water leaks, service water leaks, and secondary side leaks. This water will enter the floor drain tank and will be processed and discharged as during normal operation.

11.2.3 RADIOACTIVE RELEASES

This section describes the estimated liquid release from the plant for normal operation and anticipated operational occurrences.

11.2.3.1 Sources

Section 11.1 and Appendix 11.1A provide the bases for determining the contained sources inventory and the normal releases.

A survey has been performed of liquid discharges from different Westinghouse pressurized water reactor plants. The results are presented in Table 11.2-17 of Reference 2. The data includes radionuclides released on an unidentified basis, and are all within the permissible concentration for the release of liquid containing all unidentified radionuclide mixtures.

11.2.3.2 Release Points

Refer to Section 11.2.3.2 of the Site Addendum.

11.2.3.3 Dilution Factors

Refer to Section 11.2.3.3 of the Site Addendum.

11.2.3.4 Estimated Doses

Refer to Section 11.2.3.4 of the Site Addendum.

11.2.4 SAFETY EVALUATION

Except for two associated containment penetrations and the CCW pressure boundary integrity at the reactor coolant drain tank, the LRWS is not a safety-related system.

SAFETY EVALUATION ONE - Sections 6.2.4 and 6.2.6 provide the safety evaluation for the system containment isolation arrangement and testability.

11.2.5 TESTS AND INSPECTION

Preoperational testing is discussed in Chapter 14.0.

The operability, performance, and structural and leaktight integrity of all system components are demonstrated by intermittent or continuous operation.

11.2.6 INSTRUMENTATION DESIGN

The system instrumentation is described in Table 11.2-3 and shown on Figure 11.2-1.

The instrumentation readout is located mainly on the waste processing system panel in the radwaste building. Some instruments are read locally.

All alarms are shown separately on the waste processing system panel.

The waste processing system pumps are protected against loss of suction pressure by a control setpoint on the level instrumentation for the respective vessels feeding the pumps. The reactor coolant drain tank pumps and the spent resin sluice pump are, in addition, interlocked with flow rate instrumentation and stop operating when the delivery flows reach minimum setpoints.

Differential pressure indicators with local readout are provided for filters, strainers, and demineralizers.

11.2.7 REFERENCES

1. NUREG-0017, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors" (PWR-GALE Code), NRC, April 1976.

2. "Appendix D to RESAR-3S, Liquid Waste Management System," WCAP 8665, March 1976.

TABLE 11.2-1 LIQUID WASTE PROCESSING SYSTEM EQUIPMENT PRINCIPAL DESIGN PARAMETERS

<u>Reactor Coolant Drain Tank Pumps</u>	
Number	2
Type	Horizontal centrifugal
Design pressure, psig	150
Design temperature,°F	200
Design flow, gpm	
Point 1	100
Point 2	150
Design head, ft	
Point 1	290
Point 2	270
Material	Stainless steel
Design code(1)	MS
<u>Waste Evaporator Feed Pump</u>	
Number	1
Type	Canned centrifugal
Design pressure, psig	150
Design temperature,°F	200
Design flow, gpm	
Point 1	30
Point 2	100
Design head, ft	
Point 1	250
Point 2	200

TABLE 11.2-1 (Sheet 2)

Material	Stainless steel
Design code (2)	MS
<u>Waste Evaporator Condensate Pump</u>	
Number	1
Type	Canned centrifugal
Design pressure, psig	150
Design temperature,°F	200
Design flow, gpm	
Point 1	35
Point 2	100
Design head, ft	
Point 1	250
Point 2	230
Material	Stainless steel
Design code	MS
<u>Chemical Drain Tank Pump</u>	
Number	1
Type	Canned centrifugal
Design pressure, psig	150
Design temperature,°F	200
Design flow, gpm	
Point 1	35
Point 2	100
Design head, ft	
Point 1	250
Point 2	230

TABLE 11.2-1 (Sheet 3)

Material	Stainless steel
Design code	MS
Laundry and Hot Shower Tank 'B' Pump	
Number	1
Type	Horizontal centrifugal
Design pressure, psig	150
Design temperature,°F	200
Design flow, gpm	
Point 1	35
Point 2	100
Design head, ft	
Point 1	250
Point 2	230
Material	Stainless steel
Design code	MS
Floor Drain Tank Pumps	
Number	2
Type	Horizontal centrifugal
Design pressure, psig	150
Design temperature,°F	200
Design flow, gpm	
Point 1	35
Point 2	100
Design head, ft	
Point 1	250
Point 2	230

TABLE 11.2-1 (Sheet 4)

Material	Stainless steel
Design code	MS
<u>Waste Monitor Tank Pumps</u>	
Number	2
Type	Canned centrifugal
Design pressure, psig	150
Design temperature,°F	200
Design flow, gpm	
Point 1	35
Point 2	100
Design head, ft	
Point 1	250
Point 2	230
Material	Stainless steel
Design code	MS
<u>Laundry and Hot Shower Tank A Pump</u>	
Number	1
Type	Inline centrifugal
Design pressure, psig	150
Design temperature,°F	200
Design flow, gpm	35
Design head, ft	81
Material	Stainless steel
Design code	MS

TABLE 11.2-1 (Sheet 5)

Discharge Monitor Tank Transfer Pumps	
Number	2
Type	Horizontal centrifugal
Design pressure, psig	150
Design temperature,°F	200
Design flow, gpm	250
Design head, ft	200
Material	Stainless steel
Design code	MS
Caustic Metering Pump	
Number	1
Type	Pulsafeeder
Design Pressure	100 PSIG
Design Flow, GPH	63
Materials	
Diaphragm	Teflon (virgin)
Reagent head	Stainless Steel
Design Code	MS
Acid Metering Pump	
Number	1
Type	Pulsafeeder
Design Pressure	100 PSIG
Design Flow, GPH	63
Materials	
Diaphragm	Teflon (virgin)
Reagent head	Stainless Steel
Design Code	MS

TABLE 11.2-1 (Sheet 6)

Reactor Coolant Drain Tank Heat Exchanger

Number	1
Type	U-tube
Estimated UA, Btu/hr-F	70,000
Design flow, lb/hr	
Shell	112,000
Tube	44,600
Temperature in,°F	
Shell	105
Tube	180
Temperature out,°F	
Shell	125
Tube	130
Material	
Shell	Carbon steel
Tube	Stainless steel
Design code	
Shell side	ASME Section III
Tube side	ASME Section VIII

Reactor Coolant Drain Tank

Number	1
Type	Horizontal
Usable volume, gal	350
Design pressure, psig*	100
Design temperature,°F	250
Material	Stainless steel

TABLE 11.2-1 (Sheet 7)

Design code (2)	ASME Section VIII
<u>Waste Holdup Tank</u>	
Number	1
Type	Vertical
Usable volume, gal	10,000
Design pressure	Atmospheric
Design temperature,°F	200
Material	Stainless steel
Design code (2)	ASME Section VIII (no code stamp)
<u>Waste Evaporator Condensate Tank</u>	
Number	1
Type	Vertical
Usable volume, gal	5,000
Design pressure, psig	±0.433
Design temperature,°F	200
Material	Stainless steel
Design code	ASME Section VIII (no code stamp)
<u>Chemical Drain Tank</u>	
Number	1
Type	Vertical
Usable volume, gal	600
Design pressure, psig	±0.5
Design temperature,°F	200
Material	Stainless steel

TABLE 11.2-1 (Sheet 8)

Design code	ASME Section VIII (no code stamp)
<u>Laundry and Hot Shower Tank B</u>	
Number	1
Type	Vertical
Usable volume, gal	10,000
Design pressure, psig	±0.5
Design temperature,°F	200
Material	Stainless steel
Design code	ASME Section VIII (no code stamp)
<u>Floor Drain Tanks</u>	
Number	2
Type	Vertical
Usable volume, gal	10,000
Design pressure, psigë	±0.5
Design temperature,°F	200
Material	Stainless steel
Design code	ASME Section VIII (no code stamp)
<u>Laundry and Hot Shower Tank A</u>	
Number	1
Type	Vertical
Usable volume, gal	10,000
Design pressure	Atmospheric
Design temperature,°F	200
Material	Stainless steel

TABLE 11.2-1 (Sheet 9)

Design code	ASME Section VIII (no code stamp)
Waste Monitor Tanks	
Number	2
Type	Vertical
Usable volume, gal	5,000
Design pressure, psig	±0.5
Design temperature,°F	200
Material	Stainless steel
Design code	ASME Section VIII (no code stamp)
Discharge Monitor Tanks	
Number	2
Type	Vertical
Usable volume, gal	93,900
Design pressure,	Atmospheric
Design temperature,°F	200
Material	Stainless steel
Design code	API 650
Waste Evaporator Condensate Demineralizer	
Number	1
Type	Flushable
Design pressure, psig	300
Design temperature,°F	250
Design flow, gpm	120

TABLE 11.2-1 (Sheet 10)

Processing media volume, ft^3 max.	39
Material	Stainless steel
Design code (2)	ASME Section VIII
Waste Monitor Tank Demineralizer	
Number	1
Type	Flushable
Design pressure, psig	300
Design temperature,°F	250
Design flow, gpm	120
Processing media volume, ft^3 max.	39
Material	Stainless steel
Design code (2)	ASME Section VIII
Liquid Waste Charcoal Adsorber	
Number	1
Type	Flushable
Design pressure, psig	150
Design temperature,°F	200
Design flow rate, gpm	35
Processing media volume, ft^3	42
Material	Stainless steel
Design code	ASME Section VIII
Laundry and Hot Shower Charcoal Adsorber	
Number	1
Type	Flushable
Design pressure, psig	150

TABLE 11.2-1 (Sheet 11)

Design temperature,°F	200
Design flow rate, (gpm) avg./max.	4/10
Charcoal volume, ft^3	10
Material	Stainless steel
Design code	ASME Section VIII
<u>Waste Evaporator Feed Filter</u>	
Number	1
Design pressure, psig	300
Design temperature,°F	250
Design flow, gpm	250
ΔP at design flow, unfouled, psi	5
Size of particles, 98% ret, nominal microns (Filter may be removed for operational ease)	100 (3)
Material	Stainless steel
Design code (2)	ASME Section VIII
<u>Waste Evaporator Condensate Filter</u>	
Number	1
Design pressure, psig	300
Design temperature,°F	250
Design flow, gpm	250
ΔP at design flow, unfouled, psi	5
Size of particles, 98% ret, nominal, microns	30 (3)
Material	Stainless steel
Design code (2)	ASME Section VIII
<u>Laundry and Hot Shower Tank Filters</u>	
Number	4

TABLE 11.2-1 (Sheet 12)

Maximum Working Pressure, psig	150
Maximum Working Temperature,°F	450°
Design flow, gpm	250
Maximum Support Basket Differential Operating Pressure	75
Material	Stainless steel
Design code (2)	ASME Section VIII
<u>Waste Monitor Tank Filter</u>	
Number	1
Design pressure, psig	300
Design temperature,°F	250
Design flow, gpm	250
ΔP at design flow, unfouled, psi	5
Size of particles, 98% ret, nominal, microns	30 (3)
Material	Stainless steel
Design code (2)	ASME Section VIII
<u>Floor Drain Tank Filter</u>	
Number	1
Design pressure, psig	300
Design temperature,°F	250
Design flow, gpm	250
ΔP at design flow, unfouled, psi	5
Size of particles, 98% ret, nominal, microns (Filter may be removed for operational ease)	100 (3)
Material	Stainless steel
Design code (2)	ASME Section VIII
<u>Floor Drain Tank Strainer</u>	

TABLE 11.2-1 (Sheet 13)

Number	1
Design pressure, psig	150
Design temperature,°F	200
Design flow, gpm	35
ΔP at design flow, unfouled, psi	0.2
Basket perforation size, inch	1/16
Material	Stainless steel
Design code	ASME Section VIII

Liquid Radwaste Treatment Filter/Demineralizer Skid

Number	1
Design pressure, psig	150
Design temperature, °F	200
Design flow, gpm	0-75
Material	Stainless steel
Design Code	ASME Section VIII for vessels
	ANSI B31.1 for piping

TABLE 11.2-1 (Sheet 14)

(1) The actual code used iis ASME III, Class 3.

(2) Table indicates that the required code is based on its safety-related importance as dictated by service and functional requirements and by the consequences of their failure. Note that the equipment may be supplied to a higher principal construction code than required.

(3) Filters may be downsized as operational needs dictate.

TABLE 11.2-2 TANK UNCONTROLLED RELEASE PROTECTION PROVISIONS

I. Tanks Outside Plant Buildings REF: Figure 1.2-1 Grade Elevation: 2000'-0"

	Tanks	Elevation	Overflow Control	Level Indicator, High Alarms, Low Alarms, Etc.	Remarks
1.	Condensate storage tank	2000'-0"	Overflows to turbine building drain system	Level indicator and high level alarm are provided in control room. Level is indicated in auxiliary shutdown panel. Refer to Figure 9.2-12.	
2.	Refueling water storage tank	2000'-0"	Overflows to waste holdup tank	Low and high level alarms provided. Refer to Figure 6.3-1. Level indicator also provided.	
3.	Reactor makeup water storage tank	2000'-0"	Overflows to waste holdup tank	Low and high level alarms provided in control room. Refer to Figure 9.2-13. Level indicator also provided.	
4.	Discharge monitor tanks	1995'-6"	Overflows to dike sump; from there drains to rad. bldg. floor drain sump (DRW); from there pumped to floor drain tank	Low and high level alarms and level indicator provided in radwaste building control room. Dike high level alarm provided in radwaste building control room. Low level pump shutoff and high level tank inlet isolation provided	Tanks are located within a watertight dike
II.	Tanks Inside the Radwaste Building		REF: Figures 1.2-2 through 1.2-8		
1.	Recycle holdup tanks (2)	1976'-0"	Overflows to rad. bldg. drain sump, from there pumped to the waste holdup tank	Low and high level alarms on radwaste panel located in radwaste building. Refer to Figure 9.3-11. Level indicator also provided.	Located in watertight compartment below grade
2.	Waste gas decay tanks (8)	1976'-0"	None	None.	
3.	Deleted				
4.	Spent resin storage tanks (2)	2000'-0"	None	Low and high level alarms provided on radwaste panel in the radwaste building. Refer to Figure 11.4-1. Level indicator also provided.	Curb provided
5.	Chemical drain tank	1976'-0"	Overflows to rad. bldg. drain sump; from there to floor drain tank	Low and high level alarms provided on radwaste panel. Refer to Figure 11.2-1. Level indicator also provided.	
6.	Waste evaporator cond. tank	1976'-0"	Overflows to rad. bldg. equipment drain tank	Low and high level alarms provided on radwaste panel. Refer to Figure 11.2-1. Level indicator also provided.	

TABLE 11.2-2 (Sheet 2)

	Tanks	Elevation	Overflow Control	Level Indicator, High Alarms, Low Alarms, Etc.	Remarks
7.	Waste holdup tank	1976'-0"	Overflows to rad. bldg. drain sump; then pumped to floor drain tank	Low and high level alarms provided on radwaste panel. Refer to Figure 11.2-1. Level indicator also provided.	
8.	Floor drain tank (2)	1976'-0"	Overflows to rad. bldg. drain sump; from there to the tank itself	Low and high level alarms provided on radwaste panel. Refer to Figure 11.2-1. Level indicator also provided.	
9.	S.G. blowdown surge tank	1976'-0"	Overflows to rad. bldg. drain sump; from there to floor drain tank	Low level pump shut-off and high level blowdown isolation provided. Refer to Figure 10.4-8. Level indicator also provided.	
10.	Solid radwaste system decant tank	2000'-0"	Overflows to chemical drain tank	Low and high level alarms provided on solid radwaste control panel. Refer to Figure 11.4-1. Level indicator also provided.	
11.	Waste monitor tanks (2)	2000'-0"	Overflows to rad. bldg. drain sump; from there to floor drain tank	Low and high level alarms provided on radwaste panel. Refer to Figure 11.2-1. Level indicator also provided.	
12.	Deleted				
13.	Deleted				
14.	Laundry and hot shower tank	2031'-6"	Overflows to Rad. bldg. drain sump; then to floor drain tank	Low and high level alarms provided. Level indicator also provided. Refer to Figure 11.2-1.	
III.	Tanks Inside the Auxiliary Building		REF: Figures 1.2-9 through 1.2-18		
1.	Boric acid tanks (2)	1974'-0"	Overflows to aux. bldg. equip. drain sump, then to waste holdup tank	Low and high level alarms provided. Refer to Figure 9.3-8. Level indicator also provided.	
2.	Deleted				
3.	Deleted				
4.	Equipment drain sumps (2)	1974'-0"	None	Low and high level alarms provided in control room. Refer to Figure 9.3-5. No level indicator provided.	

TABLE 11.2-2 (Sheet 3)

	Tanks	Elevation	Overflow Control	Level Indicator, High Alarms, Low Alarms, Etc.	Remarks
5.	Volume control tank	2000'-0"	Relief valve discharge to recycle holdup tank	Low and high level alarms provided. Refer to Figure 9.3-8. Level indicator also provided.	
6.	Boric acid batching tank	2026'-0"	Overflows to aux. bldg. equip. drain sump, then to waste holdup tank	Low level alarm provided locally. Refer to Figure 9.3-8. Level indicator also provided.	
7.	Chemical addition tank (chemical mixing tank)	2026'-0"	None	No alarms or level indicator provided. Refer to Figure 9.3-8. Tank filled locally by operating personnel.	
IV.	Tanks Inside Reactor Building		REF: Figure 1.2-11		
1.	Reactor coolant drain tank	2000'-0"	None	Low and high level alarms provided. Refer to Figure 11.2-1. Level indicator also provided.	
2.	Pressurizer relief tank	2000'-0"	None	Low and high level alarms provided in control room. Refer to Figure 11.2-1. Level indicator also provided.	

TABLE 11.2-3 LIQUID WASTE MANAGEMENT SYSTEM INSTRUMENTATION PRINCIPAL DESIGN PARAMETERS

Channel Number	Location of Primary Sensor	Design Pressure (Psig)	Design Temperature (F)	Range	Location of Readout
LICA-1001	Waste holdup tank	150	200	0 to 100 pct	Local and WPS panel
LICA-1002	Chemical drain tank	150	200	0 to 100 pct	Local and WPS panel
LICA-1003	Reactor coolant drain tank	150	250	0 to 100 pct	WPS panel
LICA-1004	Reactor coolant drain tank	150	250	0 to 100 pct	WPS panel
LICA-1005	Primary spent resin storage tank	150	200	0 to 100 pct	WPS panel
PIA-1006	Primary spent resin storage tank	150	200	0 to 100 psig	WPS panel
FI-1007	Waste evaporator feed pump discharge	150	200	0 to 30 gpm	Local
FIC-1008	Reactor coolant drain tank pump discharge	150	250	0 to 250 gpm	WPS panel
FIA-1009	Reactor coolant drain tank recirculation	150	250	0 to 250 gpm	WPS panel
LICA-1010	Laundry and hot shower tank B	150	200	0 to 100 pct	WPS panel and local
FICA-1011	Primary spent resin sluice pump	150	200	0 to 150 gpm	WPS panel
LICA-1012	Waste evaporator condensate tank	150	200	0 to 100 pct	WPS panel and local
QI-1014	Reactor coolant drain tank discharge to recycle holdup tank	150	200	0 to 10 gpm	Local
PI-1017	Waste evaporator feed filter ΔP	150	200	0 to 25 psid	Local
PI-1018A	Reactor coolant drain tank pump No. 1 discharge	150	250	0 to 150 psig	Local
PI-1018B	Reactor coolant drain tank pump No. 2 discharge	150	250	0 to 150 psig	Local
PI-1018C	Laundry and hot shower tank B pump discharge	150	200	0 to 150 psig	Local
PI-1018D	Chemical drain tank pump discharge	150	200	0 to 150 psig	Local
PI-1018G	Waste evaporator condensate pump	150	200	0 to 150 psig	Local
TIA-1058	Reactor coolant drain tank	150	250	50 to 250°F	WPS panel

TABLE 11.2-3 (Sheet 2)

Channel Number	Location of Primary Sensor	Design Pressure (Psig)	Design Temperature (F)	Range	Location of Readout
PI-1074	Waste evaporator condensate demineralizer ΔP	150	200	0 to 25 psid	Local
PI-1075	Waste evaporator condensate filter ΔP	150	200	0 to 25 psid	Local
LICA-1077A	Floor drain tank	150	200	0 to 100 pct	WPS panel and local
LICA-1077B	Floor drain tank	150	200	0 to 100 pct	WPS panel and local
PI-1078	Floor drain tank filter ΔP	150	200	0 to 25 psid	Local
PI-1079	Floor drain tank strainer ΔP	150	200	0 to 25 psid	Local
LICA-1082	Waste monitor tank No. 1	150	200	0 to 100 pct	WPS panel and local
LICA-1083	Waste monitor tank No. 2	150	200	0 to 100 pct	WPS panel and local
PI-1084A	Waste monitor tank pump No. 1 discharge	150	200	0 to 150 psig	Local
PI-1084B	Waste monitor tank pump No. 2	150	200	0 to 150 psig	Local
FI-1085A	Waste monitor tank pump No. 1 discharge	150	200	0 to 100 gpm	WPS panel and local
FI-1085B	Waste monitor tank pump No. 2 discharge	150	200	0 to 100 gpm	WPS panel and local
PI-1086	Resin sluice filter ΔP	150	200	0 to 25 psid	Local
PI-1088	Waste monitor tank filter ΔP	150	200	0 to 25 psid	Local
PI-1089	Waste monitor tank demineralizer ΔP	150	200	0 to 25 psid	Local
PI-1090A	Floor drain tank pump discharge	150	200	0 to 150 psig	Local
PI-1090B	Floor drain tank pump discharge	150	200	0 to 150 psig	Local
LI-2004	Discharge monitor tank A	Atmospheric	100	0 to 100 pct	WPS panel
LI-2005	Discharge monitor tank B	Atmospheric	100	0 to 100 pct	WPS panel
PI-2020	Discharge monitor tank transfer pump A discharge	150	200	0 to 160 psig	Local

TABLE 11.2-3 (Sheet 3)

Channel Number	Location of Primary Sensor	Design Pressure (Psig)	Design Temperature (F)	Range	Location of Readout
PI-2019	Discharge monitor tank transfer pump B discharge	150	200	0 to 160 psig	Local
FI-2017	Liquid radwaste discharge	150	135	0 to 550 gpm	WPS panel
QI-2017	Liquid radwaste discharge	150	135	0 to 999, 999 x 10 gal	WPS panel
PI-0350	Laundry and Hot Shower Tk "A" Filter "A" Inlet	150	450	0 – 160 psi	Local
PI-0351	Laundry and Hot Shower Tk "A" Filter "A" Outlet	150	450	0 – 160 psi	Local
PI-0352	Laundry and Hot Shower Tk "A" Filter "B" Inlet	150	450	0 – 160 psi	Local
PI-0353	Laundry and Hot Shower Tk "A" Filter "B" Outlet	150	450	0 – 160 psi	Local
PI-0358	Laundry and Hot Shower Tk "B" Filter "B" Inlet	150	450	0 – 160 psi	Local
PI-0359	Laundry and Hot Shower Tk "B" Filter "B" Outlet	150	450	0 – 160 psi	Local
PI-0360	Laundry and Hot Shower Tk "B" Filter "A" Inlet	150	450	0 – 160 psi	Local
PI-0361	Laundry and Hot Shower Tk "B" Filter "A" Outlet	150	450	0 – 160 psi	Local
LICA-0007	Laundry and Hot Shower Tk "A"	150	200	0 – 100 pct	WPS panel and Local
PI-0008	Laundry and Hot Shower Tk "A" Pump Discharge	150	200	0 – 160 psig	Local

NOTES:

F - Flow
Q - Flow integrator
P - Pressure
L - Level
T - Temperature

R - Radiation
I - Indication
C - Control
A - Alarm
S - Switch

11.3 GASEOUS WASTE MANAGEMENT SYSTEMS

The gaseous radwaste system (GRWS) and the plant ventilation exhaust systems control, collect, process, store, and dispose of gaseous radioactive wastes generated as a result of normal operation, including anticipated operational occurrences. This section discusses the design, operating features, and performance of the GRWS and the performance of the ventilation systems. The plant ventilation exhaust systems accommodate other potential release paths for gaseous radioactivity due to miscellaneous leakages, aerated vents from systems containing radioactive fluids, and the removal of noncondensables from the secondary system. Systems which handle these gases are not normally considered gaseous waste systems and are discussed in detail in other sections. These systems are included here to the extent that they represent potential release paths for gaseous radioactivity.

11.3.1 DESIGN BASES

11.3.1.1 Safety Design Basis

The GRWS and other gaseous waste management systems serve no safety-related function.

11.3.1.2 Power Generation Design Bases

POWER GENERATION DESIGN BASIS ONE - The GRWS and the ventilation exhaust systems are designed to meet the requirements of the discharge concentration limits of 10 CFR 20 and the as low as reasonably achievable dose objective of 10 CFR 50, Appendix I.

POWER GENERATION DESIGN BASIS TWO - The GRWS includes design features to preclude the possibility of an explosion where a potential for an explosive mixture exists.

POWER GENERATION DESIGN BASIS THREE - The GRWS uses design and fabrication codes consistent with quality group D (augmented), as assigned by Regulatory Guide 1.143 for radioactive waste management systems.

POWER GENERATION DESIGN BASIS FOUR - The ventilation exhaust system complies with Regulatory Guide 1.140 to the extent specified in Table 9.4-3.

POWER GENERATION DESIGN BASIS FIVE - Gaseous effluent discharge paths are monitored for radioactivity.

11.3.2 SYSTEM DESCRIPTIONS

11.3.2.1 General Description

This section describes the design and operating features of the GRWS. The performance of the GRWS and other plant gaseous waste management systems with respect to the release of radioactive gases is discussed in Section 11.3.3. Detailed descriptions of the plant ventilation systems and main condenser evacuation system are presented in Sections 9.4 and 10.4.2, respectively.

The piping and instrumentation diagram for the GRWS is shown in Figure 11.3-1.

The main flow path in the GRWS is a closed loop comprised of two waste gas compressors, two catalytic hydrogen recombiners, six gas decay tanks for normal power service, and two gas decay tanks for service at shutdown and startup. The system also includes a gas decay tank drain collection tank, drain pump, four gas traps to handle normal operating drains from the system, and a waste gas drain filter to permit maintenance and handle normal operating drains from the system. All of the equipment is located in the radwaste building.

The closed loop has nitrogen for a carrier gas. The primary influents to the GRWS are combined with hydrogen as the stripping or carrier gas. The hydrogen that is introduced to the system is recombined with oxygen, and the resulting water is removed from the system. As a result, the bulk of all influent gases is removed, leaving trace amounts of inert gases, such as helium and radioactive noble gases to build up.

The primary source of the radioactive gas is via the purging of the volume control tank with hydrogen, as described in Section 9.3.4. The operation of the GRWS serves to reduce the fission gas concentration in the reactor coolant system which, in turn, reduces the escape of fission gases from the reactor coolant system during maintenance operations or through equipment leakage. Smaller quantities are received, via the vent connections, the reactor coolant drain tank, the pressurizer relief tank, and the recycle holdup tanks.

Since hydrogen is removed in the recombiner, this gas does not build up within the system. The largest contributor to the nonradioactive gas accumulation is helium generated by a B10(n,a)Li7 reaction in the reactor core. The second largest contributors are impurities in the bulk hydrogen and oxygen supplies. Stable and long-lived isotopes of fission gases also contribute small quantities to the system gas volume accumulation.

Operation of the system is such that fission gases are distributed throughout the six normal operation gas decay tanks. Separation of the GRWS gaseous inventory in several tanks assures that the allowable site boundary dose will not be exceeded in the event of a gas decay tank rupture. Radiological consequences of such a postulated rupture are discussed in Section 15.7.1.

The GRWS also provides the capacity for indefinite holdup of gases generated during reactor shutdown. Nitrogen gas from previous shutdowns is contained in one of the shutdown gas decay tanks for use in stripping hydrogen from the reactor coolant system. The second shutdown tank is normally at low pressure and is used to accept relief valve discharges from the normal operation gas decay tanks.

For all buildings where there is potential airborne radioactivity, the ventilation systems are designed to control the release. Where applicable, each building has a vent collection system for tanks and other equipment which contains air or aerated liquids. The condenser evacuation system discharge is filtered and discharged to the unit vent in addition to the discharges from the reactor building, auxiliary building, and fuel building. The radwaste building, which houses the GRWS, has its own release vent. The turbine building has an open ventilation system, and the steam packing exhaust discharges into the turbine building.

The vent collection systems receive the discharge of vents from tanks and other equipment in the radwaste and auxiliary buildings which contain air or aerated liquids. These components contain only a very small amount of fission product gases. Prior to release via the radwaste or auxiliary building ventilation system, the gases are monitored, as described in Section 11.5, and passed through a prefilter, HEPA filter, charcoal filter, and another HEPA filter in series which reduce any airborne particulate radioactivity to negligible levels and provide a decontamination factor of at least 10 for radioactive iodines and 100 for particulates. Expected efficiencies for iodine removal are better than 99 percent for elemental iodine and 95 percent for organic iodine at 70-percent relative humidity. However, for gaseous effluent release calculations, 70-percent efficiency is conservatively used for radioiodine isotopes.

Although plant operating procedures, equipment inspection, and preventive maintenance are performed during plant operations to minimize equipment malfunction, overall radioactive release limits have been established as a basis for controlling plant discharges during operation with the occurrence of a combination of equipment faults of moderate frequency. These faults include operation with fuel defects in combination with steam generator tube leaks and malfunction of liquid or gaseous waste processing systems or excessive leakage in reactor coolant system equipment or auxiliary system equipment. Operational occurrences such as these can result in the discharge of radioactive gases from various plant systems. These unscheduled discharges may be from plant systems which are not normally considered gas processing systems or from a gas decay tank after a 60-day holdup period. If the holdup period restricts plant operation, it may be necessary to decrease this time with prior approval from the Manager, Radiation Protection. These potential sources are tabulated in Table 11.1-2. The bases for assumed releases, the factors which tend to mitigate the release of radioactivity, and the release paths are given in Appendix 11.1A.

A further discussion of the gaseous releases from the plant is provided in Section 11.3.3.

11.3.2.2 Component Description

Codes and standards applicable to the GRWS are listed in Tables 3.2-1 and 11.3-1. The GRWS is designed and constructed in accordance with quality group D (augmented). The GRWS is seismically designed, as discussed in Table 3.2-5. The GRWS is housed within a seismically designed building. The GRWS design complies with Regulatory Guide 1.143, as specified in Table 3.2-5.

WASTE GAS COMPRESSOR - The waste gas compressor is a water-sealed centrifugal displacement unit which maintains continuous circulation of nitrogen around the waste gas loop. The compressor is provided with a mechanical shaft seal to minimize water leakage. The compressor moisture separator normal water level is maintained to keep the shaft immersed at all times.

Two waste gas compressor packages are provided. One compressor is normally used, and the other compressor is on standby. The packages are self-contained and skid-mounted. Construction is primarily of carbon steel.

CATALYTIC HYDROGEN RECOMBINER - The catalytic recombiner disposes of hydrogen brought into the GRWS. This is accomplished by adding a controlled amount of oxygen to the recombiner which reacts with the hydrogen as the gas flows through a catalyst bed. The control system for the recombiner is designed to preclude the possibility of a hydrogen explosion. This is further discussed in Section 11.3.6.

Two hydrogen recombiner packages are provided. One recombiner is normally used, and the other is on standby. The packages are self-contained and skid-mounted. The recombiner is located in the system where the hydrogen concentration and pressure are optimum with respect to hydrogen removal.

DECAY TANK - Eight gas decay tanks are provided, six for normal power operation and two for service at shutdown and startup. The tanks are of the vertical-cylindrical type and are constructed of carbon steel.

MISCELLANEOUS COMPONENTS - The gas decay drain collection tank provides a collection point for condensation drained from the gas decay tanks, recombiners, and gas compressors.

All control valves, with the exception of those on the recombiner, are provided with bellow seals to minimize the leakage of radioactive gases through the valve bonnet and stem. Valves on the recombiner package are provided with leakoffs.

Relief valves have soft seats and are exposed to pressures which are normally less than two-thirds of the relief valve set pressure. The relief valves of the major components discharge to the shutdown tanks. This permits decay and controlled disposal of all discharges less than about 3,000 scf. The relief valves are designed to relieve full flow from both waste gas compressors.

To maintain leakage from the system at the lowest practicable level, diaphragm-type manual valves are used throughout the waste gas system. For low temperature, low pressure service valves with a synthetic rubber-type diaphragm are used. This application includes all parts of the system, except the recombiners. Because of the high temperature that may exist in the recombiner, globe type valves with a metal diaphragm seal in the stem are used. There should be no measurable stem leakage from either type of valve.

The gas decay tank drain pump directs water from the gas decay drain collection tank (due to condensation or maintenance) to the waste holdup tank or recycle holdup tanks. It is used when there is insufficient pressure in the gas system to drive the fluid. All parts of the pump in contact with the drain water are of austenitic stainless steel. The pump is a canned-motor type.

The waste gas drain filter is a disposable cartridge filter provided to prevent particulate matter, including rust, larger than 30 microns from entering the LRWS and BRS. All parts of the filter in contact with the drain water are of austenitic stainless steel.

The waste gas traps are designed to prevent gases from leaving the GRWS. There are four gas traps - two in the gas decay tank drain line and one each in the recombiner drain lines and compressor drain lines.

The component description for the ventilation systems is provided in Section 9.4.

11.3.2.3 System Operation

Operation of the ventilation systems is described in Section 9.4. The following is a description of the GRWS.

NORMAL OPERATION - The GRWS system is normally operated when increased fission gases or excess hydrogen levels have accumulated in the volume control tank (VCT). When needed, nitrogen gas, with contained fission gases, is circulated around the GRWS loop by one of the two compressors. Fresh hydrogen gas is introduced into the VCT where it is mixed with fission gases stripped from the reactor coolant by the action of the VCT letdown line spray nozzle. The gas is vented from the VCT into the circulating nitrogen in the waste gas system, at the compressor suction.

The resulting mixture of nitrogen, hydrogen, and fission gases is pumped by one of the compressors to one of the two catalytic hydrogen recombiners where enough oxygen is added to react with and reduce the hydrogen to a low residual level. Water vapor formed in the recombiner by the hydrogen and oxygen reaction is condensed and removed, and the cooled gas stream (now composed primarily of nitrogen, helium, and fission gases) is discharged from the recombiner, routed through a gas decay tank, and sent back to the compressor suction to complete the loop circuit.

Only one gas decay tank is valved into the waste gas loop at any time.

If it has been determined that excessive nitrogen buildup is occurring within the system or when other occurrences require it, one tank can be valved out of service and allowed to decay for a period of 60 days. If the holdup time restricts plant operation, it may be necessary to decrease this time with prior approval from the Manager, Radiation Protection.

STARTUP - At plant startup, the system is first flushed free of air and filled with nitrogen at atmospheric pressure. One compressor, one recombiner, and one shutdown decay tank are in service. The reactor is at the cold shutdown condition. Fresh hydrogen is charged into the volume control tank, and the volume control tank vent gas mixes with the circulating nitrogen in the GRWS. This circulating mixture enters the compressor suction, passes through the recombiner and shutdown gas decay tank, and returns to the compressor suction. When the reactor coolant system hydrogen concentration is within operating specifications, the shutdown gas decay tank is isolated and the gas flow directed to one of the gas decay tanks provided for normal power operation. Gases accumulated in the shutdown tank will be retained for reuse during hydrogen stripping from the reactor coolant system during subsequent shutdown operations.

SHUTDOWN AND DEGASSING OF THE REACTOR COOLANT SYSTEM - Plant shutdown operations are essentially startup operations in reverse sequence. During normal power operations a hydrogen purge is maintained on the VCT. After Reactor shutdown, a nitrogen purge to the VCT is begun from the nitrogen header or from a shutdown gas decay tank. A Gas Decay Tank is placed in the process loop so that the gas mixture from the VCT vents to the GRW system and passes through to the recombiner where hydrogen is removed. The volume control tank nitrogen purge is maintained until hydrogen and coolant fission gas concentrations have been reduced to specified levels. During this operation, nitrogen purge flow may be increased to speed up coolant degassing. During degas operations, the inlet Hydrogen analyzer may be bypassed to facilitate Hydrogen removal. Technical Specifications provide the limits to follow during analyzer operations. The nitrogen purge continues until the reactor coolant hydrogen concentration reaches the required level. Degassing is then complete, and the reactor coolant system may be opened for maintenance or refueling.

An alternative method to degas the reactor coolant system may also be employed. This method, chemical degassing, reduces the reactor coolant dissolved hydrogen concentration through reaction with hydrogen peroxide. After Reactor shutdown, plant cooldown continues until RCS temperature is less than 180°F. A pre-determined quantity of hydrogen peroxide is added. The hydrogen peroxide reacts with dissolved hydrogen to form water. The reactor coolant is sampled to verify the hydrogen concentration has reached the required level. The VCT nitrogen purge may be performed in conjunction with chemical degas operations if it is desired to reduce reactor coolant system noble gas levels or to help expedite reducing the RCS hydrogen concentration.

11.3.3 RADIOACTIVE RELEASES

This section describes the estimated gaseous release from the plant for normal operation and anticipated operational occurrences.

11.3.3.1 Sources

Section 11.1 and Appendix 11.1A provide the bases for determining the contained source inventory and the normal releases.

11.3.3.2 Release Points

Potential release paths for gaseous radioactivity are illustrated schematically in Appendix 11.1A. The general location of potential gaseous radioactivity release points is depicted in Figure 1.2-1. A description of potential release points for radioactive gaseous effluents is given in Appendix 11.1A, along with the physical characteristics of the gaseous effluent streams. Release points from the gaseous waste processing systems are shown on Figure 11.3-2.

11.3.3.3 Dilution Factors

The annual average dilution factors used in evaluating the release of gaseous radioactive effluents for the site are derived and justified in Section 2.3 of the Site Addendum.

11.3.3.4 Estimated Doses

Table 11.3-2 gives the estimates of offsite doses from radioactive gaseous effluents for the site. Estimated doses were calculated by site consultants and reflect site characteristics, such as distance, grazing factors, and meteorology. The results shown in Table 11.3-2 demonstrate that the ALARA criteria of 10 CFR 50 are met.

For a description of assumptions and models for dose calculations, refer to Section 11.3 of the Site Addendum.

11.3.4 SAFETY EVALUATION

The GRWS serves no safety-related function.

11.3.5 TESTS AND INSPECTIONS

Preoperational testing is described in Chapter 14.0.

The operability, performance, and structural and leaktight integrity of all system components are demonstrated by intermittent or continuous operation.

11.3.6 INSTRUMENTATION APPLICATION

The GRWS instrumentation, as described in Table 11.3-3, is designed to facilitate automatic operation and remote control of the system and to provide continuous indication of system parameters.

The instrumentation readout is located mainly on the waste processing system panel in the radwaste building. Some instruments are read where the equipment is located. All alarms are shown separately on the waste processing system panel. Where suitable, instrument lines are provided with diaphragm seals to prevent fission gas outleakage through the instrument. Figure 11.3-3 shows the location of the instruments on the compressor package.

The compressors are interlocked with the seal water inventory in the moisture separators and trip off on either high or low moisture separator level. During normal operation, the proper seal water inventory is maintained automatically.

Figure 11.3-4 indicates the location of the instruments on the recombiner installation.

The catalytic recombiner system is designed for automatic operation with a minimum of operation attention. Each package includes two online gas analyzers, one to measure hydrogen and oxygen in and one to measure hydrogen and oxygen out, which are the primary means of recombiner control. Each gas concentration channel of these two online gas analyzers is independently controlled.

The GRWS is designed to operate with hydrogen concentrations above 4 percent by volume. Flammable mixtures of gases in the system are prevented by monitoring and controlling the oxygen concentration to appropriate levels. The setpoints for oxygen concentration in the catalyst bed inlet stream are 3 percent for the hi alarm and 3.5 percent for the hi-hi alarm and isolation of the oxygen supply. The setpoint for oxygen concentration downstream of the catalyst bed is 60 ppm oxygen for the hi-hi alarm and isolation of inlet oxygen supply. Thus the oxygen supply to the recombiner would be terminated before the concentration in the GRWS would reach levels favorable for hydrogen flammability.

Since the GRWS is designed to operate with hydrogen concentrations up to 6 percent by volume, up to 3 percent oxygen is necessary for operation of the catalytic recombiner. Termination of oxygen feed at 2 percent as suggested by regulatory guidance is inappropriate. Further, since the minimum oxygen concentration necessary to support combustion at 4 percent by volume hydrogen concentrations is 5 percent, the hi-alarm setpoint of 3 percent provides sufficient margin (i.e., 60 percent of the limit) to flammability.

A multipoint temperature recorder monitors temperatures at several locations in the recombiner packages.

The process gas flow rate is measured by an orifice located upstream of the recombiner preheater. Local pressure gauges indicate pressure at the recombiner inlet and oxygen supply pressure.

The following controls and alarms are incorporated to maintain the gas composition outside the range of flammable and explosive mixtures:

a. A high flow alarm sounds at the volume control tank purge flow corresponding to 3 percent hydrogen by volume at the inlet to the hydrogen recombiner.

b. If the recombiner feed concentration exceeds 4 percent by volume, a high-hydrogen alarm sounds. This alarm will be followed by a second alarm indicating high hydrogen in the recombiner discharge. These alarms warn of a possible Section 16.11.2.6 surveillance condition and a possible hydrogen accumulation in the system, respectively.

c. If the hydrogen concentration in the recombiner feed reaches 9 percent by volume, a high-high hydrogen alarm sounds, the oxygen feed is terminated, and the volume control tank hydrogen purge flow is terminated. These controls limit the possible accumulation of hydrogen in the GRWS to 3 percent by volume.

d. If the oxygen concentration in the recombiner feed reaches 3 percent by volume, an alarm sounds and oxygen feed flow is limited so that no further increase in flow is possible. This control maintains the system oxygen concentration at 3 percent or less, which is below the flammable limit for hydrogen-oxygen mixtures.

e. If the oxygen concentration in the recombiner feed reaches 3.5 percent by volume, an alarm sounds and the oxygen feed flow is terminated.

f. If hydrogen in the recombiner discharge exceeds 1.25 percent by volume, an alarm sounds. This alarm warns of high hydrogen feed, possible catalyst failure, or loss of oxygen feed.

g. If oxygen in the recombiner discharge exceeds 60 ppm, an alarm sounds and oxygen feed is terminated. This control prevents any accumulation of oxygen in the system in case of hydrogen recombiner malfunction.

h. On low flow through the recombiner, oxygen feed is terminated. This control prevents an accumulation of oxygen following system malfunction.

i. High discharge temperature from the cooler-condenser (downstream from the reactor) will terminate oxygen feed. This protects against loss of cooling water flow in the cooler-condenser.

j. High temperature indication by any one of six thermocouples in the catalyst bed will limit oxygen feed so that no further increase is possible.

k. High temperature indication at the recombiner reactor discharge will terminate oxygen feed to the recombiner.

l. If the oxygen and hydrogen concentrations in the recombiner feed reach 3 and 4 percent respectively by volume, an alarm sounds. This alarm alerts operators to a Section 16.11.2.6 surveillance condition.

m. If the oxygen and hydrogen concentration in the recombiner feed both reach 4 percent by volume, an alarm sounds. This alarm alerts operators to a Section 16.11.2.6 recombiner shutdown condition.

TABLE 11.3-1 GASEOUS WASTE PROCESSING SYSTEM MAJOR COMPONENT DESCRIPTION

Water Gas Compressors

Type	Centrifugal
Quantity	2
Design pressure, psig	150
Design temperature, °F	180
Operating temperature, °F	70 to 130
Design suction pressure, N_2 at 130°F, psig	0.5
Design discharge pressure, psig	110
Design flow, N_2 at 130°F, scfm	40
Material	Carbon steel
Design code (1)	ASME VIII/D (augmented)
Seismic design	In accordance with Table 3.2-1

Gas Decay Tanks

Type	Vertical
Quantity	8
Design pressure, psig	150
Design temperature, °F	180
Volume, each, ft^3	600
Material of construction	Carbon steel
Design code (1)	ASME VIII/D (augmented)
Seismic design	In accordance with Table 3.2-1

Recombiners

Type	Catalytic
Quantity	2
Design pressure, psig	150
Design temperature, °F	(2)
Design flow rate, scfm	50
Operating discharge pressure, psig	30
Operating discharge temperature, °F	70 to 140
Material of construction	Stainless steel
Design code (1)	ASME VIII/D (augmented)
Seismic design	In accordance with Table 3.2-1

(1) Table indicates the required code based on its safety-related importance as dictated by service and functional requirements and by the consequences of their failure. Note that the equipment may be supplied to a higher principal construction code than required.

(2) Varies by component in the recombiner package, but exceeds operating temperatures by 100°F.

TABLE 11.3-2 MAXIMUN INDIVIDUAL DOSES FROM NORMAL GASEOUS EFFLUENTS

Type of Dose	Sector	Dose	APPENDIX I Limit
Noble Gases at Site Boundary			
Cloud submersion			
Total body, mrem	S	0.017	5
Skin, mrem	S	0.045	15
Air dose			
Gamma, mrad	S	0.088	10
Beta, mrad	S	0.042	20
Radioactive iodines and particulates limiting existing pathway, mrem	NNW	2.75	15

TABLE 11.3-3 GASEOUS WASTE PROCESSING SYSTEM INSTRUMENTATION DESIGN PARAMETERS

Channel Number	Location of Primary Sensor	Design Pressure (psig)	Design Temperature (F)	Range	Alarm Setpoint	Control Setpoint	Location of Readout
Flow Instrumentation							
QIA-1091	Gas decay tank water flush	150	180	0 to 6,000 gal	3,000 to 6,000 gal(adjustable)	-	Local
HIC-1094	Volume control tank purge control	150	250	0 to 100 pct	None	Manual control (normal flow 0.7 scfm)	WPS panel
Pressure Instrumentation							
PI-1031	Moisture separator	150	180	0 to 100 psig	-	-	Local
PI-1033	Moisture separator	150	180	0 to 100 psig	-	-	Local
PIA-1036	Gas decay tank number 1	150	180	0 to 150 psig 0 to 30 psig	100 psig 20 psig	-	WPS panel
PIA-1037	Gas decay tank number 2	150	180	0 to 150 psig 0 to 30 psig	100 psig 20 psig	-	WPS panel
PIA-1038	Gas decay tank number 3	150	180	0 to 150 psig 0 to 30 psig	100 psig 20 psig	-	WPS panel
PIA-1039	Gas decay tank number 4	150	180	0 to 150 psig 0 to 30 psig	100 psig 20 psig	-	WPS panel
PIA-1052	Gas decay tank number 5	150	180	0 to 150 psig 0 to 30 psig	100 psig 20 psig	-	WPS panel
PIA-1053	Gas decay tank number 6	150	180	0 to 150 psig 0 to 30 psig	100 psig 20 psig	-	WPS panel
PIA-1054	Gas decay tank number 7	150	180	0 to 150 psig 0 to 30 psig	90 psig 20 psig	-	WPS panel
PIA-1055	Gas decay tank number 8	150	180	0 to 150 psig 0 to 30 psig	100 psig 20 psig	-	WPS panel

TABLE 11.3-3 (Sheet 2)

Channel Number	Location of Primary Sensor	Design Pressure (psig)	Design Temperature (F)	Range	Alarm Setpoint	Control Setpoint	Location of Readout
Pressure Instrumentation (Cont'd)							
PIA-1065	Hydrogen supply header	150	180	0 to 150 psig	90 psig	-	WPS panel
PIA-1066	Nitrogen supply header	150	180	0 to 150 psig	90 psig	-	WPS panel
PICA-1092	Compressor suction header	150	180	2 psi vac 2 psig	0.5 psi vac	0.5 psi vac	WPS panel
PI-1093	Gas decay tank makeup water	150	180	0 to 150 psig	N.A.	N.A.	Local
PI-1094	Volume control tank discharge pressure	150	250	0 to 20 psig	N.A.	N.A.	Local
Level Instrumentation							
LICA-1030	Compressor Moisture Separator	150	180	0 to 30 inches H_2O	15 inches H_2O 1 inch H_2O	10 inches H_2O 8 inches H_2O 5 inches H_2O	WPS panel and Local
LICA-1032	Compressor Moisture Separator	150	180	0 to 30 inches H_2O	15 inches H_2O 1 inch H_2O	10 inches H_2O 8 inches H_2O 5 inches H_2O	WPS panel and Local

11.4 SOLID WASTE MANAGEMENT SYSTEM

The solid radwaste system (SRS) is designed to meet the functional requirements of the solid waste management system. The SRS is designed to collect, process, and package radioactive wastes generated as a result of normal plant operation, including anticipated operational occurrences, and to store this packaged waste until it is shipped offsite to an intermediate processing facility or to a licensed burial site. The process and effluent radiological and sampling systems are described in Section 11.5.

11.4.1 DESIGN BASES

11.4.1.1 Safety Design Bases

The SRS performs no function related to the safe shutdown of the plant, and its failure does not adversely effect any safety-related system or component; therefore, the SRS has no safety design bases.

11.4.1.2 Power Design Bases

POWER GENERATION DESIGN BASIS ONE - The SRS is designed to meet the following objectives:

a. Provide remote transfer and hold-up capability for spent radioactive resins from the chemical and volume control system, fuel pool cooling and cleanup system, boron recycle system, liquid radwaste system, steam generator blowdown system, and secondary liquid waste system and for spent radioactive activated charcoal from the liquid radwaste system and the secondary liquid waste system.

b. Deleted

c. Provide a means to semiremotely remove and transfer the spent filter cartridges from the filter vessels to the solid radwaste processing system in a manner which minimizes radiation exposure to operating personnel and the spread of contamination.

d. Deleted

POWER GENERATION DESIGN BASIS TWO - The SRS is designed and constructed in accordance with Regulatory Guide 1.143, as described in Table 3.2-5, and Branch Technical Position ETSB 11-3, as described in Table 11.4-1. The seismic design classification of the radwaste building, which houses the solid waste management system, and the seismic design and quality group classification for the system components and piping are provided in Section 3.2.

POWER GENERATION DESIGN BASIS THREE - The SRS design parameters are based on the radionuclide concentrations and volumes consistent with reactor operating experience for similar designs and with the source terms of Section 11.1.

POWER GENERATION DESIGN BASIS FOUR - Collection, solidification, packaging, and storage of radioactive wastes are to be performed so as to maintain any potential radiation exposure to plant personnel during system operation or during maintenance to "as low as is reasonably achievable" (ALARA) levels, in accordance with the intent of Regulatory Guide 8.8 in order to maintain personnel exposures well below 10 CFR 20 requirements. Design features incorporated to maintain ALARA criteria include remote system operation, remotely actuated flushing, and equipment layout permitting the shielding of components containing radioactive materials. Additionally, access to the solidification and solid waste storage areas is controlled to minimize personnel exposure.

POWER GENERATION DESIGN BASIS FIVE - The onsite storage facilities for drummed solid wastes have a capacity for temporary storage of solid wastes resulting from up to 5 years of plant operation. Temporary onsite storage and shipping offsite of solid radwaste do not present a radiation hazard to persons onsite or offsite, for either normal conditions or extreme environmental conditions, such as tornados, floods, or seismic events.

POWER GENERATION DESIGN BASIS SIX - The SRS is designed to meet the requirements of General Design Criterion 60 of 10 CFR 50, Appendix A. Packaging and shipment of radioactive wastes is performed in accordance with the requirements of 10 CFR 71, 49 CFR 173, and applicable state regulations.

11.4.2 SYSTEM DESCRIPTION

11.4.2.1 General Description

The SRS consists of the following subsystems which are illustrated in the piping and instrumentation diagrams provided in Figure 11.4-1:

a. Solidification system

b. Dry waste system

c. Resin handling system

d. Filter handling system

The activity of the influents to the SRS is dependent on the activities of the various fluid systems, such as the boron recycle system, secondary liquid waste system, liquid waste management system, chemical and volume control system, fuel pool cooling and cleanup system, floor and equipment drain system, and the steam generator blowdown system. Reactor coolant system activities and the decontamination factors for the systems given above also determine the influent activities to the solid radwaste system.

Table 11.4-2 lists the estimated expected and maximum activities of waste to be processed on an annual basis and their physical form and source. The isotopic makeup and curie contents of the expected influents to the SRS are given in Table 11.4-2. The estimated annual quantities of solid radwaste to be shipped offsite are presented in Table 11.4-3. The estimated expected and maximum curie and isotopic content of wastes to be shipped offsite for each waste category are also presented in Table 11.4-4.

Section 11.1 and Appendix 11.1A provided the bases for determination of liquid source terms which are used to calculate the solid waste source terms. The sources presented in Tables 11.4-2 and 11.4-4 are conservatively based on Section 11.1, Appendix 11.1A and the following additional information:

a. As a basis for the shipped-from-site activities given in Table 11.4-4, 30 days' decay prior to shipment is assumed.

b. The miscellaneous dry and compacted waste volume is based on Case 6 of Table 2-49 of WASH-1258, July, 1973.

c. Shipping volumes based on packaging in 55-gallon drums:

   (1) 3.5 ft^3 primary spent resin, primary charcoal, per drum

   (2) 4.8 ft^3 liquid radwaste processing spent resin and charcoal per drum

   (3) 1 filter cartridge per drum

   (4) 7.5 ft^3 shipped volume per drum (including cement)

11.4.2.2 <u>Component Description</u>

Codes and standards applicable to the SRS are listed in Tables 3.2-1 and 11.4-5. The SRS is designed and constructed in accordance with requirements. The SRS is housed within a seismically designed building. Regulatory Guide 1.143 is complied with to the extent specified in Table 3.2-5.

SRS component parameters are presented in Table 11.4-5. The following is a functional description of the major system components:

SPENT RESIN STORAGE TANK (PRIMARY) - Provides for storage and decay of the spent resins from the demineralizers in the chemical and volume control system, fuel pool cooling and cleanup system, boron recycle system, and liquid radwaste system prior to dewatering processes.

SPENT RESIN STORAGE TANK (SECONDARY) - Provides for storage and decay of the spent resins and spent activated charcoal from the demineralizers and charcoal adsorbers in the steam generator blowdown system, secondary liquid waste system, and charcoal adsorbers in the liquid radwaste system prior to solidification or dewatering processes.

SPENT RESIN SLUICE PUMPS (PRIMARY AND SECONDARY) - Can provide the motive flow to transfer spent resin or spent activated charcoal from the various demineralizers or adsorbers to the appropriate spent resin storage tank.

CAUSTIC ADDITION TANK AND METERING PUMP - Provides chemistry control to the chemical drain tank, floor drain tank, waste holdup tank, and discharge monitor tanks.

RESIN CHARGING TANKS - Provide remote means of gravity sluicing clean resin and activated charcoal into the demineralizer and adsorber units.

SOLID RADWASTE BRIDGE CRANE - A crane, remotely operated from the solid radwaste control console, which provides the means of moving containers from station to station in the processing area, from the processing area to the solid waste storage area, and from the solid waste storage area to the shipping area. The crane is equipped with a television camera system to facilitate the remote handling operation.

BULK WASTE DISPOSAL STATION - Provides a means for bulk processing or disposal of wastes generated during plant operations. Process piping is provided within the installed solid radwaste system to allow the transfer of wastes contained within either of the evaporator bottoms tanks or spent resins storage tanks through the bulk waste processing packaging equipment.

CHEMICAL ADDITION POT - The portable skid provides the flexibility to add various chemicals to the Radwaste systems and components as needed.

11.4.2.3 System Operation

11.4.2.3.1 Solidification System

Solids inputs to the solidification system, such as spent resins and charcoal, are sluiced to either the spent resin storage tank (primary) or spent resin storage tank (secondary), depending upon which component that supplied the waste.

Solidification of process wastes is based upon formulas approved per the plant Process Control Program (PCP). These pretested formulas establish the system's process parameters and provide boundary conditions within which reasonable assurance is given that complete solidification (the lack of free water) has occurred. The boundary conditions for process parameters include mixing time, waste pH, major chemical substances, liquid waste-to-binder ratio, and solids-to-water ratio. The PCP establishes and defines the administrative controls which will be used and identifies the documentation necessary to ensure that the process is operated within the established boundaries.

SPENT RESINS - The approximate volume that can be solidified in a 55-gallon drum is 3.5 cubic feet of primary spent resins and 4.8 cubic feet of secondary spent resins.

SPENT ACTIVATED CHARCOAL - The approximate volume that can be solidified in a 55-gallon drum is 3.5 cubic feet primary spent charcoal and 4.8 cubic feet of secondary spent resins.

FILTER CARTRIDGES - Where acceptable per the applicable NRC, DOT, and state regulations, filter cartridges which may be disposed of without stabilization, may be packaged in common drums with up to 12 cartridges per drum or placed within a Low Specific Activity (LSA) box. Filter cartridges requiring stabilization for disposal, will be packaged in individual 55-gallon drums or in approved High Integrity Containers.

MISCELLANEOUS DRY WASTES - Miscellaneous paper, clothing, etc., are assumed to have the volume reduced by a factor of five in the compactor, which is a commercially available hydraulic press.

11.4.2.3.2 Dry Waste System

Low-level dry active wastes are collected at appropriate locations throughout the plant, as dictated by the volume of these wastes generated during operation or maintenance. Dry wastes, which can be compressed to minimize the shipping volume, may be compacted in 55-gallon drums with a dry waste compactor or may be packaged in approved containers for offsite volume reduction. Compactors are located in the radwaste building, and auxiliary building. The dry waste compactors have an integral shroud which directs any airborne dusts created by the compaction operation through an exhaust fan and filter, and then to the respective building's ventilation system.

Packaged containers are sealed and moved either to the drum storage area in the radwaste building, fenced radwaste yards, or to another approved storage location, where they are stored until shipment offsite.

Packaged low-level dry active waste may be placed in cargo boxes, such as "Sealands", approved for shipping low-level radioactive waste by the DOT, located in staging areas adjacent to the radwaste building within a RPA.

Large components and equipment which have been contaminated or activated during operation are normally handled either by qualified plant personnel or by outside contractors specializing in radioactive materials handling, and are packaged in shipping containers or appropriate shipping packages of an appropriate size. Due to their size, the original steam generators and original reactor vessel closure head are stored in the Old Steam Generator Storage Facility (OSGSF).

11.4.2.3.3 Resin Handling System

The resin handling system provides the capability for remote removal of spent radioactive resin and activated charcoal from the demineralizer and charcoal adsorber vessels in the chemical and volume control system, fuel pool cooling and cleanup system, boron recycle system, liquid radwaste system, steam generator blowdown system, and secondary liquid waste system and to transfer them to the associated spent resin storage tank or bulk waste disposal station.

In the resin transfer mode, the spent resin sluice pumps take suction from the storage tank via a screened connection on the tank and pump water through the respective vessel to first backflush the resin and then sluice the resin to the spent resin storage tank. Primary resin may be also sluiced from the demineralizer vessel to the primary spent resin storage tank with reactor makeup water. Steam generator blowdown resin may be sluiced from the demineralizer vessel to the secondary spent resin storage tank with reactor makeup water. Primary resin or steam generator blowdown resins may also be sluiced directly to the bulk waste disposal station with reactor makeup water. Positive indication that the resin has been sluiced to the spent resin storage tank or bulk waste disposal station is provided by an radiation measuring instrumentation located in the spent resin sluice header or by visually monitoring the bulk waste container.

The spent resin storage tank (primary), which accepts spent resins from waste processing systems, is capable of accommodating at least 60 days' waste generation at normal generation rates. The spent resin storage tank (secondary), which accepts spent resin and spent activated charcoal from the remaining vessels, is capable of accommodating at least 30-days' waste generation at normal generation rates.

Spent resin and spent activated charcoal are transferred from the spent resin storage tanks to the bulk waste disposal station by pressurizing the storage tank with nitrogen and supplying sluice water at the outlet nozzle on the tank for bulk waste processing.

The empty demineralizer or charcoal adsorber vessels are filled with clean media by gravity sluicing from the resin charging tank or by pumping a slurry directly from the new media container into the associated vessels. The filling operations are performed remotely from the vessels being filled.

11.4.2.3.4 Filter Handling System

Filter cartridge changeouts are to be performed utilizing manual changeout techniques.

11.4.2.4 Bulk Waste Disposal

Bulk waste disposal, as the name implies, involves the processing of large volumes of waste via bulk processing means for subsequent disposal.

The bulk waste disposal station consists of a set of flanged connections installed in a common crossover leg of the solid radwaste system process piping through which spent resin/spent activated charcoal from the spent resins storage tanks may be transferred.

Piping or hose connections are made between the bulk waste disposal station waste transfer flange and either a vendor processing skid or directly to an appropriate container such as a liner or a High Integrity Container (HIC). Hoses and/or piping utilized are subjected to pressure tests to verify leak-tight connections and adequacy of the hose or pipe to safely contain and transport the waste.

The addition of cement and additives are recorded and monitored so as to ensure compliance with pre-determined waste solidification formulas.

Liners or HIC's provided for bulk dewatering of spent resins/spent activated charcoal incorporate dewatering internals ensure compliance with burial site criteria regarding free water within the disposal container.

Dewatering of vendor provided liners or HIC's may be performed by plant operating personnel and equipment, provided the dewatering process and methods to verify dewatering are in compliance with vendor recommendations and applicable regulatory requirements.

Upon completion of bulk processing and packaging the liner or HIC is either stored on-site in an approved storage area or shielded storage container or shipped directly offsite for processing by an intermediate processor or for disposal.

11.4.2.5 Packaging, Storage, and Shipment

Spent resins, spent charcoal, spent filter cartridges, and solid compactable wastes such as paper, rags, and clothing are packaged in approved containers, in accordance with 49 CFR, and shipped in shielded casks, as required to meet 49 CFR dose limitations.

Packaged solid radwaste is normally stored in one of two locations, depending on the requirements for radiation shielding and the amounts of waste temporarily stored onsite. These two locations are designated drummed and bulk solid radwaste storage locations. The storage location for drummed solid radwaste is an annex to the radwaste building, on the south side, as shown in Figure 1.2-3. This storage area includes shielding cubicles for the storage of high level waste such as spent resins and filters. Other containers of radwaste may also be stored in this area. This structure (i.e., the annex to the radwaste building) has concrete walls for radiation shielding. Within this structure are two storage areas, containing 550 and 1,180 square feet of usable floor area. These areas are shielded and remotely maintained to limit radiation exposure to operating personnel. On the basis of stacking the filled drums 5 levels high, the drum capacities of the two areas are 395 and 1,055 drums, pyramidal, or 585 and 1,365 drums, palletized.

Packaged solid radwaste in drums, HICs, LSA Boxes, etc., will normally consist of:

- Spent resins, primary
- Filter cartridges, primary
- Spent resins, secondary
- Hazardous/chemical wastes
- Dry wastes

It is estimated that the maximum total of these wastes will be 923 drums per year (refer to Table 11.4-3). Based on this estimate, there is capacity in the radwaste building for approximately 2 years of drummed solid wastes.

The storage location for bulk solid radwaste is normally in the outside area adjacent to the drummed storage annex section of the Radwaste Building, on the Plant West side of the building, extending Plant South to the Discharge Monitoring Tank area. This storage area is provided with a concrete slab surface for placement of containers, and is enclosed by a fence with access gates, for control of access to the area. Packaged solid radwaste, in HICs, Boxes or DOT approved shipping containers, is temporarily stored in this or other approved locations onsite while awaiting shipment to an off-site treatment or disposal facility, or for radioactive decay prior to long term storage within a facility structure.

While no protection from the environmental elements is afforded to the packaged radwaste containers stored in outside locations, the containers used for packaging these wastes are DOT approved containers for shipment. These containers are designed and manufactured to meet the conditions incident to shipping and disposal. On-site storage containers will be used for interim storage of high integrity containers.

Refer to Table 11.4-3 for Estimated Maximum Annual Quantities of Solid Radwaste.

11.4.3 SAFETY EVALUATION

The containers that require radiation shielding are stored in the radwaste building, which is resistant to tornadoes. These drums will remain in place during any extreme environmental event. The drums or other approved shipping containers for noncompacted, dry wastes, etc., stored outside in bulk storage have low specific activities and, thus, even if dispersed by a tornado do not pose a radiation risk to onsite or off site personnel.

The drummed radwaste storage area protects the containers from rainfall and corrosion. As described in Chapter 2.0, flooding is not a potential concern in grade-level buildings at the Callaway site.

Although wastes are expected to be stored onsite for some period of time prior to shipment, normally no credit other than 30-day decay will be taken for radioactive decay realized by such storage when filling containers for shipping in accordance with 49 CFR dose limitations. That is, once filled, containers can normally be shipped immediately, subject to availability of a disposal site, with the proper shielding, without exceeding Department of Transportation radiation limits. If 49 CFR dose limitations cannot be met with the available shielding, however, the applicable containers are stored in appropriate storage areas until the doses are acceptable for shipping in accordance with Department of Transportation requirements.

The minimum onsite residence time for low level solid radwaste prior to shipping, such as dry compacted waste, steam generator blowdown spent resins, and spent charcoal, ranges from several days to a few months. The minimum onsite residence time for solid radwaste prior to shipping, such as primary spent resins and spent filter cartridges from the primary system, ranges from a few months to a few years. Onsite residence time is based on the initial activity of the container, the time required to have sufficient containers to completely load a transporting vehicle, the thickness of the shields available, the number of containers which can be stored in the available shipping casks, the availability of a transporting vehicle, and the availability of ultimate disposal facilities.

All solid radwaste is shipped from the site in Department of Transportation-approved containers by Department of Transportation-approved carriers. Containers with any significant surface dose rate are moved remotely from the shielded storage areas to the transporting vehicle.

Radiation measurements made at the time of shipment of any radioactive waste material ensure that all shipments leave the site well within prescribed limits. Similarly, external contamination measurements are made to detect any potential release of radioactive material from the container prior to shipment.

11.4.4 TESTS AND INSPECTIONS

The SRS is in intermittent use throughout normal reactor operation. Periodic visual inspection and preventative maintenance are conducted using normal industry practice. Refer to Chapter 14.0 for further information.

11.4.5 INSTRUMENTATION APPLICATION

Two control panels are provided for the equipment in the SRS which contains or processes potentially radioactive fluids or slurries. One control panel is located in the radwaste building control room and contains the instrumentation for the equipment which interfaces the influent systems (i.e., spent resin storage tank - primary, and spent resin storage tank - secondary) and for the equipment used for process control (i.e., caustic addition tank, and caustic addition metering pump).

The second control panel (solidification control panel) is located in a separate room in close proximity to the solidification processing area. The control panel contains all instrumentation, including television monitors, required for transferring waste to the bulk waste disposal station. Pertinent instruments and controls for the transferring of the wastes from the tanks containing the wastes are duplicated on this panel so that the solid radwaste solidification system operator can transfer the waste from these tanks to the bulk waste disposal station.

TABLE 11.4-1 DESIGN COMPARISON TO BRANCH TECHNICAL POSITION ETSB 11-3 REVISION 1, "DESIGN GUIDANCE FOR SOLID RADIOACTIVE WASTE MANAGEMENT SYSTEM INSTALLED IN LIGHT-WATER-COOLED NUCLEAR POWER REACTOR PLANTS"

ETSB 11-3 POSITION		UNION ELECTRIC POSITION
I. PROCESSING REQUIREMENTS		
1. Dry Wastes		
a. Compaction devices for compressible dry wastes (rags, paper, and clothing) should include a ventilated shroud around the waste container to control the release of airborne dusts generated during the compaction process.	I.1.a	Complies. Dry waste compactors are designed with ventilation shroud exhaust fan and filter to control the airborne dust during the compaction process.
b. Activated charcoal, HEPA filters, and other dry wastes which do not normally require solidification processing should be treated as radioactively contaminated solids and packaged for disposal in accordance with applicable Federal regulations.	I.1.b	Complies.
2. Wet Wastes		
a. Wet wastes such as spent bead and powdered resins and filter sludge should be rendered immobile by combining with a suitable binding agency (cement, urea formaldehyde, asphalt, etc.) to form a homogenous solid matrix (absent of free water) prior to offsite shipment. Absorbents such as vermiculite are not acceptable substitutes for binding agents.	I.2.a	Complies. Packaging of radioactive filter sludge complies in that these wastes will be combined with a suitable binding agent (e.g., cement) to form a homogeneous solid matrix prior to offsite shipment. Packaging of radioactive spent demineralizer resins also complies (resins may be combined with a suitable binding agent to create a homogeneous solid matrix prior to offsite shipment) except that they may be packaged by dewatering in a steel liner or High Integrity Container per the requirements of 10CFR61, prior to offsite shipment. Absorbent will not be used as a substitute for a binding agent for wastes requiring immobilization. Waste not requiring immobilization will be packaged using acceptable methods approved by DOT and burial site requirements.
b. Spent cartridge filter elements may be packaged in a shielded container with a suitable absorber such as vermiculite, although it would be desirable to solidify the elements in a suitable binder.	I.2.b	Complies.
II. ASSURANCE OF COMPLETE SOLIDIFICATION		
Complete solidification of wet wastes should be assured by the implementation of a process control program or by methods to detect free liquids within container contents prior to shipment.		
1. Process Control Program		

TABLE 11.4-1 (Sheet 2)

ETSB 11-3 POSITION		UNION ELECTRIC POSITION
a. Solidification (binding) agents and potential waste constituents should be tested and a set of process parameters (pH, ratio of waste to agent, etc.) established which provide boundary conditions within which reasonable assurance can be given that solidification will be complete.	II.1.a	Complies. Solidification formula demonstrating complete solidification for the expected wastes is determined by shop tests. These tests provide the boundary condition within which reasonable assurance is given that complete solidification, i.e., lack of free water, has occurred.
b. The solid waste processing system (or liquid waste processing system, as appropriate) should include appropriate instrumentation and wet waste sampling capability necessary to successfully implement and/or verify the process control program described in a., above.	II.1.b	Complies. Sample provisions exist for the determination of chemical constituents to be solidified. In addition, pH adjustments can be made to optimize solidification operations.
c. The plant operator should provide assurance that the process is run within the parameters established under a., above. Appropriate records should be maintained for individual batches showing conformance with the established parameters.	II.1.c	Complies. Administrative controls will be used and records will be maintained to ensure that the process is operated within the established boundaries.
2. Free Liquid Detection		
Each container filled with solidified wet wastes should be checked by suitable methods to verify the absence of free liquids. Visual inspection of the upper surface of the waste in the container is not alone sufficient to ensure that free water is not present in the container. Provisions to be used to verify the absence of free liquids should consider actual solidification procedures which may create a thin layer of solidification agent on top without affecting the lower portion of the container.	II.2	The shop-tested solidification formula coupled with the administrative controls assure the absence of free liquids.
III. WASTE STORAGE		
1. Tanks accumulating spent resins from reactor water purification systems should be capable of accommodating at least 60 days waste generation at normal generation rates. Tanks accumulating spent resins from other sources and tanks accumulating filter sludges should be capable of accommodating at least 30 days waste generation at normal generation rates.	III.1	Complies.
2. Storage areas for solidified wastes should be capable of accommodating at least 30 days waste generation at normal generation rates. These storage areas should be located indoors.	III.2	Complies. Outside storage of packaged radwaste staged for shipment or decay is administratively controlled in approved onsite storage locations.
3. Storage areas for dry wastes and packaged contaminated equipment should be capable of accommodating at least one full offsite waste shipment.	III.3	Complies.

TABLE 11.4-1 (Sheet 3)

ETSB 11-3 POSITION		UNION ELECTRIC POSITION
IV. ADDITIONAL DESIGN FEATURES		
The following additional design features should be incorporated into the design of the solid waste system.		
1. Deleted.		
2. Components and piping which contain radioactive slurries should have flushing connections.	IV.2	Complies.
3. Solidification agents should be stored in low radiation areas, generally less than 2.5 mr/hr, with provisions for sampling.	IV.3	Complies.
4. Tanks or equipment which use compressed gases for transport or drying of resins or filter sludges should be vented directly to the plant ventilation exhaust system which includes HEPA filters as a minimum. The vent design should prevent liquids and solids from entering the plant ventilation system.	IV.4	Complies.

TABLE 11.4-2 ESTIMATED EXPECTED AND MAXIMUM ANNUAL ACTIVITIES OF THE INFLUENTS TO THE SOLID RADWASTE SOLIDIFICATION SYSTEM, CURIES

Isotope		Spent Resins And Filter Cartridges (Primary)	Spent Resins And Filter Cartridges (Secondary)	Charcoal Filters	Dry and Compacted Waste (Note1)
Cr-51		3.0E+1	2.0E-2	NEG	-
Mn-54		2.9E+1	6.0E-3	NEG	-
Fe-55		1.9E+2	2.5E-2	NEG	-
Fe-59		2.5E1	1.5E-2	NEG	-
Co-58		6.1E+2	2.2E-1	NEG	-
Co-60		2.6E+2	2.8E-2	NEG	-
Br-83	(1)	NEG	1.7E-4	NEG	-
Br-84	(1)	NEG	1.0E-5	NEG	-
Rb-86	(1)	7.9E-1	8.2E-4	NEG	-
Rb-88	(1)	1.4E+0	3.0E-4	NEG	-
Sr-89	(1)	9.8E+0	5.1E-3	NEG	-
Sr-90	(1)	1.4E+0	1.2E-4	NEG	-
Sr-91	(1)	NEG	1.5E-4	NEG	-
Y-90	(1)	1.3E+0	1.1E-4	NEG	-
Y-91m	(1)	NEG	9.9E-5	NEG	-
Y-91	(1)	2.2E+0	8.3E-4	NEG	-
Zr-95	(1)	2.1E+0	1.1E-3	NEG	-
Nb-95	(1)	3.0E+0	1.2E-3	NEG	-
Nb-95m	(1)	2.1E+0	9.0E-4	NEG	-
Mo-99	(1)	1.4E+2	1.7E-1	NEG	-
Ru-103	(1)	1.0E+0	4.9E-4	NEG	-
Ru-106	(1)	1.0E+0	1.2E-4	NEG	-
Te-125m	(1)	9.2E-1	2.6E-4	NEG	-
Te-127m	(1)	1.5E+1	2.8E-3	NEG	-
Te-127	(1)	1.5E+1	3.0E-3	NEG	-
Te-129m	(1)	2.7E+1	1.4E-2	NEG	-
Te-129	(1)	1.7E+1	9.0E-3	NEG	-
Te-131m	(1)	1.8E+0	2.0E-3	NEG	-

TABLE 11.4-2 (Sheet 2)

Isotope		Spent Resins And Filter Cartridges (Primary)	Spent Resins And Filter Cartridges (Secondary)	Charcoal Filters	Dry and Compacted Waste (Note1)
Te-131	(1)	NEG	3.7E-4	NEG	-
Te-132	(1)	5.2E+1	5.0E-2	NEG	-
I-130	(1)	5.8E-1	5.0E-4	NEG	-
I-131	(1)	1.2E+3	1.0E+0	NEG	-
I-132	(1)	5.2E+1	5.5E-2	NEG	-
I-133	(1)	1.8E+2	1.6E-1	NEG	-
I-134	(1)	9.1E-1	3.9E-4	NEG	-
I-135	(1)	2.8E+1	2.3E-2	NEG	-
Cs-134	(1)	1.8E+3	3.9E-1	NEG	-
Cs-136	(1)	8.9E1	1.0E-1	NEG	-
Cs-137	(1)	1.5E+3	2.9E-1	NEG	-
Ba-137m	(1)	1.4E+3	2.7E-1	NEG	-
Ba-140	(1)	1.6E+0	1.6E-3	NEG	-
La-140	(1)	1.8E+0	1.7E-3	NEG	-
Ce-141	(1)	1.3E+0	9.2E-4	NEG	-
Ce-144	(1)	3.0E+0	6.0E-4	NEG	-
Pr-143	(1)	4.3E-1	3.4E-4	NEG	-
Pr-144	(1)	3.0E+0	6.0E-4	NEG	-
Total		7.7E+3	2.9E+0	NEG	<5.0E+0

Note:

(1) Consistent with Section 11.1, the maximum activities would be obtained by multiplying the Curie value given for the indicated isotopes by a factor of 2.

TABLE 11.4-3 ESTIMATED MAXIMUM ANNUAL QUANTITIES OF SOLID RADWASTE

Source	Influent Volume to Solid Radwaste System	Quantity of Drums Shipped	Comments
Spent Resins			
Primary	920 ft^3	263	2 CVCS mixed, 1 CVCS cation, 1 BTRS, 1 fuel pool cleanup, 1 waste monitor, 1 waste evaporator condensate, 2 recycle evaporator feed, and 1 recycle evaporator condensate demineralizer bed. A conservative factor of 2 is applied.
Secondary*	2,000 ft^3	415	24 steam generator blowdown demineralizer beds, 1 secondary liquid waste demineralizer bed, 1 LRW charcoal adsorber bed, 1 SLW charcoal adsorber bed, and 1 laundry and hot shower charcoal adsorber bed.
Liquid Processing			
	900 ft^3	257	This includes 400 gpd from the waste holdup tank, 1140 gpd from the floor drain tank, 184 gpd shim bleed, and 30 gpd reactor coolant drain tank (see Appendix 11.1A).

TABLE 11.4-3 (Sheet 2)

Source	Influent Volume to Solid Radwaste System	Quantity of Drums Shipped	Comments
Secondary*	22,026 ft^3	4,156	Includes 7,200 gpd from turbine building floor drains and 1 condensate demineralizer vessel regeneration every 2 days, 17,940 gallon HTDS waste per regeneration, and 50 weight percent evaporator bottoms.
Filter Cartridges			
Primary	239 cartridges/ year	239	Annual filter changeout numbers based on operational average of like systems: FBG04A/B-20, FBG05-1, FBG06-5, FBG07-1, FBM03A/B-26, FEC01A/B-2, FEC02-1, FHA01-1, FHB06-73, FHB10-76, FHB11-012, FHC01-3, FHD05-1, FHD06-1, FHD07-1, FHD08-1, FHE04-2, FHE05-5, FHE06-3.
Secondary*	72 cartridges	72	Annual filter changeout numbers based on operational averages of like systems: FHB07-7, FHB08-14, FHC02-3, FHF04A/B-24, FHF05-24.
Dry and Compacted			
Waste	10,000 ft^3	1,330	Shipped volume is based on data from operating plants and NRC Question 360.1(11.4).

TABLE 11.4-3 (Sheet 3)

Source	Influent Volume to Solid Radwaste System	Quantity of Drums Shipped	Comments
	Subtotal Primary	759	
	Subtotal Secondary	4,643	
	Subtotal Other	1,330	
	TOTAL	6,732 drums	

* Normally does not require disposal as solid radwaste

TABLE 11.4-4 ESTIMATED EXPECTED AND MAXIMUM ANNUAL ACTIVITIES OF SOLID RADWASTE SHIPPED FROM EACH UNIT, CURIES

Isotope	Spent Resins And Filter Cartridges (Primary)	Spent Resins And Filter Cartridges (Secondary)	Charcoal Filters	Dry and Compacted Waste
Cr-51	1.4E+1	9.4E-3	NEG	-
Mn-54	2.7E+1	5.6E-3	NEG	-
Fe-55	1.9E+2	2.4E-2	NEG	-
Fe-59	1.6E+1	9.5E-3	NEG	-
Co-58	4.6E+2	1.6E-1	NEG	-
Co-60	2.5E+2	2.8E-2	NEG	-
Br-83(1)	NEG	NEG	NEG	-
Br-84(1)	NEG	NEG	NEG	-
Rb-86(1)	2.6E-1	2.7E-4	NEG	-
Rb-88(1)	NEG	NEG	NEG	-
Sr-89(1)	6.5E+0	3.4E-3	NEG	-
Sr-90(1)	1.4E+0	1.2E-4	NEG	-
Sr-91(1)	NEG	NEG	NEG	-
Y-90(1)	1.3E+0	1.2E-4	NEG	-
Y-91m(1)	NEG	NEG	NEG	-
Y-91(1)	1.5E+0	5.8E-4	NEG	-
Zr-95(1)	1.5E+0	7.8E-4	NEG	-
Nb-95(1)	3.4E+0	1.5E-3	NEG	-
Nb-95m(1)	1.6E+0	8.3E-4	NEG	-
Mo-99(1)	7.4E-2	NEG	NEG	-
Ru-103(1)	5.9E-1	2.9E-4	NEG	-
Ru-106(1)	9.4E-1	1.1E-4	NEG	-
Te-125m(1)	6.4E-1	1.8E-4	NEG	-
Te-127m(1)	1.2E+1	2.4E-3	NEG	-
Te-127(1)	1.2E+1	2.4E-3	NEG	-
Te-129m(1)	1.5E+1	7.6E-3	NEG	-
Te-129(1)	9.4E+0	4.9E-3	NEG	-
Te-131m(1)	NEG	NEG	NEG	-
Te-131(1)	NEG	NEG	NEG	-

TABLE 11.4-4 (Sheet 2)

Isotope	Spent Resins And Filter Cartridges (Primary)	Spent Resins And Filter Cartridges (Secondary)	Charcoal Filters	Dry and Compacted Waste
Te-132(1)	8.6E-2	NEG	NEG	-
I-130(1)	NEG	NEG	NEG	-
I-131(1)	8.9E+1	7.6E-2	NEG	-
I-132(1)	8.7E-2	NEG	NEG	-
I-133(1)	NEG	NEG	NEG	-
I-134(1)	NEG	NEG	NEG	-
I-135(1)	NEG	NEG	NEG	-
Cs-134(1)	1.7E+3	3.8E-1	NEG	-
Cs-136(1)	1.8E+1	2.1E-2	NEG	-
Cs-137(1)	1.5E+3	2.9E-1	NEG	-
Ba-137m(1)	1.4E+3	2.7E-1	NEG	-
Ba-140(1)	3.2E-1	3.0E-4	NEG	-
La-140(1)	3.7E-1	3.5E-4	NEG	-
Ce-141(1)	6.8E-1	4.9E-4	NEG	-
Ce-144(1)	2.8E+0	5.6E-4	NEG	-
Pr-143(1)	9.2E-2	NEG	NEG	-
Pr-144(1)	2.8E+0	5.6E-4	NEG	-
Total	5.8E+3	1.3E+0	NEG	<5.0E+0

(1) Consistent with Section 11.1, the maximum activities would be obtained by multiplying the Curie value given for the indicated isotopes by a factor of 2.

TABLE 11.4-5 SOLID RADWASTE SYSTEM - COMPONENT DESCRIPTION

Spent Resin Storage Tank (Primary)	
Quantity	1
Capacity (usable), ft^3	350
Design pressure, psig	150
Design temperature, °F	200
Material	Austenitic stainless steel
Design code(1)	ASME Sec. VIII
Spent Resin Storage Tank (Secondary)	
Quantity	1
Capacity (usable), gal	4,200
Design pressure, psig	150
Design temperature, °F	200
Material	Austenitic stainless steel
Design code	ASME Sec. VIII
Spent Resin Sluice Pump (Primary)	
Quantity	1
Type	Canned centrifugal
Design pressure psig	150
Design temperature, °F	200
Design flow, gpm	
Rated	140
Runout	250
Design head, ft	
Rated	250
Runout	210
Material	Austenitic stainless steel
Design code(1)	Manufacturer's standard (MS)
Spent Resin Sluice Pump (Secondary)	
Quantity	1
Type	Vertical inline centrifugal
Design pressure, psig	300
Design temperature, °F	140
Design flow, gpm	225
Design head, ft	250
Material	Austenitic stainless steel
Design code	MS

TABLE 11.4-5 (Sheet 2)

Caustic Addition Tank	
Quantity	1
Capacity (usable), gal	550
Design pressure, psig	10
Design temperature, °F	150
Material	Austenitic stainless steel
Design code	ASME Sec. VIII
Caustic Addition Metering Pump	
Quantity	1
Type	Positive displacement diaphragm
Design pressure, psig	110
Design temperature, °F	104
Design flow, gph	60
Design head, psi	45
Material	Alloy 20 S.S
Design code	MS
Contained solution	50% NaOH
Resin Charging Tank (CVCS)	
Quantity	1
Type	Vertical, conical bottom, on wheels
Capacity (usable), gal	325
Design pressure, psig	ATM
Design temperature, °F	120
Material	Austenitic stainless steel
Design code	ASME Sec. VIII
Resin Charging Tank (Radwaste)	
Quantity	1
Type	Vertical, conical bottom, on wheels
Capacity (usable), gal	325
Design pressure, psig	Atmospheric
Design temperature, °F	120
Material	Austenitic stainless steel
Design code	ASME Sec. VIII
Spent Resin Sluice Filter (Primary)	
Quantity	1
Design pressure, psig	300
Design temperature, °F	250

TABLE 11.4-5 (Sheet 3)

Design flow, gpm	250
ΔP @ design flow, psi	5
Size of particles, 98% retention (microns)	30[2]
Material	Austenitic stainless steel
Design code[1]	ASME Sec. VIII
Spent Resin Sluice Filter (Secondary)	
Quantity	1
Design pressure, psig	150
Design temperature, °F	250
Design flow, gpm	225
ΔP @ design flow, psi	5
Size of particles, 98% retention (microns)	30[2]
Material	Austenitic stainless steel
Design code	ASME Section VIII
Dry Waste Compactors	
Quantity	2
Type	Hydraulic press
Design code	MS
Solid Radwaste Bridge Crane	
Quantity	1
Capacity, tons	9.33
TV cameras, quantity	4

(1) Table indicates the required code based on its safety-related importance as dictated by service and functional requirements and by the consequences of their failure. Note that the actual equipment may be supplied to a higher principal construction code than required.

(2) Filters may be downsized as operational needs dictate.

11.5 PROCESS AND EFFLUENT RADIOLOGICAL MONITORING AND SAMPLING SYSTEMS

The function of the process and effluent radiological monitoring systems is to monitor, record, and control the release of radioactive materials that may be generated during normal operation, anticipated operational occurrences, and postulated accidents.

The process and effluent radioactivity monitoring systems furnish information to operations personnel concerning radioactivity levels in principal plant process streams and atmospheres. The monitoring systems indicate and alarm excessive radioactivity levels (GDC-63). They initiate operation of standby systems, provide inputs to the ventilation and liquid discharge isolation systems, and record the rate of release of radioactive materials to the environs, as outlined in Regulatory Guide 1.21 and GDCs 60 and 64. The systems consist of permanently installed, continuous-monitoring devices together with a program and provisions for specific sample collections and laboratory analyses.

11.5.1 DESIGN BASES

The principal objectives and criteria of the process and effluent radiological monitoring systems are provided below.

11.5.1.1 Safety Design Bases

SAFETY DESIGN BASES - The control room ventilation monitors, the containment purge monitors, and the fuel building exhaust monitors are designed to activate engineered safety features systems in the event that airborne radioactivity in excess of allowable limits exists. Additional design bases are stated in the following sections:

a. Containment purge isolation system, Sections 6.2.4, 7.3.2, 9.4.6, and 12.3.4.

b. Fuel building ventilation isolation, Sections 7.3.3, 9.4.2, and 12.3.4.

c. Control room intake isolation, Sections 6.4.1, 7.3.4, 9.4.1, and 12.3.4.

These radioactivity monitors are protection system elements and are designed in accordance with IEEE Standard 279.

The safety evaluation of these systems is discussed in Section 7.3.

These monitors also serve for in-plant worker protection, and this function is discussed in Section 12.3.4. Compliance with Regulatory Guide 1.97 is discussed in Appendix 7A.

11.5.1.2 Power Generation Design Bases

POWER GENERATION DESIGN BASIS ONE - The process and effluent radioactivity monitors operate continuously during both intermittent and continuous discharges of potentially radioactive plant effluents, in compliance with Regulatory Guide 1.21. The monitors verify that the most restrictive anticipated nuclides are at concentrations within the limits specified in Table II of Appendix B of 10 CFR 20 and that the concentrations are low enough that 10 CFR 50 Appendix I dose guidelines are met for unrestricted areas.

POWER GENERATION DESIGN BASIS TWO - The process and effluent radioactivity monitors alarm and automatically terminate the release of effluents when radionuclide concentrations exceed the limits specified (GDC-60). Where termination of releases is not feasible, the monitors provide continuous indication of the magnitude of the activity released.

POWER GENERATION DESIGN BASIS THREE - The radwaste process system monitors measure radioactivity in process streams to aid personnel in the treatment of radioactive fluids prior to recycle or discharge (GDC-63).

POWER GENERATION DESIGN BASIS FOUR - The process and effluent radioactivity monitors monitor the containment atmosphere, spaces containing components for recirculation of LOCA fluids, effluent discharge paths, and for radioactivity that may be released from postulated accidents, as required by GDC-64.

POWER GENERATION DESIGN BASIS FIVE - The process and effluent monitors indicate the existence and, to the extent possible, the magnitude of reactor coolant and reactor auxiliary system leakage to the containment atmosphere, cooling water systems, or the secondary side of the steam generators.

POWER GENERATION DESIGN BASIS SIX - The process and effluent radioactivity monitors provide alarm and automatic termination of the transfer of radioactivity fluids to storage facilities in zone A areas, defined in Section 12.4.1.1.

POWER GENERATION DESIGN BASIS SEVEN - Process radioactivity monitors provide alarm and gross indication of the extent of any failed fuel within the primary system.

POWER GENERATION DESIGN BASIS EIGHT - The effluent radioactivity monitors provide sufficient radioactivity release data to prepare the reports required by Regulatory Guide 1.21.

11.5.1.3 Codes and Standards

Codes and standards applicable to the process and effluent radioactivity monitors are indicated in Table 3.2-1. The monitors listed in Section 11.5.1.1 are designed as protection system elements.

11.5.2 SYSTEM DESCRIPTION

11.5.2.1 General Description

11.5.2.1.1 Data Collection

The process and effluent radiological monitoring systems consist of liquid and airborne radioactivity monitors with the attendant controls, alarms, pumps, valves, and indicators required to meet the design bases. Each monitor consists of the detector assembly and a local microprocessor. The local microprocessor processes the detector assembly signal in digital form, computes average radioactivity levels, stores data, performs alarm or control functions, and transmits the digital signal to the control room microprocessor. Signal transmission is accomplished via redundant data highways. A single fault in either data highway will not prevent the control room microprocessor from receiving the data. The Laundry Decon Facility Dryer Exhaust Monitor is a self contained unit and provides alarms and control function locally.

The local microprocessors for monitors which perform safety functions (control room ventilation, fuel building ventilation, containment atmosphere, and containment purge monitors, refer to Section 12.3.4) are wired directly to individual indicators located on the seismic Category I radioactivity monitoring system cabinets in the control room. The input from the safety-related channels to the daisy-chain loop is an isolated signal to ensure that the safety-related signals will not be affected by signals or conditions existing in the nonsafety portion of the system.

The control room microprocessor provides controls and indication for the radioactivity monitoring system. Indication is via a Visual Display located in the control room. The signals from each monitor may also be recorded on a system printer.

11.5.2.1.2 Alarms

Each monitor channel is provided with a three-level alarm system. One alarm setpoint is below the background counting rate and serves as a circuit failure alarm. The other two-alarm setpoints provide sequential alarms on increasing radioactivity levels. Loss of power will cause an alarm on all three-alarm circuits. The alarms must be manually reset and can be reset only after the alarm condition is corrected. The Laundry Decon Facility Dryer Effluent Monitor will alarm and isolate the effluent path when measured levels are above the alarm setpoint or the monitor fails.

11.5.2.1.3 Check Sources

Each monitor is provided with a check source, operated from the control room, which simulates a radioactive sample in the detector assembly for operational and gross calibration checks. The Laundry Decon Facility Dryer Effluent Monitor is source checked manually.

11.5.2.1.4 Power Supplies

All Class 1E radioactivity monitoring systems are powered from Class 1E motor control centers. The power supplies for all of the monitors are given in Table 11.5-5.

11.5.2.1.5 Calibration and Maintenance

The radioactivity monitors are calibrated by the manufacturer for at least the principal radionuclides listed in Tables 11.5-1 through 11.5-4. The manufacturer's calibration standards are traceable to National Bureau of Standards primary calibration standard sources and are accurate to at least 5 percent. The source detector geometry during this primary calibration is identical to the sample detector geometry. Secondary standards counted in reproducible geometry during the primary calibration are supplied with each continuous monitor. The secondary standards are accurate to at least 10 percent. The Laundry Decon Facility Dryer Exhaust Monitor is calibrated on site using plant procedures.

Channel checks and source checks are performed at regular intervals to ensure proper monitor function. The monitors are re-calibrated at regular intervals, and following repairs or modifications, using the secondary radionuclide standard.

Any effluent released to the environment is analyzed for radioactivity prior to release. If, at any time, an effluent monitor requires maintenance or decontamination, the effluent stream will be terminated or periodic grab sampling with laboratory analysis will be implemented in accordance with Offsite Dose Calculation Manual requirements. This does not impair system integrity since the detector is off-line and not installed in the stream.

11.5.2.1.6 Sensitivities

Each effluent monitoring system will be able to detect a minimum concentration within the release limits established in the Offsite Dose Calculation Manual.

Due to sensitivity considerations, monitors are located at the effluent release points. Dilution factors between the release point and the site boundary are considered in complying with the limitations of 10 CFR 50, Appendix I. Tables 11.5-1 through 11.5-4 provide the detailed sensitivity requirements for the process and effluent monitors.

11.5.2.1.7 Monitor Locations

The monitors are located in low background areas, near the systems being monitored, to minimize background and sampling interferences.

11.5.2.1.8 Ranges and Setpoints

The ranges of the various process monitors are based on the expected activity levels in the system being monitored. The bases for their setpoints are determined by the need for process control and to alert the operators of leakage of radioactivity into normally nonradioactive systems.

The ranges of the various effluent monitors are based on the ability to detect radioactivity concentrations at the effluent release point which might result in site boundary doses in excess of 10 CFR 50 Appendix I levels to those from postulated accidents. The Alert alarm is administratively established at a point sufficiently below the High alarm so as to provide additional assurance that Offsite Dose Calculation Manual limits are not exceeded. The High alarm is established to ensure that Offsite Dose Calculation Manual limits are not exceeded.

The ranges and setpoints for the process and effluent monitors are provided in Tables 11.5-1 through 11.5-4.

11.5.2.1.9 Expected System Parameters

The expected ranges of system parameters, such as flow, composition, and concentrations, are summarized in Tables 11.5-1 through 11.5-4. Detailed information on the individual systems can be found in other sections of the FSAR, principally Chapters 9.0 and 11.0.

11.5.2.2 <u>Liquid Monitoring Systems</u>

11.5.2.2.1 Selection Criteria for Liquid Monitors

The liquid monitors consist of fixed-volume, off-line, lead-shielded sample chambers through which the liquid samples flow. A NaI(Tl) gamma scintillation detector is located within each sample chamber to detect the activity level. Except for the Chemical and Volume Control (CVCS) Letdown Monitor, the detector assemblies monitor gross gamma activity in the range of 10^{-7} to 10^{-2} μCi/ml. The CVCS letdown monitor detector assembly monitors failed fuel product activity in the range of 1.7×10^{-3} to $1.7 \times 10^{+3}$ μCi/ml. The controlling isotope for the liquid monitors is Cs-137. Minimum detectable concentrations are listed in Tables 11.5-1 and 11.5-2.

A motor operated valve at the sample chamber inlet is provided to isolate sample flow to permit purging of the sample chamber to facilitate background activity checks. A source of noncontaminated water is provided for decontamination purposes.

Sample chambers in which permanent contamination interferes with measurement can readily be replaced.

Liquid monitor alarms are annunciated in the control room on the plant annunciator and the radiation monitoring system Visual Dislay and printer. The radiation monitoring system Visual Display provides a visual alarm display in the control room.

The liquid radioactivity monitors are located to comply with the design bases. The specific sample points are selected to provide representative samples of the systems monitored, to reduce sample transport times, and to limit the amount of radioactivity released in the event of a high radioactivity signal.

The continuous liquid radioactivity monitoring systems are discussed in the following sections. A summary of the functions and characteristics of each monitor is presented in Tables 11.5-1 and 11.5-2.

11.5.2.2.2 Liquid Process Radioactivity Monitors

A detailed listing of liquid process monitor parameters is given in Table 11.5-1.

11.5.2.2.2.1 Component Cooling Water Monitors

The component cooling water system (CCWS) is discussed in Section 9.2.2.

The CCW radioactivity monitors, 0-EG-RE-9 and 0-EG-RE-10, detect, indicate, and alarm any inleakage to the CCWS from potentially radioactive systems and components served by the CCWS. Each detector assembly receives a continuous sample flow from the CCW heat exchanger inlet in the associated loop and returns the sample to the component cooling pump section header. This sample point is downstream of all potential radioactive inleakage. The component cooling pumps provide the motive force for the sample. The alert alarm provides indication of inleakage to the system. A high alarm is provided to indicate increasing radioactivity levels and to close the component cooling water surge tank air vent valves.

11.5.2.2.2.2 Steam Generator Liquid Radioactivity Monitor

The steam generator liquid sample system is discussed in Section 9.3.2.

The steam generator liquid radioactivity monitor, 0-SJ-RE-2, monitors the blowdown from the steam generators, either individually or collectively, to detect, indicate, and alarm primary-to-secondary system leaks in the steam generators.

The monitor also provides backup information and verification of the condenser air removal system gaseous radioactivity monitor (Section 11.5.2.3.2.1). The fixed-volume detector assembly receives a continuous flow from the steam generator liquid sample header which samples the tube sheet area near the minimum water level of the steam generators. The sample point is located downstream of the sample system heat exchanger to provide conditioning and pressure reduction of the radioactivity monitor sample. The radioactivity alarms provide indication of primary-to-secondary leakage in the steam generator.

11.5.2.2.2.3 Steam Generator Blowdown Processing System Radioactivity Monitor

The steam generator blowdown processing system is discussed in Section 10.4.8.

The steam generator blowdown processing radioactivity monitor, 0-BM-RE-25, continuously monitors the fluid entering the steam generator blowdown filters to detect, alarm, and indicate excessive radioactivity levels in the blowdown system. The monitor provides backup information for the steam generator liquid radioactivity monitor (Section 11.5.2.2.2.2) and the condenser air removal gaseous radioactivity monitor (Section 11.5.2.3.2.1) for the detection of a primary-to-secondary leakage in the steam generator. The fixed-volume detector assembly receives a continuous flow from the discharge of the blowdown system heat exchangers and returns the sample to the system. The sample location provides an unfiltered sample at temperatures within the limits of the detector. The high radioactivity alarm closes the blowdown system discharge valve to prevent discharge of radioactivity from the steam generators.

11.5.2.2.2.4 Essential Service Water/Service Water System Radioactivity Monitor

No radioactivity monitors are required in the Service Water/Essential Service Water (SW/ESW) System. Monitors are not required because components served by SW/ESW are normally non-radioactive. To detect inleakage into the SW/ESW system, periodic samples of the SW/ESW system will be analyzed. Analysis of SW/ESW for activity will be performed weekly when the Component Cooling Water and the Steam Generator Blowdown activity is less than the alarm setpoint of 0-EG-RE-09, 0-EG-RE-10, 0-SJ-RE-02 and 0-BM-RE-25. This sampling will be performed more frequently if radiation monitors 0-EG-RE-09, 0-EG-RE-10, 0-SJ-RE-02 or 0-BM-RE-25 reach the alarm setpoint.

11.5.2.2.2.5 Deleted

11.5.2.2.2.6 Chemical and Volume Control Letdown Monitor

The chemical and volume control system (CVCS) is discussed in Section 9.3.4.

The CVCS letdown radioactivity monitor, 0-SJ-RE-01, acts as a gross failed fuel detector. The fixed-volume detector assembly continuously monitors the CVCS letdown sample line which extracts a sample upstream of the CVCS letdown demineralizers. The radiation alarms alert the operator to an abnormal increase in gamma activity in the CVCS letdown system. Determination of the cause can be made by laboratory analysis. The sample location provides an unfiltered sample prior to demineralization. The arrangement and location of the sample line provide sufficient delay in transport to allow decay of nitrogen-16, which could cause erroneously high readings.

11.5.2.2.2.7 Auxiliary Steam System Condensate Recovery Monitor

The auxiliary steam system is discussed in Section 9.5.9.

The auxiliary steam condensate recovery radioactivity monitor, 0-FB-RE-50, detects radioactive contamination from the potentially radioactive systems which discharge to the auxiliary steam condensate recovery tank. The fixed-volume detector assembly continuously monitors the discharge of the auxiliary steam condensate transfer pumps. The radioactivity alarms alert the operator to possible contamination. The source of the contamination can be determined by selective isolation of the potentially radioactive systems. The sample location ensures that all potentially radioactive sources are monitored.

11.5.2.2.3 Liquid Effluent Radioactivity Monitors

A detailed listing of the liquid effluent monitor parameters is given in Table 11.5-2.

11.5.2.2.3.1 Steam Generator Blowdown Discharge Radioactivity Monitor

The steam generator blowdown system is discussed in Section 10.4.8.

The steam generator blowdown discharge radioactivity monitor, 0-BM-RE-52, continuously monitors the blowdown discharge pump outlet to detect radioactivity due to system demineralizer breakthrough and to provide backup to the steam generator blowdown process radioactivity monitor (Section 11.5.2.2.2.3) to prevent discharge of radioactive fluid. The sample point is located on the discharge of the pump in order to monitor discharge or recycled blowdown fluid and upstream of the discharge isolation valve to limit the radioactivity released.

The high radioactivity alarm acts to close the blowdown isolation valves and the blowdown discharge valve.

Laboratory isotopic analyses will be performed in accordance with the Offsite Dose Calculation Manual.

11.5.2.2.3.2 Liquid Radwaste Discharge Monitor

The liquid radwaste system is discussed in Section 11.2.

The liquid radwaste radiation monitor, 0-HB-RE-18, continuously monitors the discharge of the liquid radwaste, steam generator blowdown, secondary liquid waste, and liquid waste discharged from the radwaste discharge monitor tanks to prevent the discharge of radioactive fluid to the environs. The fixed-volume detector assembly continuously monitors the system discharge line upstream of the discharge valve. The high radioactivity alarm closes the liquid radwaste system discharge valve to terminate discharge. The sample point is located to ensure that all potentially radioactive fluids from the liquid radwaste processing system are monitored prior to discharge. Laboratory isotopic analyses will be performed on each batch, prior to discharge, in accordance with the Offsite Dose Calculation Manual.

11.5.2.2.3.3 Deleted

11.5.2.2.3.4 Deleted

11.5.2.3 Airborne Monitoring Systems

11.5.2.3.1 Selection Criteria for Airborne Monitors

11.5.2.3.1.1 Introduction

The type of fixed instrumentation used for monitoring airborne radioactivity is offline. The offline system extracts a sample from the process stream and transports that sample to the radioactivity monitoring system, which contains the specified equipment to detect particulates, halogens, and/or noble gases.

11.5.2.3.1.2 Sampling Criteria

The sampling system for the particulate/halogen/noble gas monitors is designed and installed to meet the intent of ANSI N13.1-1969 guide to sampling of airborne radioactive materials. Systems whose sensitivity is dependent upon sample flow employ isokinetic nozzles and suitable control of flow rate.

11.5.2.3.1.3 Detection Criteria

Since both radioactive particulates and radioactive noble gases are beta emitters, beta sensitive scintillation detectors are used to sense radioactivity in order to minimize the effects due to background radiation and, consequently, obtain a lower minimum detectable concentration. The Laundry Decon Facility Dryer Exhaust Monitor uses a Geiger-Mueller counter.

Where spectrometric analysis is required (such as in iodine monitoring) an NaI(Tl), gamma scintillation detector assembly is employed.

11.5.2.3.1.4 Instrumentation Criteria

Instrumentation necessary to indicate, alarm, and perform control functions will be provided to complete the monitoring system.

Since radioactive concentrations may vary substantially, wide range instruments are utilized. The particulate and charcoal filters can readily be removed for periodic isotopes laboratory analyses, as required by the Offsite Dose Calculation Manual.

The airborne particulate monitors each consist of a fixed filter upon which radioactive particulate matter is deposited. The fixed filter is located in front of a beta scintillation detector coupled to a photomultiplier tube. The fixed filter for the Laundry Decon Facility Dryer Exhaust Monitor is located in front of a Geiger-Mueller counter.

Each airborne iodine monitor consists of a charcoal cartridge upon which iodine is adsorbed. The air sample is prefiltered to remove particulates. The charcoal cartridge is located in front of a gamma scintillation detector coupled to a photomultiplier tube.

Each airborne noble gas monitor consists of a fixed-volume sample chamber through which prefiltered sample air is passed. A beta scintillation detector is located within the sample chamber to detect the activity level of the air sample.

All of the detectors and sample chambers are enclosed in heavily shielded lead pigs. Two motor-operated valves operated locally are provided to permit air-purging of the sample chamber to facilitate background activity checks. The Laundry Decon Facility Dryer Exhaust Monitor detector is shielded from background. Isolation and purge valves are not installed.

The sensitivities and alarm setpoints are given in Tables 11.5-3 and 11.5-4. The alert-alarm points are based on the most restrictive isotopes which are expected to be present.

11.5.2.3.2 Airborne Process Radioactivity Monitors

A detailed listing of airborne process monitor parameters is given in Table 11.5-3.

11.5.2.3.2.1 Condenser Air Discharge Monitor

The condenser air discharge monitor, 0-GE-RE-92, is provided to detect, indicate, and alarm gaseous activity in the condenser air removal system exhaust. This monitor provides backup to the steam generator liquid and the steam generator blowdown processing radiation monitors for detection of primary-to-secondary leaks in the steam generator. The condenser air removal system removes noncondensable gases which would be present if a primary-to-secondary leakage occurred.

The monitor extracts a representative sample of air and noncondensable gases from the exhaust duct. A sample cooler is provided to dry the sample prior to entering the fixed-volume gaseous detector assembly to preclude damage to the detector. The sample point is located upstream of the condenser air removal system filters.

The radiation alarms alert the operator to the presence of gaseous activity and the possibility of steam generator tube leakage.

11.5.2.3.2.2 Containment Atmosphere Radioactivity Monitors

The containment atmosphere radioactivity monitors, 0-GT-RE-31 and 0-GT-RE-32, continuously monitor the containment atmosphere for particulate, iodine, and gaseous radioactivity.

These monitors also serve for reactor coolant pressure boundary leakage detection (See Section 5.2.5 for a detailed description of this function) and for personnel protection (see Section 12.3.4 for a detailed description of this function). The containment atmosphere radioactivity monitors provide backup indication for the containment purge monitors. These seismic Category I monitors are completely redundant.

Samples are extracted from the operating deck level (El. 2047'-6") through sample lines which penetrate the containment. The monitors are located as close as possible to the containment penetrations to minimize the length of the sample tubing and the effects of sample plate out. The sample points are located in areas which ensure that representative samples are obtained. Each sample passes through the penetration, then through the fixed filter (particulate), charcoal filter (iodine), and fixed-volume gaseous detector assemblies. After passing through the pumping system, the sample is discharged back to the containment through a separate penetration.

Indication is provided for each monitor on individual indicators on the radioactivity monitoring system control panel and, through isolated signals, on the radioactivity monitoring system Visual Display in the control room.

11.5.2.3.2.3 Containment Purge System Radioactivity Monitors

The containment purge system radioactivity monitors, 0-GT-RE-22 and 0-GT-RE-33, continuously monitor the containment purge exhaust duct during purge operations for particulate, iodine, and gaseous radioactivity. The purpose of these monitors is to isolate the containment purge system on high gaseous activity via the ESFAS. See Sections 7.3.2 and 9.4.6 for additional information concerning this function. These monitors also serve as backup indication for personnel protection (see Section 12.3.4) and reactor coolant pressure boundary leakage detection (see Section 5.2.5) for the containment atmosphere radioactivity monitors.

These seismic Category I monitors are completely redundant.

The sample points are located outside the containment between the containment isolation dampers and the containment purge filter adsorber unit.

Each monitor is provided with two isokinetic nozzles to ensure that representative samples are obtained for both normal purge and minipurge flow rates. Isokinetic nozzle selection is accomplished by sample selector valves which automatically align the correct nozzle to the monitor based on operation of the minipurge and normal purge exhaust systems. The sample is extracted through the selected nozzle and then passed through the selector valve, the fixed filter (particulate), charcoal filter (iodine), and fixed-volume gaseous detectors. The sample then passes through the pumping system and is discharged back to the duct.

Indication is provided for each monitor on individual indicators on the radioactivity monitoring system control panel and, through isolated signals, on the radioactivity monitoring system Visual Display in the control room.

For plant conditions during CORE ALTERATIONS and during movement of irradiated fuel within containment, the function of the monitors is to alarm only and the trip signals for automatic actuation of CPIS may be bypassed. One instrumentation channel at a minimum is required for the alarm only function during plant refueling activities.

11.5.2.3.2.4 Containment High Range Radiation Monitors

The containment digital high range radiation monitor (DHRRM) system includes two redundant monitors, 0-GT-RT-59 and 0-GT-RT-60, to detect and indicate gamma radiation levels in the containment over a range from 1 rad/hr to 10^8 rads/hr. The DHRRM also provides an alarm function.

Each DHRRM subsystem consists of a gamma radiation detector, a microprocessor, junction box, and control/display module. The subsystems are safety related and designed and qualified to IEEE 323-1974 for the normal and accident environments for their installed locations. The subsystems are also designed and qualified to be seismic Category I. The detector locations are indicated on Figure 12.3-2, Sheet 4. Detectors are mounted on the inside surface of the containment wall at El. 2052'-0". The DHRRM subsystems are also connected to the process and effluent radiation monitoring system (optically isolated) for readout on the Visual Display in the control room.

11.5.2.3.2.5 Fuel Building Ventilation Exhaust Radioactivity Monitor

The fuel building ventilation exhaust radiation monitors, 0-GG-RE-27 and 0-GG-RE-28, continuously monitor for particulate, iodine, and gaseous radioactivity in the fuel building ventilation exhaust system. In the event of a fuel handling accident, these monitors function to isolate the normal ventilation and start up the emergency ventilation system on high gaseous activity via the ESFAS. Sections 7.3.3 and 9.4.2 have additional information about this function. These monitors have an additional function to alert workers to high airborne radioactivity in the fuel building. This latter function is discussed in Section 12.3.4.

These seismic Category I monitors are completely redundant.

During normal operation, each monitor extracts a sample from the normal exhaust duct through individual isokinetic nozzles and sample selector valves. This normal sample point is upstream of the fuel building normal exhaust filter adsorber unit.

When the emergency ventilation system is in use, the capability is provided from the control room to transfer the sample points via sample selector valves to isokinetic nozzles located in the fuel building emergency exhaust system upstream of the emergency exhaust filter adsorber units, with one monitor aligned to each emergency exhaust duct.

Indication is provided by individual indicators on the radioactivity monitoring system control panel and, through isolated signals, by the radioactivity monitoring system Visual Display in the control room.

11.5.2.3.2.6 Control Room Ventilation Radioactivity Monitor

The control room ventilation radioactivity monitors, 0-GK-RE-04 and 0-GK-RE-05, continuously monitor the supply air of the normal heating, ventilation, and air-conditioning system for particulate, iodine, and gaseous radioactivity to provide protection for the control room operators. These monitors function automatically to switch the control room from the normal to the emergency ventilation system on high gaseous activity via the ESFAS. See Sections 6.4, 7.3.4, and 9.4.1 for more details. These monitors also function to alert the operators to high airborne radioactivity in the control room ventilation supply. This function is described in Section 12.3.4.

These seismic Category I monitors are completely redundant.

Samples are extracted through individual isokinetic nozzles, and flow through the fixed filter (particulate), charcoal filter (iodine), and fixed-volume gaseous detector assemblies prior to passing through the pumping system for discharge to the auxiliary building atmosphere.

Indication for these monitors is provided on individual indicators on the radioactivity monitoring system control panel and, through isolated signals, on the radioactivity monitoring system Visual Display in the control room.

11.5.2.3.3 Airborne Effluent Radioactivity Monitors

A detailed listing of airborne effluent monitor parameters is given in Table 11.5-4.

11.5.2.3.3.1 Unit Vent Radioactivity Monitor

The unit vent radioactivity monitor, 0-GT-RE-21, continuously monitors the effluent from the unit vent for particulate, iodine (halogen), and gaseous radioactivity. The unit vent, via ventilation exhaust systems, continuously purges various tanks and sumps normally containing low-level radioactive aerated liquids that can potentially generate airborne activity.

The exhaust systems which supply air to the unit vent are from the fuel building, auxiliary building, the access control area, the containment purge, and the condenser air discharge.

All of these systems are filtered before they exhaust to the unit vent. The unit vent monitor measures actual plant effluents and not inplant concentrations. Thus, the system continuously monitors downstream of the last point of potential radioactivity entry. The monitoring system consists of an off-line, three-way airborne radioactivity monitor. An isokinetic sampling probe is located downstream of the last point of potential radioactivity entry for sample collection.

The Alert alarms are set below the High alarms to act as precautionary warnings. The High alarm is set to ensure that the Offsite Dose Calculation Manual limits are not exceeded. Refer to Table 11.5-4 for the alert and high alarm setpoints, the range, and the sensitivity.

Portions of the sample tubing located outside the building are adequately protected and routed to prevent the accumulation and freezing of condensate. The sample extracted by the isokinetic nozzle is passed through the fixed filter (particulate), charcoal filter (iodine), and fixed-volume (gaseous) detector assemblies and then through the pumping system for discharge back to the unit vent.

Indication is provided on the radioactivity monitoring system Visual Display in the control room. This monitor provides a signal to the radioactive release report generation system described in Section 11.5.2.1.1.

11.5.2.3.3.2 Radwaste Building Ventilation Effluent Radioactivity Monitor

The radwaste building ventilation effluent radiation monitor, 0-GH-RE-10, continuously monitors for particulate, halogen, and gaseous radioactivity in the effluent duct downstream of the exhaust filter and fans. The sample point is located downstream of the last possible point of radioactive influent, including the waste gas decay tank discharge line. The flow path provides ventilation exhaust for all parts of the building structure and components within the building and provides a discharge path for the waste gas decay tank release line. These components represent potential sources for the release of gaseous and air particulate and iodine activities in addition to the drainage sumps, tanks, and equipment purged by the waste processing system.

The monitoring system consists of a fixed filter particulate monitor, an iodine monitor, and gaseous activity monitor.

The sample is extracted through an isokinetic nozzle to ensure that a representative sample of the air is obtained prior to release to the environment. After passing through the fixed filter (particulate), charcoal filter (halogen), and fixed-volume (noble gas) detector assemblies and the pumping system, the sample is discharged back to the exhaust duct.

The sensitivities and alarm setpoints are given in Table 11.5-4. The Alert alarm is set below the High alarm to act as a precautionary warning. The High alarm is set to ensure that Offsite Dose Calculation Manual limits are not exceeded.

Indication of this monitor is provided on the radiation monitoring system Visual Display in the control room. This monitor provides a signal to the radioactive release report generation system in the computer room (see Section 11.5.2.1.1).

This monitor will isolate the waste gas decay tank discharge line if the radioactivity release rate is above the preset limit when the waste gas discharge valve has been deliberately or inadvertently opened.

11.5.2.3.3.3 Laundry Decon Facility Dryer Exhaust Monitor

The Laundry Decon Facility Dryer Exhaust Monitor, 0-GL-RE-202, continuously monitors for particulate radioactivity in the effluent duct downstream of the exhaust filter and fans. This flow path provides ventilation exhaust for the Decon Facility Dryers.

The air in this flow path is filtered before exhausted to the environment. The Laundry Decon Facility Dryer Exhaust Monitor measures actual plant effluents and not inplant conditions. The monitoring system consists of an off-line, fixed filter particulate monitor.

The sample is extracted through an isokinetic nozzle to ensure that a representative sample of the air is obtained prior to release to the environment. After passing through the fixed filter (particulate) the sample is discharge locally.

The sensitivities and alarm setpoint is given in Table 11.5-4. The alarm is set to ensure that the Offsite Dose Calculation Manual limits are not exceeded.

The monitor will isolate the discharge path when measured levels are above the alarm setpoint or the monitor fails.

11.5.2.4 Safety Evaluation

The control room ventilation monitors, the containment atmosphere monitors, the containment purge monitors, the containment LOCA atmosphere monitors, and the fuel building exhaust monitors are redundant, independent, seismic Category I, with Class 1E power supplies. The control room and fuel building monitors will automatically switch from the normal to the emergency ventilation systems on high gaseous activity via the ESFAS. The containment atmosphere and containment purge monitors will automatically isolate the containment purge and stop the fans on high gaseous activity via the ESFAS.

11.5.3 EFFLUENT MONITORING AND SAMPLING

All potentially radioactive effluent discharge paths are continuously monitored for gross radiation level, except as described below. Liquid releases are monitored for gross gamma. Airborne releases are monitored for gross beta activity (particulates and noble gases) and gross gamma (iodines). The Laundry Decon Facility Dryer Exhaust is monitored for particulates.

Airborne batch release for the Containment ILRT post-test vent may utilize pre-test grab samples in conjunction with ODCM calculation methodology, without the need for continuous monitoring. Refer to Table 16.11-4.

Laboratory isotopic analyses are performed on continuous and batch effluent releases in accordance with the Offsite Dose Calculation Manual requirements. Results of these analyses are compiled and appropriate portions are utilized to produce the Annual Radioactive Effluent Release Report in accordance with Technical Specification 6.9.1.7.

By a combination of the installed equipment described previously in Section 11.5 and the installed equipment described in Section 12.3.4, along with portable equipment described in Section 12.5, and the emergency plan as described in Section 13.3, the requirements of General Design Criterion 64 to monitor normal operations, anticipated operational occurrences, and postulated accidents are met.

11.5.4 PROCESS MONITORING AND SAMPLING

All potentially significant radioactive systems which lead to effluent discharge paths are equipped with a control system to automatically isolate the discharge on indication of a high radioactivity level. These include the containment purge system, the fuel building ventilation system, and the gaseous and liquid radwaste systems. Batch releases are sampled and analyzed in accordance with Offsite Dose Calculation Manual requirements, in addition to the continuous effluent monitoring.

By means of the continuous radioactivity monitors mentioned above and their associated control valves, and due to the extensive sampling program described in the Environmental Report, General Design Criterion 60 and the Offsite Dose Calculation Manual requirements are met with regard to the control of releases of radioactivity to the environment.

Process monitoring is accomplished by continuous radioactivity monitors discussed in Sections 11.5.2.2.2 and 11.5.2.3.2. By means of the continuous radioactivity monitors, GDC-63 is met with regard to monitoring radioactivity levels in the radioactive waste process systems.

TABLE 11.5-1 LIQUID PROCESS RADIOACTIVITY MONITORS

Monitor Number	Description	Type (continuous)	Detection	Range (µCi/cc)	MDC (1) (µCi/cc)	Controlling Isotope	Alert Alarm (µCi/cc)	Hi Alarm (µCi/cc)	Sample Flow Rate (gpm)	Monitor Control Function
0-EG-RE-9 0-EG-RE-10	Component cooling water monitor	Liquid	NaI (T1) gamma scintillation	10^{-7} to 10^{-2}	1×10^{-6}	Cs137	1×10^{-5}(3)	1×10^{-4}(4)	1-5	Isolates air vents on component cooling water surge tanks on Hi alarms
0-SJ-RE-2	Steam generator liquid radioactivity monitor	Liquid (2)	NaI (T1) gamma scintillation	10^{-7} to 10^{-2}	1×10^{-6}	Cs137	1.2×10^{-6}(9)	variable (10)	500 cc/ min	Alarms
0-BM-RE-25	Steam generator blowdown processing system monitor	Liquid (2)	NaI (T1) gamma scintillation	10^{-7} to 10^{-2}	1×10^{-6}	Cs137	1.2×10^{-6}(9)	variable (10)	1-5	Closes blowdown discharge valve and trips blowdown discharge pumps on Hi alarm
0-SJ-RE-01	Chemical and volume control system letdown monitor	Liquid	NaI (T1) gamma scintillation	1.7×10^{-3} to $1.7 \times 10^{+3}$	NA	---	variable (7)	variable (8)	500 cc/ min	Alarms
0-FB-RE-50	Auxiliary steam system condensate recovery monitor	Liquid (2)	NaI (T1) gamma scintillation	10^{-7} to 10^{-2}	1×10^{-6}	Cs137	1×10^{-5}(3)	1×10^{-4}(4)	1-5	Hi alarm isolates auxiliary steam supply to radwaste building and trips auxiliary steam condensate transfer pumps

(1) MDC minimum detectable concentration.

(2) When in operation.

(3) One order of magnitude above MDC to avoid spurious alarms and to indicate the leakage of radioactivity into an otherwise nonradioactive system.

(4) Two orders of magnitude above MDC to indicate significant inleakage of radioactivity.

(5) Only water cleaner than this will be sent to the reactor makeup water storage tank.

(6) High activity may indicate evaporator operating problem.

TABLE 11.5-1 (Sheet 2)

(7) High activity may indicate a crud burst or iodine spiking. Setpoint established at 5E-1 µCi/cc above background reading to indicate 0.1% failed fuel in 30 minutes.

(8) High activity may indicate a crud burst, iodine spiking, or failed fuel. Laboratory analyses will be performed to determine cause. Setpoint established at 5E-0 µCi/cc above background reading to indicate 1% failed fuel in 30 minutes.

(9) Value shown is approximately two times background based on no failed fuel to prevent spurious alarms but still provides early warning of increasing radioactivity. Setpoint may be adjusted as background levels change in accordance with approved plant procedures to maintain an early warning of increased primary-to-secondary leakage.

(10) Setpoint is adjusted in accordance with approved plant procedures.

TABLE 11.5-2 LIQUID EFFLUENT RADIOACTIVITY MONITORS

Monitor Number	Description	Type (continuous)	Detection	Range (µCi/cc)	MDC (1) (µCi/cc)	Controlling Isotope	Alert Alarm (µCi/cc)	Hi Alarm (µCi/cc)	Sample Flow Rate (gpm)	Monitor Control Function
0-HB-RE-18	Liquid radwaste discharge monitor	Liquid	NaI (Tl) gamma scintillation	10^{-7} to 10^{-2}	1×10^{-6}	Cs-137	(3)	(2)	1-5	Closes discharge valve on high alarm
0-BM-RE-52	Steam generator blowdown discharge monitor	Liquid (4)	NaI (Tl) gamma scintillation	10^{-7} to 10^{-2}	1×10^{-6}	Cs-137	(3)	(2)	1-5	Closes discharge and blowdown isolation valves on high alarm

(1) MDC = minimum detectable concentration.

(2) High alarm is set to ensure that Offsite Dose Calculation Manual limits (the 10 CFR 20 general population MPCs for the controlling isotope at the boundary of the restricted area) are not exceeded and to initiate isolation (except valve HF-RV-0045) before the limit can be exceeded.

(3) Alert alarm set at 1/2 of Hi alarm value to alert operators of increasing radioactivity levels.

(4) Normally, all of this liquid will be recycled. The monitor is to prevent inadvertent discharge valve opening and to ensure that any releases that might become necessary are within limits. In accordance with the Offsite Dose Calculation Manual, batch analyses will be performed before any releases are made.

(5) Normally, not radioactive since potentially radioactive drains are segregated from this and recycled.

(6) Alert alarm set at 1½ times monitor background to avoid spurious alarms and to indicate inleakage of radioactivity.

(7) High alarm set at 2 times monitor background to indicate significant inleakage of radioactivity.

TABLE 11.5-3 AIRBORNE PROCESS RADIOACTIVITY MONITORING

Monitor	Type (continuous)	Range (μCi/cc)	MDC (1) (μCi/cc)	Controlling Isotope	Alert (16) Alarm (μCi/cc)	Hi (16) Alarm (μCi/cc)	Total Ventilation Flow (cfm)	Minimum Required Sensitivity (μCi/cc)	Monitor Control Function
0-GT-RE-31 0-GT-RE-32 Containment atmosphere monitors	Particulate (3) Iodine (4) Gaseous (3)	10^{-12} to 10^{-7} 10^{-11} to 10^{-6} 10^{-7} to 10^{-2}	1×10^{-11} 1×10^{-10} 2×10^{-7}	Cs-137 I-131 Xe-133	1.0×10^{-9} (17) 1.0×10^{-8} 1.0×10^{-4}	1.0×10^{-7} 9.0×10^{-7} 1.0×10^{-3}	420,000 420,000 420,000	1×10^{-7} (7) 9×10^{-8} (7) 1×10^{-4} (7)	NA
0-GT-RE-22 0-GT-RE-33 Containment purge system monitors	Particulate (3) Iodine (4) Gaseous (3)	10^{-12} to 10^{-7} 10^{-11} to 10^{-6} 10^{-7} to 10^{-2}	1×10^{-11} 1×10^{-10} 2×10^{-7}	Cs-137 I-131 Xe-133	5.0×10^{-8} 5.0×10^{-8} (12)	1.0×10^{-7} 9.0×10^{-8} (11) (15)	20,000/4000 20,000/4000 20,000/4000	1×10^{-7} (7) 9×10^{-8} (7) 1×10^{-4} (7)	Isolates containment purge, deenergizes purge fans on high gaseous activity via the ESFAS (see Section 7.3)
0-GT-RE-59 0-GT-RE-60 Containment high activity monitors	Gamma (5)	1 to 10^{8} rads/hr	1 rad/hr	NA	6.4×10^{0} R/hr	2.8×10^{3} R/hr	NA	NA	NA
0-GE-RE-92 Condenser air discharge monitor	Gaseous (continuous) (3), (6)	10^{-7} to 10^{-2}	2×10^{-7}	Xe-133	2×10^{-6} (9)	variable (10)	25	NA	Alarms
0-GG-RE-27 0-GG-RE-28 Fuel building exhaust monitors (2)	Particulate (3) Iodine (4) Gaseous (3)	10^{-12} to 10^{-7} 10^{-11} to 10^{-6} 10^{-7} to 10^{-2}	1×10^{-11} 1×10^{-10} 2×10^{-7}	Cs-137 I-131 Xe-133	1×10^{-8} (8) 9×10^{-9} (8) 1.6×10^{-3}	1×10^{-7} (7) 9×10^{-8} (7) 3.2×10^{-3} (14)	20,000 20,000 20,000	1×10^{-7} (7) 9×10^{-8} (7) 1×10^{-4} (7)	Initiates switch to fuel building emergency ventilation on high gaseous activity via the ESFAS (see Section 7.3)
0-GK-RE-04 0-GK-RE-05 Control room air supply monitors	Particulate (3) Iodine (4) Gaseous (3)	10^{-12} to 10^{-7} 10^{-11} to 10^{-6} 10^{-7} to 10^{-2}	1×10^{-11} 1×10^{-10} 2×10^{-7}	Cs-137 I-131 Xe-133	1×10^{-8} (8) 9×10^{-9} (8) 1.1×10^{-3}	1×10^{-7} (7) 9×10^{-8} (7) 2.2×10^{-3} (13)	2000 2000 2000	1×10^{-7} (7) 9×10^{-8} (7) 1×10^{-4} (7)	Initiates switch to control room emergency ventilation on high gaseous activity via the ESFAS (see Section 7.3)

TABLE 11.5-3 (Sheet 2)

Sample flow for each channel is 3 cfm

(1) MDC = minimum detectable concentration.

(2) When fuel is in the building.

(3) Beta scintillation detector.

(4) Gamma scintillation detector.

(5) Gamma sensitive ion chamber.

(6) When in operation.

(7) 10 MPC.

(8) MPC

(9) Value shown is approximately two times background based on no failed fuel to prevent spurious alarms but still provide early warning of increasing radioactivity. Setpoint may be adjusted as background levels change in accordance with approved plant procedures to maintain an early warning of increased primary-to-secondary leakage.

(10) Setpoint is adjusted in accordance with approved plant procedures to corresopnd to a primary-to-secondary leak rate of 30 gpd based on existing RCS activity.

(11) High alarm is set to ensure that Offsite Dose Calculation Manual limits are not exceeded.

(12) Alert alarm is administratively established at a point sufficiently below the High alarm so as to provide additional assurance that Offsite Dose Calculation Manual limits are not exceeded.

(13) Submersion dose rate does not exceed 2 mr/hr in the control room.

(14) Submersion dose rate does not exceed 4 mr/hr in the fuel building.

(15) High alarm setpoint is established to ensure that Offsite Dose Calculation Manual limits are not exceeded.

(16) Alert and High alarm values do not include instrument loop uncertainty estimates.

17)Alert alarm value is set to meet the criteria of Note 12 and to meet RCS leakage detection requirements described in FSAR Section 5.2.5.2.3.

TABLE 11.5-4 AIRBORNE EFFLUENT RADIOACTIVITY MONITORS

Monitor	Type (continuous)	Range (μCi/cc)	MDC (1) (μCi/cc)	Controlling Isotope	Alert Alarm (μCi/cc)	Hi Alarm (μCi/cc)	Total Ventilation Flow (cfm)	Dilution Factor	Minimum Required Sensitivity (μCi/cc)	Monitor Control Function
0-GT-RE-21A Plant unit vent monitor	Particulate (2)	10^{-12} to 10^{-7}	1×10^{-11}	Cs-137	5E-8	1E-7	66,000/82,000	(4)	(5)	Alarms
	Iodine (3)	10^{-11} to 10^{-6}	1×10^{-10}	I-131	5E-7	1E-6	66,000/82,000	(4)	(5) (6)	
0-GT-RE-21B Plant unit vent monitor	Gaseous (2)	10^{-7} to 10^{5}	2×10^{-7}	Xe-133	(8)	(7)	66,000/82,000	(4)	(5)	
0-GH-RE-10A Radwaste building exhaust monitor	Particulate (2)	10^{-12} to 10^{-7}	2×10^{-11}	Cs-137	5E-8	1E-7	12,000	(4)	(5)	
	Iodine (3)	10^{-11} to 10^{-6}	2×10^{-10}	I-131	5E-7	1E-6	12,000	(4)	(5)	
0-GH-RE-10B Radwaste building exhaust monitor line	Gaseous (2)	10^{-7} to 10^{5}	2×10^{-7}	Xe-133	(8)	(7)	12,000	(4)	(5)	Hi alarm isolates the waste gas decay tank discharge line
0-GL-RE-60 Auxiliary building ventilation exhaust monitor	Particulate (2)	10^{-12} to 10^{-7}	1×10^{-11}	Cs-137	1E-8	1E-7	12,000	(11)	(11)	Alarms
0-GK-RE-41 Access control area ventilation exhaust monitor	Particulate (2)	10^{-12} to 10^{-7}	1×10^{-11}	Cs-137	1E-9(9)	1E-8(10)	6,000	(11)	(11)	Alarms
0-GL-RE-202 Laundry Decon Facility Dryer Exhaust Monitor	Particulate (GM Detector)	10 to 100,000 cpm	1×10^{-11}	Co-58	none	(7)	Variable	(4)	(5)	Hi alarm isolates the release point

Sample flow for each channel is 3 cfm

(1) MDC = minimum detectable concentration.

(2) Beta scintillation detector.

TABLE 11.5-4 (Sheet 2)

(3) Gamma scintillation detector.

(4) Dilution factor = vent flow rate in m^3/sec $\frac{X}{Q}$ (annual average).

(5) Minimum required sensitivity of monitor in µCi/cc at maximum permissible concentration of controlling isotope at monitor which will result in annual average Appendix I dose at the site boundary

$= \text{MPC for controlling isotope} \times \frac{1}{100} \times \frac{1}{\text{bioaccumulation factor}} \times \frac{1}{\text{dilution factor}}$ where the bioaccumulation factor is 1 for noble gases and 1,000 for iodines and particulates.

See 10CFR20.1-601, Appendix B, Table II, Column 1 MPC values.

(6) Grab samples will be analyzed in the laboratory, and low iodine concentrations will be calculated, using previously established ratios.

(7) High alarm is set to ensure that Offsite Dose Calculation Manual limits are not exceeded.

(8) Alert alarm is administratively established at a point sufficiently below the High alarm so as to provide additional assurance that Offsite Dose Calculation Manual limits are not exceeded.

(9) MPC x dilution factor.

(10) 10 MPC x dilution factor.

(11) See Table 12.3-3 for dilution factors and minimum required sensitivity.

TABLE 11.5-5 POWER SUPPLIES FOR PROCESS AND EFFLUENT MONITORS

Monitor Name and Number	Normal Power Supply	Restored After Loss of Offsite Power
Liquid Process Radioactivity Monitors (non-1E)		
Component cooling water 0-EG-RE-9 0-EG-RE-10	Non-1E MCCs	No
Steam generator liquid radoioactivity 0-SJ-RE-2	Non-1E MCCS	No
Steam generator blowdown processing system 0-BM-RE-25	Non-1E MCCs	No
CVCS letdown 0-SJ-RE-01	Non-1E MCCs	No
Auxiliary steam system liquid condensate recovery 0-FB-RE-50	Non-1E MCCs	No
Liquid Effluent Radioactivity Monitors (Non-1E)		
Liquid radwaste discharge	Non-1E MCCs	No
Steam generator blowdown discharge 0-BM-RE-52	Non-1E MCCs	No
Airborne Process Radioactivity Monitors (Class 1E)		
Containment atmosphere 0-GT-RE-31 0-GT-RE-32	Class 1E MCCs	Yes
Containment purge system 0-GT-RE-22 0-GT-RE-33	Class 1E MCCs	Yes
Containment high activity monitors 0-GT-RE-59 0-GT-RE-60	Class 1E MCCs	Yes
Fuel building exhaust 0-GG-RE-27 0-GG-RE-28	Class 1E MCCs	Yes

TABLE 11.5-5 (Sheet 2)

Monitor Name and Number	Normal Power Supply	Restored After Loss of Offsite Power
Control room air supply 0-GK-RE-04 0-GK-RE-05	Class 1E MCCs	Yes
Condenser air discharge 0-GE-RE-92	Non-1E MCC	No
Airborne Effluent Radioactivity Monitors (Non-1E)		
Plant unit vent 0-GT-RE-21	Non-1E MCCs	No
Radwaste building exhaust 0-GH-RE-10	Non-1E MCCs	No
Laundry Decon Facility Dryer Exhaust 0-GL-RE-202	Non-1E MCCs	No

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CHAPTER 11.0

RADIOACTIVE WASTE MANAGEMENT

LIST OF TABLES

11.1.1 Radioactive Concentrations and Releases

Estimated radioactive liquid effluent concentrations for Callaway Plant are provided in Section 11.1 of the Standard Plant.

11.2.3.2 Release Points

The Callaway Plant normal effluent releases as calculated per the guidance in Section 11.1.1, were considered for evaluating the local surface-water environment in dispersing, diluting, or otherwise concentrating radioactive effluents as related to existing or potential future water users. Since routine plant releases will be discharge directly to the Missouri River by pipeline, there will be no impact on the local ground-water system(s) from this source.

11.2.3.3 Dilution Factors

11.2.3.3.1 Description of Surface-Water Analytical Model

A steady-state stream tube model was utilized for evaluating the transport of radionuclides in the Missouri River downstream from the Callaway Plant effluent release point. This model, based on Equation 17 in Regulatory Guide 1.113 (NRC, 1977), applies to nontidal river/stream systems.

For evaluating radionuclide transport in the Missouri River from plant effluent releases, flow was assumed to be steady and uniform. Application of the steady-state stream tube model for evaluating plant effluent releases was based on simplifying assumptions of idealized rectangular stream channel geometry and velocity in the Missouri River under assumed steady and uniform flow conditions. The Missouri River is gauged and streamflow in the immediate vicinity of the Callaway Plant site, and only channel velocity distributions are known several miles downstream at the USGS gauging station at Hermann.

For steady open-channel flow, K_y can be determined from hydrodynamic properties of the channel by using Elder's empirical formula (NRC, 1977):

$$K_y = \beta u^* d \qquad (11.2\text{-}1)$$

where:

d	=	River depth;
u*	=	Shear velocity; and
β	=	A dimensionless constant.

The dimensionless constant, β, has a value of approximately 0.23 for straight natural stream channels (NRC, 1977). For curved channels, however, secondary flows can lead to increased lateral mixing, and the value of β is larger (Fischer, 1969; Yotsukura et al., 1970; Sayre and Yeh, 1973). Fischer (1969) has demonstrated that the lateral mixing coefficient can be increased in bending streams, varying inversely as the square of the radius of curvature. The dimensionless parameter, β, as determined by field investigations, is reportedly 0.6 to 0.7 for a gradually curving reach of the Missouri River near Blair, Nebraska (Yotsukura et al., 1970). Another field investigation conducted near Brownsville, Nebraska for a test reach containing a very sharp bend reported average and maximum values of β equal to 3.3 and 10, respectively (Sayre and Yeh, 1973).

The certified computer program, DISPERN, was used for performing the routine effluent analysis. This program is based on the steady-state stream tube model.

11.2.3.3.2 Selection of Surface-Water Model Parameters

A summary of parameters used in the routine effluent analysis is presented in Table 11.2-1. Representative channel geometry parameters of the Missouri River for 50 miles downstream of the Callaway Plant effluent discharge pipeline are noted for the estimated average flow conditions. Average flow conditions are discussed in Section 2.4 and are based on stage-discharge relationships developed for the Missouri River at the Hermann gauging site (see Figure 2.4-10) and near the Callaway Plant site (see Figure 2.4-12), hydrographic survey data from the U.S. Army Corps of Engineers (1978), and hydrologic analysis for river channel variables.

In the analysis, methods for evaluating the lateral turbulent diffusion coefficient, K_y, were reviewed. The minimum value of β, 0.23 for determining K_y, was not considered appropriate to use since it applies specifically to straight natural stream channels and ignores secondary flows which have been experimentally found (as in the Missouri River) to lead to increased lateral mixing. A value of β equal to 0.65 for determining K_y was adopted, as found experimentally for a gradually curving reach of the Missouri River upstream of the Callaway Plant site.

11.2.3.3.3 Results of Analysis

In the analysis for radionuclide transport in the Missouri River from the estimated Callaway Plant annual liquid effluent releases (see Section 11.1.1 of Standard Plant), dilution factors and transit times were predicted from the plant effluent discharge to a distance 50 miles downstream. These are presented in the computer output summary in Table 11.2-2 and 11.2-3. Values are indicated at various cross-stream distances from the near shore for incremental distances beginning at 1 foot.

In tables 11.2-2 and 11.2-3, the dilution factors are presented at the given cross-stream distances from the near shore out to within 50 feet of where the farthest influence of radionuclide transport is estimated.

11.2.3.3.4 Water Usage

For noting liquid pathways to man and for evaluating potential impacts from effluent releases from the Callaway Plant on man and other biota (Section 11.2.3.4), Missouri

River water users were identified along its entire length (115 river miles) downstream from the Callaway Plant site. Dischargers were also identified. These are discussed in Section 2.4 and are identified in Tables 2.4-18 and 2.4-19. Locations of these water withdrawals and water discharge points are shown on Figure 2.4-8. The closest municipal user of Missouri River water downstream from the Callaway Plant site is St. Louis City (Howard Bend), and its water intake is located at Missouri River mile 36.8, some 78 river miles downstream of the Callaway Plant site. The cities of Hermann, New Haven, and Washington, all within 50 miles downstream of the plant effluent discharge pipeline, are the major dischargers to the Missouri River; however, these communities derive their municipal water suppliers from deep wells only. Two known irrigation users that utilize Missouri River water downstream of the Callaway Plant site have intakes located at Missouri River miles 64.5 and 61.4, the nearest of which is located 51 river miles downstream from the plant effluent discharge pipeline. The Union Electric Company also withdraws water from the Missouri River at river mile 58.1 and discharges downstream at river mile 57.9, just below the city of Washington.

Since water users upstream of the Callaway Plant site can alter flows at and downstream of the site and because relocation of contaminated and potentially contaminated materials upstream in the physical environment (such as occurs in dredging operations) could potentially affect the conditions near the site (NRC, 1977 and 1976), Missouri River water users and dischargers upstream from the site were also sufficiently identified to the best extent possible. These are shown on Figure 2.4-9. No potential contaminant source areas were identified. Also, NRC Regulatory Guide 1.113 (1977) suggests identification of the following features in relation to a nuclear plant site:

> (1) surface water usage [Use types include water, irrigation, process water (consumed by such users as breweries and soft drink manufacturers), recreation areas, and fisheries. Ground-water users with wells whose zones of influence extend to streams should also be included (NRC, 1977).] upstream and downstream of the plant site, (2) major tributaries and their junctions, (3) streamflow gauging stations (including their periods of record), and (4) major reservoirs and diversions upstream and downstream of the plant site. Approximate contributing drainage areas and types of water use for all points identified should be shown on the diagram or tabulated separately.

Section 2.4.1 presents a description of surface and ground-water uses in the region surrounding the Callaway Plant site, based on the best available data, both published and unpublished. Descriptions of the Missouri River and its major tributaries, streamflow gauging stations, major reservoirs, and ground-water characteristics in this region are discussed in Section 2.4.1. All of the above were considered for modeling the Missouri River under present conditions and for evaluating the impacts on man and other biota from effluent releases from the Callaway Plant (refer to Section 11.2.3.4).

11.2.3.3.5 Ground-Water Models

Since routine plant releases will be discharged directly to the Missouri River by pipeline, there will be no impact on the local ground-water regime from this source. Therefore, effluent releases were not considered in evaluating the local ground-water environment in dispersing, diluting, or otherwise concentrating radioactive effluents as related to existing or potential future ground-water users.

11.2.3.4 Estimated Doses

11.2.3.4.1 Dose Rate Estimates for Biota Other than Man

From considerations of the exposure pathways and the distribution of facility-derived radioactivity, dose rate estimates to local biota have been formulated through the use of the LADTAP II computer code. This code is based on the methodology presented in Regulatory Guide 1.109, which uses the standard ICRP model for computation of effective radionuclide decay energies and resultant dose factors.

Doses to aquatic flora and fauna can be calculated from a knowledge of concentrations of radionuclides in the Missouri River 0.05 miles downstream of the discharge. Based on radionuclide concentrations present and bio-accumulation factors in Table A-8 in Regulatory Guide 1.109, doses to fish and shellfish living continuously in the section of the Missouri River 0.05 miles downstream of the discharge of the plant were calculated to be 2.19 mrad/yr and 3.95 mrad/yr respectively.

Doses to terrestrial and semi-aquatic animals from the radionuclides in the gaseous and liquid effluent and direct radiation from the plant are expected to be less than or equal to those calculated for man. Dose rates due to liquid radioactive effluents from the Callaway Plant were calculated for the muskrat and raccoon, a semi-aquatic herbivore and a terrestrial omnivore, respectively. Total exposures were 7.10 mrad/yr and 0.845 mrad/yr for the muskrat and raccoon, respectively. It was assumed that the animals obtained all of their food and water from the shore and waters of the Missouri River 0.05 miles downstream of the Callaway discharge. The doses to such animals as migrating ducks, bald eagles, etc. whose presence within 50 miles of the site is on a sporadic or seasonal basis is expected to be considerably less than doses to animals which inhabit the area on a continuous basis.

The dose to organisms other than man will be a very small percentage of that resulting from naturally occurring radiation.

11.2.3.4.2 Dose Rate Estimates for Man

Dose rates to individuals were calculated for drinking water, fish consumption, and recreational activity pathways. Assumptions, including point of exposure, are described for each pathway in the following paragraphs; the calculated liquid pathway doses are summarized in Table 11.2-4. Releases calculated using the guidance presented in Section 11.1.1 were used.

Crop irrigation is not considered a potential pathway of liquid effluents to man. This is because most water used for irrigation by local farmers comes from small streams in the vicinity rather than the Missouri River.

No drinking water is drawn from the Missouri River within 50 miles downstream of the Callaway Plant discharge. Nevertheless, the dose to an individual obtaining his entire annual water requirements from the Missouri River 0.05 miles downstream of the plant discharge was calculated. The maximum calculated dose to a single organ from this pathway was calculated to be 9.39 x 10^{-2} mrem/yr to an infant's liver; maximum total-body dose was calculated to be 7.27 x 10^{-2} mrem/yr to an infant.

Radionuclides released from the plant were assumed to be immediately available for uptake by fish. In lieu of site specific fish consumption data the values recommended by the NRC for use with the LADTAP II program were used. The maximum predicted dose of 0.573 mrem/yr to an adult liver was calculated from the fish consumption pathway due to fish caught 0.05 miles downstream of the plant discharge. The maximum total-body dose calculated was 0.434 mrem/yr to an adult.

The Missouri River has been designated unsuitable for swimming by the State of Missouri but of suitable quality for wading or boating. Potential recreational use of the Missouri River does, however, justify calculation of shoreline activity doses. The maximum calculated dose to a single organ from shoreline recreation 0.05 miles downstream of the plant discharge was 1.78 x 10^{-3} mrem/yr to the skin on a teenager. A maximum total body dose of 1.53 x 10^{-3} mrem/yr was calculated at the same location.

Examination of Table 11.2-4 reveals that, based on the dose calculation assumptions described above, the liquid pathway of primary importance in individual total-body exposure is ingestion of fish caught in the Missouri River downstream of the discharge structure. Exposure from shoreline activities will generally be of less importance. No drinking water pathway exists within 50 miles of the plant.

11.2.3.4.3 Estimated Population Doses

Population doses were calculated for fish ingestion, shoreline, and boating exposure pathway. As explained in Section 11.2.3.4.2, the drinking water, swimming, and crop irrigation exposure pathways are not expected to contribute a measurable percentage to the population doses within 50 miles downstream of the Callaway Plant on the Missouri River.

The dose to the population from fish ingestion was based upon a fish harvest of 4.58 x 10^{-6} kg/yr from the Missouri River from the plant discharge structure to 50 miles downstream, and includes both commercial and sport fish harvest.

Calculation of population doses from recreational exposure was based on usage rates taken from data compiled by the Army Corp or Engineers (Recreational Development Missouri River Rulo, Nebraska, to the Mouth, June 1978).

Fish ingestion accounts for more than 95 percent of the total man-rem dose from the Missouri River. Exposure from recreational activity is expected to contribute the other 5 percent of the total man-rem dose.

TABLE 11.2-1 PARAMETER VALUES USED IN SURFACE-WATER TRANSPORT OF RADIONUCLIDES IN MISSOURI RIVER FROM CALLAWAY PLANT ANNUAL LIQUID EFFLUENT RELEASES

Parameter	Average Annual Flow Condition
Average Width of River, B (feet)	1,100
Average Depth of River, D (feet)	14
Discharge in River, Q (cfs)	69,000
Average River Bed Slope, S (ft/ft)	0.000165
Distance from Near Shore for Source, YS (feet)	0
β for determining K_y	0.65

Values noted are for regulated flow conditions.

TABLE 11.2-2 RESULTS OF ROUTINE EFFLUENT ANALYSIS

Incremental Distance: 264 feet

AVERAGE WIDTH OF RIVER = 1100.0 FEET

AVERAGE DEPTH OF RIVER = 14.0 FEET

AVERAGE DISCHARGE OF RIVER = 69000.0 CFS

AVERAGE SLOPE OF RIVER BED = .000165 FT/FT

POINT SOURCE DISTANCE FROM NEAR SHORE = 0.0 FEET

FACTORS TO INCREASE DISPERSION COEFFICIENT FOR INCREASED MIXING DUE TO CHANNEL CURVATURE

TRANVERSE FACTOR = 2.8

INCREMENTAL DISTANCE AT WHICH TO PERFORM CALCULATIONS = 264.0 FEET

MAXIMUM DOWNSTREAM DISTANCE TO PERFORM CALCULATIONS = 5280.0 FEET

A VALUE OF 11.14 CFS HAS BEEN POSTULATED AS THE DISCHARGE RATE.

DISTANCE DOWNSTREAM (FT)	264.0									
TRANSIT TIME (SECS)	58.9									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	59.8	0.	0.	0.	0.	0.	0.	0.	0.	0.
DISTANCE DOWNSTREAM (FT)	528.0									
TRANSIT TIME (SECS)	117.8									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	84.5	0.	0.	0.	0.	0.	0.	0.	0.	0.
DISTANCE DOWNSTREAM (FT)	792.0									
TRANSIT TIME (SECS)	176.8									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	103	0.	0.	0.	0.	0.	0.	0.	0.	0.

TABLE 11.2-2 (Continued)

DISTANCE DOWNSTREAM (FT)	1056.0									
TRANSIT TIME (SECS)	235.7									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	119	9420	0.	0.	0.	0.	0.	0.	0.	0.
DISTANCE DOWNSTREAM (FT)	1320.0									
TRANSIT TIME (SECS)	294.6									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.134E+03	.440E+04	0.	0.	0.	0.	0.	0.	0.	0.
DISTANCE DOWNSTREAM (FT)	1584.0									
TRANSIT TIME (SECS)	353.5									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.146E+03	.269E+04	0.	0.	0.	0.	0.	0.	0.	0.
DISTANCE DOWNSTREAM (FT)	1848.0									
TRANSIT TIME (SECS)	412.5									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.158E+03	.192E+04	0.	0.	0.	0.	0.	0.	0.	0.
DISTANCE DOWNSTREAM (FT)	2112.0									
TRANSIT TIME (SECS)	471.4									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.169E+03	.150E+04	0.	0.	0.	0.	0.	0.	0.	0.
DISTANCE DOWNSTREAM (FT)	2376.0									
TRANSIT TIME (SECS)	530.3									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.179E+03	.1250E+04	0.	0.	0.	0.	0.	0.	0.	0.

TABLE 11.2-2 (Continued)

DISTANCE DOWNSTREAM (FT)	2640.0									
TRANSIT TIME (SECS)	589.2									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.189E+03	.108E+04	0.	0.	0.	0.	0.	0.	0.	0.
DISTANCE DOWNSTREAM (FT)	2904.0									
TRANSIT TIME (SECS)	648.1									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.198E+03	.969E+03	0.	0.	0.	0.	0.	0.	0.	0.
DISTANCE DOWNSTREAM (FT)	3168.0									
TRANSIT TIME (SECS)	707.1									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.207E+03	.887E+03	0.	0.	0.	0.	0.	0.	0.	0.
DISTANCE DOWNSTREAM (FT)	3432.0									
TRANSIT TIME (SECS)	766.0									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.215E+03	.825E+03	0.	0.	0.	0.	0.	0.	0.	0.
DISTANCE DOWNSTREAM (FT)	3696.0									
TRANSIT TIME (SECS)	824.9									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.223E+03	.778E+03	0.	0.	0.	0.	0.	0.	0.	0.
DISTANCE DOWNSTREAM (FT)	3960.0									
TRANSIT TIME (SECS)	883.8									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.231E+03	.741E+03	.244E+04	0.	0.	0.	0.	0.	0.	0.

TABLE 11.2-2 (Continued)

DISTANCE DOWNSTREAM (FT)	4224.0									
TRANSIT TIME (SECS)	942.7									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.239E+03	.712E+03	.188E+05	0.	0.	0.	0.	0.	0.	0.
DISTANCE DOWNSTREAM (FT)	4488.0									
TRANSIT TIME (SECS)	1001.7									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	246E+03	.688E+03	.150E+05	0.	0.	0.	0.	0.	0.	0.
DISTANCE DOWNSTREAM (FT)	4752.0									
TRANSIT TIME (SECS)	1060.6									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.253 E+03	.669E+03	.123E+05	0.	0.	0.	0.	0.	0.	0.
DISTANCE DOWNSTREAM (FT)	5016.0									
TRANSIT TIME (SECS)	1119.5									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.260E+03	.653E+03	.103E+05	0.	0.	0.	0.	0.	0.	0.
DISTANCE DOWNSTREAM (FT)	5280.0									
TRANSIT TIME (SECS)	1178.4									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.267E+03	.640E+03	.879E+04	0.	0.	0.	0.	0.	0.	0.

TABLE 11.2-3 RESULTS OF ROUTINE EFFLUENT ANALYSIS

Incremental Distance: 1 Mile

AVERAGE WIDTH OF RIVER = 1100.0 FEET
AVERAGE DEPTH OF RIVER = 14.0 FEET
AVERAGE DISCHARGE OF RIVER = 69000.0 CFS
AVERAGE SLOPE OF RIVER BED = .000165 FT/FT
POINT SOURCE DISTANCE FROM NEAR SHORE = 0.0 FEET
FACTORS TO INCREASE DISPERSION COEFFICIENT FOR INCREASED MIXING DUE TO CHANNEL CURVATURE
TRANVERSE FACTOR = 2.8
INCREMENTAL DISTANCE AT WHICH TO PERFORM CALCULATIONS = 5280.0 FEET
MAXIMUM DOWNSTREAM DISTANCE TO PERFORM CALCULATIONS = 264000.0 FEET
A VALUE OF 11.14 CFS HAS BEEN POSTULATED AS THE DISCHARGE RATE.

DISTANCE DOWNSTREAM (FT)	5280.0									
TRANSIT TIME (SECS)	1178.4									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.267E+03	.640E+03	.879E+04	0.	0.	0.	0.	0.	0.	0.
DISTANCE DOWNSTREAM (FT)	10560.0									
TRANSIT TIME (SECS)	2356.9									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.378E+03	.584E+03	.217E+04	.192E+05	0.	0.	0.	0.	0.	0.
DISTANCE DOWNSTREAM (FT)	15840.0									
TRANSIT TIME (SECS)	3535.3									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.462E+03	.619E+03	.148E+04	.636E+04	0.	0.	0.	0.	0.	0.
DISTANCE DOWNSTREAM (FT)	21120.0									
TRANSIT TIME (SECS)	4713.7									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.534E+03	.664E+03	.128E+04	.381E+04	.176E+05	0.	0.	0.	0.	0.

TABLE 11.2-3 (Continued)

DISTANCE DOWNSTREAM (FT)	26400.0									
TRANSIT TIME (SECS)	5892.2									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.597E+03	.711E+03	.120E+04	.288E+04	.977E+04	0.	0.	0.	0.	0.
DISTANCE DOWNSTREAM (FT)	31680.0									
TRANSIT TIME (SECS)	7070.6									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.654E+03	.756E+03	.117E+04	.242E+04	.672E+04	.249E+05	0.	0.	0.	0.
DISTANCE DOWNSTREAM (FT)	36960.0									
TRANSIT TIME (SECS)	8249.0									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.706E+03	.800E+03	.116E+04	.217E+04	.520E+04	.160E+05	0.	0.	0.	0.
DISTANCE DOWNSTREAM (FT)	42240.0									
TRANSIT TIME (SECS)	9427.5									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.755E+03	.842E+03	.117E+04	.202E+04	.433E+04	.116E+05	0.	0.	0.	0.
DISTANCE DOWNSTREAM (FT)	47520.0									
TRANSIT TIME (SECS)	10605.9									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.801E+03	.883E+03	.118E+04	.192E+04	.379E+04	.907E+04	.264E+05	0.	0.	0.
DISTANCE DOWNSTREAM (FT)	52800.0									
TRANSIT TIME (SECS)	11784.3									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.844E+03	.921E+03	.120E+04	.185E+04	.342E+04	.750E+04	.196E+05	0.	0.	0.

TABLE 11.2-3 (Continued)

DISTANCE DOWNSTREAM (FT)	58080.0									
TRANSIT TIME (SECS)	12962.8									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.885E+03	.959E+03	.122E+04	.181E+04	.316E+04	.645E+04	.154E+05	0.	0.	0.
DISTANCE DOWNSTREAM (FT)	63360.0									
TRANSIT TIME (SECS)	14141.2									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.925E+03	.995E+03	.124E+04	.178E+04	.296E+04	.571E+04	.127E+05	0.	0.	0.
DISTANCE DOWNSTREAM (FT)	68640.0									
TRANSIT TIME (SECS)	15319.7									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.963E+03	.103E+04	.126E+04	.176E+04	.282E+04	.517E+04	.108E+05	.259E+05	0.	0.
DISTANCE DOWNSTREAM (FT)	73920.0									
TRANSIT TIME (SECS)	16498.1									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.999E+03	.106E+04	.128E+04	.175E+04	.271E+04	.475E+04	.944E+04	.213E+05	0.	0.
DISTANCE DOWNSTREAM (FT)	79200.0									
TRANSIT TIME (SECS)	17676.5									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.103E+04	.110E+04	.131E+04	.175E+04	.263E+04	.443E+04	.842E+04	.179E+05	0.	0.
DISTANCE DOWNSTREAM (FT)	84480.0									
TRANSIT TIME (SECS)	18855.0									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.107E+04	.113E+04	.133E+04	.175E+04	.256E+04	.418E+04	.762E+04	.155E+05	0.	0.

TABLE 11.2-3 (Continued)

DISTANCE DOWNSTREAM (FT)	89760.0									
TRANSIT TIME (SECS)	20033.4									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.110E+04	.116E+04	.135E+04	.175E+04	.250E+04	.398E+04	.700E+04	.137E+05	0.	0.
DISTANCE DOWNSTREAM (FT)	95040.0									
TRANSIT TIME (SECS)	21211.0									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.113E+04	.119E+04	.138E+04	.175E+04	.246E+04	.381E+04	.650E+04	.122E+05	0.	0.
DISTANCE DOWNSTREAM (FT)	100320.0									
TRANSIT TIME (SECS)	22390.3									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.116E+04	.122E+04	.140E+04	.176E+04	.243E+04	.367E+04	.609E+04	.111E+05	0.	0.
DISTANCE DOWNSTREAM (FT)	105600.0									
TRANSIT TIME (SECS)	23588.7									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.119E+04	.125E+04	.142E+04	.177E+04	.240E+05	.356E+05	.575E+05	.101E+05	0.	0.
DISTANCE DOWNSTREAM (FT)	110880.0									
TRANSIT TIME (SECS)	24747.1									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.122E+04	.128E+04	.144E+04	.178E+04	.238E+04	.346E+04	.547E+04	.939E+04	0.	0.
DISTANCE DOWNSTREAM (FT)	116160.0									
TRANSIT TIME (SECS)	25925.6									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.125E+04	.130E+04	.147E+04	.179E+04	.236E+04	.338E+04	.523E+04	.876E+04	.303E+05	0.

TABLE 11.2-3 (Continued)

DISTANCE DOWNSTREAM (FT)	121440.0									
TRANSIT TIME (SECS)	27104.0									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.128E+04	.133E+04	.149E+04	.180E+04	.235E+04	.331E+04	.502E+04	.822E+04	.268E+05	0.
DISTANCE DOWNSTREAM (FT)	126720.0									
TRANSIT TIME (SECS)	28282.4									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.131E+04	.136E+04	.151E+04	.181E+04	.234E+04	.325E+04	.485E+04	.777E+04	.240E+05	0.
DISTANCE DOWNSTREAM (FT)	132000.0									
TRANSIT TIME (SECS)	29460.9									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.133E+04	.138E+04	.154E+04	.183E+04	.233E+04	.320E+04	.469E+04	.738E+04	.216E+05	0.
DISTANCE DOWNSTREAM (FT)	137280.0									
TRANSIT TIME (SECS)	30639.3									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.136E+04	.141E+04	.156E+04	.184E+04	.233E+04	.315E+04	.456E+04	.704E+04	.197E+05	0.
DISTANCE DOWNSTREAM (FT)	142560.0									
TRANSIT TIME (SECS)	31817.7									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.139E+04	.143E+04	.158E+04	.186E+04	.233E+04	.311E+04	.444E+04	.675E+04	.180E+05	0.
DISTANCE DOWNSTREAM (FT)	147840.0									
TRANSIT TIME (SECS)	32996.2									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.141E+04	.146E+04	.160E+04	.187E+04	.233E+04	.308E+04	.434E+04	.649E+04	.166E+05	.308E+05

TABLE 11.2-3 (Continued)

DISTANCE DOWNSTREAM (FT)	153120.0									
TRANSIT TIME (SECS)	34174.6									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.144E+04	.148E+04	.162E+04	.189E+04	.233E+04	.305E+04	.425E+04	.626E+04	.154E+05	.275E+05
DISTANCE DOWNSTREAM (FT)	158400.0									
TRANSIT TIME (SECS)	35353.0									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.146E+04	.151E+04	.164E+04	.190E+04	.233E+04	.303E+04	.417E+04	.606E+04	.144E+05	.246E+05
DISTANCE DOWNSTREAM (FT)	163680.0									
TRANSIT TIME (SECS)	36531.5									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.149E+04	.153E+04	.166E+04	.192E+04	.233E+04	.301E+04	.409E+04	.587E+04	.134E+05	.225E+05
DISTANCE DOWNSTREAM (FT)	168960.0									
TRANSIT TIME (SECS)	37709.9									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.151E+04	.155E+04	.168E+04	.193E+04	.234E+04	.299E+04	.403E+04	.571E+04	.126E+05	.205E+05
DISTANCE DOWNSTREAM (FT)	174240.0									
TRANSIT TIME (SECS)	38888.3									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.153E+04	.157E+04	.170E+04	.195E+04	.234E+04	.297E+04	.397E+04	.556E+04	.119E+05	.189E+05
DISTANCE DOWNSTREAM (FT)	179520.0									
TRANSIT TIME (SECS)	40066.8									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.156E+04	.160E+04	.173E+04	.196E+04	.235E+04	.296E+04	.391E+04	.542E+04	.113E+05	.174E+05

TABLE 11.2-3 (Continued)

DISTANCE DOWNSTREAM (FT)	184800.0									
TRANSIT TIME (SECS)	41245.2									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.158E+04	.162E+04	.175E+04	.198E+04	.235E+04	.294E+04	.386E+04	.530E+04	.107E+05	.162E+05
DISTANCE DOWNSTREAM (FT)	190080.0									
TRANSIT TIME (SECS)	42423.7									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.160E+04	.164E+04	.177E+04	.199E+04	.236E+04	.293E+04	.382E+04	.519E+04	.102E+05	.151E+05
DISTANCE DOWNSTREAM (FT)	195360.0									
TRANSIT TIME (SECS)	43602.1									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.162E+04	.166E+04	.178E+04	.201E+04	.237E+04	.292E+04	.378E+04	.509E+04	.977E+04	.141E+05
DISTANCE DOWNSTREAM (FT)	200640.0									
TRANSIT TIME (SECS)	44780.5									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.165E+04	.168E+04	.180E+04	.202E+04	.238E+04	.292E+04	.374E+04	.499E+04	.936E+04	.133E+05
DISTANCE DOWNSTREAM (FT)	205920.0									
TRANSIT TIME (SECS)	45959.0									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.167E+04	.170E+04	.182E+04	.204E+04	.238E+04	.291E+04	.371E+04	.490E+04	.898E+04	.125E+05
DISTANCE DOWNSTREAM (FT)	211200.0									
TRANSIT TIME (SECS)	47137.4									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.169E+04	.173E+04	.184E+04	.205E+04	.239E+04	.291E+04	.368E+04	.482E+04	.864E+04	.119E+05

TABLE 11.2-3 (Continued)

DISTANCE DOWNSTREAM (FT)	216480.0									
TRANSIT TIME (SECS)	48315.8									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.171E+04	.175E+04	.186E+04	.207E+04	.240E+04	.290E+04	.365E+04	.475E+04	.833E+04	.113E+05
DISTANCE DOWNSTREAM (FT)	221760.0									
TRANSIT TIME (SECS)	49494.3									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.173E+04	.177E+04	.188E+04	.209E+04	.241E+04	.290E+04	.362E+04	.467E+04	.804E+04	.107E+05
DISTANCE DOWNSTREAM (FT)	227040.0									
TRANSIT TIME (SECS)	50672.7									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.175E+04	.179E+04	.190E+04	.210E+04	.242E+04	.290E+04	.360E+04	.461E+04	.778E+04	.102E+05
DISTANCE DOWNSTREAM (FT)	232320.0									
TRANSIT TIME (SECS)	51851.1									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.177E+04	.181E+04	.192E+04	.212E+04	.243E+04	.289E+04	.357E+04	.455E+04	.753E+04	.979E+04
DISTANCE DOWNSTREAM (FT)	237600.0									
TRANSIT TIME (SECS)	53029.6									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.179E+04	.183E+04	.193E+04	.213E+04	.244E+04	.289E+04	.355E+04	.449E+04	.731E+04	.938E+04
DISTANCE DOWNSTREAM (FT)	242880.0									
TRANSIT TIME (SECS)	54208.0									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	181E+04	.184E+04	.195E+04	.215E+04	.245E+04	.289E+04	.353E+04	.444E+04	.710E+04	.901E+04

TABLE 11.2-3 (Continued)

DISTANCE DOWNSTREAM (FT)	248160.0									
TRANSIT TIME (SECS)	55886.4									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.183E+04	.186E+04	.197E+04	.216E+04	.246E+04	.289E+04	.352E+04	.438E+04	.690E+04	.868E+04
DISTANCE DOWNSTREAM (FT)	253440.0									
TRANSIT TIME (SECS)	56564.9									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.185E+04	.188E+04	.199E+04	.218E+04	.247E+04	.289E+04	.350E+04	.434E+04	.672E+04	.837E+04
DISTANCE DOWNSTREAM (FT)	258720.0									
TRANSIT TIME (SECS)	57743.3									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.187E+04	.190E+04	.201E+04	.219E+04	.248E+04	.289E+04	.348E+04	.429E+04	.656E+04	.808E+04
DISTANCE DOWNSTREAM (FT)	264000.0									
TRANSIT TIME (SECS)	58921.7									
CROSSTREAM DISTANCE (FT)	1.	100.	200.	300.	400.	500.	600.	700.	900.	1100.
DILUTION OF ALL NUCLID	.189E+04	.192E+04	.202E+04	.220E+04	.249E+04	.289E+04	.347E+04	.425E+04	.640E+04	.782E+04

TABLE 11.2-4 SUMMARY OF CALCULATED LIQUID PATHWAY DOSES - CALLAWAY PLANT

Pathway	Location	Age Group	Organ Receiving Maximum Dose: Organ	Organ Receiving Maximum Dose: Dose (mrem/yr)	Total Body Dose (mrem/yr)
Fish Ingestion	Missouri River - 0.05 miles downstream of discharge	Adult	Liver	5.73E-1	4.34E-1
		Teen	Liver	5.86E-1	2.52E-1
		Child	Liver	5.06E-1	1.01E-1
Shoreline Activity	Recreational access points on the Missouri River within 50 miles downstream of the discharge	Adult	Skin	3.19E-4	2.73E-4
		Teen	Skin	1.78E-3	1.53E-3
		Child	Skin	3.72E-4	3.19E-4

11.3.3.4.1 Diffusion Models

Annual average dilution factors (χ/Q's) utilized in evaluating the releases of gaseous effluents were calculated according to the straightline method set forth in Regulatory Guide 1.111, based on three years of on-site meteorological data acquired during the periods of May 4, 1973, through May 4, 1975, and March 16, 1978, through March 16, 1979. A detailed discussion of the applicable methodology appears in Sections 2.3.4 and 2.3.5 with the results of the calculation of annual χ/Q values listed in Table 2.3-61 through 2.3-86.

11.4.2.4 Packaging, Storage, and Shipment

See FSAR Standard Plant,Section 11.4.1.2 and11.4.2.5.