Southern Nuclear

Regulatory Affairs

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U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
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Edwin I. Hatch Nuclear Plant – Units 1&2
Joseph M. Farley Nuclear Plant – Units 1&2
Vogtle Electric Generating Plant – Units 1&2
Vogtle Electric Generating Plant – Unit 3
Annual Non-Radiological Environmental Operating Reports and Annual Radioactive Effluent Release Reports for 2022

Ladies and Gentlemen:

In accordance with subsection 5.4.1 of the Edwin I. Hatch Nuclear Plant (HNP) – Units 1&2, Joseph M. Farley Nuclear Plant (FNP) – Units 1&2, and Vogtle Electric Generating Plant (VEGP) – Units 1&2 Environmental Protection Plans (Appendix B to the operating licenses), Southern Nuclear Operating Company hereby submits the Annual Non-Radiological Environmental Operating Reports for 2022. These reports are included as attachments to this letter. The VEGP Unit 3 Environmental Protection Plan does not require submittal of an Annual Non-Radiological Environmental Operating Report.

In accordance with section 5.6.3 of the HNP, FNP, and VEGP Units 1&2 Technical Specifications (TS), Southern Nuclear Operating Company hereby submits the Annual Radioactive Effluent Release Reports for 2022. In accordance with section 5.6.2 of the VEGP Unit 3 TS, SNC hereby submits the Annual Radioactive Effluent Release Report for 2022. These reports are included as attachments to this letter.

TS 5.5.1.c for each plant requires that the Offsite Dose Calculation Manual (ODCM) be provided as part of, or concurrent with, the Radioactive Effluent Release Report for the period of the report in which any change in the ODCM was made. During the reporting period for the Annual Radioactive Effluent Release Reports for 2022, there were ODCM revisions for VEGP Units 1&2 and VEGP Unit 3. These ODCM revisions are included as attachments to this letter.

This letter contains no NRC commitments. If you have any questions, please contact Amy Chamberlain at 205.992.6361.

Respectfully submitted,

R. Keith Brown
Regulatory Affairs Director

RKB/kgl/cg

Enclosures:

1. Edwin I. Hatch Nuclear Plant – Units 1&2 Annual Non-Radiological Environmental Operating Report for 2022

2. Joseph M. Farley Nuclear Plant – Units 1&2 Annual Non-Radiological Environmental Operating Report for 2022

3. Vogtle Electric Generating Plant – Units 1&2 Annual Non-Radiological Environmental Operating Report for 2022

4. Edwin I. Hatch Nuclear Plant – Units 1&2 Annual Radioactive Effluent Release Report for 2022

5. Joseph M. Farley Nuclear Plant – Units 1&2 Annual Radioactive Effluent Release Report for 2022

6. Vogtle Electric Generating Plant – Units 1&2 Annual Radioactive Effluent Release Report for 2022

7. Vogtle Electric Generating Plant – Unit 3 Annual Radioactive Effluent Release Report for 2022

8. Vogtle Electric Generating Plant - Units 1&2 Offsite Dose Calculation Manual – Version 35

9. Vogtle Electric Generating Plant - Units 1&2 Offsite Dose Calculation Manual – Version 36

10. Vogtle Electric Generating Plant – Unit 3 Offsite Dose Calculation Manual – Version 3

cc: Regional Administrator, Region II
NRR Project Manager – Farley, Hatch, Vogtle 1 & 2
Project Manager – Vogtle Project Office
Senior Resident Inspector – Farley, Hatch, Vogtle 1 & 2, Vogtle 3
RType: CGA02.001

Edwin I. Hatch Nuclear Plant – Units 1&2
Joseph M. Farley Nuclear Plant – Units 1&2
Vogtle Electric Generating Plant – Units 1&2
Vogtle Electric Generating Plant – Unit 3
Annual Non-Radiological Environmental Operating Reports and Annual Radioactive Effluent Release Reports for 2022

Enclosure 1

Edwin I. Hatch Nuclear Plant – Units 1&2
Annual Non-Radiological Environmental Operating Report for 2022

EDWIN I. HATCH NUCLEAR PLANT – UNITS 1 AND 2

I. Introduction

This report is submitted in accordance with Subsection 5.4.1 of the Edwin I. Hatch Nuclear Plant Environmental Protection Plan, Appendix B to Facility Operating Licenses DPR-57 and NPF-5. This report describes implementation of the Environmental Protection Plan for the calendar year 2022.

II. Reporting Requirements

A. Summaries and Analyses of Results of Environmental Protection Activities Required by Subsection 4.2 of the Environmental Protection Plan (EPP) for the Reporting Period

1. Aquatic Monitoring - Liquid effluent monitoring was performed in accordance with the State of Georgia National Pollutant Discharge Elimination System (NPDES) Permit GA0004120; there was no additional requirement for aquatic monitoring during the year.

2. Terrestrial Monitoring - Terrestrial monitoring is not required.

3. Maintenance of Transmission Line Corridors – There is no reporting requirement associated with this condition.

B. Comparisons of the Year's Monitoring Activities with Preoperational Studies, Operational Controls, and Previous Nonradiological Environmental Monitoring Reports

These comparisons were not required because no nonradiological environmental monitoring programs were conducted during the reporting period beyond those performed in accordance with NPDES Permit No. GA0004120.

C. Assessment of the Observed Impacts of Plant Operation on the Environment

There were no significant adverse environmental impacts associated with plant operation during the year.

D. EPP Noncompliance and Corrective Actions

There were no EPP noncompliances during the year.

E. Changes in Station Design or Operation, Tests, or Experiments Made in Accordance with EPP Subsection 3.1 Which Involved a Potentially Significant Unreviewed Environmental Question

There were no changes in station design or operation, tests, or experiments which involved a potentially significant, unreviewed environmental question.

F. Nonroutine Reports Submitted in Accordance with EPP Section 5.4.2

There were no nonroutine reports submitted during the year.

Edwin I. Hatch Nuclear Plant – Units 1&2
Joseph M. Farley Nuclear Plant – Units 1&2
Vogtle Electric Generating Plant – Units 1&2
Vogtle Electric Generating Plant – Unit 3
Annual Non-Radiological Environmental Operating Reports and Annual Radioactive Effluent Release Reports for 2022

Enclosure 2

Joseph M. Farley Nuclear Plant – Units 1&2
Annual Non-Radiological Environmental Operating Report for 2022

JOSEPH M. FARLEY NUCLEAR PLANT - UNITS 1 AND 2

I. Introduction

In accordance with Subsection 5.4.1 of the Joseph M. Farley Nuclear Plant Environmental Protection Plan, Appendix B to Facility Operating License Nos. NPF-2 and NPF-8, this report is submitted summarizing implementation of the Environmental Protection Plan for calendar year 2022.

II. Reporting Requirements

A. Summaries and Analyses of Results of Environmental Protection Activities Required by Subsection 4.2 of the Environmental Protection Plan (EPP) for the Reporting Period

1. Aerial Remote Sensing - Aerial Remote Sensing is no longer required.
2. Herbicide Application - There is no reporting requirement associated with this condition.
3. Land Management - There is no reporting requirement associated with this condition.

B. Comparison of the Year's Monitoring Activities with Preoperational Studies, Operational Controls, and Previous Non-Radiological Monitoring Reports

These comparisons were not required because no nonradiological environmental monitoring programs were conducted during the reporting period beyond those performed in accordance with NPDES Permit No. AL0024619.

C. Assessment of the Observed Impacts of Plant Operation on the Environment

There were no significant adverse environmental impacts associated with plant operation during the year.

D. EPP Noncompliance and Corrective Actions

There were no EPP noncompliances during the year.

E. Changes in Station Design or Operation, Tests, or Experiments Made in Accordance with EPP Section 3.1 Which Involved a Potentially Significant Unreviewed Environmental Question

There were no changes in station design or operation, tests, or experiments which involved a potentially significant, unreviewed environmental question.

F. Nonroutine Reports Submitted in Accordance with EPP Section 5.4.2

There were no nonroutine reports submitted during the year.

Edwin I. Hatch Nuclear Plant – Units 1&2
Joseph M. Farley Nuclear Plant – Units 1&2
Vogtle Electric Generating Plant – Units 1&2
Vogtle Electric Generating Plant – Unit 3
Annual Non-Radiological Environmental Operating Reports and Annual Radioactive Effluent Release Reports for 2022

Enclosure 3

Vogtle Electric Generating Plant – Units 1&2
Annual Non-Radiological Environmental Operating Report for 2022

VOGTLE ELECTRIC GENERATING PLANT - UNITS 1 AND 2

I. Introduction

In accordance with Subsection 5.4.1 of the Vogtle Electric Generating Plant (VEGP) Environmental Protection Plan (Nonradiological), Appendix B to Facility Operating License Nos. NPF-68 and NPF-81, this report is submitted describing implementation of the Environmental Protection Plan for the calendar year 2022.

II. Reporting Requirements

A. Summaries and Analyses of Results of Environmental Protection Activities Required by Subsection 4.2 of the Environmental Protection Plan (EPP) for the Reporting Period

1. Aquatic Monitoring - Liquid effluent monitoring was performed in accordance with State of Georgia National Pollutant Discharge Elimination System (NPDES) Permit GA0026786; there was no additional requirement for aquatic monitoring during the year.

2. Terrestrial Monitoring - Terrestrial monitoring is not required.

3. Maintenance of Transmission Line Corridors – There is no reporting requirement associated with this condition.

4. Noise Monitoring - There were no complaints reported regarding noise along the VEGP-related, high-voltage transmission lines.

B. Comparison of the Year's Monitoring Activities with Preoperational Studies, Operational Controls, and Previous Monitoring Reports

These programs were not required because no nonradiological environmental monitoring programs were conducted during the reporting period beyond those performed in accordance with NPDES Permit No. GA0026786 referenced in Section A above.

C. Assessment of the Observed Impacts of Plant Operation on the Environment

There were no significant adverse environmental impacts associated with plant operation during the year.

D. EPP Noncompliance and Corrective Actions

There were no EPP noncompliances during the year.

E. Changes in Station Design or Operation, Tests, or Experiments Made in Accordance with EPP Subsection 3.1 Which Involved a Potentially Significant Unreviewed Environmental Question

There were no changes in station design or operation, tests, or experiments which involved a potentially significant, unreviewed environmental question.

F. Nonroutine Reports Submitted in Accordance with EPP Section 5.4.2

There were no nonroutine reports submitted during the year.

Edwin I. Hatch Nuclear Plant – Units 1&2
Joseph M. Farley Nuclear Plant – Units 1&2
Vogtle Electric Generating Plant – Units 1&2
Vogtle Electric Generating Plant – Unit 3
Annual Non-Radiological Environmental Operating Reports and Annual Radioactive Effluent Release Reports for 2022

Enclosure 4

Edwin I. Hatch Nuclear Plant – Units 1&2
Annual Radioactive Effluent Release Report for 2022

Southern Nuclear

E. I. Hatch Nuclear Plant

2022
Annual Radioactive Effluent Release Report

Document Number: 50-321 & 50-366

Prepared By: Chris Edmund / Chris Edmund Date: 4-20-23
Chemistry Supervisor

Reviewed By: Steven Sellers / Steven Sellers Date: 4/20/23
Chemistry Manager

TABLE OF CONTENTS

TABLES

FIGURES

ATTACHMENTS

1.0 LIST OF ACRONYMS AND DEFINITIONS

1. Airborne Activity Sampling: Sampling of air through the collection of particulates and radionuclides on filter media, collection of noble gases in a container, and collection of water vapor containing tritium.

2. Alpha Particle (α): A charged particle emitted from the nucleus of an atom having a mass and charge equal in magnitude of a helium nucleus.

3. BWR: Boiling Water Reactor

4. Composite Sample: A series of single collected portions (aliquots) analyzed as one sample. The aliquots making up the sample are collected at time intervals that are very short compared to the composite period.

5. Control: A sampling station in a location not likely to be affected by plant effluents due to its distance and/or direction from the Plant.

6. Counting Error: An estimate of the two-sigma uncertainty associated with the sample results based on total counts accumulated.

7. Curie (Ci): A measure of radioactivity; equal to 3.7×10^{10} disintegrations per second, or 2.22×10^{12} disintegrations per minute.

8. Direct Radiation Monitoring: The measurement of radiation dose at various distances from the plant is assessed using thermoluminescent dosimeters (TLDs), optically stimulated luminescent dosimeters (OSLDs), and/or pressurized ionization chambers.

9. ECL: Effluent Concentration Limit from 10 CFR 20, Appendix B, Table 2 Columns 2.

10. Grab Sample: A single discrete sample drawn at one point in time.

11. Indicator: A sampling location that is likely to be affected by plant effluents due to its proximity and/or direction from the plant.

12. Ingestion Pathway: The ingestion pathway includes milk, fish, and garden produce. Meat or other food products may also be included.

13. ISFSI: Independent Spent Fuel Storage Installation

14. Lower Limit of Detection (LLD): The smallest concentration of radioactive material in a sample that will yield a net count (above system background) that will be detected with 95% probability with a 5% probability of a false conclusion that a blank observation represents "real" signal.

15. MDA: Minimum Detectable Activity. - For radiochemistry instruments, the MDA is the a posteriori minimum concentration that a counting system detects. The smallest concentration or activity of radioactive material in a sample that will yield a net count above instrument background and that is detected with 95% probability, with only five % probability of falsely concluding that a blank observation represents a true signal.

16. MDC: Minimum Detectable Concentration, essentially synonymous with MDA for the purposes of radiological monitoring.

17. Mean: The average, i.e., the sum of results divided by the number of results.

18. Microcurie (µCi): 3.7 x 10^4 disintegrations per second, or 2.22 x10^6 disintegrations per minute.

19. millirem (mrem): 1/1000 rem; a unit of radiation dose equivalent in tissue.

20. Milliroentgen (mR): 1/1000 Roentgen; a unit of exposure to X- or gamma radiation.

21. MWe: Megawatts Electric

22. MWTh: Megawatts Thermal

23. NA: Not Applicable

24. NDM: No Detectable Measurement

25. NEI: Nuclear Energy Institute

26. NS: Not Sampled

27. NRC: Nuclear Regulatory Commission

28. ODCM: Offsite Dose Calculation Manual

29. OSLD: Optically Stimulated Luminescence Dosimeter

30. Protected Area: The fenced area immediately surrounding the Plant. Access to the protected area requires a security badge or escort.

31. PWR: Pressurized Water Reactor

32. REC: Radiological Effluent Control

33. REMP: Radiological Environmental Monitoring Program

34. Restricted Area: Any area where access is controlled for the purpose of protecting individuals from exposure to radiation or radioactive materials.

35. SLCs: Selected Licensee Commitments

36. TEDE: Total Effective Dose Equivalent (TEDE) means the sum of the effective dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

37. TLD: Thermoluminescent Dosimeter

38. TRM: Technical Requirements Manual

39. TS: Technical Specification

2.0 EXECUTIVE SUMMARY

E. I. Hatch Nuclear Plant (HNP) Radiological Effluent Control (REC) Program was established to limit the quantities of radioactive material that may be released based on calculated radiation doses or dose rates. Dose to Members of the Public due to radioactive materials released from the plant is limited by Appendix I of 10 CFR 50 and by 40 CFR 190. Operational doses to the public during 2022 were calculated to be very small compared to the limits required by regulation and compared to other sources of radiation dose and pose no health hazard. These doses are summarized and compared to the regulatory limits in Section 2.1, Comparison to Regulatory Limits, below.

The Annual Radioactive Effluent Release Report (ARERR) is published per REC requirements and provides data related to plant operation, including: quantities of radioactive materials released in liquid and gaseous effluents; radiation doses to members of the public; solid radioactive waste shipped offsite for disposal; and other information as required by site licensing documents.

In 2022 the Land Use Census dose assessments due to radioactive gaseous effluents showed that the critical receptor for E. I. Hatch Nuclear Plant is the Child, due to the Inhalation Pathway, at the Site Boundary. The maximum Annual Organ Doses calculated for this receptor were 1.54E-02 and 3.79E-02 mrem, to the thyroid from Unit 1 and Unit 2, respectively. This annual dose is a small fraction (1.03E-01% and 2.52E-01%), respectively of the 10 CFR 50, Appendix I guideline of 15 mrem to the Maximum Organ per reactor unit.

Solid radioactive waste shipped offsite for disposal included 8.56E+02 Curies and 9.46E+02 m^3, shipped in 51 shipments.

In addition to monitoring radioactive effluents, HNP has a Radiological Environmental Monitoring Program (REMP) that monitors for buildup of radioactivity in the offsite environment. Data from the REMP is published in the Annual Radiological Environmental Operating Report (AREOR).

2.1 Comparison to Regulatory Limits

During 2022 all solid, liquid, and gaseous radioactive effluents from E. I. Hatch Nuclear Plant were well below regulatory limits, as summarized in Table 1 Table 2, and Table 3.

Table 1, E. I. Hatch Nuclear Plant Unit 1 Dose Summary[1]

		Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual
Liquid Effluent Dose Limit, Total Body	Limit	**1.5 mrem**	**1.5 mrem**	**1.5 mrem**	**1.5 mrem**	**3 mrem**
	Total Body Dose	5.73E-04	1.06E-05	1.25E-04	1.18E-05	7.20E-04
	% of Limit	3.82E-02	7.05E-04	8.36E-03	7.89E-04	2.40E-02
Liquid Effluent Dose Limit, Any Organ	Limit	**5 mrem**	**5 mrem**	**5 mrem**	**5 mrem**	**10 mrem**
	Max Organ Dose	1.16E-03	1.06E-05	9.82E-05	2.23E-05	1.29E-03
	% of Limit	2.33E-02	2.12E-04	1.96E-03	4.46E-04	1.29E-02
Gaseous Effluent Dose Limit, Gamma Air (Noble Gas)	Limit	**5 mrad**	**5 mrad**	**5 mrad**	**5 mrad**	**10 mrad**
	Gamma Air Dose	6.17E-06	1.68E-05	3.69E-06	1.31E-05	3.97E-05
	% of Limit	1.23E-04	3.36E-04	7.39E-05	2.61E-04	3.97E-04
Gaseous Effluent Dose Limit, Beta Air (Noble Gas)	Limit	**10 mrad**	**10 mrad**	**10 mrad**	**10 mrad**	**20 mrad**
	Beta Air Dose	1.90E-06	1.48E-05	3.53E-06	2.54E-06	2.28E-05
	% of Limit	1.90E-05	1.48E-04	3.53E-05	2.54E-05	1.14E-04
Gaseous Effluent Organ Dose Limit (Iodine, Tritium, Particulates with > 8-day half-life)	Limit	**7.5 mrem**	**7.5 mrem**	**7.5 mrem**	**7.5 mrem**	**15 mrem**
	Max Organ Dose	5.08E-03	3.43E-03	3.45E-03	3.48E-03	1.54E-02
	% of Limit	6.78E-02	4.58E-02	4.60E-02	4.63E-02	1.03E-01

[1] Table 1 demonstrates compliance with 10 CFR Part 50, App. I Limits.

Table 2, E. I. Hatch Nuclear Plant Unit 2 Dose Summary[1]

		Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual
Liquid Effluent Dose Limit, Total Body	Limit	**1.5 mrem**	**1.5 mrem**	**1.5 mrem**	**1.5 mrem**	**3 mrem**
	Total Body Dose	1.45E-04	1.08E-05	9.22E-05	6.71E-05	3.15E-04
	% of Limit	9.64E-03	7.19E-04	6.15E-03	4.47E-03	1.05E-02
Liquid Effluent Dose Limit, Any Organ	Limit	**5 mrem**	**5 mrem**	**5 mrem**	**5 mrem**	**10 mrem**
	Max Organ Dose	1.72E-04	1.24E-05	8.92E-05	8.70E-04	1.14E-03
	% of Limit	3.43E-03	2.49E-04	1.78E-03	1.74E-02	1.14E-02
Gaseous Effluent Dose Limit, Gamma Air (Noble Gas)	Limit	**5 mrad**	**5 mrad**	**5 mrad**	**5 mrad**	**10 mrad**
	Gamma Air Dose	5.43E-06	6.09E-06	1.09E-06	1.23E-05	2.49E-05
	% of Limit	1.09E-04	1.22E-04	2.18E-05	2.46E-04	2.49E-04
Gaseous Effluent Dose Limit, Beta Air (Noble Gas)	Limit	**10 mrad**	**10 mrad**	**10 mrad**	**10 mrad**	**20 mrad**
	Beta Air Dose	1.51E-06	1.69E-06	3.03E-07	3.84E-06	7.34E-06
	% of Limit	1.51E-05	1.69E-05	3.03E-06	3.84E-05	3.67E-05
Gaseous Effluent Organ Dose Limit (Iodine, Tritium, Particulates with > 8-day half-life)	Limit	**7.5 mrem**	**7.5 mrem**	**7.5 mrem**	**7.5 mrem**	**15 mrem**
	Max Organ Dose	7.52E-03	8.85E-03	1.23E-02	9.19E-03	3.79E-02
	% of Limit	1.00E-01	1.18E-01	1.64E-01	1.23E-01	2.52E-01

[1] Table 2 demonstrates compliance with 10 CFR Part 50, App. I Limits.

Table 3, Total Annual Offsite-Dose Comparison to 40 CFR 190 Limits for HNP[1]

	Whole Body	**Thyroid**	**Max Other Organ**
Gaseous[2]	5.30E-02	5.33E-02	5.30E-02
C-14	6.32E-02	6.32E-02	3.18E-01
Liquid	1.04E-03	4.14E-04	2.43E-03
Total Site Dose	1.17E-01	1.17E-01	3.73E-01
Other Nearby Facility[3]	N/A	N/A	N/A
Total	1.17E-01	1.17E-01	3.73E-01
Limit	**25 mrem**	**75 mrem**	**25 mrem**
% of Limit	4.69E-01	1.56E-01	1.49E+00

[1] Table 3 is a summation of Units to show compliance with 40 CFR Part 190 Limits.
[2] Gaseous dose values in Table 3 include organ dose from Iodine, Tritium, and particulates.
[3] Other fuel cycle sources within 5 miles of the site are considered in this analysis.

3.0 INTRODUCTION

3.1 About Nuclear Power

Commercial nuclear power plants are generally classified as either Boiling Water Reactors (BWRs) or Pressurized Water Reactors (PWRs), based on their design. A BWR includes a single coolant system where water used as reactor coolant boils as it passes through the core and the steam generated is used to turn the turbine generator for power production. A PWR, in contrast, includes two separate water systems: radioactive reactor coolant and a secondary system. Reactor coolant is maintained under high pressure, preventing boiling. The high-pressure coolant is passed through a heat exchanger called a steam generator where the secondary system water is boiled, and the steam is used to turn the turbine generator for power production.

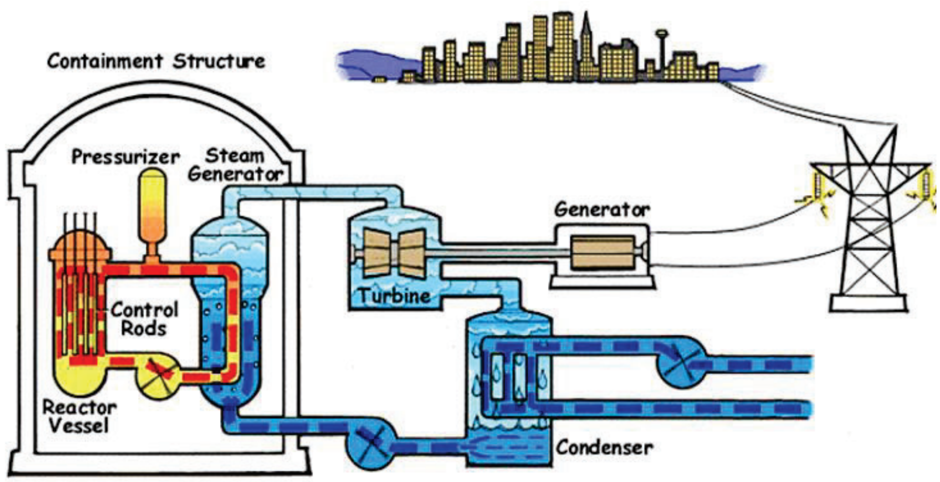

Figure 1, Pressurized Water Reactor (PWR) [1]

3.1 (Continued)

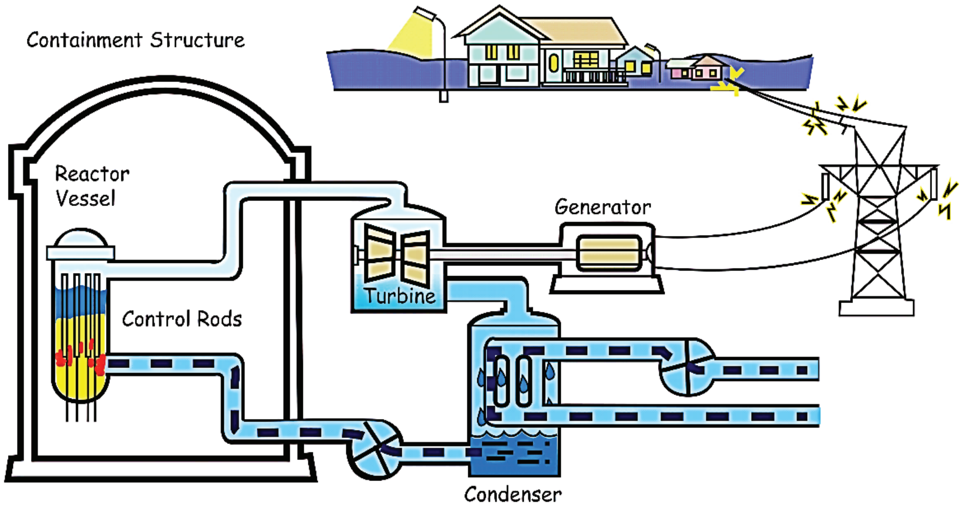

Figure 2, Boiling Water Reactor (BWR) [2]

Electricity is generated by a nuclear power plant similarly to the way that electricity is generated at other conventional types of power plants, such as those driven by coal or natural gas. Water is boiled to generate steam; the steam turns a turbine that is attached to a generator and the steam is condensed back into water to be returned to the boiler. What makes nuclear power different from these other types of power plants is that the heat is generated by fission and decay reactions occurring within and around the core containing fissionable uranium (U-235).

Nuclear fission occurs when certain nuclides (primarily U-233, U-235, or Pu-239) absorb a neutron and break into several smaller nuclides (called fission products) as well as some additional neutrons.

Fission results in production of radioactive materials including gases and solids that must be contained to prevent release or treated prior to release. These effluents are generally treated by filtration and/or hold-up prior to release. Releases are generally monitored by sampling and by continuously indicating radiation monitors. The effluent release data is used to calculate doses to ensure that dose to the public due to plant operation remains within required limits.

3.2 About Radiation Dose

Ionizing radiation, including alpha, beta, and gamma radiation from radioactive decay, has enough energy to break chemical bonds in tissues and result in damage to tissue or genetic material. The amount of ionization that will be generated by a given exposure to ionizing radiation is quantified as dose. Radiation dose is generally reported in units of millirem (mrem) in the US.

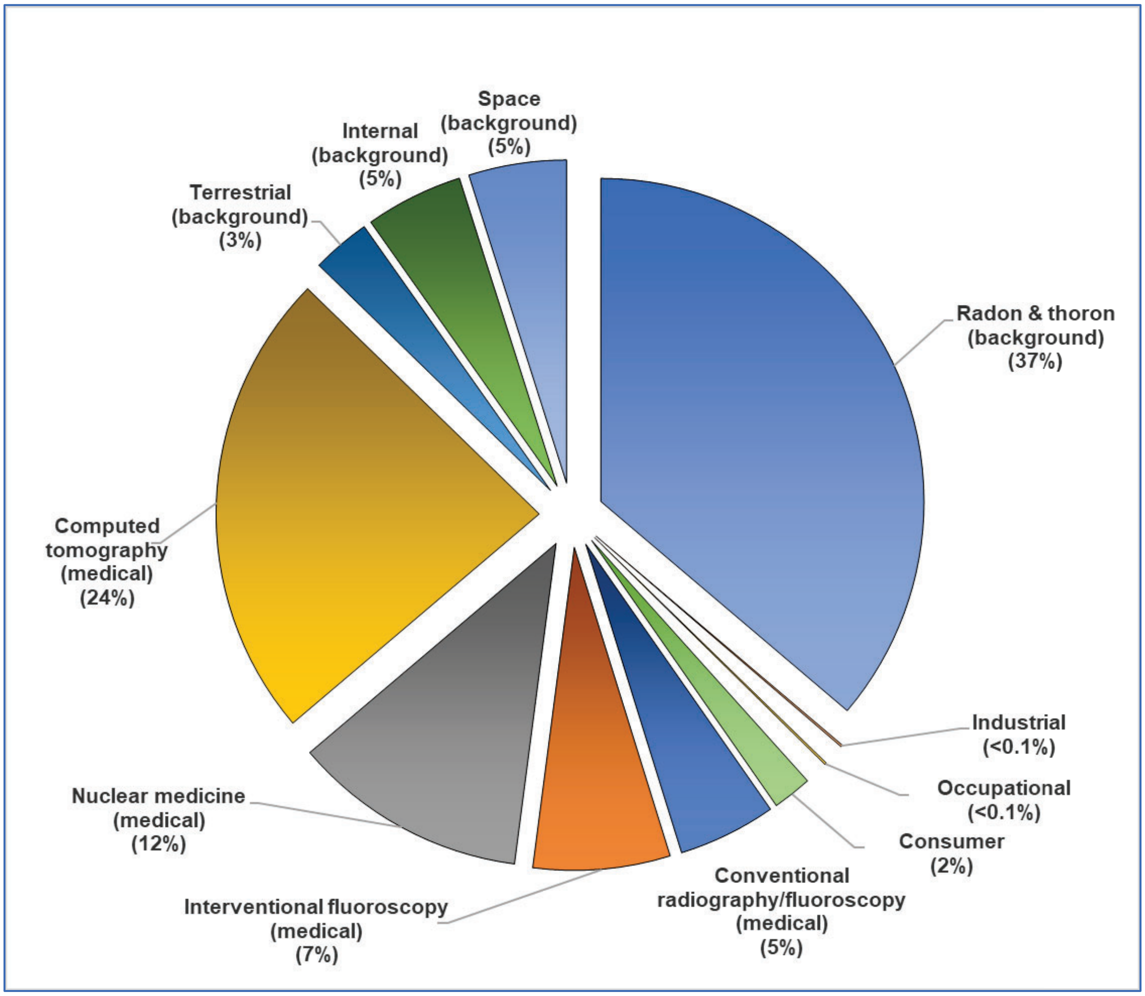

Figure 3, Sources of Radiation Exposure [3]

3.2 (Continued)

The National Council on Radiation Protection (NCRP) has evaluated the population dose for the US and determined that the average individual is exposed to approximately 620 mrem per year [3]. There are many sources for radiation dose, ranging from natural background sources to medical procedures, air travel, and industrial processes. Approximately half (310 mrem) of the average exposure is due to natural sources of radiation including exposure to Radon, cosmic radiation, and internal radiation and terrestrial due to naturally occurring radionuclides. The remaining 310 mrem of exposure is due to man-made sources of exposure, with the most significant contributors being medical (48%) due to radiation used in various types of medical scans and treatments. Of the remaining 2% of dose, most is due to consumer activities such as air travel, smoking cigarettes, and building materials. A small fraction of this 2% is due to industrial activities including generation of nuclear power.

Readers that are curious about common sources and effects of radiation dose that they may encounter can find excellent sources of information from the Health Physics Society, including the Radiation Fact Sheets [4], and from the US Nuclear Regulatory Commission website [5].

3.3 About Dose Calculation

The concentrations of radioactive material in the environment resulting from plant operations are very small and it is not possible to determine doses directly using measured activities of environmental samples. To overcome this, Dose Calculations based on measured activities of effluent streams are used to model the dose impact for Members of the Public due to plant operation and effluents. There are several mechanisms that can result in dose to Members of the Public, including: Ingestion of radionuclides in food or water; Inhalation of radionuclides in air; Immersion in a plume of noble gases; and Direct Radiation from the ground, the plant or from an elevated plume.

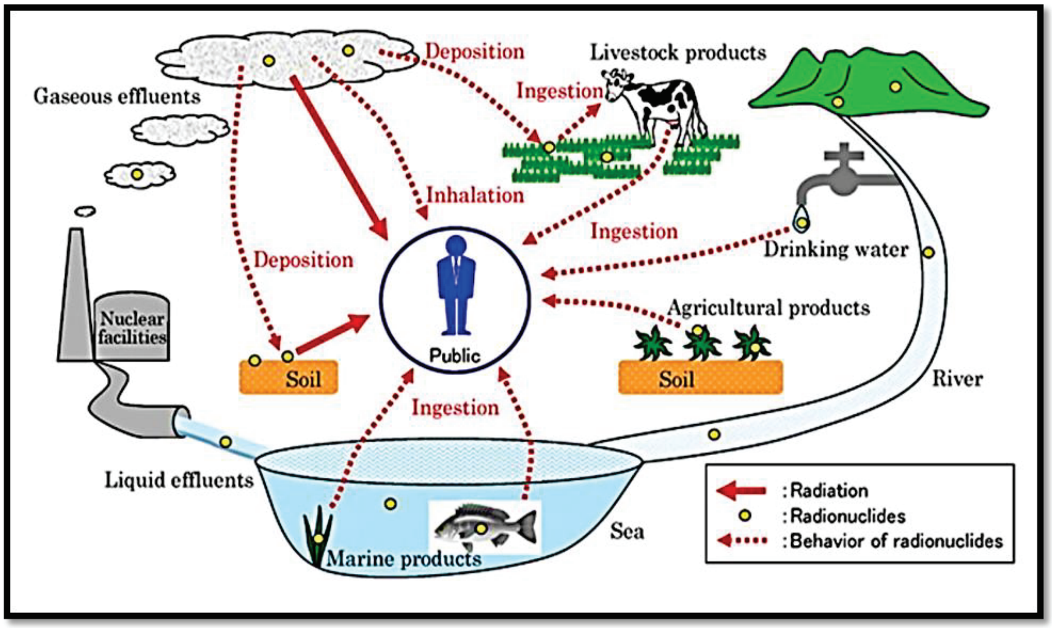

Figure 4, Potential exposure pathways to Members of the Public due to Plant Operations [6]

The Offsite Dose Calculation Manual (ODCM) specifies the methodology used to obtain the doses in the Dose Assessment section of this report. The methodology in the ODCM is based on NRC Regulatory Guide 1.109 [7] and NUREG-0133 [8]. Doses are calculated by determining what the nuclide concentration will be in air, water, on the ground, or in food products based on plant effluent releases. Release points are continuously monitored to quantify what concentrations of nuclides are being released. For gaseous releases meteorological data is used to determine how much of the released activity will be present at a given location outside of the plant either deposited onto the ground or in gaseous form. Intake patterns and nuclide bio-concentration factors are used to determine how much activity will be transferred into animal milk or meat. Finally, human ingestion factors and dose factors are used to determine how much activity will be consumed and how much dose the consumer will receive. Inhalation dose is calculated by determining the concentration of nuclides and how much air is breathed by the individual.

3.3 (Continued)

For liquid releases, dilution and mixing factors are used to model the environmental concentrations in water. Drinking water pathways are modeled by determining the concentration of nuclides in the water at the point where the drinking water is sourced. Fish and invertebrate pathways are determined by using concentration at the release point, bioaccumulation factors for the fish or invertebrate and an estimate of the quantity of fish consumed.

Each year a Land Use Census is performed to determine what potential dose pathways currently exist within a five-mile radius around the plant, the area most affected by plant operations. The Annual Land Use Census identifies the locations of vegetable gardens, nearest residences, milk animals and meat animals. The data from the census is used to determine who is the likely to be most exposed to radiation dose as a result of plant operation.

There is significant uncertainty in dose calculation results, due to modeling dispersion of material released and bioaccumulation factors, as well as assumptions associated with consumption and land-use patterns. Even with these sources of uncertainty, the calculations do provide a reasonable estimate of the order of magnitude of the exposure. Conservative assumptions are made in the calculation inputs such as the number of various foods and water consumed, the amount of air inhaled, and the amount of direct radiation exposure from the ground or plume, such that the actual dose received are likely lower than the calculated dose. Even with the built-in conservatism, doses calculated for the highest hypothetical exposed individual due to plant operation are a very small fraction of the annual dose that is received due to other sources. The low calculated doses due to plant effluents, along with REMP results, serve to provide assurance that the site is not having a negative impact on the environment or people living near the plant.

4.0 DOSE ASSESSMENT FOR PLANT OPERATIONS

4.1 Regulatory Limits

Regulatory limits are detailed in Station Licensing documents such as the Offsite Dose Calculation Manual (ODCM) and Technical Specifications 5.5.4. These documents contain the limits to which HNP must adhere. HNP drives to maintain the philosophy to keep dose "as low as reasonably achievable" (ALARA) and actions are taken to reduce the amount of radiation released to the environment. Liquid and gaseous release data show that the dose from HNP is well below the ODCM limits. The concentration of liquid radioactive material released shall be limited to ten times the concentration specified in 10 CFR 20, Appendix B, Table 2, Column 2, for radionuclides other than dissolved or entrained noble gases. For dissolved or entrained noble gases, the total concentration released shall be limited to 2.0×10^{-4} microcuries/ml. For gross alpha in liquid radwaste, the ECL is 2E-09 μCi/ml. This data reveal that the radioactive effluents have an overall minimal dose contribution to the surrounding environment.

The annual whole body, skin and organ dose was computed using the 2022 source term with the dose calculation methodology provided in the ODCM. The calculated doses due to gaseous effluents to demonstrate compliance with offsite dose limits are presented in Table 1, E. I. Hatch Nuclear Plant Unit 1 Dose Summary, Table 2, E. I. Hatch Nuclear Plant Unit 2 Dose Summary, and Table 3, Total Annual Offsite-Dose Comparison to 40 CFR 190 Limits for HNP.

4.2 Regulatory Limits for Gaseous Effluent Doses:

1. Fission and activation gases:

   a. Noble gases dose rate due to radioactive materials released in gaseous effluents from the site to areas at and beyond the site boundary shall be limited to the following:

      1) Less than or equal to 500 mrem/year to the total body

      2) Less than or equal to 3000 mrem/year to the skin

   b. Noble gas air dose due to noble gases released in gaseous effluents, from each reactor unit to areas at and beyond the site boundary shall be limited to the following:

      1) Quarterly
         a) Less than or equal to 5 mrads gamma
         b) Less than or equal to 10 mrads beta
      2) Yearly
         a) Less than or equal to 10 mrads gamma
         b) Less than or equal to 20 mrads beta

4.2 (Continued)

2. Iodine, tritium, and all radionuclides in particulate form with half-lives greater than 8 days.

    a. The dose rate for iodine-131, iodine-133, tritium, and all radionuclides in particulate form with half-lives greater than 8 days in gaseous effluents released from the site to areas at and beyond the site boundary shall be limited to the following:

        1) Less than or equal to 1500 mrem/yr to any organ

    b. The dose to a MEMBER OF THE PUBLIC from iodine-131, iodine-133, tritium, and all radionuclides in particulate form with half-lives greater than 8 DAYS in gaseous effluents released, from each reactor unit to areas at and beyond the site boundary shall be limited to the following:

        1) Quarterly

            a) Less than or equal to 7.5 mrem to any organ

        2) Yearly

            a) Less than or equal to 15 mrem to any organ

4.3 Regulatory Limits for Liquid Effluent Doses

1. The dose or dose commitment to a MEMBER OF THE PUBLIC from radioactive materials in liquid effluents released, from each reactor unit to unrestricted areas shall be limited to the following:

    a. Quarterly

        1) Less than or equal to 1.5 mrem total body

        2) Less than or equal to 5 mrem critical organ

    b. Yearly

        1) Less than or equal to 3 mrem total body

        2) Less than or equal to 10 mrem critical organ

4.4 40 CFR 190 Regulatory Dose Limits for a Member of the Public

1. Total Dose (40 CFR 190)

   a. The annual (calendar year) dose or dose commitment to any MEMBER OF THE PUBLIC in the unrestricted area due to releases of radioactivity and to radiation from uranium fuel cycle sources shall be limited to the following:

      1) Less than or equal to 25 mrem, Total Body or any Organ except Thyroid.

      2) Less than or equal to 75 mrem, Thyroid.

4.5 Onsite Doses (Within Site Boundary)

This section evaluates dose to non-occupationally exposed workers and members of the public that may be onsite for various reasons. The report must include any other information as may be required by the Commission to estimate maximum potential annual radiation doses to the public resulting from effluent releases as required by 10 CFR 50.36a(a)(2). While within controlled or restricted areas, the limits from Sections 4.1 through 4.4 do not apply; however, 10 CFR 20.1301 dose limit of 100 mrem per year TEDE and dose rate limit of 2 mrem per hour from external sources continue to apply. Occupancy times within the controlled areas are generally sufficiently low to compensate for the increase in the atmospheric dispersion factor above the site boundary. Groups of concern include Visitors to the several recreational areas near the HNP site. Use of a conservative assumption of between 2 hours and 208 hours per year spent inside the site boundary by these groups conservatively represents the most-exposed individual.

Table 4, Onsite Doses (Within Site Boundary)

Location	Sector	Occupancy Hours	Approx. Distance (Meters)	Total Body Dose (mrem)	
				Noble Gas	H-3, Iodine, & Particulate
Roadside Park	WNW	2	1180	0.00E+00	5.83E-08
Camping Area	WNW	48	1270	0.00E+00	1.26E-06
Recreation Area	SSE	208	1030	0.00E+00	4.96E-06
Visitor Center	WSW	4	694	0.00E+00	2.87E-07

5.0 SUPPLEMENTAL INFORMATION

5.1 Gaseous Batch Releases

5.1.1 HNP Unit 1

	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual
1. Number of Batch Releases		0	0	0	0	0
2. Total duration of batch releases	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3. Maximum batch release duration	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4. Average batch release duration	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5. Minimum batch release duration	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

5.1.2 HNP Unit 2

	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual
1. Number of Batch Releases		0	0	0	0	0
2. Total duration of batch releases	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3. Maximum batch release duration	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4. Average batch release duration	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5. Minimum batch release duration	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

5.2 Liquid Batch Releases

5.2.1 HNP Unit1

	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual
1. Number of Batch Releases		77	5	26	4	112
2. Total duration of batch releases	minutes	9.09E+03	7.24E+02	3.55E+03	6.22E+02	1.40E+04
3. Maximum batch release duration	minutes	1.78E+02	1.67E+02	1.80E+02	1.80E+02	1.80E+02
4. Average batch release duration	minutes	1.18E+02	1.45E+02	1.37E+02	1.56E+02	1.25E+02
5. Minimum batch release duration	minutes	6.70E+01	1.11E+02	8.60E+01	1.15E+02	6.70E+01
6. Avg stream flow during periods of release of liquid effluent into a flowing stream[1]	Ft^3/sec	2.16E+04	9.28E+03	8.31E+03	1.06E+04	1.24E+04

[1] Values used are the same as last years.

5.2.2 HNP Unit 2

	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual
1. Number of Batch Releases		45	3	39	22	109
2. Total duration of batch releases	minutes	6.03E+03	3.70E+02	4.48E+03	2.63E+03	1.35E+04
3. Maximum batch release duration	minutes	2.53E+02	1.28E+02	1.28E+02	1.37E+02	2.53E+02
4. Average batch release duration	minutes	1.34E+02	1.23E+02	1.15E+02	1.20E+02	1.24E+02
5. Minimum batch release duration	minutes	1.06E+02	1.20E+02	9.60E+01	1.07E+02	9.60E+01
6. Avg stream flow during periods of release of liquid effluent into a flowing stream[1]	Ft^3/sec	2.16E+04	9.28E+03	8.31E+03	1.06E+04	1.24E+04

5.3 Abnormal Releases

5.3.1 Gaseous Abnormal Releases

There were no abnormal gaseous releases during this period.

5.3.2 Liquid Abnormal Releases

There were no abnormal liquid releases during this period.

5.4 Land Use Census Changes

There were no changes in the Land Use Census that impacted Radiological Controls Program.

5.5 Meteorological Data

The meteorological monitoring program achieved a joint data recovery rate for 2022 of > 90%.

The annual summary of hourly meteorological data collected over the previous year may be either in the form of an hour-by-hour listing of wind speed, wind direction, atmospheric stability, and precipitation (if measured), on magnetic tape, or, in the form of joint frequency distributions of wind speed, wind direction and atmospheric stability. In lieu of submission with the Radioactive Effluent Release Report, the licensee has retained this summary of required meteorological data on site in a file. It will be provided to the NRC upon request.

5.6 Effluent Radiation Monitors Out of Service Greater Than 30 Days

There were no effluent radiation monitors out of service for greater than 30 days in 2022.

[1] Values used are the same as last years.

5.7 Offsite Dose Calculation Manual (ODCM) Changes

There were no changes to the ODCM in 2022.

5.8 Process Control Program (PCP) Changes

There were no changes to the PCP in 2022.

5.9 Radioactive Waste Treatment System Changes

The Radioactive Effluent Release Report shall include any major change to liquid, gaseous, or solid radwaste treatment systems pursuant to ODCM Chapter 7, Section 7.2.2.7.

There were no major changes to the gaseous radwaste, solid radwaste or liquid radwaste systems during this reporting period.

5.10 Other Supplemental Information

5.10.1 Minimal Detectable Concentrations

The values in this table represent a priori Minimum Detectable Concentrations (MDC) that are typically achieved in laboratory analyses of liquid radwaste samples.

Radionuclide	MDC	Units
Mn-54	1.97E-08	µCi/ml
Fe-59	3.94E-08	µCi/ml
Co-58	1.59E-08	µCi/ml
Co-60	1.72E-08	µCi/ml
Zn-65	2.92E-08	µCi/ml
Mo-99	1.20E-07	µCi/ml
Cs-134	1.75E-08	µCi/ml
Cs-137	1.62E-08	µCi/ml
Ce-141	1.92E-08	µCi/ml
Ce-144	8.83E-08	µCi/ml
I-131	1.43E-08	µCi/ml
Xe-135	1.03E-08	µCi/ml
Fe-55	2.34E-08	µCi/ml
Sr-89	1.44E-08	µCi/ml
Sr-90	8.50E-09	µCi/ml
H-3	6.00E-07	µCi/ml

The values in this table represent a priori Minimum Detectable Concentrations (MDC) that are typically achieved in laboratory analyses of gaseous radwaste samples.

Radionuclide	MDC	Units
Kr-87	2.94E-08	µCi/ml
Kr-88	3.22E-08	µCi/ml
Xe-133	2.30E-08	µCi/ml
Xe-133m	7.30E-08	µCi/ml
Xe-135	8.73E-09	µCi/ml
Xe-138	1.99E-07	µCi/ml
I-131	1.34E-13*	µCi/ml
I-133	1.53E-13*	µCi/ml
Mn-54	1.62E-13*	µCi/ml
Fe-59	3.42E-13*	µCi/ml
Co-58	1.30E-13*	µCi/ml
Co-60	1.54E-13*	µCi/ml
Zn-65	2.54E-13*	µCi/ml
Mo-99	9.61E-13*	µCi/ml
Cs-134	1.42E-13*	µCi/ml
Cs-137	1.28E-13*	µCi/ml
Ce-141	1.26E-13*	µCi/ml
Ce-144	5.64E-13*	µCi/ml
Sr-89	1.10E-16	µCi/ml
Sr-90	6.70E-16	µCi/ml
H-3	4.00E-07	µCi/ml

* Based on an estimated sample quantity of 4.078E+07 cc.

5.10.2 Total Error Estimation

1. Liquid Releases:

   The maximum error associated with volume and flow measurements, based upon plant calibration practice, is estimated to be + or - 10%. The average error associated with counting is estimated to be less than + or - 15%. Therefore, the total error estimation is + or - 18%.

2. Gaseous Releases:

   The total or maximum error associated with the effluent measurement will include the cumulative errors resulting from the total process of sampling and measurement. Due to the difficulty with assigning error terms for each parameter affecting the final measurement, detailed statistical evaluation of error is not suggested. The objective is to obtain an overall estimate of the error associated with measurements of radioactive materials released in liquid and gaseous effluents and solid waste. Estimated errors are associated with counting equipment calibration, counting statistics, vent-flow rates, vent sample flow rates, non-steady release rates, chemical yield factors and sample losses for such items as charcoal cartridges.

Fission and activation total release was calculated from sample analysis results and release point flow rates.

Statistical error	60%
Counting equipment calibration	10%
Vent flow rates	10%
Non-steady release rates	20%
TOTAL ERROR	65%

I-131 releases were calculated from each weekly sample.

Statistical error	60%
Counting equipment calibration	10%
Vent flow rates	10%
Vent sample flow rates	10%
Non-steady release rates	10%
Losses from charcoal cartridges	10%
TOTAL ERROR	64%

Particulates with half-lives greater than 8 days releases were calculated from sample analysis results and release point flow rates.

Statistical error	60%
Counting equipment calibration	10%
Vent flow rates	10%
Vent sample flow rates	10%
Non-steady release rates	10%
TOTAL ERROR	63%

Total tritium releases were calculated from sample analysis results and release point flow rates.

Water vapor in sample stream determination	20%
Vent flow rates	10%
Counting calibration and statistics	10%
Non-steady release rates	50%
TOTAL ERROR	56%

Gross Alpha radioactivity was calculated from sample analysis results and release point flow rates.

Statistical error	60%
Counting equipment calibration	10%
Vent flow rates	10%
Vent sample flow rates	10%
Non-steady release rates	10%
TOTAL ERROR	63%

5.10.3 Outside Temporary Tanks

There were no outside temporary tanks, for liquids, that exceeded the limit of Technical Specification 5.5.8.b during this reporting period.

5.10.4 Independent Spent Fuel Storage Installation (ISFSI) Monitoring Program

The annual report on radioactive releases is submitted as a separate report.

5.10.5 Carbon-14

Carbon-14 (C-14) is a naturally occurring radionuclide with a 5730-year half-life. Nuclear weapons testing in the 1950s and 1960s significantly increased the amount of C-14 in the atmosphere. Nuclear power plants also produce C-14, but the amount is infinitesimal compared to what has been distributed in the environment due to weapons testing and what is produced by natural cosmic ray interactions.

As nuclear plants have improved gaseous waste processing systems and improved fuel performance, the percentages of "principal radionuclides" in gaseous effluents have changed, and C-14 has become a larger percentage. "Principal radionuclides" are determined based on public dose contribution or the amount of activity discharged compared to other radionuclides of the same effluent type. In Revision 2 (June 2009) of Regulatory Guide 1.21 (RG 1.21), "Measuring, Evaluating, and Reporting Radioactive Material in Liquid and Gaseous Effluents and Solid Waste," the NRC recommended re-evaluating "principal radionuclides" and reporting C-14 as appropriate. In 2010 Radioactive Effluent Release Reports, virtually all U. S. nuclear power plants will report C-14 amounts released and resulting doses to the maximally exposed member of the public.

Because C-14 is considered a hard-to-detect radionuclide which must be chemically separated from the effluent stream before it can be measured, RG 1.21 provides the option of calculating the C-14 source term based on power generation. The Electric Power Research Institute (EPRI) developed an accepted methodology for calculating C-14 and published the results in Technical Report 1021106 (December 2010), "Estimation of Carbon-14 in Nuclear Power Plant Gaseous Effluents." Evaluation of C-14 in radioactive liquid effluents is not required because the quantity and dose contribution has been determined to be insignificant.

At Plant Hatch, the quantity of C-14 released in gaseous effluents in 2010 was estimated to be 14.16 Curies (per unit). Approximately 95% of the C-14 released is in the form of 14CO2 and is incorporated into plants through photosynthesis. Ingestion dose results from this pathway. The remaining 5% is estimated to be organic. Both the organic and inorganic forms of C-14 contribute to inhalation dose. A child is the maximally exposed individual, and bone dose is the highest organ dose. Using the dose calculation methodology from the Hatch ODCM, the resulting bone dose to a child located at the controlling receptor location would be 1.59E-01 mrem in a year which is 1.06% of the regulatory limit of 15 mrem per year (per unit) to any organ due to gaseous effluents. The resulting total body dose to a child located at the controlling receptor location would be 3.18E-02 mrem in a year which is 0.21% of the regulatory limit of 15 mrem per year (per unit) total body dose due to gaseous effluents. C-14 dose is not included in the dose calculation results in Tables 1 and 2 but is included in Table 3.

5.10.6 Errata/Corrections to Previous ARERRs

In February of 2021 a pump seal failure resulted in tritiated water entering the environment through an expansion joint in the pump containment of the Unit 2 Condensate Storage Tank. In May of 2021 a leak was identified in the bottom of the Unit 1 Condensate Storage Tank which ultimately leaked from the tank containment into the environment. Both issues have been repaired and there was no offsite release of licensed material.

6.0 NEI 07-07 ONSITE RADIOLOGICAL GROUNDWATER MONITORING PROGRAM

E. I. Hatch Nuclear Plant has developed a Groundwater Protection Initiative (GPI) program in accordance with NEI 07-07, Industry Ground Water Protection Initiative – Final Guidance Document [9]. The purpose of the GPI is to ensure timely detection and an effective response to situations involving inadvertent radiological releases to groundwater to prevent migration of licensed radioactive material off-site and to quantify impacts on decommissioning. The summary of results for 2022, HNP GPI is located in Attachment 3, 2022 Radiological Groundwater Protection Program (RGPP) Report.

Table 5, Groundwater Protection Program Monitoring Well Results for Tritium, 2022

Well Name	Number of Positive Detections	Number of Analyses	Average Concentration[1] pCi/L	Maximum Concentration pCi/L
GW1	4	4	297	396
GW2	2	3	236	245
GW3	4	4	235	285
LD1	0	25	NDM	NDM
LD2	5	25	88,066	118,100
LD3	3	25	11,763	14,260
LD4	2	25	1,442	1,828
LD5	27	27	584	1,733
LD6	26	27	2,287	6,310
LD7	14	26	811	2,613
LD8	22	26	791	2,329
NU1	25	25	867	1,978
NU2	4	5	11,178	17,200
NW10	30	30	920,614	1,505,000
NW2A	27	27	6,473	23,600
NW2B	1	2	154	154

[1] Tritium results marked as NDM or NS are not included in the average concentration calculation.

Table 5, Groundwater Protection Program Monitoring Well Results for Tritium, 2022

Well Name	Number of Positive Detections	Number of Analyses	Average Concentration[1] pCi/L	Maximum Concentration pCi/L
NW3A	1	2	88	88
NW3B	0	0	NS	NS
NW4A	1	2	119	119
NW5A	0	0	NS	NS
NW5B	1	2	166	166
NW6	1	2	288	288
NW8	0	2	NDM	NDM
NW9	2	2	437	598
P15A	0	1	NDM	NDM
P15B	1	1	239	239
P17A	1	1	220	220
R1	0	2	NDM	NDM
R2	0	2	NDM	NDM
R3	2	2	1,045	1,090
R4	1	5	240	240
R5	26	26	499	1,959
R6	25	26	418	791
T10	25	25	4,300	5,872
T11	25	25	6,163	7,928
T12	57	57	10,146	12,280
T13	25	25	391	583
T14	24	24	420	714
T15	25	25	5,488	9,812
T16	25	25	3,857	5,777
T2	0	0	NS	NS
T3	2	2	33,050	33,400
T5	0	0	NS	NS
T7	55	55	2,097	26,270
T4	0	0	NS	NS
NW7A	0	0	NS	NS

NS – No Sample, either due to sample schedule, field conditions (i.e. dry well) or pump OOS (out of service).
NDM – No Detectable Measurement.

6.1 Voluntary Notification

During 2022, E. I. Hatch Nuclear Plant did not make a voluntary NEI 07-07 notification to State/Local officials, NRC, or other stakeholders required by site procedures.

7.0 BIBLIOGRAPHY

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[16] "40 CFR Part 141, “National Primary Drinking Water Regulations,”," US Environmental Protection Agency, Washington, DC..

[17] "40 CFR 190 - Environmental Radiation Protection Standards for Nuclear Power Operation," US Environmental Protection Agency, Washington, DC.

[18] "10 CFR 20 - Standards for Protection Against Radiation," US Nuclear Regulatory Commission, Washington, DC.

Attachment 1, ARERR Release Summary Tables (RG-1.21 Tables)

1.0 GASEOUS EFFLUENTS

Table 6, Gaseous Effluents Summation of All Releases for Unit 1

A. Fission & Activation Gases	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total	Est. Total Error %
1. Total Release	Ci	2.23E-01	2.70E-01	4.97E-02	7.38E-01	1.28E+00	6.50E+01
2. Average release rate for the period	μCi/sec	2.83E-02	3.42E-02	6.30E-03	9.37E-02	4.06E-02	
B. Iodine							
1. Total Iodine – 131	Ci	7.05E-07	2.16E-06	6.20E-07	2.35E-06	5.84E-06	6.40E+01
2. Average release rate for the period	μCi/sec	8.95E-08	2.74E-07	7.86E-08	2.97E-07	1.85E-07	
C. Particulates							
1. Particulates with half-lives > 8 days	Ci	1.22E-06	3.61E-06	1.47E-06	1.64E-06	7.94E-06	6.30E+01
2. Average release rate for the period	μCi/sec	1.55E-07	4.58E-07	1.87E-07	2.08E-07	2.52E-07	
D. Tritium							
1. Total Release	Ci	9.99E+00	7.11E+00	7.31E+00	7.69E+00	3.21E+01	5.60E+01
2. Average release rate for the period	μCi/sec	1.27E+00	9.01E-01	9.27E-01	9.75E-01	1.02E+00	
E. Gross Alpha							
1. Total Release	Ci	7.17E-07	1.37E-07	1.87E-07	6.31E-07	1.67E-06	6.3E+01
2. Average release rate for the period	μCi/sec	9.10E-08	1.73E-08	2.37E-08	8.00E-08	5.30E-08	

% of limit is on E. I. Hatch Nuclear Plant Unit 1 Dose Summary.

Attachment 1, ARERR Release Summary Tables (RG-1.21 Tables)

Table 7, Gaseous Effluents – Elevated Level Releases   Batch Mode for Unit 1

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission Gases						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Iodines						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Ci					
	Ci					
(List Others)	Ci					
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Ci					
	Ci					
(List Others)	Ci					
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tritium						
H-3	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gross Alpha						
Alpha	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Zeroes in this table indicate that no radioactivity was present at detectable levels. There were no batch mode releases from Unit 1.

Attachment 1, ARERR Release Summary Tables (RG-1.21 Tables)

Table 8, Gaseous Effluents – Elevated Level Release Continuous Mode for Unit 1

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission Gases						
Ar-41	Ci	2.22E-01	2.49E-01	4.45E-02	5.30E-01	1.05E+00
Xe-133	Ci	0.00E+00	0.00E+00	0.00E+00	2.09E-01	2.09E-01
	Ci					
(List Others)	Ci					
Total for Period	**Ci**	2.22E-01	2.49E-01	4.45E-02	7.38E-01	1.25E+00
Iodines						
I-131	Ci	7.05E-07	2.16E-06	6.20E-07	2.35E-06	5.84E-06
I-133	Ci	2.05E-06	5.57E-06	1.19E-06	5.92E-06	1.47E-05
	Ci					
(List Others)	Ci					
Total for Period	**Ci**	2.75E-06	7.73E-06	1.81E-06	8.26E-06	2.06E-05
Particulates						
Cr-51	Ci	0.00E+00	1.59E-07	0.00E+00	0.00E+00	1.59E-07
Mn-54	Ci	9.32E-08	8.75E-08	5.88E-09	0.00E+00	1.87E-07
Co-58	Ci	2.80E-08	5.30E-08	1.04E-08	0.00E+00	9.14E-08
Co-60	Ci	1.51E-07	2.85E-07	6.11E-08	0.00E+00	4.97E-07
Zn-65	Ci	6.74E-08	7.60E-08	0.00E+00	0.00E+00	1.43E-07
Sr-89	Ci	6.65E-07	1.56E-06	1.27E-06	1.19E-06	4.69E-06
Sr-90	Ci	0.00E+00	0.00E+00	1.47E-09	1.18E-08	1.33E-08
Cs-137	Ci	7.18E-09	0.00E+00	1.17E-08	0.00E+00	1.89E-08
Ba-140	Ci	0.00E+00	0.00E+00	1.14E-07	0.00E+00	1.14E-07
(List Others)	Ci					
Total for Period	**Ci**	1.01E-06	2.22E-06	1.47E-06	1.20E-06	5.90E-06
Tritium						
H-3	Ci	1.79E-01	5.13E-01	6.61E-01	1.01E+00	2.36E+00
Gross Alpha						
Alpha	Ci	2.48E-08	1.84E-08	2.40E-08	3.59E-07	4.26E-07

Zeroes in this table indicate that no radioactivity was present at detectable levels.

Attachment 1, ARERR Release Summary Tables (RG-1.21 Tables)

Table 9, Gaseous Effluents – Ground Level Releases Batch Mode for Unit 1

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission Gases						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Iodines						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Ci					
	Ci					
(List Others)	Ci					
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Ci					
	Ci					
(List Others)	Ci					
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tritium						
H-3	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gross Alpha						
Alpha	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Zeroes in this table indicate that no radioactivity was present at detectable levels. There were no batch mode releases from Unit 1.

Attachment 1, ARERR Release Summary Tables (RG-1.21 Tables)

Table 10, Gaseous Effluents – Ground Level Release Continuous Mode for Unit 1

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission Gases						
Xe-135	Ci	1.46E-03	2.10E-02	5.11E-03	0.00E+00	2.76E-02
	Ci					
	Ci					
	Ci					
	Ci					
(List Others)	Ci					
Total for Period	**Ci**	1.46E-03	2.10E-02	5.11E-03	0.00E+00	2.76E-02
Iodines						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Ci					
	Ci					
(List Others)	Ci					
Total for Period	**Ci**					
Particulates						
Mn-54	Ci	2.03E-07	0.00E+00	0.00E+00	0.00E+00	2.03E-07
Co-60	Ci	3.84E-09	1.30E-06	0.00E+00	0.00E+00	1.30E-06
Sr-89	Ci	0.00E+00	0.00E+00	0.00E+00	4.35E-07	4.35E-07
Sr-90	Ci	0.00E+00	8.86E-08	0.00E+00	0.00E+00	8.86E-08
	Ci					
(List Others)	Ci					
Total for Period	**Ci**	2.07E-07	1.38E-06	0.00E+00	4.35E-07	2.02E-06
Tritium						
H-3	Ci	9.81E+00	6.59E+00	6.65E+00	6.68E+00	2.97E+01
Gross Alpha						
Alpha	Ci	6.93E-07	1.18E-07	1.63E-07	2.72E-07	1.25E-06

Zeroes in this table indicate that no radioactivity was present at detectable levels.

Attachment 1, ARERR Release Summary Tables (RG-1.21 Tables)

Table 11, Gaseous Effluents Summation of All Releases for Unit 2

A. Fission & Activation Gases	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total	Est. Total Error %
1. Total Release	Ci	2.22E-01	2.49E-01	4.45E-02	7.07E-01	1.22E+00	6.50E+01
2. Average release rate for the period	μCi/sec	2.81E-02	3.15E-02	5.65E-03	8.97E-02	3.88E-02	
B. Iodine							
1. Total Iodine – 131	Ci	5.47E-06	4.06E-06	5.89E-06	8.18E-06	2.36E-05	6.40E+01
2. Average release rate for the period	μCi/sec	6.94E-07	5.15E-07	7.47E-07	1.04E-06	7.48E-07	
C. Particulates							
1. Particulates with half-lives > 8 days	Ci	3.29E-06	3.37E-06	2.67E-06	2.73E-06	1.21E-05	6.30E+01
2. Average release rate for the period	μCi/sec	4.18E-07	4.28E-07	3.38E-07	3.47E-07	3.82E-07	
D. Tritium							
1. Total Release	Ci	1.48E+01	1.75E+01	2.42E+01	1.85E+01	7.50E+01	5.60E+01
2. Average release rate for the period	μCi/sec	1.88E+00	2.22E+00	3.07E+00	2.34E+00	2.38E+00	
E. Gross Alpha							
1. Total Release	Ci	1.01E-06	4.65E-07	5.03E-07	1.06E-06	3.04E-06	6.30E+01
2. Average release rate for the period	μCi/sec	1.28E-07	5.90E-08	6.39E-08	1.34E-07	9.63E-08	

% of limit is on Table 2, E. I. Hatch Nuclear Plant Unit 2 Dose Summary

Attachment 1, ARERR Release Summary Tables (RG-1.21 Tables)

Table 12, Gaseous Effluents – Elevated Level Releases Batch Mode for Unit 2

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission Gases						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Iodines						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Ci					
	Ci					
(List Others)	Ci					
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Ci					
	Ci					
(List Others)	Ci					
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tritium						
H-3	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gross Alpha						
Alpha	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Zeroes in this table indicate that no radioactivity was present at detectable levels. There were no batch mode releases from Unit 2.

Attachment 1, ARERR Release Summary Tables (RG-1.21 Tables)

Table 13, Gaseous Effluents – Elevated Level Release   Continuous Mode for Unit 2

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission Gases						
Ar-41	Ci	2.22E-01	2.49E-01	4.45E-02	4.99E-01	1.01E+00
Xe-133	Ci	0.00E+00	0.00E+00	0.00E+00	2.09E-01	2.09E-01
	Ci					
(List Others)	Ci					
Total for Period	**Ci**	2.22E-01	2.49E-01	4.45E-02	7.07E-01	1.22E+00
Iodines						
I-131	Ci	1.08E-06	2.16E-06	6.20E-07	1.88E-06	5.74E-06
I-133	Ci	2.75E-06	5.57E-06	1.19E-06	3.90E-06	1.34E-05
	Ci					
(List Others)	Ci					
Total for Period	**Ci**	3.83E-06	7.73E-06	1.81E-06	5.78E-06	1.92E-05
Particulates						
Cr-51	Ci	0.00E+00	1.59E-07	0.00E+00	0.00E+00	1.59E-07
Mn-54	Ci	9.32E-08	8.75E-08	5.88E-09	0.00E+00	1.87E-07
Co-58	Ci	2.80E-08	5.30E-08	1.04E-08	0.00E+00	9.14E-08
Co-60	Ci	1.51E-07	2.85E-07	6.11E-08	0.00E+00	4.97E-07
Zn-65	Ci	6.74E-08	7.60E-08	0.00E+00	0.00E+00	1.43E-07
Sr-89	Ci	1.08E-06	1.56E-06	1.27E-06	1.15E-06	5.06E-06
Sr-90	Ci	0.00E+00	0.00E+00	1.47E-09	1.14E-08	1.29E-08
Cs-137	Ci	7.18E-09	0.00E+00	1.17E-08	0.00E+00	1.89E-08
Ba-140	Ci	0.00E+00	0.00E+00	1.14E-07	0.00E+00	1.14E-07
(List Others)	Ci					
Total for Period	**Ci**	1.43E-06	2.22E-06	1.47E-06	1.16E-06	6.28E-06
Tritium						
H-3	Ci	4.88E-01	5.13E-01	6.61E-01	9.75E-01	2.64E+00
Gross Alpha						
Alpha	Ci	3.99E-08	1.84E-08	2.40E-08	3.57E-07	4.39E-07

Zeroes in this table indicate that no radioactivity was present at detectable levels.

Attachment 1, ARERR Release Summary Tables (RG-1.21 Tables)

Table 14, Gaseous Effluents – Ground Level Releases   Batch Mode for Unit 2

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission Gases						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Iodines						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Ci					
	Ci					
(List Others)	Ci					
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Ci					
	Ci					
(List Others)	Ci					
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tritium						
H-3	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gross Alpha						
Alpha	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Zeroes in this table indicate that no radioactivity was present at detectable levels. There were no batch mode releases from Unit 2.

Attachment 1, ARERR Release Summary Tables (RG-1.21 Tables)

Table 15, Gaseous Effluents – Ground Level Release Continuous Mode for Unit 2

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission Gases						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Ci					
	Ci					
	Ci					
	Ci					
(List Others)	Ci					
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Iodines						
I-131	Ci	4.39E-06	1.90E-06	5.27E-06	6.29E-06	1.79E-05
I-133	Ci	1.67E-05	2.65E-05	2.28E-05	4.48E-05	1.11E-04
	Ci					
(List Others)	Ci					
Total for Period	**Ci**	2.11E-05	2.84E-05	2.81E-05	5.11E-05	1.29E-04
Particulates						
Sr-89	Ci	1.87E-06	1.15E-06	1.10E-06	1.49E-06	5.61E-06
Sr-90	Ci	0.00E+00	0.00E+00	9.03E-08	8.36E-08	1.74E-07
	Ci					
	Ci					
	Ci					
(List Others)	Ci					
Total for Period	**Ci**	1.87E-06	1.15E-06	1.19E-06	1.57E-06	5.78E-06
Tritium						
H-3	Ci	1.44E+01	1.70E+01	2.36E+01	1.75E+01	7.25E+01
Gross Alpha						
Alpha	Ci	9.69E-07	4.46E-07	4.80E-07	6.98E-07	2.59E-06

Zeroes in this table indicate that no radioactivity was present at detectable levels.

Attachment 1, ARERR Release Summary Tables (RG-1.21 Tables)

Table 16, Gaseous Effluents Summation of All Releases for the Site

A. Fission & Activation Gases	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total	Est. Total Error %
1. Total Release	Ci	4.45E-01	5.18E-01	9.42E-02	1.45E+00	2.51E+00	6.50E+01
2. Average release rate for the period	µCi/sec	5.64E-02	6.58E-02	1.19E-02	1.83E-01	7.95E-02	
B. Iodine							
1. Total Iodine – 131	Ci	6.17E-06	6.22E-06	6.51E-06	1.05E-05	2.94E-05	6.40E+01
2. Average release rate for the period	µCi/sec	7.83E-07	7.89E-07	8.25E-07	1.33E-06	9.32E-07	
C. Particulates							
1. Particulates with half-lives > 8 days	Ci	4.51E-06	6.98E-06	4.14E-06	4.37E-06	2.00E-05	6.30E+01
2. Average release rate for the period	µCi/sec	5.72E-07	8.85E-07	5.25E-07	5.54E-07	6.34E-07	
D. Tritium							
1. Total Release	Ci	2.48E+01	2.46E+01	3.15E+01	2.62E+01	1.07E+02	5.60E+01
2. Average release rate for the period	µCi/sec	3.15E+00	3.12E+00	4.00E+00	3.32E+00	3.40E+00	
E. Gross Alpha							
1. Total Release	Ci	1.73E-06	6.01E-07	6.91E-07	1.69E-06	4.71E-06	3.30E+01
2. Average release rate for the period	µCi/sec	2.19E-07	7.63E-08	8.76E-08	2.14E-07	1.49E-07	

Attachment 1, ARERR Release Summary Tables (RG-1.21 Tables)

Table 17, Gaseous Effluents – Elevated Level Releases Batch Mode for the Site

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission Gases						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Iodines						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Ci					
	Ci					
(List Others)	Ci					
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Ci					
	Ci					
(List Others)	Ci					
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tritium						
H-3	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gross Alpha						
Alpha	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Zeroes in this table indicate that no radioactivity was present at detectable levels.

Attachment 1, ARERR Release Summary Tables (RG-1.21 Tables)

Table 18, Gaseous Effluents – Elevated Level Release   Continuous Mode for the Site

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission Gases						
Ar-41	Ci	4.43E-01	4.97E-01	8.91E-02	1.03E+00	2.06E+00
Xe-133	Ci	0.00E+00	0.00E+00	0.00E+00	4.18E-01	4.18E-01
	Ci					
(List Others)	Ci					
Total for Period	**Ci**	4.43E-01	4.97E-01	8.91E-02	1.45E+00	2.48E+00
Iodines						
I-131	Ci	1.79E-06	4.32E-06	1.24E-06	4.23E-06	1.16E-05
I-133	Ci	4.79E-06	1.11E-05	2.37E-06	9.82E-06	2.81E-05
	Ci					
(List Others)	Ci					
Total for Period	**Ci**	6.58E-06	1.55E-05	3.61E-06	1.40E-05	3.97E-05
Particulates						
Cr-51	Ci	0.00E+00	3.18E-07	0.00E+00	0.00E+00	3.18E-07
Mn-54	Ci	1.86E-07	1.75E-07	1.18E-08	0.00E+00	3.73E-07
Co-58	Ci	5.60E-08	1.06E-07	2.08E-08	0.00E+00	1.83E-07
Co-60	Ci	3.03E-07	5.70E-07	1.22E-07	0.00E+00	9.95E-07
Zn-65	Ci	1.35E-07	1.52E-07	0.00E+00	0.00E+00	2.87E-07
Sr-89	Ci	1.74E-06	3.12E-06	2.54E-06	2.34E-06	9.74E-06
Sr-90	Ci	0.00E+00	0.00E+00	2.95E-09	2.32E-08	2.62E-08
Cs-137	Ci	1.44E-08	0.00E+00	2.34E-08	0.00E+00	3.78E-08
Ba-140	Ci	0.00E+00	0.00E+00	2.27E-07	0.00E+00	2.27E-07
(List Others)	Ci					
Total for Period	**Ci**	2.44E-06	4.44E-06	2.95E-06	2.36E-06	1.22E-05
Tritium						
H-3	Ci	6.67E-01	1.03E+00	1.32E+00	1.98E+00	5.00E+00
Gross Alpha						
Alpha	Ci	6.47E-08	3.68E-08	4.80E-08	7.16E-07	8.66E-07

Zeroes in this table indicate that no radioactivity was present at detectable levels.

Attachment 1, ARERR Release Summary Tables (RG-1.21 Tables)

Table 19, Gaseous Effluents – Ground Level Releases Batch Mode for the Site

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission Gases						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Iodines						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Ci					
	Ci					
(List Others)	Ci					
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Ci					
	Ci					
(List Others)	Ci					
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tritium						
H-3	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gross Alpha						
Alpha	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Zeroes in this table indicate that no radioactivity was present at detectable levels.

Attachment 1, ARERR Release Summary Tables (RG-1.21 Tables)

Table 20, Gaseous Effluents – Ground Level Release   Continuous Mode for the Site

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission Gases						
Xe-135	Ci	1.46E-03	2.10E-02	5.11E-03	0.00E+00	2.76E-02
	Ci					
	Ci					
	Ci					
	Ci					
(List Others)	Ci					
Total for Period	**Ci**	1.46E-03	2.10E-02	5.11E-03	0.00E+00	2.76E-02
Iodines						
I-131	Ci	4.39E-06	1.90E-06	5.27E-06	6.29E-06	1.79E-05
I-133	Ci	1.67E-05	2.65E-05	2.28E-05	4.48E-05	1.11E-04
	Ci					
(List Others)	Ci					
Total for Period	**Ci**	2.11E-05	2.84E-05	2.81E-05	5.11E-05	1.29E-04
Particulates						
Mn-54	Ci	2.03E-07	0.00E+00	0.00E+00	0.00E+00	2.03E-07
Co-60	Ci	3.84E-09	1.30E-06	0.00E+00	0.00E+00	1.30E-06
Sr-89	Ci	1.87E-06	1.15E-06	1.10E-06	1.92E-06	6.04E-06
Sr-90	Ci	0.00E+00	8.86E-08	9.03E-08	8.36E-08	2.63E-07
	Ci					
(List Others)	Ci					
Total for Period	**Ci**	2.07E-06	2.53E-06	1.19E-06	2.01E-06	7.80E-06
Tritium						
H-3	Ci	2.42E+01	2.36E+01	3.02E+01	2.42E+01	1.02E+02
Gross Alpha						
Alpha	Ci	1.66E-06	5.65E-07	6.43E-07	9.70E-07	3.84E-06

Zeroes in this table indicate that no radioactivity was present at detectable levels.

Attachment 1, ARERR Release Summary Tables (RG-1.21 Tables)

2.0 LIQUID EFFLUENTS

Table 21, Liquid Effluents – Summation of All Releases for Unit 1

A. Fission & Activation Products	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	**Total**	Est. Total Error %
1. Total Release	Ci	3.81E-03	2.93E-05	3.32E-04	4.59E-05	4.22E-03	1.80E+01
2. Average diluted concentration	μCi/mL	7.56E-09	5.89E-10	1.40E-09	1.49E-09	5.13E-09	
B. Tritium							
1. Total Release	Ci	1.73E+01	8.09E-01	5.16E+00	6.55E-01	2.39E+01	1.80E+01
2. Average diluted concentration	μCi/mL	3.44E-05	1.63E-05	2.18E-05	2.13E-05	2.91E-05	
C. Dissolved & Entrained Gases							
1. Total Release	Ci	1.68E-05	7.44E-06	3.77E-06	0.00E+00	2.80E-05	1.80E+01
2. Average diluted concentration	μCi/mL	3.34E-11	1.49E-10	1.59E-11	0.00E+00	3.41E-11	
D. Gross Alpha Activity							
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	2.63E-08	2.63E-08	1.80E+01
E. Volume of Waste Released (prior to dilution)	Liters	2.19E+06	1.75E+05	8.40E+05	1.39E+05	3.34E+06	
F. Volume of Dilution Water Used During Period	Liters	5.04E+08	4.98E+07	2.37E+08	3.08E+07	8.22E+08	

Zeroes in this table indicate that no radioactivity was present at detectable levels.

% of limit is on the E. I. Hatch Nuclear Plant Unit 1 Dose Summary.

Attachment 1, ARERR Release Summary Tables (RG-1.21 Tables)

Table 22, Batch Mode Liquid Effluents for Unit 1

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission and Activation Products						
Sb-124	Ci	1.07E-04	0.00E+00	0.00E+00	0.00E+00	1.07E-04
Sn-117M	Ci	0.00E+00	0.00E+00	3.68E-06	0.00E+00	3.68E-06
Mn-54	Ci	7.78E-04	1.91E-06	3.40E-05	5.63E-06	8.20E-04
Ag-110M	Ci	3.96E-05	0.00E+00	0.00E+00	2.54E-07	3.99E-05
Cr-51	Ci	3.39E-04	0.00E+00	8.13E-06	0.00E+00	3.47E-04
Co-60	Ci	1.43E-03	1.31E-05	1.32E-04	2.36E-05	1.60E-03
Ru-103	Ci	0.00E+00	0.00E+00	2.44E-07	0.00E+00	2.44E-07
Sb-125	Ci	2.88E-06	0.00E+00	0.00E+00	0.00E+00	2.88E-06
Co-58	Ci	4.58E-04	0.00E+00	1.81E-05	3.60E-06	4.80E-04
Na-24	Ci	4.65E-05	0.00E+00	3.99E-06	0.00E+00	5.05E-05
Sb-122	Ci	9.35E-07	0.00E+00	0.00E+00	0.00E+00	9.35E-07
Cs-137	Ci	9.47E-05	2.08E-06	3.39E-05	1.11E-06	1.32E-04
Au-199	Ci	0.00E+00	0.00E+00	2.35E-06	0.00E+00	2.35E-06
Zn-69M	Ci	1.17E-06	0.00E+00	2.67E-05	0.00E+00	2.79E-05
La-140	Ci	8.32E-06	0.00E+00	0.00E+00	0.00E+00	8.32E-06
Zn-65	Ci	3.79E-04	2.99E-06	6.97E-05	6.69E-06	4.58E-04
Fe-55	Ci	1.12E-04	9.23E-06	0.00E+00	5.06E-06	1.26E-04
Fe-59	Ci	5.13E-06	0.00E+00	0.00E+00	0.00E+00	5.13E-06
Mn-56	Ci	2.01E-06	0.00E+00	0.00E+00	0.00E+00	2.01E-06
(List Others)	Ci					
Total for Period	Ci	3.81E-03	2.93E-05	3.32E-04	4.59E-05	4.22E-03
Tritium						
H-3	Ci	1.73E+01	8.09E-01	5.16E+00	6.55E-01	2.39E+01
Gross Alpha						
Alpha	Ci	0.00E+00	0.00E+00	0.00E+00	2.63E-08	2.63E-08
Entrained Gases						
Xe-133	Ci	0.00E+00	6.29E-06	0.00E+00	0.00E+00	6.29E-06
Xe-135	Ci	1.68E-05	1.14E-06	3.77E-06	0.00E+00	2.17E-05
(List Others)	Ci					
Total for Period	Ci	1.68E-05	7.44E-06	3.77E-06	0.00E+00	2.80E-05

Zeroes in this table indicate that no radioactivity was present at detectable levels.

Attachment 1, ARERR Release Summary Tables (RG-1.21 Tables)

Table 23, Continuous Mode Liquid Effluents for Unit 1

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission and Activation Products						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
(List Others)	Ci					
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tritium						
H-3	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gross Alpha						
Alpha	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Entrained Gases						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Ci					
(List Others)	Ci					
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Zeroes in this table indicate that no radioactivity was present at detectable levels. There were no continuous releases from Unit 1.

Attachment 1, ARERR Release Summary Tables (RG-1.21 Tables)

Table 24, Liquid Effluents – Summation of All Releases for Unit 2

A. Fission & Activation Products	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	**Total**	Est. Total Error %
1. Total Release	Ci	1.38E-04	3.00E-06	1.15E-04	1.04E-03	1.30E-03	1.80E+01
2. Average diluted concentration	μCi/mL	2.34E-11	6.02E-13	1.78E-11	2.39E-10	5.97E-11	
B. Tritium							
1. Total Release	Ci	1.77E+01	1.22E+00	8.04E+00	5.79E+00	3.28E+01	1.80E+01
2. Average diluted concentration	μCi/mL	2.98E-06	2.45E-07	1.25E-06	1.33E-06	1.51E-06	
C. Dissolved & Entrained Gases							
1. Total Release	Ci	2.32E-05	2.23E-05	4.60E-05	1.50E-05	1.07E-04	1.80E+01
2. Average diluted concentration	μCi/mL	3.92E-12	4.48E-12	7.15E-12	3.43E-12	4.91E-12	
D. Gross Alpha Activity							
1. Total Release	Ci	2.67E-08	0.00E+00	0.00E+00	6.99E-07	7.26E-07	1.80E+01
E. Volume of Waste Released (prior to dilution)	Liters	4.82E+06	2.82E+06	4.82E+06	3.31E+06	1.58E+07	
F. Volume of Dilution Water Used During Period	Liters	5.93E+09	4.98E+09	6.43E+09	4.36E+09	2.17E+10	

Zeroes in this table indicate that no radioactivity was present at detectable levels.

% of limit is on the Table 2, E. I. Hatch Nuclear Plant Unit 2 Dose Summary

Attachment 1, ARERR Release Summary Tables (RG-1.21 Tables)

Table 25, Batch Mode Liquid Effluents for Unit 2

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission and Activation Products						
Mn-54	Ci	7.58E-06	0.00E+00	8.85E-06	6.34E-05	7.98E-05
Sn-117M	Ci	0.00E+00	0.00E+00	0.00E+00	3.55E-06	3.55E-06
Sr-92	Ci	0.00E+00	0.00E+00	0.00E+00	1.53E-05	1.53E-05
Ag-110M	Ci	1.57E-06	0.00E+00	0.00E+00	3.85E-04	3.87E-04
Co-58	Ci	8.63E-06	0.00E+00	7.40E-06	8.11E-05	9.71E-05
As-76	Ci	0.00E+00	0.00E+00	2.62E-06	0.00E+00	2.62E-06
Sb-124	Ci	1.48E-05	0.00E+00	0.00E+00	0.00E+00	1.48E-05
Zn-69M	Ci	0.00E+00	0.00E+00	4.83E-07	0.00E+00	4.83E-07
Cr-51	Ci	0.00E+00	0.00E+00	0.00E+00	1.96E-04	1.96E-04
Te-125M	Ci	4.80E-05	0.00E+00	0.00E+00	0.00E+00	4.80E-05
Na-24	Ci	2.09E-06	0.00E+00	4.98E-05	5.05E-05	1.02E-04
Cs-137	Ci	3.11E-06	0.00E+00	7.03E-06	1.02E-06	1.12E-05
I-133	Ci	0.00E+00	0.00E+00	1.68E-07	2.85E-07	4.53E-07
Zn-65	Ci	4.20E-06	0.00E+00	4.86E-06	2.37E-05	3.28E-05
Co-60	Ci	4.85E-05	3.00E-06	3.32E-05	1.54E-04	2.39E-04
Zr-97	Ci	0.00E+00	0.00E+00	2.00E-07	0.00E+00	2.00E-07
La-140	Ci	0.00E+00	0.00E+00	0.00E+00	6.80E-06	6.80E-06
Au-199	Ci	0.00E+00	0.00E+00	0.00E+00	5.88E-05	5.88E-05
Fe-59	Ci	0.00E+00	0.00E+00	0.00E+00	2.90E-06	2.90E-06
(List Others)	Ci					
Total for Period	Ci	1.38E-04	3.00E-06	1.15E-04	1.04E-03	1.30E-03
Tritium						
H-3	Ci	1.76E+01	1.18E+00	8.01E+00	5.77E+00	3.26E+01
Gross Alpha						
Alpha	Ci	2.67E-08	0.00E+00	0.00E+00	6.99E-07	7.26E-07
Entrained Gases						
Xe-133	Ci	9.39E-06	1.48E-05	1.41E-05	0.00E+00	3.83E-05
Xe-135	Ci	1.38E-05	7.46E-06	3.19E-05	1.50E-05	6.82E-05
(List Others)	Ci					
Total for Period	Ci	2.32E-05	2.23E-05	4.60E-05	1.50E-05	1.07E-04

Zeroes in this table indicate that no radioactivity was present at detectable levels.

Attachment 1, ARERR Release Summary Tables (RG-1.21 Tables)

Table 26, Continuous Mode Liquid Effluents for Unit 2

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission and Activation Products						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
(List Others)	Ci					
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tritium						
H-3	Ci	1.05E-01	4.26E-02	3.33E-02	1.73E-02	1.98E-01
Gross Alpha						
Alpha	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Entrained Gases						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Ci					
(List Others)	Ci					
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Zeroes in this table indicate that no radioactivity was present at detectable levels.

Attachment 1, ARERR Release Summary Tables (RG-1.21 Tables)

Table 27, Liquid Effluents – Summation of All Releases for the Site

A.	Fission & Activation Products	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	**Total**	Est. Total Error %
1.	Total Release	Ci	3.95E-03	3.23E-05	4.47E-04	1.09E-03	5.52E-03	
2.	Average diluted concentration	μCi/mL	6.14E-10	6.42E-12	6.71E-11	2.48E-10	2.45E-10	
B.	Tritium							
1.	Total Release	Ci	3.50E+01	2.03E+00	1.32E+01	6.44E+00	5.67E+01	
2.	Average diluted concentration	μCi/mL	5.44E-06	4.04E-07	1.98E-06	1.47E-06	2.52E-06	
C.	Dissolved & Entrained Gases							
1.	Total Release	Ci	4.00E-05	2.97E-05	4.97E-05	1.50E-05	1.34E-04	
2.	Average diluted concentration	μCi/mL	6.22E-12	5.91E-12	7.46E-12	3.41E-12	5.97E-12	
D.	Gross Alpha Activity							
1.	Total Release	Ci	2.67E-08	0.00E+00	0.00E+00	7.25E-07	7.52E-07	
E.	Volume of Waste Released (prior to dilution)	Liters	7.01E+06	2.99E+06	5.66E+06	3.45E+06	1.91E+07	
F.	Volume of Dilution Water Used During Period	Liters	6.43E+09	5.03E+09	6.67E+09	4.39E+09	2.25E+10	

Zeroes in this table indicate that no radioactivity was present at detectable levels.

Attachment 1, ARERR Release Summary Tables (RG-1.21 Tables)

Table 28, Batch Mode Liquid Effluents for the Site

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission and Activation Products						
Cr-51	Ci	3.39E-04	0.00E+00	8.13E-06	1.96E-04	5.43E-04
Mn-56	Ci	2.01E-06	0.00E+00	0.00E+00	0.00E+00	2.01E-06
Fe-55	Ci	1.12E-04	9.23E-06	0.00E+00	5.06E-06	1.26E-04
Ag-110M	Ci	4.11E-05	0.00E+00	0.00E+00	3.86E-04	4.27E-04
Ru-103	Ci	0.00E+00	0.00E+00	2.44E-07	0.00E+00	2.44E-07
I-133	Ci	0.00E+00	0.00E+00	1.68E-07	2.85E-07	4.53E-07
Zn-69M	Ci	1.17E-06	0.00E+00	2.71E-05	0.00E+00	2.83E-05
Sb-125	Ci	2.88E-06	0.00E+00	0.00E+00	0.00E+00	2.88E-06
Co-58	Ci	4.66E-04	0.00E+00	2.55E-05	8.47E-05	5.76E-04
Mn-54	Ci	7.86E-04	1.91E-06	4.28E-05	6.91E-05	9.00E-04
Zr-97	Ci	0.00E+00	0.00E+00	2.00E-07	0.00E+00	2.00E-07
Sr-92	Ci	0.00E+00	0.00E+00	0.00E+00	1.53E-05	1.53E-05
Sn-117M	Ci	0.00E+00	0.00E+00	3.68E-06	3.55E-06	7.23E-06
Cs-137	Ci	9.78E-05	2.08E-06	4.09E-05	2.13E-06	1.43E-04
As-76	Ci	0.00E+00	0.00E+00	2.62E-06	0.00E+00	2.62E-06
La-140	Ci	8.32E-06	0.00E+00	0.00E+00	6.80E-06	1.51E-05
Sb-122	Ci	9.35E-07	0.00E+00	0.00E+00	0.00E+00	9.35E-07
Co-60	Ci	1.48E-03	1.61E-05	1.65E-04	1.77E-04	1.84E-03
Na-24	Ci	4.86E-05	0.00E+00	5.38E-05	5.05E-05	1.53E-04
Te-125M	Ci	4.80E-05	0.00E+00	0.00E+00	0.00E+00	4.80E-05
Fe-59	Ci	5.13E-06	0.00E+00	0.00E+00	2.90E-06	8.03E-06
Zn-65	Ci	3.84E-04	2.99E-06	7.46E-05	3.04E-05	4.92E-04
Au-199	Ci	0.00E+00	0.00E+00	2.35E-06	5.88E-05	6.12E-05
Sb-124	Ci	1.22E-04	0.00E+00	0.00E+00	0.00E+00	1.22E-04
(List Others)	Ci					
Total for Period	Ci	3.95E-03	3.23E-05	4.47E-04	1.09E-03	5.52E-03
Tritium						
H-3	Ci	3.49E+01	1.99E+00	1.32E+01	6.43E+00	5.65E+01
Gross Alpha						
Alpha	Ci	2.67E-08	0.00E+00	0.00E+00	7.25E-07	7.52E-07
Entrained Gases						
Xe-133	Ci	9.39E-06	2.11E-05	1.41E-05	0.00E+00	4.46E-05
Xe-135	Ci	3.06E-05	8.60E-06	3.57E-05	1.50E-05	8.99E-05
(List Others)	Ci					
Total for Period	Ci	4.00E-05	2.97E-05	4.97E-05	1.50E-05	1.34E-04

Zeroes in this table indicate that no radioactivity was present at detectable levels.

Attachment 1, ARERR Release Summary Tables (RG-1.21 Tables)

Table 29, Continuous Mode Liquid Effluents for the Site

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission and Activation Products						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
(List Others)	Ci					
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tritium						
H-3	Ci	1.05E-01	4.26E-02	3.33E-02	1.73E-02	1.98E-01
Gross Alpha						
Alpha	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Entrained Gases						
None	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Ci					
(List Others)	Ci					
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Zeroes in this table indicate that no radioactivity was present at detectable levels.

Attachment 2, Solid Waste Information

1.0 SOLID WASTE SHIPPED OFFSITE FOR BURIAL OR DISPOSAL (NOT IRRADIATED FUEL)

Table 30, Semi-Annual Report of Solid Waste and Irradiated Fuel Shipments for the E. I. Hatch Site, 01/01/2022 to 06/30/2022

A. SOLID WASTE SHIPPED OFFSITE FOR BURIAL OR DISPOSAL (Not irradiated fuel)			
1. Type of waste	UNIT	6 month period	Est. Total ERROR %
a. Spent resins, filter sludges, evaporator bottoms, etc.	m^3	8.48 E+01	
	Ci	6.65 E+01	9.0 E+00
b. Dry compressible waste, contaminated equip etc.	m^3	5.69 E+02	
	Ci	1.31 E+00	2.0 E+00
c. Irradiated components, control rods,	m^3	. E	
	Ci	. E	. E
d. Control Rod Drive Filters	m^3	. E	
	Ci	. E	. E
e. Other (describe) equip. etc.	m^3	. E	
	Ci	. E	. E

2. Estimate of major nuclide composition (by type of waste)		
ISOTOPE	PERCENT	CURIES
a. Spent resins, filter sludges, evaporator bottoms, etc.		
H-3	0.25%	1.66E-01
C-14	1.66%	1.10E+00
Cr-51	2.02%	1.34E+00
Mn-54	13.23%	8.80E+00
Fe-55	20.14%	1.34E+01
Fe-59	0.29%	1.90E-01
Co-57	0.05%	3.33E-02
Co-58	8.36%	5.56E+00
Co-60	33.32%	2.22E+01
Ni-63	1.6%	1.06E+00
Zn-65	16.24%	1.08E+01
Sr-90	0.04%	2.95E-02
Sr-92	0%	3.51E-40
Tc-99	0%	2.83E-03
Tc-99m	0%	2.43E-07
Ag-110m	0.46%	3.06E-01
Sb-124	0.07%	4.56E-02
Sb-125	0.01%	4.26E-03
I-129	0%	2.27E-04
I-131	0.11%	7.49E-02
I-133	0%	2.75E-08

Attachment 2, Solid Waste Information

Table 30, Semi-Annual Report of Solid Waste and Irradiated Fuel Shipments for the E. I. Hatch Site, 01/01/2022 to 06/30/2022

a. Spent resins, filter sludges, evaporator bottoms, etc. (continued)		
ISOTOPE	PERCENT	CURIES
Xe-131m	0%	3.70E-04
Cs-137	2.03%	1.35E+00
Ba-140	0.09%	5.70E-02
La-140	0.01%	7.21E-03
Ce-141	0.02%	1.14E-02
Ce-144	0.02%	1.31E-02
Am-241	0%	2.48E-04
b. Dry compressible waste, contaminated equip. etc.		
ISOTOPE	PERCENT	CURIES
H-3	0.34%	4.39E-03
C-14	0.05%	6.90E-04
Cr-51	0.38%	4.95E-03
Mn-54	4.21%	5.51E-02
Fe-55	70.5%	9.21E-01
Fe-59	0.29%	3.78E-03
Co-58	0.54%	7.01E-03
Co-60	20.3%	2.65E-01
Ni-63	1.21%	1.58E-02
Zn-65	1.38%	1.80E-02
Sr-90	0.07%	9.50E-04
Ag-110m	0.38%	5.01E-03
Sb-124	0.02%	2.93E-04
Cs-137	0.34%	4.42E-03
c. Irradiated components, control rods,		
d. Control Rod Drive Filters		
e. Other		

Attachment 2, Solid Waste Information

Table 30, Semi-Annual Report of Solid Waste and Irradiated Fuel Shipments for the E. I. Hatch Site, 01/01/2022 to 06/30/2022

3. Solid Waste Disposition

Number of Shipments	Mode of Transportation	Destination
30	Highway	Energy Solutions, Tennessee

B. IRRADIATED FUEL SHIPMENTS (Disposition)

Number of Shipments	Mode of Transportation	Destination
N/A	N/A	N/A

Offsite Dose Calculation Manual, Section 7.2 Radioactive Effluent Release Report;
7.2.2.4 Solid Radwaste Data for Unit 1 and 2 From 01/01/2022 to 06/30/2022

Type of Waste	Total Curie Quantity-Estimate	Principal Radionuclides - Estimate	Type of Container	Container Volume (ft^3)	Solidification Agent
Dewatered Resin/Filters	6.65 E+01	C-14, Cr-51, Mn-52, Fe-55, Co-58, Co-60, Ni-63, Zn-65, Cs-137	LSA-II	(14) 210	None
Dry Active Waste	1.31 E+00	Mn-54, Fe-55, Co-60, Ni-63, Zn-65	SCO-II LSA-I LSA-II, LSA-II, LSA-I SCO-II LSA-II LSA-1 SCO-II	(1) 1040 (7) 2080 (1) 210 (2) 2080 (7) 90[(1)] (5) 90[(1)] (4) 90[(1)] (1) 480 (2) 480	None

(1) These 16 containers represent two (2) shipments

Attachment 2, Solid Waste Information

Table 31, Semi-Annual Report of Solid Waste and Irradiated Fuel Shipments for the E. I. Hatch Site, 07/01/2022 to 12/31/2022

A. SOLID WASTE SHIPPED OFFSITE FOR BURIAL OR DISPOSAL (Not irradiated fuel)			
1. Type of waste	UNIT	6 month period	Est. Total ERROR %
a. Spent resins, filter sludges, evaporator bottoms, etc.	m^3	6.94 E+01	
	Ci	7.85 E+02	2.8 E+01
b. Dry compressible waste, contaminated equip etc.	m^3	2.23 E+02	
	Ci	3.07 E+00	2.0 E+00
c. Irradiated components, control rods,	m^3	. E	
	Ci	. E	. E
d. Control Rod Drive Filters	m^3	. E	
	Ci	. E	. E
e. Other (describe) equip. etc.	m^3	. E	
	Ci	. E	. E

2. Estimate of major nuclide composition (by type of waste)		
ISOTOPE	PERCENT	CURIES
a. Spent resins, filter sludges, evaporator bottoms, etc.		
H-3	0.04%	3.37E-01
C-14	0.08%	6.61E-01
Na-24	0%	2.32E-05
Cr-51	0.64%	4.99E+00
Mn-54	9.15%	7.18E+01
Fe-55	56.21%	4.41E+02
Fe-59	0.23%	1.77E+00
Co-57	0.03%	1.97E-01
Co-58	4.44%	3.48E+01
Co-60	19.32%	1.52E+02
Ni-59	0%	3.36E-02
Ni-63	0.81%	6.35E+00
Zn-65	8.4%	6.59E+01
Sr-89	0.02%	1.91E-01
Sr-90	0.01%	9.42E-02
Sr-92	0%	1.29E-16
Zr-95	0.03%	2.30E-01
Nb-95	0.02%	1.42E-01
Tc-99	0.01%	4.35E-02
Ag-110m	0.28%	2.22E+00
Sb-124	0.02%	1.83E-01
Sb-125	0%	1.18E-02
Te-129m	0%	1.27E-03
I-129	0%	2.80E-04
I-131	0.01%	7.10E-02
I-133	0%	2.46E-06

Attachment 2, Solid Waste Information

Table 31, Semi-Annual Report of Solid Waste and Irradiated Fuel Shipments for the E. I. Hatch Site, 07/01/2022 to 12/31/2022

a. Spent resins, filter sludges, evaporator bottoms, etc. (continued)		
ISOTOPE	PERCENT	CURIES
Cs-137	0.22%	1.74E+00
Ba-140	0.01%	4.99E-02
La-140	0%	4.87E-03
Ce-141	0%	1.42E-02
Ce-144	0.03%	2.23E-01
Hf-181	0%	7.40E-04
Au-199	0%	5.98E-05
Pu-238	0%	1.74E-04
Pu-239	0%	8.98E-05
Am-241	0%	3.72E-04
Cm-242	0%	5.39E-04
Cm-243	0%	6.90E-05
b. Dry compressible waste, contaminated equip etc.		
H-3	0.14%	4.41E-03
Cr-51	0.15%	4.46E-03
Mn-54	1.78%	5.45E-02
Fe-55	27.33%	8.38E-01
Fe-59	0.29%	8.78E-03
Co-57	0.04%	1.22E-03
Co-58	14.54%	4.46E-01
Co-60	49.11%	1.51E+00
Ni-63	0.48%	1.48E-02
Zn-65	5.8%	1.78E-01
Sr-89	0.01%	4.11E-04
Sr-90	0.03%	9.51E-04
Tc-99	0%	3.47E-05
Ag-110m	0.12%	3.82E-03
Sb-124	0.01%	2.80E-04
Cs-137	0.1%	3.15E-03
Ce-144	0.07%	2.08E-03
Pu-238	0%	3.56E-06
Pu-239	0%	1.49E-06
Am-241	0%	4.06E-06
c. Irradiated components, control rods,		
d. Control Rod Drive Filters		
e. Other		

Attachment 2, Solid Waste Information

Table 31, Semi-Annual Report of Solid Waste and Irradiated Fuel Shipments for the E. I. Hatch Site, 07/01/2022 to 12/31/2022

3. Solid Waste Disposition

Number of Shipments	Mode of Transportation	Destination
21	Highway	Energy Solutions, Tennessee

B. IRRADIATED FUEL SHIPMENTS (Disposition)

Number of Shipments	Mode of Transportation	Destination
N/A	N/A	N/A

Offsite Dose Calculation Manual, Section 7.2 Radioactive Effluent Release Report;
7.2.2.4 Solid Radwaste Data for Unit 1 and 2 From 07/01/2022 to 12/31/2022

Type of Waste	Total Curie Quantity-Estimate	Principal Radionuclides - Estimate	Type of Container	Container Volume (ft^3)	Solidification Agent
Dewatered Resin/Filters	7.85 E+02	Fe-55, Co-60, Mn-54, Co-58, Zn-65,	LSA-II Type B	(13) 207.4 (1) 125.4	None
Dry Active Waste	3.07 E+00	Co-60, Fe-55, Co-58, Zn-65, Mn-54	SCO-II LSA-I	(3) 1040 (3) 2080	None

Attachment 3, 2022 Radiological Groundwater Protection Program (RGPP) Report

To ensure compliance with NEI 07-07 (Industry Ground Water Protection Initiative – Final Guidance Document), Southern Nuclear implemented a groundwater protection program which is proceduralized in Nuclear Management Procedure, Radiological Groundwater Protection Program. The procedure contains detailed site-specific monitoring plans, program technical bases, and communications protocol (to ensure that radioactive leaks and spills are addressed and communicated appropriately). To prevent future leaks of radioactive material to groundwater, SNC plants have established buried piping and tank inspection programs.

Plant Hatch maintained the following wells (Table 32), which were sampled at a frequency that satisfied the requirements of NEI 07-07. Table 33 contains the results of the groundwater Protection Program tritium results (in pCi/L).

Table 32 Groundwater Monitoring Locations

Well	Depth (Feet)	Monitoring Purpose
R1	82.9	Confined Aquifer Upgradient
R2	82.7	Confined Aquifer Near Diesel Generator Bldg.
R3	89.2	Confined Aquifer Near CST-1
R4	41	Dilution Line Near River Water Discharge Structure
R5	33.6	Between Subsurface Drain Lines Downgradient
R6	38.2	Between Subsurface Drain Lines Downgradient
NW2A	27	Water Table Near CST-2 Inside of Subsurface Drain
NW2B	27	Water Table Outside of Subsurface Drain
NW3A	26.5	Water Table Inside of Subsurface Drain
NW3B	25.3	Water Table Outside of Subsurface Drain
NW4A	27	Water Table Upgradient Inside of Subsurface Drain
NW5A	26.7	Water Table Upgradient Inside of Subsurface Drain
NW5B	26.3	Water Table Upgradient Outside of Subsurface Drain
NW6	27	Water Table Near Diesel Generator Bldg.
NW8	23	Water Table Near Diesel Generator Bldg.
NW9	26.1	Water Table Downgradient Inside of Subsurface Drain
NW10	26.2	Water Table Near CST-2
T3	18	Water Table Near Turbine Bldg.
T7	21.4	Water Table Near Diesel Generator Bldg.
T10	18.8	Water Table Near CST-1
T12	23.2	Water Table Near CST-1

Attachment 3, 2022 Radiological Groundwater Protection Program (RGPP) Report

Table 32 Groundwater Monitoring Locations

Well	Depth (Feet)	Monitoring Purpose
T15	27.4	Water Table Near CST-1
P15A	74.5	Confined Aquifer Near Turbine Bldg.
P15B	18	Water Table Near Turbine Bldg.
P17A	77	Confined Aquifer Near Diesel Generator Bldg.
P17B	14.8	Water Table Near Diesel Generator Bldg.
Deep Well 1	680	Backup Supply for Potable Water (infrequently used)
Deep Well 2	711	Plant Potable Water Supply
Deep Well 3	710	Potable Water Supply – Rec. Center, Firing Range, and Garage
NU-2	~60	Confined Aquifer Near CST-1
GW-1	19.6	Water Table downstream of CST-1 (outside CW tunnel boundary)
GW-2	19.7	Water Table downstream of CST-1 (inside CW tunnel boundary)
GW-3	21	Water Table downstream of CST-1 (outside CW tunnel boundary)
LD-1	15	Water Table Near CST-2
LD-2	15	Water Table Near CST-2
LD-3	15	Water Table Near CST-2
LD-4	15	Water Table Near CST-2
LD-5	15	Water Table Near CST-2
LD-6	15	Water Table Near CST-2
LD-7	15	Water Table Near CST-2
LD-8	15	Water Table Near CST-2

Attachment 3, 2022 Radiological Groundwater Protection Program (RGPP) Report

Table 33, Groundwater Protection Program Tritium Results
(pCi/L)

Well/Date	Tritium
GW1	
8-Mar	192
7-Jun	358
20-Sep	241
29-Nov	396
GW2	
8-Mar	NDM
7-Jun	245
20-Sep	227
GW3	
8-Mar	147
7-Jun	283
20-Sep	226
29-Nov	285
LD1	
7-Feb	NDM
14-Feb	NDM
21-Feb	NDM
28-Feb	NDM
7-Mar	NDM
14-Mar	NDM
21-Mar	NDM
28-Mar	NDM
4-Apr	NDM
11-Apr	NDM
18-Apr	NDM
25-Apr	NDM
2-May	NDM
9-May	NDM
16-May	NDM
23-May	NDM
31-May	NDM
6-Jun	NDM
13-Jun	NDM
20-Jun	NDM

Attachment 3, 2022 Radiological Groundwater Protection Program (RGPP) Report

Table 33, Groundwater Protection Program Tritium Results
(pCi/L)

Well/Date	Tritium
27-Jun	NDM
25-Jul	NDM
22-Aug	NDM
26-Sep	NDM
29-Dec	NDM
LD2	
7-Feb	NDM
14-Feb	NDM
21-Feb	118,100
28-Feb	NDM
7-Mar	NDM
14-Mar	NDM
21-Mar	NDM
28-Mar	NDM
4-Apr	NDM
11-Apr	95,870
18-Apr	90,940
25-Apr	NDM
2-May	NDM
9-May	NDM
16-May	NDM
23-May	NDM
31-May	NDM
6-Jun	NDM
13-Jun	NDM
20-Jun	NDM
27-Jun	NDM
25-Jul	76,150
22-Aug	NDM
26-Sep	59,270
29-Dec	NDM
LD3	
7-Feb	NDM
14-Feb	NDM
21-Feb	NDM

Attachment 3, 2022 Radiological Groundwater Protection Program (RGPP) Report

Table 33, Groundwater Protection Program Tritium Results
(pCi/L)

Well/Date	Tritium
28-Feb	NDM
7-Mar	NDM
14-Mar	NDM
21-Mar	NDM
28-Mar	NDM
4-Apr	NDM
11-Apr	13,160
18-Apr	14,260
25-Apr	NDM
2-May	NDM
9-May	NDM
16-May	NDM
23-May	NDM
31-May	NDM
6-Jun	NDM
13-Jun	NDM
20-Jun	NDM
27-Jun	NDM
25-Jul	NDM
22-Aug	NDM
26-Sep	7,870
29-Dec	NDM
LD4	
7-Feb	NDM
14-Feb	NDM
21-Feb	NDM
28-Feb	NDM
7-Mar	NDM
14-Mar	NDM
21-Mar	NDM
28-Mar	NDM
4-Apr	NDM
11-Apr	NDM
18-Apr	NDM
25-Apr	NDM

Attachment 3, 2022 Radiological Groundwater Protection Program (RGPP) Report

Table 33, Groundwater Protection Program Tritium Results
(pCi/L)

Well/Date	Tritium
2-May	NDM
9-May	NDM
16-May	NDM
23-May	NDM
31-May	NDM
6-Jun	NDM
13-Jun	NDM
20-Jun	NDM
27-Jun	NDM
25-Jul	1,828
22-Aug	NDM
26-Sep	1,056
29-Dec	NDM
LD5	
2-Feb	544
7-Feb	402
14-Feb	446
21-Feb	1,213
25-Feb	534
28-Feb	352
7-Mar	405
14-Mar	684
21-Mar	633
28-Mar	710
4-Apr	417
11-Apr	1,733
18-Apr	502
25-Apr	514
2-May	510
9-May	633
16-May	624
23-May	501
31-May	486
6-Jun	391
13-Jun	429

Attachment 3, 2022 Radiological Groundwater Protection Program (RGPP) Report

Table 33, Groundwater Protection Program Tritium Results
(pCi/L)

Well/Date	Tritium
20-Jun	439
27-Jun	404
25-Jul	678
22-Aug	508
26-Sep	439
29-Dec	640
LD6	
2-Feb	563
7-Feb	394
14-Feb	4,443
21-Feb	6,310
25-Feb	2,163
28-Feb	1,299
7-Mar	511
14-Mar	4,154
21-Mar	460
28-Mar	2,794
4-Apr	4,793
11-Apr	1,461
18-Apr	4,341
25-Apr	5,019
2-May	3,597
9-May	2,763
16-May	NDM
23-May	632
31-May	3,708
6-Jun	989
13-Jun	965
20-Jun	491
27-Jun	629
25-Jul	2,456
22-Aug	1,361
26-Sep	1,982
29-Dec	1,187

Attachment 3, 2022 Radiological Groundwater Protection Program (RGPP) Report

Table 33, Groundwater Protection Program Tritium Results
(pCi/L)

Well/Date	Tritium
LD7	
7-Feb	NDM
14-Feb	NDM
21-Feb	NDM
28-Feb	NDM
7-Mar	382
14-Mar	NDM
21-Mar	NDM
28-Mar	NDM
4-Apr	NDM
11-Apr	764
18-Apr	454
25-Apr	642
2-May	510
9-May	499
16-May	451
23-May	NDM
31-May	451
6-Jun	NDM
13-Jun	NDM
20-Jun	NDM
27-Jun	976
7-Jul	595
25-Jul	1,069
22-Aug	876
26-Sep	2,613
29-Dec	1,074
LD8	
7-Feb	416
14-Feb	721
21-Feb	1,753
25-Feb	541
28-Feb	389
7-Mar	353
14-Mar	NDM

Attachment 3, 2022 Radiological Groundwater Protection Program (RGPP) Report

Table 33, Groundwater Protection Program Tritium Results (pCi/L)

Well/Date	Tritium
21-Mar	566
28-Mar	781
4-Apr	2,329
11-Apr	1,028
18-Apr	599
25-Apr	498
2-May	434
9-May	623
16-May	468
23-May	NDM
31-May	NDM
6-Jun	NDM
13-Jun	389
20-Jun	437
27-Jun	605
25-Jul	700
22-Aug	502
26-Sep	2,008
29-Dec	1,268
NU1	
2-Feb	688
9-Feb	411
16-Feb	868
23-Feb	771
2-Mar	893
9-Mar	580
16-Mar	825
23-Mar	1,354
30-Mar	748
6-Apr	747
13-Apr	1,201
21-Apr	986
28-Apr	712
4-May	510
11-May	563

Attachment 3, 2022 Radiological Groundwater Protection Program (RGPP) Report

Table 33, Groundwater Protection Program Tritium Results
(pCi/L)

Well/Date	Tritium
18-May	765
26-May	744
1-Jun	1,015
8-Jun	1,653
16-Jun	504
20-Jun	1,019
12-Jul	1,978
8-Aug	1,397
12-Sep	400
12-Dec	335
NU2	
9-Mar	9,390
8-Jun	9,150
19-Jul	NS
20-Sep	17,200
29-Nov	8,970
NW10	
7-Feb	1,242,000
14-Feb	1,225,000
21-Feb	1,505,000
25-Feb	1,164,000
28-Feb	1,116,000
7-Mar	1,112,000
8-Mar	1,210,000
14-Mar	1,175,000
21-Mar	1,020,000
28-Mar	998,800
4-Apr	1,028,000
11-Apr	1,021,000
18-Apr	981,500
25-Apr	944,800
2-May	896,200
9-May	911,200
16-May	900,100
23-May	881,400

Attachment 3, 2022 Radiological Groundwater Protection Program (RGPP) Report

Table 33, Groundwater Protection Program Tritium Results
(pCi/L)

Well/Date	Tritium
31-May	813,700
6-Jun	767,700
8-Jun	866,000
13-Jun	810,400
20-Jun	758,600
27-Jun	827,600
25-Jul	750,500
22-Aug	692,100
21-Sep	548,000
26-Sep	588,000
29-Nov	444,405
29-Dec	419,400
NW2A	
7-Feb	4,427
14-Feb	4,053
21-Feb	6,113
28-Feb	5,229
7-Mar	6,723
14-Mar	6,169
21-Mar	6,818
28-Mar	5,978
4-Apr	6,066
11-Apr	6,968
18-Apr	6,927
25-Apr	6,707
2-May	6,474
9-May	6,563
16-May	6,727
23-May	6,105
31-May	6,043
6-Jun	5,855
7-Jun	5,900
13-Jun	5,002
20-Jun	5,098
27-Jun	4,934

Attachment 3, 2022 Radiological Groundwater Protection Program (RGPP) Report

Table 33, Groundwater Protection Program Tritium Results
(pCi/L)

Well/Date	Tritium
25-Jul	3,771
22-Aug	1,020
26-Sep	3,411
29-Nov	12,100
29-Dec	23,600
NW2B	
7-Jun	NDM
29-Nov	154
NW3A	
7-Jun	NDM
29-Nov	88
NW3B	NS
NW4A	
7-Jun	NDM
30-Nov	119
NW5A	
7-Jun	NDM
30-Nov	NDM
NW5B	
9-Jun	NDM
23-Jun	NS
30-Nov	166
NW6	
8-Jun	NDM
1-Dec	288
NW8	
7-Jun	NDM
30-Nov	NDM
NW9	
7-Jun	275
30-Nov	598
P15A	
1-Dec	NDM
P15B	
1-Dec	239

Attachment 3, 2022 Radiological Groundwater Protection Program (RGPP) Report

Table 33, Groundwater Protection Program Tritium Results
(pCi/L)

Well/Date	Tritium
P17A	
1-Dec	220
R1	
7-Jun	NDM
30-Nov	NDM
R2	
7-Jun	NDM
30-Nov	NDM
R3	
8-Jun	1,090
30-Nov	1,000
R4	
21-Feb	240
8-Mar	NDM
9-Jun	NDM
20-Sep	NDM
30-Nov	NDM
R5	
2-Feb	351
9-Feb	382
16-Feb	486
23-Feb	365
2-Mar	502
9-Mar	607
16-Mar	436
23-Mar	173
30-Mar	313
6-Apr	475
13-Apr	415
21-Apr	478
28-Apr	548
4-May	405
11-May	413
18-May	491
26-May	362

Attachment 3, 2022 Radiological Groundwater Protection Program (RGPP) Report

Table 33, Groundwater Protection Program Tritium Results
(pCi/L)

Well/Date	Tritium
1-Jun	404
8-Jun	1,959
16-Jun	571
20-Jun	421
12-Jul	565
8-Aug	704
12-Sep	403
21-Sep	436
12-Dec	313
R6	
2-Feb	334
9-Feb	328
16-Feb	492
23-Feb	359
2-Mar	401
8-Mar	NDM
9-Mar	371
16-Mar	260
23-Mar	332
30-Mar	305
6-Apr	553
13-Apr	638
21-Apr	420
28-Apr	382
4-May	418
11-May	402
18-May	283
26-May	408
1-Jun	388
7-Jun	174
8-Jun	791
16-Jun	425
20-Jun	411
12-Jul	719
8-Aug	457

Attachment 3, 2022 Radiological Groundwater Protection Program (RGPP) Report

Table 33, Groundwater Protection Program Tritium Results
(pCi/L)

Well/Date	Tritium
12-Sep	406
20-Sep	164
12-Dec	347
T10	
2-Feb	5,872
9-Feb	4,481
16-Feb	5,742
23-Feb	5,669
2-Mar	4,350
9-Mar	4,440
16-Mar	4,450
23-Mar	4,425
30-Mar	4,232
6-Apr	4,059
13-Apr	4,874
21-Apr	4,281
28-Apr	5,164
4-May	4,563
11-May	4,514
18-May	4,494
26-May	4,231
1-Jun	4,631
8-Jun	4,411
16-Jun	4,161
20-Jun	1,977
12-Jul	1,362
8-Aug	2,126
12-Sep	4,678
12-Dec	4,309
T11	
2-Feb	5,535
9-Feb	6,717
16-Feb	7,911
23-Feb	7,334
2-Mar	7,708

Attachment 3, 2022 Radiological Groundwater Protection Program (RGPP) Report

Table 33, Groundwater Protection Program Tritium Results
(pCi/L)

Well/Date	Tritium
9-Mar	7,336
16-Mar	7,928
23-Mar	7,440
30-Mar	6,560
6-Apr	6,224
13-Apr	6,841
21-Apr	5,868
28-Apr	6,074
4-May	6,707
11-May	6,247
18-May	5,813
26-May	4,941
1-Jun	5,656
8-Jun	6,224
16-Jun	5,011
20-Jun	4,182
12-Jul	3,937
8-Aug	5,849
12-Sep	4,980
12-Dec	5,064
T12	
2-Feb	8,902
9-Feb	9,430
16-Feb	9,997
23-Feb	9,450
2-Mar	9,370
9-Mar	8,826
16-Mar	9,071
23-Mar	12,190
30-Mar	10,140
6-Apr	11,000
13-Apr	10,280
21-Apr	9,940
28-Apr	12,280
4-May	10,670

Attachment 3, 2022 Radiological Groundwater Protection Program (RGPP) Report

Table 33, Groundwater Protection Program Tritium Results
(pCi/L)

Well/Date	Tritium
11-May	11,130
18-May	10,800
26-May	9,772
1-Jun	10,610
8-Jun	11,010
13-Jun	10,860
15-Jun	10,480
20-Jun	9,582
22-Jun	10,730
27-Jun	11,320
29-Jun	9,970
5-Jul	7,964
7-Jul	10,610
11-Jul	11,070
13-Jul	9,600
19-Jul	10,560
20-Jul	10,070
25-Jul	10,280
27-Jul	11,190
2-Aug	11,300
3-Aug	10,980
8-Aug	10,860
10-Aug	11,190
15-Aug	11,850
17-Aug	11,810
22-Aug	12,190
24-Aug	12,170
29-Aug	12,100
31-Aug	10,950
5-Sep	9,832
7-Sep	9,582
12-Sep	10,490
14-Sep	10,300
19-Sep	10,840
21-Sep	9,561

Attachment 3, 2022 Radiological Groundwater Protection Program (RGPP) Report

Table 33, Groundwater Protection Program Tritium Results (pCi/L)

Well/Date	Tritium
26-Sep	10,130
29-Sep	10,480
1-Dec	7,231
6-Dec	7,468
8-Dec	7,872
12-Dec	5,940
21-Dec	7,691
29-Dec	6,326
T13	
2-Feb	305
9-Feb	395
16-Feb	392
23-Feb	390
2-Mar	344
9-Mar	351
16-Mar	370
23-Mar	185
30-Mar	372
6-Apr	405
13-Apr	313
21-Apr	356
28-Apr	583
4-May	499
11-May	460
18-May	389
26-May	403
1-Jun	456
8-Jun	418
9-Jun	NS
16-Jun	406
20-Jun	418
12-Jul	449
8-Aug	422
12-Sep	363
12-Dec	333

Attachment 3, 2022 Radiological Groundwater Protection Program (RGPP) Report

Table 33, Groundwater Protection Program Tritium Results
(pCi/L)

Well/Date	Tritium
T14	
2-Feb	347
9-Feb	437
16-Feb	403
23-Feb	365
2-Mar	342
9-Mar	408
16-Mar	389
23-Mar	73
30-Mar	351
6-Apr	467
21-Apr	630
28-Apr	714
4-May	509
11-May	475
18-May	376
26-May	427
1-Jun	431
8-Jun	504
16-Jun	441
20-Jun	457
12-Jul	432
8-Aug	355
12-Sep	382
12-Dec	377
T15	
2-Feb	5,934
9-Feb	4,584
16-Feb	4,190
23-Feb	4,213
2-Mar	3,814
9-Mar	4,347
16-Mar	4,892
23-Mar	4,766
30-Mar	5,075

Attachment 3, 2022 Radiological Groundwater Protection Program (RGPP) Report

Table 33, Groundwater Protection Program Tritium Results
(pCi/L)

Well/Date	Tritium
6-Apr	6,543
13-Apr	8,611
21-Apr	9,812
28-Apr	8,901
4-May	7,516
11-May	7,202
18-May	6,193
26-May	5,142
1-Jun	6,387
8-Jun	6,189
16-Jun	4,266
20-Jun	3,114
12-Jul	3,146
8-Aug	4,548
12-Sep	3,242
12-Dec	4,568
T16	
2-Feb	3,627
9-Feb	3,374
16-Feb	5,777
23-Feb	3,859
2-Mar	3,443
9-Mar	4,167
16-Mar	3,938
23-Mar	4,165
30-Mar	3,733
6-Apr	4,496
13-Apr	4,092
21-Apr	4,218
28-Apr	3,954
4-May	3,891
11-May	3,526
18-May	3,770
26-May	3,025
1-Jun	3,476

Attachment 3, 2022 Radiological Groundwater Protection Program (RGPP) Report

Table 33, Groundwater Protection Program Tritium Results
(pCi/L)

Well/Date	Tritium
8-Jun	3,987
16-Jun	3,811
20-Jun	3,388
12-Jul	3,990
8-Aug	3,908
12-Sep	3,456
12-Dec	3,350
T2	NS
T3	
8-Jun	32,700
1-Dec	33,400
T5	NS
T7	
8-Jun	1,550
15-Mar	206
16-Jun	674
16-Sep	170
15-Dec	730
3-Feb	2,218
17-Feb	2,503
24-Feb	1,412
3-Mar	1,635
10-Mar	2,633
17-Mar	1,088
24-Mar	2,565
31-Mar	2,596
7-Apr	2,012
14-Apr	2,182
21-Apr	2,036
28-Apr	2,257
5-May	2,374
12-May	2,206
19-May	2,676
26-May	2,709
2-Jun	1,562

Attachment 3, 2022 Radiological Groundwater Protection Program (RGPP) Report

Table 33, Groundwater Protection Program Tritium Results (pCi/L)

Well/Date	Tritium
9-Jun	2,439
16-Jun	3,464
20-Jun	2,664
23-Jun	1,655
30-Jun	3,214
7-Jul	2,576
14-Jul	1,637
21-Jul	2,127
28-Jul	1,976
4-Aug	438
12-Aug	2,365
18-Aug	2,226
25-Aug	1,794
1-Sep	2,225
8-Sep	951
15-Sep	655
22-Sep	1,871
29-Sep	2,179
1-Dec	1,964
8-Dec	1,376
15-Dec	1,836
24-Dec	1,561
29-Dec	1,426
15-Mar	219
16-Jun	564
16-Sep	161
15-Dec	191
15-Mar	213
16-Jun	935
16-Sep	363
15-Dec	26,270
16-Dec	1,262
19-Dec	519

Attachment 3, 2022 Radiological Groundwater Protection Program (RGPP) Report

Table 33, Groundwater Protection Program Tritium Results
(pCi/L)

Well/Date	Tritium
T4	
23-Jun	NS
23-Jun	NS
NW7A	
23-Jun	NS

NS – No Sample, either due to sample schedule, field conditions (i.e. dry well) or pump OOS (out of service).
NDM – No Detectable Measurement

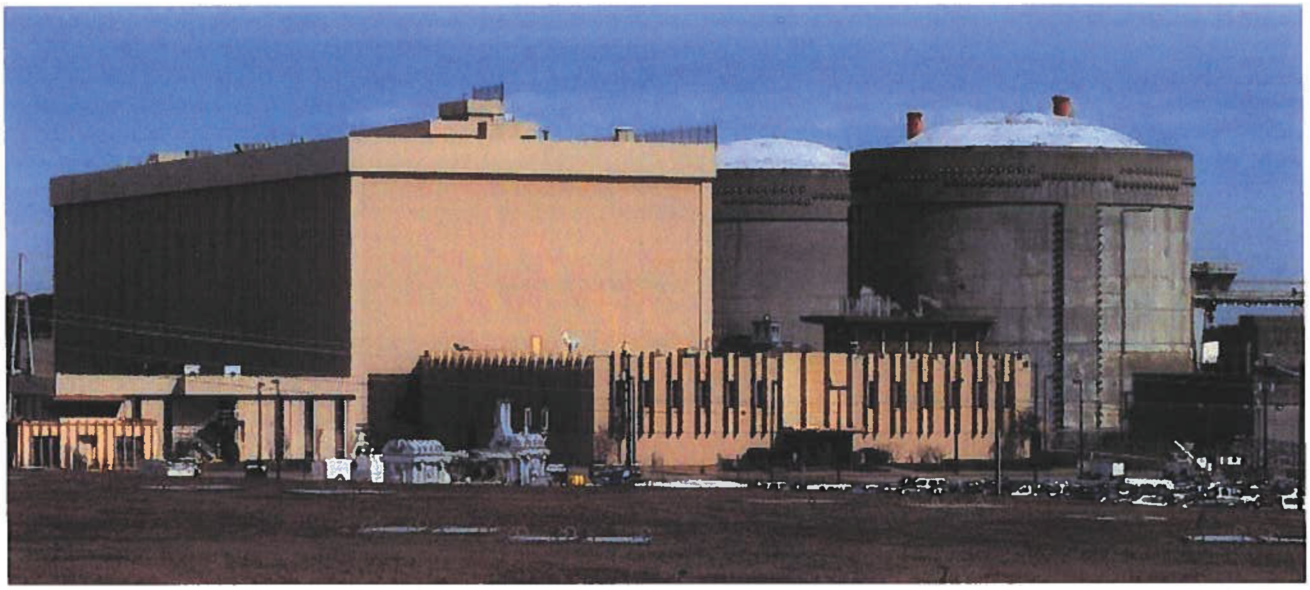
Edwin I. Hatch Nuclear Plant – Units 1&2
Joseph M. Farley Nuclear Plant – Units 1&2
Vogtle Electric Generating Plant – Units 1&2
Vogtle Electric Generating Plant – Unit 3
Annual Non-Radiological Environmental Operating Reports and Annual Radioactive Effluent Release Reports for 2022

Enclosure 5

Joseph M. Farley Nuclear Plant – Units 1&2
Annual Radioactive Effluent Release Report for 2022

Southern Nuclear

Joseph M. Farley Nuclear Plant



2022

Annual Radioactive Effluent Release Report

Document Number: 50-348 & 50-364
Facility Operating License Nos. NPF-2 & NPF-8

Prepared By: Joseph Pruitt / Date: 04-17-23

Reviewed By: Antonio Benford / Date: 4-17-23

TABLE OF CONTENTS

TABLES

FIGURES

ATTACHMENTS

1.0 LIST OF ACRONYMS AND DEFINITIONS

1. Airborne Activity Sampling: Sampling of air through the collection of particulates and radionuclides on filter media, collection of noble gases in a container, and collection of water vapor containing tritium.

2. Alpha Particle (α): A charged particle emitted from the nucleus of an atom having a mass and charge equal in magnitude of a helium nucleus.

3. BWR: Boiling Water Reactor

4. Composite Sample: A series of single collected portions (aliquots) analyzed as one sample. The aliquots making up the sample are collected at time intervals that are very short compared to the composite period.

5. Control: A sampling station in a location not likely to be affected by plant effluents due to its distance and/or direction from the Plant.

6. Counting Error: An estimate of the two-sigma uncertainty associated with the sample results based on total counts accumulated.

7. Curie (Ci): A measure of radioactivity; equal to 3.7×10^{10} disintegrations per second, or 2.22×10^{12} disintegrations per minute.

8. Direct Radiation Monitoring: The measurement of radiation dose at various distances from the plant is assessed using thermoluminescent dosimeters (TLDs), optically stimulated luminescent dosimeters (OSLDs), and/or pressurized ionization chambers.

9. ECL: Effluent Concentration Limit

10. Grab Sample: A single discrete sample drawn at one point in time.

11. Indicator: A sampling location that is likely to be affected by plant effluents due to its proximity and/or direction from the plant.

12. Ingestion Pathway: The ingestion pathway includes milk, fish, and garden produce. Meat or other food products may also be included.

13. ISFSI: Independent Spent Fuel Storage Installation

14. Lower Limit of Detection (LLD): The smallest concentration of radioactive material in a sample that will yield a net count (above system background) that will be detected with 95% probability with a 5% probability of a false conclusion that a blank observation represents "real" signal.

15. MDA: Minimum Detectable Activity. - For radiochemistry instruments, the MDA is the a posteriori minimum concentration that a counting system detects. The smallest concentration or activity of radioactive material in a sample that will yield a net count above instrument background and that is detected with 95% probability, with only five 5% probability of falsely concluding that a blank observation represents a true signal.

16. MDC: Minimum Detectable Concentration, essentially synonymous with MDA for the purposes of radiological monitoring.

17. Mean: The average, i.e., the sum of results divided by the number of results.

18. Microcurie (µCi): 3.7 x 10^4 disintegrations per second, or 2.22 x10^6 disintegrations per minute.

19. millirem (mrem): 1/1000 rem; a unit of radiation dose equivalent in tissue.

20. Milliroentgen (mR): 1/1000 Roentgen; a unit of exposure to X- or gamma radiation.

21. MWe: Megawatts Electric

22. MWTh: Megawatts Thermal

23. NA: Not Applicable

24. NEI: Nuclear Energy Institute

25. NRC: Nuclear Regulatory Commission

26. ODCM: Offsite Dose Calculation Manual

27. OSLD: Optically Stimulated Luminescence Dosimeter

28. Protected Area: The fenced area immediately surrounding the Plant. Access to the protected area requires a security badge or escort.

29. PWR: Pressurized Water Reactor

30. REC: Radiological Effluent Control

31. REMP: Radiological Environmental Monitoring Program

32. Restricted Area: Any area where access is controlled for the purpose of protecting individuals from exposure to radiation or radioactive materials.

33. SLCs: Selected Licensee Commitments

34. TEDE: Total Effective Dose Equivalent (TEDE) means the sum of the effective dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

35. TLD: Thermoluminescent Dosimeter

36. TRM: Technical Requirements Manual

37. TS: Technical Specification

2.0 EXECUTIVE SUMMARY

Joseph M. Farley Nuclear Plant (FNP) Radiological Effluent Control (REC) Program was established to limit the quantities of radioactive material that may be released based on calculated radiation doses or dose rates. Dose to Members of the Public due to radioactive materials released from the plant is limited by Appendix I of 10 CFR 50 and by 40 CFR 190. Operational doses to the public during 2022 were calculated to be very small compared to the limits required by regulation and compared to other sources of radiation dose and pose no health hazard. These doses are summarized and compared to the regulatory limits in Section 2.1, Comparison to Regulatory Limits, below.

The Annual Radioactive Effluent Release Report (ARERR) is published per REC requirements and provides data related to plant operation, including: quantities of radioactive materials released in liquid and gaseous effluents; radiation doses to members of the public; solid radioactive waste shipped offsite for disposal; and other information as required by site licensing documents.

In 2022 the Land Use Census dose assessments due to radioactive gaseous effluents showed that the critical receptor for Joseph M. Farley Nuclear Plant is Child, due to exposure pathways inhalation, ground plane, grass-cow-meat and garden vegetation, at location 1.2 miles, SW. The maximum Annual Organ Dose calculated for this receptor was 5.47E-03 mrem, to the thyroid. This annual dose is a small fraction of the 10 CFR 50, Appendix I guideline of 15 mrem to the Maximum Organ per reactor unit.

Solid radioactive waste shipped offsite for disposal included 3.14E+02 Curies and 5.38E+02 m^3, shipped in 16 shipments.

In addition to monitoring radioactive effluents, FNP has a Radiological Environmental Monitoring Program (REMP) that monitors for buildup of radioactivity in the offsite environment. Data from the REMP is published in the Annual Radiological Environmental Operating Report (AREOR).

2.1 Comparison to Regulatory Limits

During 2022 all solid, liquid, and gaseous radioactive effluents from Joseph M. Farley Nuclear Plant were well below regulatory limits, as summarized in Table 1 and Table 2.

Table 1, Joseph M. Farley Nuclear Plant (Unit 1) Dose Summary[1]

		Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual
Liquid Effluent Dose Limit, Total Body	**Limit**	**1.5 mrem**	**1.5 mrem**	**1.5 mrem**	**1.5 mrem**	**3 mrem**
	Total Body Dose	3.73E-03	2.23E-03	3.43E-03	6.08E-04	1.00E-02
	% of Limit	2.49E-01	1.49E-01	2.29E-01	4.05E-02	3.33E-01
Liquid Effluent Dose Limit, Any Organ	**Limit**	**5 mrem**	**5 mrem**	**5 mrem**	**5 mrem**	**10 mrem**
	Max Organ Dose	3.02E-02	2.47E-02	5.54E-03	1.93E-03	6.24E-02
	% of Limit	6.04E-01	4.95E-01	1.11E-01	3.86E-02	6.24E-01
Gaseous Effluent Dose Limit, Gamma Air (Noble Gas)	**Limit**	**5 mrad**	**5 mrad**	**5 mrad**	**5 mrad**	**10 mrad**
	Gamma Air Dose	1.73E-04	2.18E-04	4.55E-04	6.45E-06	8.53E-04
	% of Limit	3.47E-03	4.36E-03	9.10E-03	1.29E-04	8.53E-03
Gaseous Effluent Dose Limit, Beta Air (Noble Gas)	**Limit**	**10 mrad**	**10 mrad**	**10 mrad**	**10 mrad**	**20 mrad**
	Beta Air Dose	6.13E-05	7.75E-05	6.39E-04	1.08E-05	7.88E-04
	% of Limit	6.13E-04	7.75E-04	6.39E-03	1.08E-04	3.94E-03
Gaseous Effluent Organ Dose Limit (Iodine, Tritium, Particulates with > 8-day half-life)	**Limit**	**7.5 mrem**	**7.5 mrem**	**7.5 mrem**	**7.5 mrem**	**15 mrem**
	Max Organ Dose	5.05E-04	1.65E-04	8.15E-04	1.49E-04	1.64E-03
	% of Limit	6.73E-03	2.21E-03	1.09E-02	1.99E-03	1.09E-02

[1] Table 1 demonstrates compliance with 10 CFR Part 50, App. I Limits.

Table 2, Joseph M. Farley Nuclear Plant (Unit 2) Dose Summary[1]

		Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual
Liquid Effluent Dose Limit, Total Body	**Limit**	**1.5 mrem**	**1.5 mrem**	**1.5 mrem**	**1.5 mrem**	**3 mrem**
	Total Body Dose	5.11E-03	2.23E-03	1.54E-03	1.20E-03	1.01E-02
	% of Limit	3.41E-01	1.49E-01	1.03E-01	8.03E-02	3.36E-01
Liquid Effluent Dose Limit, Any Organ	**Limit**	**5 mrem**	**5 mrem**	**5 mrem**	**5 mrem**	**10 mrem**
	Max Organ Dose	5.49E-02	2.11E-02	2.40E-03	2.21E-03	8.07E-02
	% of Limit	1.10E+00	4.22E-01	4.80E-02	4.43E-02	8.07E-01
Gaseous Effluent Dose Limit, Gamma Air (Noble Gas)	**Limit**	**5 mrad**	**5 mrad**	**5 mrad**	**5 mrad**	**10 mrad**
	Gamma Air Dose	1.28E-04	2.23E-04	4.47E-04	1.13E-04	9.12E-04
	% of Limit	2.57E-03	4.47E-03	8.94E-03	2.27E-03	9.12E-03
Gaseous Effluent Dose Limit, Beta Air (Noble Gas)	**Limit**	**10 mrad**	**10 mrad**	**10 mrad**	**10 mrad**	**20 mrad**
	Beta Air Dose	4.53E-05	7.90E-05	1.58E-04	4.03E-05	3.23E-04
	% of Limit	4.53E-04	7.90E-04	1.58E-03	4.03E-04	1.61E-03
Gaseous Effluent Organ Dose Limit (Iodine, Tritium, Particulates with > 8-day half-life)	**Limit**	**7.5 mrem**	**7.5 mrem**	**7.5 mrem**	**7.5 mrem**	**15 mrem**
	Max Organ Dose	6.62E-04	8.34E-04	2.09E-03	2.47E-04	3.84E-03
	% of Limit	8.83E-03	1.11E-02	2.79E-02	3.29E-03	2.56E-02

[1] Table 2 demonstrates compliance with 10 CFR Part 50, App. I Limits.

Technical Specification 5.5.4.j states that the dose or dose commitment to any MEMBER OF THE PUBLIC over a calendar year, due to releases of radioactivity and to radiation from uranium fuel cycle sources, shall be limited to less than or equal to 25 mrem to the total body or to any organ, except the thyroid, which shall be limited to less than or equal to 75 mrem (as stated in ODCM 5.1).

With the calculated doses from the release of radioactive materials in liquid or gaseous effluents exceeding twice the limits of ODCM 2.1.3, 3.1.3, or 3.1.4, calculations shall be made according to ODCM 5.2 methods to determine whether the above (ODCM 5.1) limits have been exceeded (as stated in ODCM 5.1.2).

Since none of the ODCM 2.1.3, 3.1.3, or 3.1.4 limits were exceeded during 2022, no calculations were required, however, Table 3, Total Annual Offsite-Dose Comparison to 40 CFR 190 Limits for FNP was included to demonstrate compliance with 40 CFR 190.

Table 3, Total Annual Offsite-Dose Comparison to 40 CFR 190 Limits for FNP[1]

	Whole Body	**Thyroid**	**Max Other Organ**
Gaseous[2]	7.32E-03	5.47E-03	5.47E-03
Carbon-14	1.64E-01	1.64E-01	8.22E-01
Liquid	2.01E-02	1.92E-02	1.43E-01
Direct Shine*	N/A	N/A	N/A
Total Site Dose	1.92E-01	1.89E-01	9.71E-01
Total w/Other Nearby Facility[3]	N/A	N/A	N/A
Limit	**25 mrem**	**75 mrem**	**25 mrem**
% of Limit	7.66E-01	2.52E-01	3.88E+00

*Based on data from the Radiological Environmental Monitoring Program, direct radiation at the nearest residence is indistinguishable from background.

[1] Table 3 is a summation of Units to show compliance with 40 CFR Part 190 Limits.
[2] Gaseous dose values in Table 3 includes organ dose from Noble Gas, Iodine, Tritium, and particulates.
[3] Other fuel cycle sources within 5 miles of the site are considered in this analysis.

3.0 INTRODUCTION

3.1 About Nuclear Power

Commercial nuclear power plants are generally classified as either Boiling Water Reactors (BWRs) or Pressurized Water Reactors (PWRs), based on their design. A BWR includes a single coolant system where water used as reactor coolant boils as it passes through the core and the steam generated is used to turn the turbine generator for power production. A PWR, in contrast, includes two separate water systems: radioactive reactor coolant and a secondary system. Reactor coolant is maintained under high pressure, preventing boiling. The high-pressure coolant is passed through a heat exchanger called a steam generator where the secondary system water is boiled, and the steam is used to turn the turbine generator for power production.

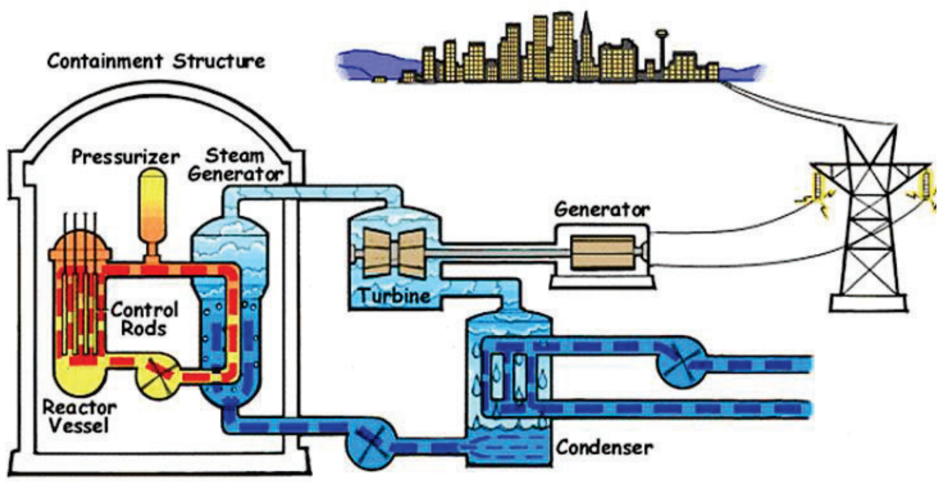


Figure 1, Pressurized Water Reactor (PWR) **[1]**

3.1 (Continued)

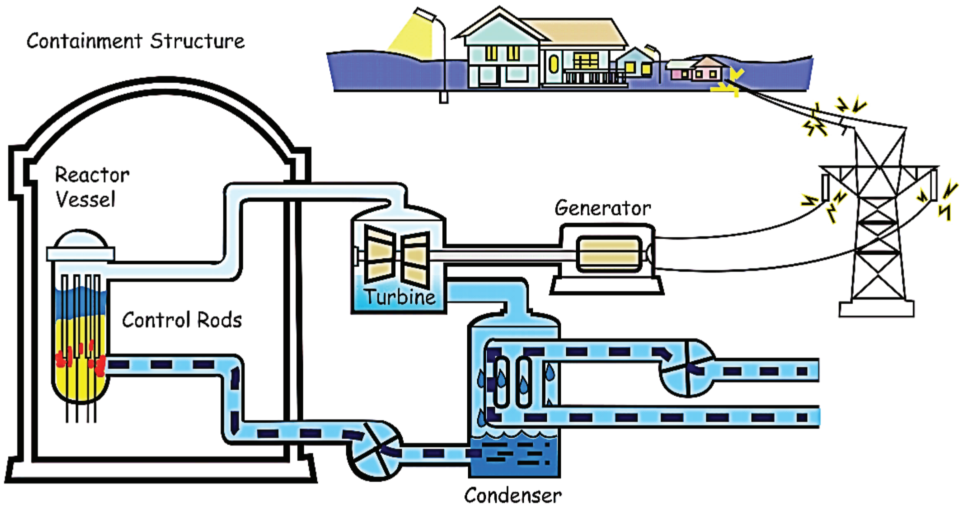


Figure 2, Boiling Water Reactor (BWR) **[2]**

Electricity is generated by a nuclear power plant similarly to the way that electricity is generated at other conventional types of power plants, such as those driven by coal or natural gas. Water is boiled to generate steam; the steam turns a turbine that is attached to a generator and the steam is condensed back into water to be returned to the boiler. What makes nuclear power different from these other types of power plants is that the heat is generated by fission and decay reactions occurring within and around the core containing fissionable uranium (U-235).

Nuclear fission occurs when certain nuclides (primarily U-233, U-235, or Pu-239) absorb a neutron and break into several smaller nuclides (called fission products) as well as some additional neutrons.

Fission results in production of radioactive materials including gases and solids that must be contained to prevent release or treated prior to release. These effluents are generally treated by filtration and/or hold-up prior to release. Releases are generally monitored by sampling and by continuously indicating radiation monitors. The effluent release data is used to calculate doses in order to ensure that dose to the public due to plant operation remains within required limits.

3.2 About Radiation Dose

Ionizing radiation, including alpha, beta, and gamma radiation from radioactive decay, has enough energy to break chemical bonds in tissues and result in damage to tissue or genetic material. The amount of ionization that will be generated by a given exposure to ionizing radiation is quantified as dose. Radiation dose is generally reported in units of millirem (mrem) in the US.

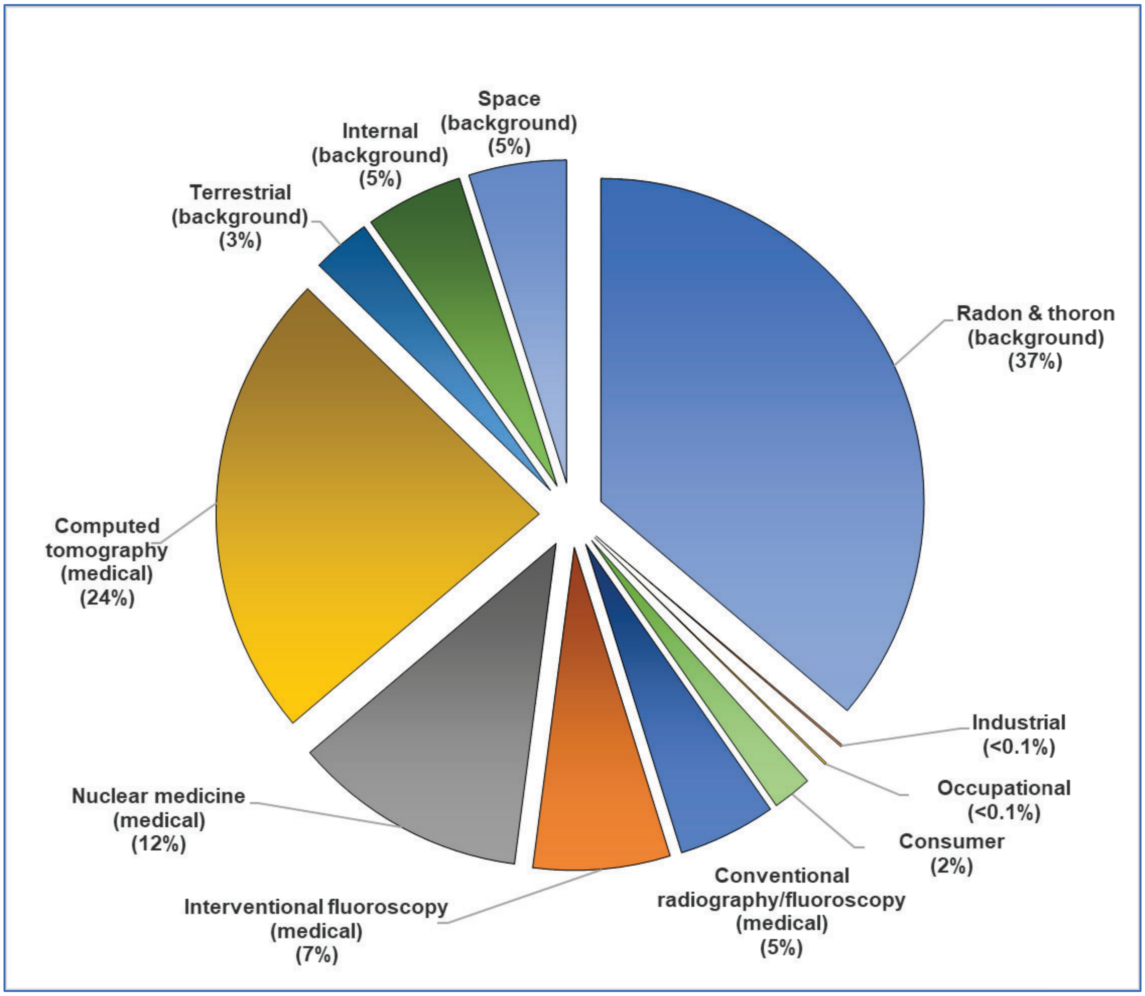


Figure 3, Sources of Radiation Exposure (NCRP Report No. 160) **[3]**

3.2 (Continued)

The National Council on Radiation Protection (NCRP) has evaluated the population dose for the US and determined that the average individual is exposed to approximately 620 mrem per year [3]. There are many sources for radiation dose, ranging from natural background sources to medical procedures, air travel, and industrial processes. Approximately half (310 mrem) of the average exposure is due to natural sources of radiation including exposure to Radon, cosmic radiation, and internal radiation and terrestrial due to naturally occurring radionuclides. The remaining 310 mrem of exposure is due to man-made sources of exposure, with the most significant contributors being medical (48%) due to radiation used in various types of medical scans and treatments. Of the remaining 2% of dose, most is due to consumer activities such as air travel, smoking cigarettes, and building materials. A small fraction of this 2% is due to industrial activities including generation of nuclear power.

Readers that are curious about common sources and effects of radiation dose that they may encounter can find excellent sources of information from the Health Physics Society, including the Radiation Fact Sheets [4], and from the US Nuclear Regulatory Commission website [5].

3.3 About Dose Calculation

Concentrations of radioactive material in the environment resulting from plant operations are very small and it is not possible to determine doses directly using measured activities of environmental samples. To overcome this, Dose Calculations based on measured activities of effluent streams are used to model the dose impact for Members of the Public due to plant operation and effluents. There are several mechanisms that can result in dose to Members of the Public, including: Ingestion of radionuclides in food or water; Inhalation of radionuclides in air; Immersion in a plume of noble gases; and Direct Radiation from the ground, the plant or from an elevated plume.

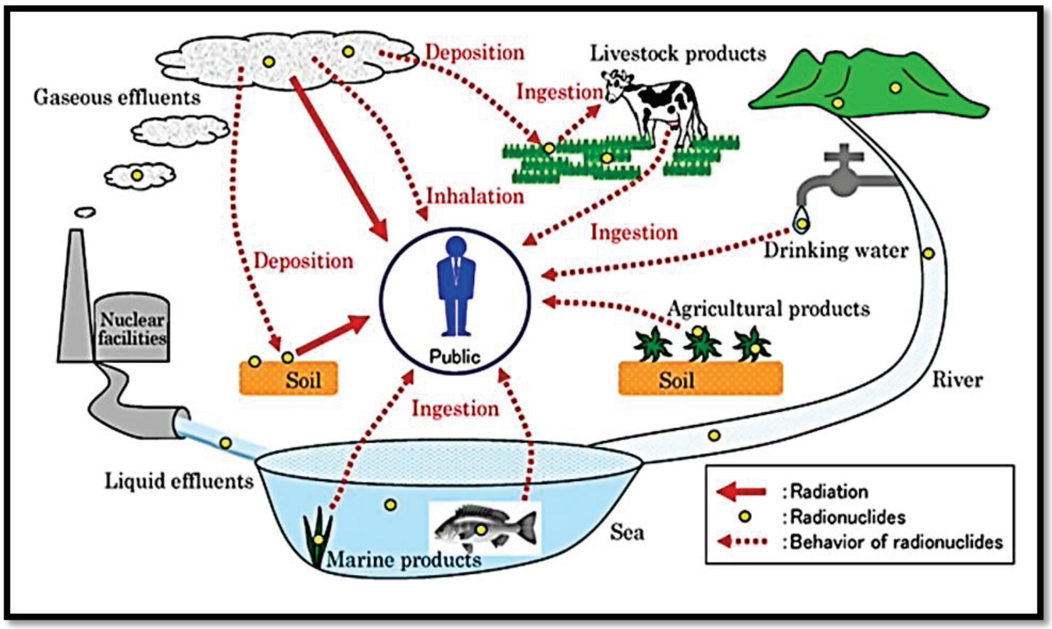


Figure 4, Potential exposure pathways to Members of the Public due to Plant Operations **[6]**

The Offsite Dose Calculation Manual (ODCM) specifies the methodology used to obtain the doses in the Dose Assessment section of this report. The methodology in the ODCM is based on NRC Regulatory Guide 1.109 [7] and NUREG-0133 [8]. Doses are calculated by determining what the nuclide concentration will be in air, water, on the ground, or in food products based on plant effluent releases. Release points are continuously monitored to quantify what concentrations of nuclides are being released. For gaseous releases meteorological data is used to determine how much of the released activity will be present at a given location outside of the plant either deposited onto the ground or in gaseous form. Intake patterns and nuclide bio-concentration factors are used to determine how much activity will be transferred into animal milk or meat. Finally, human ingestion factors and dose factors are used to determine how much activity will be consumed and how much dose the consumer will receive. Inhalation dose is calculated by determining the concentration of nuclides and how much air is breathed by the individual.

3.3 (Continued)

For liquid releases, dilution and mixing factors are used to model the environmental concentrations in water. Drinking water pathways are modeled by determining the concentration of nuclides in the water at the point where the drinking water is sourced. Fish and invertebrate pathways are determined by using concentration at the release point, bioaccumulation factors for the fish or invertebrate and an estimate of the quantity of fish consumed.

Each year a Land Use Census is performed to determine what potential dose pathways currently exist within a five-mile radius around the plant, the area most affected by plant operations. The Annual Land Use Census identifies the locations of vegetable gardens, nearest residences, milk animals and meat animals. The data from the census is used to determine who is the likely to be most exposed to radiation dose as a result of plant operation.

There is significant uncertainty in dose calculation results, due to modeling dispersion of material released and bioaccumulation factors, as well as assumptions associated with consumption and land-use patterns. Even with these sources of uncertainty, the calculations do provide a reasonable estimate of the order of magnitude of the exposure. Conservative assumptions are made in the calculation inputs such as the number of various foods and water consumed, the amount of air inhaled, and the amount of direct radiation exposure from the ground or plume, such that the actual dose received are likely lower than the calculated dose. Even with the built-in conservatism, doses calculated for the highest hypothetical exposed individual due to plant operation are a very small fraction of the annual dose that is received due to other sources. The low calculated doses due to plant effluents, along with REMP results, serve to provide assurance that the site is not having a negative impact on the environment or people living near the plant.

4.0 DOSE ASSESSMENT FOR PLANT OPERATIONS

4.1 Regulatory Limits

Regulatory limits are detailed in Station Licensing documents such as the Offsite Dose Calculation Manual (ODCM) and Technical Specifications 5.5.1, 5.5.4, 5.6.2 and 5.6.3. These documents contain the limits to which FNP must adhere. FNP drives to maintain the philosophy to keep dose "as low as reasonably achievable" (ALARA) and actions are taken to reduce the amount of radiation released to the environment. Liquid and gaseous release data show that the dose from FNP is well below the ODCM limits. The concentration of liquid radioactive material released shall be limited to ten times the concentration specified in 10 CFR 20, Appendix B, Table 2, Column 2, for radionuclides other than dissolved or entrained noble gases. For dissolved or entrained noble gases, the total concentration released shall be limited to 1.0×10^{-4} microcuries/ml. For gross alpha in liquid radwaste, the ECL is 2E-09 uCi/ml. These data reveals that the radioactive effluents have an overall minimal dose contribution to the surrounding environment.

The annual whole body, skin and organ dose was computed using the 2022 source term using the dose calculation methodology provided in the ODCM. The calculated doses due to gaseous effluents to demonstrate compliance with offsite dose limits are presented in Table 1, Joseph M. Farley Nuclear Plant (Unit 1) Dose Summary, Table 2, Joseph M. Farley Nuclear Plant (Unit 2) Dose Summary and Table 3, Total Annual Offsite-Dose Comparison to 40 CFR 190 Limits for FNP.

4.2 Regulatory Limits for Gaseous Effluent Doses:

1. Fission and activation gases:

   a. Noble gases dose rate due to radioactive materials released in gaseous effluents from the site to areas at and beyond the site boundary shall be limited to the following:

      1) Less than or equal to 500 mrem/year to the total body

      2) Less than or equal to 3000 mrem/year to the skin

   b. Noble gas air dose due to noble gases released in gaseous effluents, from each reactor unit, to areas at and beyond the site boundary shall be limited to the following:

      1) Quarterly

         a) Less than or equal to 5 mrads gamma

         b) Less than or equal to 10 mrads beta

4.2 (Continued)

1) Yearly

a) Less than or equal to 10 mrads gamma

b) Less than or equal to 20 mrads beta

2. Iodine, tritium, and all radionuclides in particulate form with half-lives greater than 8 days.

a. The dose rate for iodine-131, iodine-133, tritium, and all radionuclides in particulate form with half-lives greater than 8 days in gaseous effluents released from the site to areas at and beyond the site boundary shall be limited to the following:

1) Less than or equal to 1500 mrem/yr to any organ

b. The dose to a MEMBER OF THE PUBLIC from iodine-131, iodine-133, tritium, and all radionuclides in particulate form with half-lives greater than 8 DAYS in gaseous effluents released, from each reactor unit, to areas at and beyond the site boundary shall be limited to the following:

1) Quarterly

a) Less than or equal to 7.5 mrem to any organ

2) Yearly

a) Less than or equal to 15 mrem to any organ

4.3 <u>Regulatory Limits for Liquid Effluent Doses</u>

1. The dose or dose commitment to a MEMBER OF THE PUBLIC from radioactive materials in liquid effluents released, from each reactor unit, to unrestricted areas shall be limited to the following:

a. Quarterly

1) Less than or equal to 1.5 mrem total body

2) Less than or equal to 5 mrem critical organ

b. Yearly

1) Less than or equal to 3 mrem total body

2) Less than or equal to 10 mrem critical organ

4.4 40 CFR 190 Regulatory Dose Limits for a Member of the Public

1. Total Dose (40 CFR 190)

   a. The annual (calendar year) dose or dose commitment to any MEMBER OF THE PUBLIC in the unrestricted area due to releases of radioactivity and to radiation from uranium fuel cycle sources shall be limited to the following:

      1) Less than or equal to 25 mrem, Total Body or any Organ except Thyroid.

      2) Less than or equal to 75 mrem, Thyroid.

4.5 Onsite Doses (Within Site Boundary)

This section evaluates dose to non-occupationally exposed workers and members of the public that may be onsite for various reasons. The report must include any other information as may be required by the Commission to estimate maximum potential annual radiation doses to the public resulting from effluent releases as required by 10 CFR 50.36a(a)(2). While within controlled or restricted areas, the limits from Sections 4.1 through 4.4 do not apply; however, 10 CFR 20.1301 dose limit of 100 mrem per year TEDE and dose rate limit of 2 mrem per hour from external sources continue to apply. Occupancy times within the controlled areas are generally sufficiently low to compensate for increase in the atmospheric dispersion factor above the site boundary. Groups of concern and occupancy factors (number of hours/year spent inside the site boundary), are listed in Table 4. These groups conservatively represent the most-exposed individual.

Table 4, Onsite Doses (Within Site Boundary)[1]

Location	Sector	Occupancy Hours	Approx. Distance (Meters)	Dose (mrem)	
				Total Body	Organ
Visitor Center	WSW	12	306	1.71E-07	1.71E-07
Service Water Pond	SSW	66	966	1.04E-07	1.05E-07
River Water Discharge	SE	100	1640	1.14E-07	1.14E-07

[1] Current FNP effluent controls as established by ODCM 6.1 do not require assessment of the radiation doses from radioactive liquid and gaseous effluents to MEMBERS OF THE PUBLIC due to their activities inside the SITE BOUNDARY (ODCM Figure 10-1). However, this assessment has been performed for 2022 using the methods described in ODCM 6.2.

5.0 SUPPLEMENTAL INFORMATION

5.1 Gaseous Batch Releases

5.1.1 FNP (Unit 1)

	Units	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual
1. Number of Batch Releases		118	127	54	5	304
2. Total duration of batch releases	minutes	6.56E+03	9.33E+03	1.33E+04	2.88E+03	3.21E+04
3. Maximum batch release duration	minutes	3.80E+02	8.45E+02	2.84E+03	8.99E+02	2.84E+03
4. Average batch release duration	minutes	5.56E+01	7.34E+01	2.47E+02	5.76E+02	1.06E+02
5. Minimum batch release duration	minutes	4.00E+00	1.00E+00	1.00E+00	2.84E+02	1.00E+00

5.1.2 FNP (Unit 2)

	Units	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual
1. Number of Batch Releases		86	49	69	86	290
2. Total duration of batch releases	minutes	6.48E+03	3.17E+03	5.74E+03	4.26E+03	1.96E+04
3. Maximum batch release duration	minutes	4.94E+02	3.15E+02	1.54E+03	1.20E+02	1.54E+03
4. Average batch release duration	minutes	7.53E+01	6.46E+01	8.32E+01	4.95E+01	6.77E+01
5. Minimum batch release duration	minutes	5.00E+00	4.00E+00	4.00E+00	3.00E+00	3.00E+00

5.2 Liquid Batch Releases

5.2.1 FNP (Unit 1)

	Units	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual
1. Number of Batch Releases		83	80	117	81	361
2. Total duration of batch releases	minutes	9.85E+03	9.06E+03	1.32E+04	8.90E+03	4.10E+04
3. Maximum batch release duration	minutes	1.70E+02	1.62E+02	1.65E+02	1.33E+02	1.70E+02
4. Average batch release duration	minutes	1.19E+02	1.13E+02	1.13E+02	1.10E+02	1.14E+02
5. Minimum batch release duration	minutes	9.50E+01	7.30E+01	9.00E+01	8.30E+01	7.30E+01
6. Average stream flow during periods of release of liquid effluent into a flowing stream[1]	CFS	1.53E+04	9.43E+03	4.74E+03	5.99E+03	8.86E+03

[1] Average River Flow Rate, taken at Walter F. George Lock and Dam, located 30.7 miles above Farley Nuclear Plant.

5.2.2 FNP (Unit 2)

	Units	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual
1. Number of Batch Releases		86	90	81	58	315
2. Total duration of batch releases	minutes	9.96E+03	9.87E+03	8.67E+03	6.14E+03	3.46E+04
3. Maximum batch release duration	minutes	1.40E+02	1.61E+02	1.47E+02	1.80E+02	1.80E+02
4. Average batch release duration	minutes	1.16E+02	1.10E+02	1.07E+02	1.06E+02	1.10E+02
5. Minimum batch release duration	minutes	8.50E+01	9.00E+01	9.00E+01	9.00E+01	8.50E+01
6. Average stream flow during periods of release of liquid effluent into a flowing stream[1]	CFS	1.53E+04	9.43E+03	4.74E+03	5.99E+03	8.86E+03

5.3 Abnormal Releases

5.3.1 Gaseous Abnormal Releases (Unit 1)

	Units	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual
1. Number of Releases		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Total Time For All Releases	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3. Maximum Time For A Release	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4. Average Time For A Release	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5. Minimum Time For A Release	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
6. Total activity for all releases	Curies	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

5.3.2 Gaseous Abnormal Releases (Unit 2)

	Units	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual
1. Number of Releases		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Total Time For All Releases	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3. Maximum Time For A Release	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4. Average Time For A Release	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5. Minimum Time For A Release	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
6. Total activity for all releases	Curies	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

There were no abnormal gaseous releases during 2022.

[1] Average River Flow Rate, taken at Walter F. George Lock and Dam, located 30.7 miles above Farley Nuclear Plant.

5.3.3 Liquid Abnormal Releases (Unit 1)

	Units	**1st Quarter**	**2nd Quarter**	**3rd Quarter**	**4th Quarter**	**Annual**
1. Number of Releases		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Total Time For All Releases	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3. Maximum Time For A Release	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4. Average Time For A Release	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5. Minimum Time For A Release	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
6. Total activity for all releases	Curies	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

5.3.4 Liquid Abnormal Releases (Unit 2)

	Units	**1st Quarter**	**2nd Quarter**	**3rd Quarter**	**4th Quarter**	**Annual**
1. Number of Releases		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Total Time For All Releases	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3. Maximum Time For A Release	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4. Average Time For A Release	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5. Minimum Time For A Release	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
6. Total activity for all releases	Curies	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

There were no abnormal liquid releases during 2022

5.4 Land Use Census Changes

There were no changes to receptors, receptor locations, sample media availability, or new (or changed) routes of exposure as determined by the 2022 Land Use Census.

5.5 Meteorological Data

ODCM 7.2.2.2 states in part:

The Radioactive Effluent Release Report shall include an annual summary of hourly meteorological data collected over the previous year. This annual summary may be either in the form of an hour-by-hour listing of wind speed, wind direction, atmospheric stability, and precipitation (if measured) on magnetic tape; or in the form of joint frequency distributions of wind speed, wind direction and atmospheric stability.

In lieu of submission with the Radioactive Effluent Release Report, the licensee has the option of retaining this summary of required meteorological data on site in a file that shall be provided to the NRC upon request.

5.5 (Continued)

Meteorological data accumulation was greater that 98% for all variables required by Regulatory Guide 1.23. At least a 90% data recovery is required by the Regulatory Guide.

5.6 Effluent Radiation Monitors Out of Service Greater Than 30 Days

ODCM 7.2.2.6 states in part that the Annual Radioactive Effluent Release Report (the report) shall include deviations from the liquid and gaseous effluent monitoring instrumentation operability requirements included in Sections 2.1.1 and 3.1.1 of the ODCM. The report must also include an explanation as to why the inoperability was not corrected in a timely manner. There were no Effluent Radiation Monitors out of service for greater than 30 days in 2022.

5.7 Offsite Dose Calculation Manual (ODCM) Changes

Pursuant to Technical Specification 5.5.1.c and ODCM 7.2.2.5, licensee initiated changes to the ODCM shall be submitted to the Nuclear Regulatory Commission as a part of or concurrent with the Annual Radioactive Effluent Release Report for the period in which any changes were made. Included are changes to the radiological environmental monitoring program sampling locations or dose calculation locations or pathways, including any changes made pursuant to ODCM 4.1.2.2.2 (land use census). There were no changes to the ODCM in 2022.

5.8 Process Control Program (PCP) Changes

Process Control Program (PCP) B.5.1.2 states that licensee initiated major changes to the solid radioactive waste treatment system shall be reported to the Nuclear Regulatory Commission in the Annual Radioactive Effluent Release Report for the period in which the change was implemented. The discussion of each change shall include the information specified in PCP B.4.1. There were no changes to the PCP in 2022.

5.9 Radioactive Waste Treatment System Changes

ODCM 7.2.2.7 states in part that, as required by ODCM 2.1.5 and 3.1.6, licensee initiated MAJOR CHANGES TO RADIOACTIVE WASTE TREATMENT SYSTEMS (liquid and gaseous) shall be reported to the Nuclear Regulatory Commission in the Annual Radioactive Effluents Release Report covering the period in which the change was reviewed and accepted for implementation. There were no changes to the Radioactive Waste Treatment System in 2022.

5.10 Other Supplemental Information

5.10.1 Measurements and Approximation of Total Radioactivity Gaseous Effluents

1. The following noble gases are specifically considered in evaluating gaseous effluents, Kr-87, Kr-88, Xe-133m, Xe-133, Xe-135 and Xe-138.

2. The following radioiodines and radioactive materials in particulate form are specifically considered in evaluating gaseous effluents, Mn-54, Fe-59, Co-58, Co-60, Zn-65, Sr-89, Sr-90, Mo-99, I-131, Cs-134, Cs-137, Ce-141, Ce-144 and H-3.

3. Sample collection and Analysis

   Periodic grab samples from plant effluent streams are analyzed by a computerized pulse height analyzer system utilizing high resolution germanium detectors. Samples are obtained and analyzed in accordance with ODCM Table 3-3. Isotopic values thus obtained are used for release rate calculations as specified in ODCM 3.4.2 and ODCM 3.4.3. Only those nuclides which are detected are used in calculations. For radioiodines and particulates, in addition to the nuclides listed above, other nuclides with half-lives greater than 8 days which are identified are also considered.

   Continuous Releases: Continuous sampling is performed on the continuous release points (i.e. the Plant Vent Stack, Containment Purge when in continuous mode, and the Turbine Building Vent). Particulate material is collected by filtration. At least weekly, these filters are removed and analyzed on the pulse height analyzer to identify and quantify radioactive materials collected on the filters. Particulate filters are then analyzed for gross alpha and strontium as required. All gross alpha, Sr-89 and Sr-90 samples are sent offsite to the Georgia Power Environmental Laboratory for analysis.

   Batch Releases: The processing of batch type releases (from Containment when in batch mode, or Waste Gas Decay Tanks) is analogous to continuous releases, except that the release is not commenced until samples have been obtained and analyzed. Containment Purge batch releases were commenced at FNP beginning in 2006 in order to take advantage of additional decay time for short lived radionuclides.

   Typically achieved minimum detectable concentrations for gaseous effluent sample analyses are reported in Table 20, Minimum Detectable Concentrations Gaseous Sample Analysis.

5.10.1 (Continued)

4. Total Quantities of Radioactivity, Dose Rates, and Cumulative Doses

   a. Fission and Activation Gases

      The released radioactivity is determined using sample analyses results collected as described in section 5.10.13 and the average release flow rates over the period represented by the collected sample.

      Dose rates due to noble gases, radioiodines, tritium, and particulates are calculated (with computer assistance). The calculated dose rates are compared to the dose rate limits specified in ODCM 3.1.2 for noble gases, radioiodine, tritium, and particulates. Dose rate calculation methodology is presented in the ODCM.

      Beta and gamma air doses due to noble gases are calculated for the location in the unrestricted area with the potential for the highest exposure due to gaseous releases. Air doses are calculated for each release period and cumulative totals are kept for each unit for the calendar quarter and year. Cumulative air doses are compared to the dose limits specified in ODCM 3.1.3. The current percent of the ODCM limits are shown on the printout for each release period. Air dose calculation methodology is presented in the ODCM.

   b. Radioiodine, Tritium, and Particulate Releases

      Released quantities of radioiodines are determined using the weekly samples and release flow rates for the applicable release points. Radioiodine concentrations are determined by gamma spectroscopy.

      Release quantities of particulates are determined using the weekly (filter) samples and release flow rates for the applicable release points. Gamma spectroscopy is used to quantify the concentrations of principal gamma emitters.

      After each quarter, the particulate filters from each applicable vent (plant vent stack and containment purge) are combined, fused, and a strontium separation is performed. Since sample flows and vent flows are almost constant over each quarterly period the filters from each vent can be dissolved together. Decay corrections are performed back to the middle of the quarterly collection period. If Sr-89 or Sr-90 is not detected, MDCs are calculated. Strontium concentrations are input into the composite file of the computer and used for release dose rate and individual dose calculations.

5.10.1 (Continued)

Tritium samples are obtained monthly from the Plant Vent Stack, the Containment Purge when in batch mode, and the Turbine Building Vent (and weekly for Containment Purge when in continuous mode) by passing the sample stream through a cold trap or by using the bubble method. The grams of water vapor/cubic meter are measured upstream of the cold trap in order to alleviate the difficulties in determining water vapor collection efficiencies. The tritium samples are analyzed onsite and the results furnished in μCi/ml of water. The tritium concentration in water is converted to the tritium concentration in air and this value is input into the composite file of the computer and used in release, dose rate, and individual dose calculations.

Dose rates due to radioiodine, tritium and particulates are calculated for a hypothetical child exposed to the inhalation pathway at the location in the unrestricted area where the potential dose rate is expected to be the highest. Dose rates are calculated, for each release point for each release period, and the dose rates from each release point is compared to the dose rate limits specified in ODCM 3.1.2, allocated for each release point as described in ODCM 3.3.2.

Doses to a Member of the Public (individual doses) due to radioiodine, tritium and particulates are calculated for the controlling receptor, which is described in the ODCM. Individual doses are calculated for each release period, and cumulative totals are kept for each unit, for the current calendar quarter and year. Cumulative individual doses are compared to the dose limits specified in ODCM 3.1.4. The current percent of ODCM limits are shown on the printout for each release period.

c. Gross Alpha Release

The gross alpha release is computed each month by counting the particulate filters, for each week for gross alpha activity in a proportional counter. The highest concentration calculated for any of these weeks is used for the monthly value. This value is input into the composite file of the computer and used for release calculations.

5.10.1 (Continued)

5. Total Error Estimation

The maximum errors associated with monitor readings, sample flow, vent flow, sample collection, monitor calibration and laboratory procedure are collectively estimated to be:

F&A Gases	Iodine	Particulates	Tritium
75%	60%	50%	45%

The average error associated with counting is estimated to be:

F&A Gases	Iodine	Particulates	Tritium
19%	28%	20%	8%

5.10.2 **Measurements and Approximation of Total Radioactivity Liquid Effluents**

1. The radionuclides listed below are specifically considered when evaluating liquid effluents are Mn-54,Fe-59, Co-58, Co-60, Zn-65, Sr-89, Sr-90, I-131, Cs-134, Cs-137, Ce-141, Ce-144, Mo-99, Fe-55 and H-3.

2. Total Radioactivity Determination

Batch Releases: Representative pre-release grab samples are obtained and analyzed in accordance with ODCM Table 2-3. Isotopic analyses are performed by the computerized pulse height analysis system utilizing high resolution germanium detectors. Isotopic radionuclide concentrations thus obtained are used for release rate calculations as specified in the ODCM. Only those nuclides that are detected are used in the calculations. All Gross Alpha, Strontium, and Iron-55, samples are sent offsite to the Georgia Power Environmental Laboratory for analysis. Gross beta determinations are made using 2 pi gas flow proportional counters. Tritium determinations are made using liquid scintillation techniques. Dissolved gases are determined employing grab sampling techniques and then counting on the gamma spectrometry system.

The sample analyses results are used along with the ECL values to determine the ECL fraction for the planned release. The ECL fraction is then used, with the appropriate safety factors, and the expected dilution stream flow, to calculate the maximum permissible release rate and a liquid effluent monitor setpoint. The monitor setpoint is calculated to assure that the limits of the ODCM are not exceeded. A monitor reading in excess of the calculated setpoint will result in automatic termination of the liquid radwaste discharge.

5.10.2 (Continued)

Radionuclide concentrations, safety factors, dilution stream flow rate, and liquid effluent radiation monitor calibration factors are used by the computer to generate a pre-release printout. If the release is not permissible, appropriate warnings will be displayed on the computer screen and on the printout. If the release is permissible, it is approved by a Chemistry Technician. The release permit is transferred from the Chemistry Department to the Operations Department for release. When the release is completed, the actual release data are provided to the Chemistry Department. These release data, including release rate and release duration, are input into the computer and a post-release printout is generated. This printout contains the actual release rates, radionuclide concentrations and quantities, dilution flow, and calculated doses to an individual.

Continuous Releases: Continuous releases are analogous to batch releases except that they are analyzed on a weekly composite basis in accordance with ODCM Table 2-3.

Typically achieved liquid effluent sample analyses minimum detectable concentrations are reported in Table 30, Minimum Detectable Concentrations-Liquid Sample Analyses.

3. Total Error Estimation

The maximum error associated with volume and flow measurements, based upon plant calibration practice is estimated to be + or - 10%. The average error associated with counting is estimated to be less than + or - 15%.

5.10.3 **Effluent Sample Analysis Exceeding Minimum Detectable Concentration (MDC)**

ODCM 7.2.2.6 states in part that the report shall include deviations from the MDC requirements included in ODCM Tables 2-3 and 3-3. There were no deviations from the MDC requirements in 2022.

5.10.4 Outside Tanks

No outside tanks exceeded ODCM or Technical Specification Limits.

5.10.5 Carbon-14

Carbon-14 (C-14) is a naturally occurring radionuclide with a 5730 year half-life. Nuclear weapons testing in the 1950s and 1960s significantly increased the amount of C-14 in the atmosphere. Nuclear power plants also produce C-14, but the amount is infinitesimal compared to what has been distributed in the environment due to weapons testing and what is produced by natural cosmic ray interactions.

As nuclear plants have improved gaseous waste processing systems and improved fuel performance, the percentages of “principal radionuclides” in gaseous effluents have changed, and C-14 has become a larger percentage. “Principal radionuclides” are determined based on public dose contribution or the amount of activity discharged compared to other radionuclides of the same effluent type. In Revision 2 (June 2009) of Regulatory Guide 1.21 (RG 1.21), “Measuring, Evaluating, and Reporting Radioactive Material in Liquid and Gaseous Effluents and Solid Waste,” the NRC recommended re-evaluating “principal radionuclides” and reporting C-14 as appropriate. In 2010 Radioactive Effluent Release Reports, virtually all U. S. nuclear power plants started reporting C-14 amounts released and resulting doses to the maximally exposed member of the public.

Because C-14 is considered a hard-to-detect radionuclide which must be chemically separated from the effluent stream before it can be measured, RG 1.21 provides the option of calculating the C-14 source term based on power generation. The Electric Power Research Institute (EPRI) developed an accepted methodology for calculating C-14, and published the results in Technical Report 1021106 (December 2010), “Estimation of Carbon-14 in Nuclear Power Plant Gaseous Effluents.” Evaluation of C-14 in radioactive liquid effluents is not required because the quantity and dose contribution has been determined to be insignificant.

At Plant Farley, the annual quantity of C-14 released in gaseous effluents was estimated to be 9.28 Curies (per unit). Approximately 30% of the C-14 released is in the form of $^{14}CO2$ and is incorporated into plants through photosynthesis. Ingestion dose results from this pathway. The remaining 70% is estimated to be organic. Both the organic and inorganic forms of C-14 contribute to inhalation dose. A child is the maximally exposed individual, and bone dose is the highest organ dose. Using the dose calculation methodology from the Farley ODCM, the resulting bone dose to a child located at the controlling receptor location would be 4.11E-01 mrem in a year which is 2.74% of the regulatory limit of 15 mrem per year (per unit) to any organ due to gaseous effluents. The resulting total body dose to a child located at the controlling receptor location would be 8.21E-02 mrem in a year which is 0.54% of the regulatory limit of 15 mrem per year (per unit) total body dose due to gaseous effluents.

5.10.6 Errata/Corrections to Previous ARERRs

No errata required for previous ARERRs at this time.

6.0 NEI 07-07 ONSITE RADIOLOGICAL GROUNDWATER MONITORING PROGRAM

Joseph M. Farley Nuclear Plant has developed a Groundwater Protection Initiative (GPI) program in accordance with NEI 07-07, Industry Ground Water Protection Initiative – Final Guidance Document [9]. The purpose of the GPI is to ensure timely detection and an effective response to situations involving inadvertent radiological releases to groundwater in order to prevent migration of licensed radioactive material off-site and to quantify impacts on decommissioning. The summary of results of 2022, FNP GPI is located in Attachment 3, NEI 07-07 Onsite Radiological Groundwater Monitoring Program.

6.1 Voluntary Notification

During 2022, Joseph M. Farley Nuclear Plant did not make a voluntary NEI 07-07 notification to State/Local officials, NRC, and to other stakeholders required by site procedures.

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Attachment 1, ARERR Release Summary Tables (RG-1.21 Tables)

1.0 GASEOUS EFFLUENTS

Table 5, Gaseous Effluents Summation of All Releases (Unit 1)

A. Fission & Activation Gases	**Unit**	**Quarter 1**	**Quarter 2**	**Quarter 3**	**Quarter 4**	**Annual**	**Est. Total Error %**
1. Total Release	Ci	5.47E-01	6.88E-01	1.35E+01	2.06E-01	1.49E+01	*
2. Average release rate for the period	μCi/sec	6.94E-02	8.73E-02	1.71E+00	2.61E-02	4.74E-01	
B. Iodine-131							
1. Total Release	Ci	0.00E+00	0.00E+00	2.15E-07	1.48E-06	1.70E-06	*
2. Average release rate for the period	μCi/sec	0.00E+00	0.00E+00	2.73E-08	1.88E-07	5.37E-08	
C. Particulates							
1. Total Release	Ci	0.00E+00	0.00E+00	6.50E-09	2.91E-07	2.98E-07	*
2. Average release rate for the period	μCi/sec	0.00E+00	0.00E+00	8.25E-10	3.69E-08	9.43E-09	
D. Tritium							
1. Total Release	Ci	3.69E+00	1.21E+00	5.93E+00	8.94E-01	1.17E+01	*
2. Average release rate for the period	μCi/sec	4.68E-01	1.53E-01	7.52E-01	1.13E-01	3.72E-01	
E. Gross Alpha							
1. Total Release	Ci	7.39E-07	7.83E-07	4.95E-07	4.40E-07	2.46E-06	*
2. Average release rate for the period	μCi/sec	9.37E-08	9.93E-08	6.27E-08	5.58E-08	7.79E-08	
F. Carbon-14**							
1. Total Release	Ci	2.32E+00	2.32E+00	2.32E+00	2.32E+00	9.28E+00	
2. Average release rate for the period	μCi/sec	2.94E-01	2.94E-01	2.94E-01	2.94E-01	2.94E-01	

% of limit is on Table 1, Joseph M. Farley Nuclear Plant (Unit 1) Dose Summary
Zeroes in this table indicate that no radioactivity was present at detectable levels.
* % error see page 25
**Carbon-14 is calculated in accordance with section 5.10.5. It is a conservative estimate based on maximum power output and does not account for outages when C-14 is not produced.

Table 6, Gaseous Effluents – Mixed Level Release Continuous Mode (Unit 1)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission Gases						
Ar-41	Ci	0.00E+00	0.00E+00	2.17E-01	0.00E+00	2.17E-01
Xe-133	Ci	0.00E+00	0.00E+00	1.06E+01	0.00E+00	1.06E+01
Xe-135	Ci	0.00E+00	0.00E+00	2.30E+00	0.00E+00	2.30E+00
Total for Period	Ci	0.00E+00	0.00E+00	1.31E+01	0.00E+00	1.31E+01
Iodines						
I-131	Ci	0.00E+00	0.00E+00	2.15E-07	0.00E+00	2.15E-07
I-133	Ci	0.00E+00	0.00E+00	8.86E-07	0.00E+00	8.86E-07
Total for Period	Ci	0.00E+00	0.00E+00	1.10E-06	0.00E+00	1.10E-06
Particulates						
Be-7	Ci	0.00E+00	0.00E+00	0.00E+00	1.09E-07	1.09E-07
Co-58	Ci	0.00E+00	0.00E+00	0.00E+00	9.50E-08	9.50E-08
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	2.04E-07	2.04E-07
Tritium						
H-3	Ci	3.62E+00	9.89E-01	5.82E+00	8.94E-01	1.13E+01
Gross Alpha						
Alpha	Ci	7.39E-07	7.83E-07	4.95E-07	4.40E-07	2.46E-06
If Not Detected, Nuclide is Not Reported. Zeroes in this table indicate that no radioactivity was present at detectable levels. See Table 20, Minimum Detectable Concentrations Gaseous Sample Analysis for typical minimum detectable concentrations.						

Table 7, Gaseous Effluents – Mixed Level Release Batch Mode (Unit 1)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission Gases						
Ar-41	Ci	5.45E-01	6.80E-01	3.31E-01	2.26E-04	1.56E+00
Kr-85M	Ci	0.00E+00	0.00E+00	0.00E+00	8.83E-04	8.83E-04
Kr-88	Ci	0.00E+00	0.00E+00	0.00E+00	3.47E-04	3.47E-04
Kr-89	Ci	0.00E+00	2.54E-03	0.00E+00	0.00E+00	2.54E-03
Xe-131M	Ci	2.02E-05	1.10E-04	5.01E-04	0.00E+00	6.31E-04
Xe-133M	Ci	0.00E+00	7.82E-06	2.03E-04	4.57E-03	4.78E-03
Xe-133	Ci	2.71E-03	5.54E-03	3.15E-02	1.31E-01	1.71E-01
Xe-135M	Ci	0.00E+00	0.00E+00	2.35E-04	2.23E-04	4.58E-04
Xe-135	Ci	1.52E-06	1.23E-05	5.38E-04	6.84E-02	6.90E-02
Total for Period	Ci	5.47E-01	6.88E-01	3.64E-01	2.06E-01	1.81E+00
Iodines						
I-131	Ci	0.00E+00	0.00E+00	0.00E+00	1.48E-06	1.48E-06
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	1.48E-06	1.48E-06
Particulates						
Cr-51	Ci	0.00E+00	0.00E+00	0.00E+00	3.76E-08	3.76E-08
Co-58	Ci	0.00E+00	0.00E+00	3.32E-10	1.79E-08	1.82E-08
Y-88	Ci	0.00E+00	0.00E+00	2.59E-10	0.00E+00	2.59E-10
Zr-95	Ci	0.00E+00	0.00E+00	0.00E+00	6.50E-09	6.50E-09
Nb-95	Ci	0.00E+00	0.00E+00	0.00E+00	2.56E-08	2.56E-08
Nd-147	Ci	0.00E+00	0.00E+00	5.91E-09	0.00E+00	5.91E-09
Total for Period	Ci	0.00E+00	0.00E+00	6.50E-09	8.76E-08	9.41E-08
Tritium						
H-3	Ci	7.70E-02	2.21E-01	1.10E-01	0.00E+00	4.08E-01
Gross Alpha						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
If Not Detected, Nuclide is Not Reported. Zeroes in this table indicate that no radioactivity was present at detectable levels. See Table 20, Minimum Detectable Concentrations Gaseous Sample Analysis for typical minimum detectable concentrations.						

Table 8, Gaseous Effluents – Ground Level Release Continuous Mode (Unit 1)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission Gases						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Iodines						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tritium						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gross Alpha						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
If Not Detected, Nuclide is Not Reported. Zeroes in this table indicate that no radioactivity was present at detectable levels. See Table 20, Minimum Detectable Concentrations Gaseous Sample Analysis for typical minimum detectable concentrations.						

Table 9, Gaseous Effluents – Ground Level Release Batch Mode (Unit 1)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission Gases						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Iodines						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tritium						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gross Alpha						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
If Not Detected, Nuclide is Not Reported. Zeroes in this table indicate that no radioactivity was present at detectable levels. See Table 20, Minimum Detectable Concentrations Gaseous Sample Analysis for typical minimum detectable concentrations.						

Table 10, Gaseous Effluents Summation of All Releases (Unit 2)

A. Fission & Activation Gases	**Unit**	**Quarter 1**	**Quarter 2**	**Quarter 3**	**Quarter 4**	**Annual**	**Est. Total Error %**
1. Total Release	Ci	4.03E-01	7.08E-01	1.42E+00	3.66E-01	2.90E+00	*
2. Average release rate for the period	μCi/sec	5.12E-02	8.98E-02	1.80E-01	4.64E-02	9.19E-02	
B. Iodines - 131							
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	*
2. Average release rate for the period	μCi/sec	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
C. Particulates							
1. Total Release	Ci	0.00E+00	5.38E-08	1.54E-07	5.03E-09	2.13E-07	*
2. Average release rate for the period	μCi/sec	0.00E+00	6.83E-09	1.95E-08	6.39E-10	6.75E-09	
D. Tritium							
1. Total Release	Ci	4.84E+00	6.10E+00	1.53E+01	1.80E+00	2.80E+01	*
2. Average release rate for the period	μCi/sec	6.14E-01	7.73E-01	1.94E+00	2.29E-01	8.89E-01	
E. Gross Alpha							
1. Total Release	Ci	6.96E-07	7.42E-07	4.53E-07	4.64E-07	2.36E-06	*
2. Average release rate for the period	μCi/sec	8.83E-08	9.42E-08	5.74E-08	5.89E-08	7.47E-08	
F. Carbon-14**							
1. Total Release	Ci	2.32E+00	2.32E+00	2.32E+00	2.32E+00	9.28E+00	
2. Average release rate for the period	μCi/sec	2.94E-01	2.94E-01	2.94E-01	2.94E-01	2.94E-01	

% of limit is on Table 2, Joseph M. Farley Nuclear Plant (Unit 2) Dose Summary
Zeroes in this table indicate that no radioactivity was present at detectable levels.
* % error see page 25
**Carbon-14 is calculated in accordance with section 5.10.5. It is a conservative estimate based on maximum power output and does not account for outages when C-14 is not produced.

Table 11, Gaseous Effluents – Mixed Level Release Continuous Mode (Unit 2)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission Gases						
Ar-41	Ci	0.00E+00	5.41E-01	1.02E+00	0.00E+00	1.56E+00
Total for Period	Ci	0.00E+00	5.41E-01	1.02E+00	0.00E+00	1.56E+00
Iodines						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates						
Co-58	Ci	0.00E+00	2.33E-08	0.00E+00	0.00E+00	2.33E-08
Co-60	Ci	0.00E+00	1.46E-08	0.00E+00	0.00E+00	1.46E-08
Sr-89	Ci	0.00E+00	9.29E-09	1.08E-07	0.00E+00	1.17E-07
Sr-90	Ci	0.00E+00	3.96E-09	4.60E-08	0.00E+00	5.00E-08
Eu-155	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	5.12E-08	1.54E-07	0.00E+00	2.05E-07
Tritium						
H-3	Ci	4.83E+00	6.09E+00	1.52E+01	1.77E+00	2.79E+01
Gross Alpha						
Alpha	Ci	6.96E-07	7.42E-07	4.53E-07	4.64E-07	2.36E-06
If Not Detected, Nuclide is Not Reported. Zeroes in this table indicate that no radioactivity was present at detectable levels. See Table 20, Minimum Detectable Concentrations Gaseous Sample Analysis for typical minimum detectable concentrations.						

Table 12, Gaseous Effluents – Mixed Level Release Batch Mode (Unit 2)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission Gases						
Ar-41	Ci	4.03E-01	1.60E-01	3.80E-01	3.55E-01	1.30E+00
Kr-85M	Ci	0.00E+00	0.00E+00	6.55E-05	1.50E-06	6.70E-05
Xe-133M	Ci	0.00E+00	1.73E-05	2.94E-05	4.54E-05	9.21E-05
Xe-133	Ci	0.00E+00	6.77E-03	1.41E-02	1.06E-02	3.15E-02
Xe-135	Ci	2.04E-04	2.01E-04	3.09E-03	1.45E-04	3.64E-03
Total for Period	Ci	4.03E-01	1.67E-01	3.97E-01	3.66E-01	1.33E+00
Iodines						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates						
Co-58	Ci	0.00E+00	0.00E+00	2.51E-10	0.00E+00	2.51E-10
Y-88	Ci	0.00E+00	2.67E-09	0.00E+00	5.03E-09	7.70E-09
Total for Period	Ci	0.00E+00	2.67E-09	2.51E-10	5.03E-09	7.95E-09
Tritium						
H-3	Ci	6.78E-03	5.43E-03	6.05E-02	2.92E-02	1.02E-01
Gross Alpha						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
If Not Detected, Nuclide is Not Reported. Zeroes in this table indicate that no radioactivity was present at detectable levels. See Table 20, Minimum Detectable Concentrations Gaseous Sample Analysis for typical minimum detectable concentrations.						

Table 13, Gaseous Effluents – Ground Level Release Continuous Mode (Unit 2)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission Gases						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Iodines						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tritium						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gross Alpha						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
If Not Detected, Nuclide is Not Reported. Zeroes in this table indicate that no radioactivity was present at detectable levels. See Table 20, Minimum Detectable Concentrations Gaseous Sample Analysis for typical minimum detectable concentrations.						

Table 14, Gaseous Effluents – Ground Level Release Batch Mode (Unit 2)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission Gases						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Iodines						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tritium						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gross Alpha						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
If Not Detected, Nuclide is Not Reported. Zeroes in this table indicate that no radioactivity was present at detectable levels. See Table 20, Minimum Detectable Concentrations Gaseous Sample Analysis for typical minimum detectable concentrations.						

Table 15, Gaseous Effluents Summation of All Releases (Site)

A. Fission & Activation Gases	**Unit**	**Quarter 1**	**Quarter 2**	**Quarter 3**	**Quarter 4**	**Annual**	**Est. Total Error %**
1. Total Release	Ci	9.51E-01	1.40E+00	1.49E+01	5.72E-01	1.78E+01	*
2. Average release rate for the period	µCi/sec	1.21E-01	1.77E-01	1.89E+00	7.25E-02	5.65E-01	
B. Iodine-131							
1. Total Release	Ci	0.00E+00	0.00E+00	2.15E-07	1.48E-06	1.70E-06	*
2. Average release rate for the period	µCi/sec	0.00E+00	0.00E+00	2.73E-08	1.88E-07	5.37E-08	
C. Particulates							
1. Total Release	Ci	0.00E+00	5.38E-08	1.61E-07	2.96E-07	5.11E-07	*
2. Average release rate for the period	µCi/sec	0.00E+00	6.83E-09	2.04E-08	3.76E-08	1.62E-08	
D. Tritium							
1. Total Release	Ci	8.53E+00	7.31E+00	2.12E+01	2.70E+00	3.97E+01	*
2. Average release rate for the period	µCi/sec	1.08E+00	9.27E-01	2.69E+00	3.42E-01	1.26E+00	
E. Gross Alpha							
1. Total Release	Ci	1.43E-06	1.53E-06	9.47E-07	9.04E-07	4.81E-06	*
2. Average release rate for the period	µCi/sec	1.82E-07	1.93E-07	1.20E-07	1.15E-07	1.53E-07	
F. Carbon-14							
1. Total Release	Ci	4.64E+00	4.64E+00	4.64E+00	4.64E+00	1.86E+01	
2. Average release rate for the period	µCi/sec	5.89E-01	5.89E-01	5.89E-01	5.89E-01	5.89E-01	

* % error see page 25

Zeroes in this table indicate that no radioactivity was present at detectable levels.

Table 16, Gaseous Effluents – Mixed Level Release Continuous Mode (Site)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission Gases						
Ar-41	Ci	0.00E+00	5.41E-01	1.24E+00	0.00E+00	1.78E+00
Xe-133	Ci	0.00E+00	0.00E+00	1.06E+01	0.00E+00	1.06E+01
Xe-135	Ci	0.00E+00	0.00E+00	2.30E+00	0.00E+00	2.30E+00
Total for Period	Ci	0.00E+00	5.41E-01	1.42E+01	0.00E+00	1.47E+01
I-131	Ci	0.00E+00	0.00E+00	2.15E-07	0.00E+00	2.15E-07
I-133	Ci	0.00E+00	0.00E+00	8.86E-07	0.00E+00	8.86E-07
Total for Period	Ci	0.00E+00	0.00E+00	1.10E-06	0.00E+00	1.10E-06
Be-7	Ci	0.00E+00	0.00E+00	0.00E+00	1.09E-07	1.09E-07
Co-58	Ci	0.00E+00	2.33E-08	0.00E+00	9.50E-08	1.18E-07
Co-60	Ci	0.00E+00	1.46E-08	0.00E+00	0.00E+00	1.46E-08
Sr-89	Ci	0.00E+00	9.29E-09	1.08E-07	0.00E+00	1.17E-07
Sr-90	Ci	0.00E+00	3.96E-09	4.60E-08	0.00E+00	5.00E-08
Eu-155	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	5.12E-08	1.54E-07	2.04E-07	4.09E-07
H-3	Ci	8.45E+00	7.08E+00	2.11E+01	2.67E+00	3.93E+01
Alpha	Ci	1.43E-06	1.53E-06	9.47E-07	9.04E-07	4.81E-06

If Not Detected, Nuclide is Not Reported. Zeroes in this table indicate that no radioactivity was present at detectable levels. See Table 20, Minimum Detectable Concentrations Gaseous Sample Analysis for typical minimum detectable concentrations.

Table 17, Gaseous Effluents – Mixed Level Release Batch Mode (Site)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission Gases						
Ar-41	Ci	9.48E-01	8.40E-01	7.11E-01	3.56E-01	2.86E+00
Kr-85M	Ci	0.00E+00	0.00E+00	6.55E-05	8.84E-04	9.50E-04
Kr-88	Ci	0.00E+00	0.00E+00	0.00E+00	3.47E-04	3.47E-04
Kr-89	Ci	0.00E+00	2.54E-03	0.00E+00	0.00E+00	2.54E-03
Xe-131M	Ci	2.02E-05	1.10E-04	5.01E-04	0.00E+00	6.31E-04
Xe-133M	Ci	0.00E+00	2.51E-05	2.33E-04	4.61E-03	4.87E-03
Xe-133	Ci	2.71E-03	1.23E-02	4.56E-02	1.42E-01	2.03E-01
Xe-135M	Ci	0.00E+00	0.00E+00	2.35E-04	2.23E-04	4.58E-04
Xe-135	Ci	2.06E-04	2.13E-04	3.62E-03	6.85E-02	7.25E-02
Total for Period	Ci	9.51E-01	8.55E-01	7.62E-01	5.72E-01	3.14E+00
Iodines						
I-131	Ci	0.00E+00	0.00E+00	0.00E+00	1.48E-06	1.48E-06
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	1.48E-06	1.48E-06
Particulates						
Cr-51	Ci	0.00E+00	0.00E+00	0.00E+00	3.76E-08	3.76E-08
Co-58	Ci	0.00E+00	0.00E+00	5.83E-10	1.79E-08	1.85E-08
Y-88	Ci	0.00E+00	2.67E-09	2.59E-10	5.03E-09	7.96E-09
Zr-95	Ci	0.00E+00	0.00E+00	0.00E+00	6.50E-09	6.50E-09
Nb-95	Ci	0.00E+00	0.00E+00	0.00E+00	2.56E-08	2.56E-08
Nd-147	Ci	0.00E+00	0.00E+00	5.91E-09	0.00E+00	5.91E-09
Total for Period	Ci	0.00E+00	2.67E-09	6.76E-09	9.26E-08	1.02E-07
Tritium						
H-3	Ci	8.38E-02	2.26E-01	1.70E-01	2.92E-02	5.09E-01
Gross Alpha						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

If Not Detected, Nuclide is Not Reported. Zeroes in this table indicate that no radioactivity was present at detectable levels. See Table 20, Minimum Detectable Concentrations Gaseous Sample Analysis for typical minimum detectable concentrations.

Table 18, Gaseous Effluents – Ground Level Release Continuous Mode (Site)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission Gases						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Iodines						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tritium						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gross Alpha						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
If Not Detected, Nuclide is Not Reported. Zeroes in this table indicate that no radioactivity was present at detectable levels. See Table 20, Minimum Detectable Concentrations Gaseous Sample Analysis for typical minimum detectable concentrations.						

Table 19, Gaseous Effluents – Ground Level Release Batch Mode (Site)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission Gases						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Iodines						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tritium						
H-3	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gross Alpha						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
If Not Detected, Nuclide is Not Reported. Zeroes in this table indicate that no radioactivity was present at detectable levels. See Table 20, Minimum Detectable Concentrations Gaseous Sample Analysis for typical minimum detectable concentrations.						

Table 20, Minimum Detectable Concentrations Gaseous Sample Analysis

The values in this table represent a priori Minimum Detectable Concentrations (MDC) that are typically achieved in laboratory analyses of gaseous effluent samples

Nuclide	MDC(uCi/ML)	Nuclide	MDC(uCi/ML)
MN-54	1.53E-14	KR-87	4.22E-08
CO-58	9.12E-15	KR-88	5.72E-08
FE-59	2.32E-14	XE-133	3.92E-08
CO-60	1.52E-14	XE-133M	1.36E-07
ZN-65	3.93E-14	XE-135	1.62E-08
MO-99	1.06E-13	XE-138	1.11E-07
CS-134	8.98E-15	I-131	1.39E-14
CS-137	1.25E-14	I-133	7.89E-14
CE-141	9.95E-15		
CE-144	3.38E-14		

2.0 LIQUID EFFLUENTS

Table 21, Liquid Effluents – Summation of All Releases (Unit 1)

A. Fission & Activation Products	Unit	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual	Est. Total Error %
1. Total Release	Ci	5.90E-03	1.34E-02	8.83E-03	5.45E-03	3.36E-02	*
2. Average diluted concentration	µCi/mL	4.85E-10	9.52E-10	6.10E-10	2.05E-09	7.75E-10	
B. Tritium							
1. Total Release	Ci	4.04E+02	2.46E+02	4.43E+02	6.84E+01	1.16E+03	*
2. Average diluted concentration	µCi/mL	3.32E-05	1.75E-05	3.06E-05	2.58E-05	2.68E-05	
C. Dissolved & Entrained Gases							
1. Total Release	Ci	2.41E-04	5.02E-04	7.38E-03	1.86E-05	8.14E-03	*
2. Average diluted concentration	µCi/mL	1.98E-11	3.57E-11	5.10E-10	7.00E-12	1.88E-10	
D. Gross Alpha Activity							
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	*
E. Volume of Waste Released (prior to dilution)	Liters	2.41E+07	2.27E+07	2.04E+07	6.49E+06	7.37E+07	
F. Volume of Dilution Water Used During Period	Liters	1.21E+10	1.40E+10	1.45E+10	2.65E+09	4.33E+10	

% of limit is on the Table 1, Joseph M. Farley Nuclear Plant (Unit 1) Dose Summary
* % Error see page 26
Zeroes in this table indicate that no radioactivity was present at detectable levels.

Table 22, Continuous Mode Liquid Effluents (Unit 1)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission and Activation Products						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
H-3	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
If Not Detected, Nuclide is Not Reported. Zeroes in this table indicate that no radioactivity was present at detectable levels. See Table 30, Minimum Detectable Concentrations-Liquid Sample Analyses for typical minimum detectable concentrations.						

Table 23, Batch Mode Liquid Effluents (Unit 1)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission and Activation Products						
Nb-97	Ci	2.18E-06	2.72E-06	3.62E-06	0.00E+00	8.52E-06
I-131	Ci	6.12E-06	0.00E+00	0.00E+00	0.00E+00	6.12E-06
Ru-103	Ci	0.00E+00	0.00E+00	0.00E+00	3.30E-06	3.30E-06
Mn-54	Ci	1.52E-06	9.10E-05	1.82E-04	5.71E-05	3.32E-04
Cr-51	Ci	1.19E-05	1.48E-03	2.39E-04	1.57E-03	3.30E-03
Y-93	Ci	0.00E+00	0.00E+00	1.09E-05	0.00E+00	1.09E-05
Cs-137	Ci	9.95E-07	3.66E-05	2.14E-05	6.92E-06	6.59E-05
Sb-122	Ci	0.00E+00	3.78E-06	0.00E+00	0.00E+00	3.78E-06
Se-75	Ci	1.49E-05	1.49E-05	0.00E+00	0.00E+00	2.98E-05
Rh-106	Ci	0.00E+00	1.57E-05	0.00E+00	0.00E+00	1.57E-05
Fe-59	Ci	0.00E+00	5.78E-06	0.00E+00	0.00E+00	5.78E-06
Y-94	Ci	0.00E+00	0.00E+00	0.00E+00	5.58E-07	5.58E-07
Tc-99M	Ci	5.21E-05	9.47E-06	0.00E+00	0.00E+00	6.16E-05
Y-91	Ci	2.15E-04	0.00E+00	0.00E+00	0.00E+00	2.15E-04
Ba-140	Ci	0.00E+00	0.00E+00	1.98E-06	0.00E+00	1.98E-06
Y-88	Ci	0.00E+00	4.46E-07	0.00E+00	0.00E+00	4.46E-07
Tc-101	Ci	0.00E+00	0.00E+00	3.31E-07	0.00E+00	3.31E-07
Te-129	Ci	0.00E+00	0.00E+00	5.97E-06	0.00E+00	5.97E-06
Cs-136	Ci	0.00E+00	0.00E+00	4.77E-07	0.00E+00	4.77E-07
Co-60	Ci	8.46E-04	4.07E-03	5.45E-03	1.25E-03	1.16E-02
Cs-134	Ci	0.00E+00	0.00E+00	1.89E-06	0.00E+00	1.89E-06
Rh-105	Ci	0.00E+00	5.02E-04	9.92E-05	3.30E-04	9.31E-04
Te-134	Ci	0.00E+00	0.00E+00	3.05E-06	0.00E+00	3.05E-06
Sn-113	Ci	0.00E+00	1.11E-05	0.00E+00	2.43E-06	1.35E-05
Nd-147	Ci	0.00E+00	0.00E+00	7.65E-07	0.00E+00	7.65E-07
Nb-95	Ci	0.00E+00	4.46E-04	2.96E-04	4.74E-04	1.22E-03
Ru-106	Ci	0.00E+00	1.57E-05	0.00E+00	0.00E+00	1.57E-05
Eu-155	Ci	0.00E+00	0.00E+00	6.01E-07	0.00E+00	6.01E-07
Te-127M	Ci	0.00E+00	1.04E-04	0.00E+00	0.00E+00	1.04E-04
Ni-56	Ci	0.00E+00	0.00E+00	0.00E+00	1.02E-06	1.02E-06
Te-131	Ci	0.00E+00	1.13E-06	0.00E+00	0.00E+00	1.13E-06
Pm-149	Ci	9.13E-06	0.00E+00	0.00E+00	0.00E+00	9.13E-06
Pr-144	Ci	0.00E+00	8.93E-05	0.00E+00	0.00E+00	8.93E-05
Ag-110M	Ci	9.24E-07	0.00E+00	7.70E-07	0.00E+00	1.69E-06

Table 23, Batch Mode Liquid Effluents (Unit 1)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission and Activation Products						
Sb-126	Ci	0.00E+00	8.57E-06	0.00E+00	0.00E+00	8.57E-06
Rb-86	Ci	0.00E+00	0.00E+00	0.00E+00	2.78E-06	2.78E-06
Hg-203	Ci	1.05E-06	4.34E-07	0.00E+00	0.00E+00	1.48E-06
Sb-125	Ci	4.44E-03	4.10E-03	4.85E-04	2.70E-04	9.30E-03
I-133	Ci	8.23E-06	3.95E-07	0.00E+00	0.00E+00	8.63E-06
Co-57	Ci	0.00E+00	2.69E-06	6.34E-06	9.62E-07	9.99E-06
Te-132	Ci	0.00E+00	6.17E-07	0.00E+00	0.00E+00	6.17E-07
Zr-95	Ci	0.00E+00	2.48E-04	1.09E-04	2.43E-04	6.00E-04
Eu-154	Ci	0.00E+00	0.00E+00	0.00E+00	1.38E-06	1.38E-06
Sb-124	Ci	0.00E+00	1.98E-04	0.00E+00	0.00E+00	1.98E-04
Co-58	Ci	4.61E-05	1.71E-03	1.81E-03	1.20E-03	4.77E-03
Zn-65	Ci	0.00E+00	3.74E-05	8.12E-06	1.55E-05	6.10E-05
Ag-108M	Ci	5.14E-07	0.00E+00	0.00E+00	0.00E+00	5.14E-07
Te-129M	Ci	0.00E+00	1.68E-04	0.00E+00	0.00E+00	1.68E-04
Fe-55	Ci	2.49E-04	2.31E-05	9.76E-05	2.12E-05	3.91E-04
Ba-133	Ci	0.00E+00	0.00E+00	5.57E-07	0.00E+00	5.57E-07
Total for Period	Ci	5.90E-03	1.34E-02	8.83E-03	5.45E-03	3.36E-02
Tritium						
H-3	Ci	4.04E+02	2.46E+02	4.43E+02	6.84E+01	1.16E+03
Gross Alpha						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Entrained Gases						
Xe-133M	Ci	0.00E+00	0.00E+00	4.82E-05	0.00E+00	4.82E-05
Xe-133	Ci	2.40E-04	5.01E-04	7.19E-03	1.86E-05	7.95E-03
Xe-131M	Ci	0.00E+00	0.00E+00	1.12E-05	0.00E+00	1.12E-05
Kr-88	Ci	0.00E+00	0.00E+00	6.00E-06	0.00E+00	6.00E-06
Xe-135	Ci	6.81E-07	6.50E-07	1.25E-04	0.00E+00	1.26E-04
Total for Period	Ci	2.41E-04	5.02E-04	7.38E-03	1.86E-05	8.14E-03

If Not Detected, Nuclide is Not Reported. Zeroes in this table indicate that no radioactivity was present at detectable levels. See Table 30, Minimum Detectable Concentrations-Liquid Sample Analyses for typical minimum detectable concentrations.

Table 24, Liquid Effluents – Summation of All Releases (Unit 2)

A. Fission & Activation Products	Unit	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual	Est. Total Error %
1. Total Release	Ci	1.14E-02	7.74E-03	2.93E-03	3.08E-03	2.52E-02	*
2. Average diluted concentration	μCi/mL	9.45E-10	5.74E-10	1.82E-10	2.47E-10	4.65E-10	
B. Tritium							
1. Total Release	Ci	5.94E+02	2.70E+02	2.17E+02	1.46E+02	1.23E+03	*
2. Average diluted concentration	μCi/mL	4.91E-05	2.00E-05	1.35E-05	1.18E-05	2.27E-05	
C. Dissolved & Entrained Gases							
1. Total Release	Ci	5.24E-04	6.13E-04	8.06E-03	1.34E-04	9.33E-03	*
2. Average diluted concentration	μCi/mL	4.34E-11	4.55E-11	5.03E-10	1.07E-11	1.72E-10	
D. Gross Alpha Activity							
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	*
E. Volume of Waste Released (prior to dilution)	Liters	2.58E+07	3.21E+07	2.69E+07	2.10E+07	1.06E+08	
F. Volume of Dilution Water Used During Period	Liters	1.21E+10	1.35E+10	1.60E+10	1.24E+10	5.40E+10	

% of limit is on the Table 2, Joseph M. Farley Nuclear Plant (Unit 2) Dose Summary

* % Error see page 26

Zeroes in this table indicate that no radioactivity was present at detectable levels.

Table 25, Continuous Mode Liquid Effluents (Unit 2)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission and Activation Products						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
H-3	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
If Not Detected, Nuclide is Not Reported. Zeroes in this table indicate that no radioactivity was present at detectable levels. See Table 30, Minimum Detectable Concentrations-Liquid Sample Analyses for typical minimum detectable concentrations.						

Table 26, Batch Mode Liquid Effluents (Unit 2)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission and Activation Products						
Se-75	Ci	7.61E-05	7.52E-06	0.00E+00	0.00E+00	8.36E-05
Mn-56	Ci	3.82E-07	0.00E+00	0.00E+00	0.00E+00	3.82E-07
Y-90M	Ci	0.00E+00	0.00E+00	1.56E-07	0.00E+00	1.56E-07
Sb-122	Ci	0.00E+00	8.52E-07	0.00E+00	0.00E+00	8.52E-07
Cd-109	Ci	1.99E-05	0.00E+00	0.00E+00	0.00E+00	1.99E-05
Ni-56	Ci	8.50E-07	0.00E+00	0.00E+00	6.07E-07	1.46E-06
Te-129M	Ci	0.00E+00	5.41E-05	0.00E+00	0.00E+00	5.41E-05
Fe-55	Ci	2.40E-04	5.22E-05	5.13E-05	9.24E-06	3.53E-04
Nb-95	Ci	0.00E+00	1.12E-04	5.79E-05	1.89E-04	3.59E-04
Te-132	Ci	1.37E-06	0.00E+00	0.00E+00	0.00E+00	1.37E-06
Zn-65	Ci	0.00E+00	1.35E-05	1.04E-05	1.20E-05	3.59E-05
Rh-105	Ci	0.00E+00	1.59E-04	1.33E-05	1.68E-04	3.40E-04
Sb-125	Ci	8.37E-03	3.59E-03	2.05E-04	2.10E-04	1.24E-02
Ag-110M	Ci	4.40E-06	0.00E+00	1.68E-06	0.00E+00	6.08E-06
Rb-88	Ci	0.00E+00	0.00E+00	0.00E+00	4.65E-06	4.65E-06
Zr-97	Ci	3.96E-07	0.00E+00	0.00E+00	2.42E-07	6.38E-07
I-133	Ci	2.71E-06	1.35E-06	0.00E+00	0.00E+00	4.06E-06
Co-57	Ci	8.88E-07	0.00E+00	0.00E+00	0.00E+00	8.88E-07
Mn-54	Ci	7.14E-06	1.53E-05	3.07E-05	2.92E-05	8.23E-05
Sr-90	Ci	0.00E+00	9.86E-06	0.00E+00	0.00E+00	9.86E-06
Hg-203	Ci	8.92E-07	0.00E+00	0.00E+00	0.00E+00	8.92E-07
Zr-95	Ci	0.00E+00	5.27E-05	2.16E-05	9.73E-05	1.72E-04
Pr-144	Ci	0.00E+00	6.77E-05	0.00E+00	0.00E+00	6.77E-05
Te-125M	Ci	8.34E-04	0.00E+00	0.00E+00	0.00E+00	8.34E-04
I-131	Ci	7.03E-06	1.62E-06	0.00E+00	0.00E+00	8.65E-06
Co-60	Ci	1.61E-03	1.52E-03	1.92E-03	9.67E-04	6.02E-03
Sb-126	Ci	0.00E+00	2.71E-06	0.00E+00	0.00E+00	2.71E-06
Te-129	Ci	4.14E-06	3.49E-06	0.00E+00	0.00E+00	7.63E-06
Te-131	Ci	0.00E+00	0.00E+00	0.00E+00	3.89E-07	3.89E-07
Nd-147	Ci	0.00E+00	0.00E+00	1.63E-06	0.00E+00	1.63E-06
Br-84	Ci	0.00E+00	0.00E+00	2.30E-06	0.00E+00	2.30E-06
Tc-99M	Ci	6.82E-05	1.08E-05	0.00E+00	0.00E+00	7.90E-05
Ag-108M	Ci	5.98E-06	1.27E-06	2.25E-06	0.00E+00	9.50E-06
Co-58	Ci	7.07E-05	1.16E-03	5.72E-04	6.34E-04	2.44E-03

Table 26, Batch Mode Liquid Effluents (Unit 2)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission and Activation Products						
Ru-103	Ci	0.00E+00	0.00E+00	0.00E+00	1.56E-06	1.56E-06
Cr-51	Ci	9.08E-05	7.87E-04	3.55E-05	7.58E-04	1.67E-03
Sn-113	Ci	6.44E-07	0.00E+00	6.94E-07	1.94E-06	3.28E-06
Nb-97	Ci	1.08E-05	0.00E+00	0.00E+00	0.00E+00	1.08E-05
Sb-124	Ci	0.00E+00	1.21E-04	0.00E+00	0.00E+00	1.21E-04
Total for Period	Ci	1.14E-02	7.74E-03	2.93E-03	3.08E-03	2.52E-02
Tritium						
H-3	Ci	5.94E+02	2.70E+02	2.17E+02	1.46E+02	1.23E+03
Gross Alpha						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Entrained Gases						
Xe-133	Ci	2.94E-04	6.11E-04	7.83E-03	1.33E-04	8.87E-03
Kr-89	Ci	2.25E-04	0.00E+00	0.00E+00	0.00E+00	2.25E-04
Xe-135	Ci	2.98E-06	2.58E-06	1.68E-04	0.00E+00	1.74E-04
Xe-133M	Ci	0.00E+00	0.00E+00	6.32E-05	0.00E+00	6.32E-05
Ar-41	Ci	9.71E-07	0.00E+00	0.00E+00	4.09E-07	1.38E-06
Xe-127	Ci	7.28E-07	0.00E+00	2.10E-07	0.00E+00	9.38E-07
Total for Period	Ci	5.24E-04	6.13E-04	8.06E-03	1.34E-04	9.33E-03
If Not Detected, Nuclide is Not Reported. Zeroes in this table indicate that no radioactivity was present at detectable levels. See Table 30, Minimum Detectable Concentrations-Liquid Sample Analyses for typical minimum detectable concentrations.						

Table 27, Liquid Effluents – Summation of All Releases (Site)

A. Fission & Activation Products	Unit	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual	Est. Total Error %
1. Total Release	Ci	1.73E-02	2.11E-02	1.18E-02	8.53E-03	5.87E-02	*
2. Average diluted concentration	μCi/mL	7.15E-10	7.67E-10	3.85E-10	5.64E-10	6.02E-10	
B. Tritium							
1. Total Release	Ci	9.98E+02	5.16E+02	6.60E+02	2.15E+02	2.39E+03	*
2. Average diluted concentration	μCi/mL	4.12E-05	1.87E-05	2.16E-05	1.42E-05	2.45E-05	
C. Dissolved & Entrained Gases							
1. Total Release	Ci	7.65E-04	1.12E-03	1.54E-02	1.52E-04	1.74E-02	*
2. Average diluted concentration	μCi/mL	3.16E-11	4.05E-11	5.06E-10	1.01E-11	1.79E-10	
D. Gross Alpha Activity							
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	*
E. Volume of Waste Released (prior to dilution)	Liters	4.98E+07	5.48E+07	4.73E+07	2.75E+07	1.79E+08	
F. Volume of Dilution Water Used During Period	Liters	2.42E+10	2.75E+10	3.05E+10	1.51E+10	9.73E+10	

% of limit is on the Table 1 and Table 2

* % Error see page 26

Zeroes in this table indicate that no radioactivity was present at detectable levels.

Table 28, Continuous Mode Liquid Effluents (Site)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission and Activation Products						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tritium						
H-3	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gross Alpha						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Entrained Gases						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
If Not Detected, Nuclide is Not Reported. Zeroes in this table indicate that no radioactivity was present at detectable levels. See Table 30, Minimum Detectable Concentrations-Liquid Sample Analyses for typical minimum detectable concentrations.						

Table 29, Batch Mode Liquid Effluents (Site)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission and Activation Products						
Fe-55	Ci	4.89E-04	7.53E-05	1.49E-04	3.04E-05	7.44E-04
Se-75	Ci	9.10E-05	2.24E-05	0.00E+00	0.00E+00	1.13E-04
Tc-99M	Ci	1.20E-04	2.03E-05	0.00E+00	0.00E+00	1.40E-04
Mn-54	Ci	8.66E-06	1.06E-04	2.12E-04	8.63E-05	4.13E-04
Sn-113	Ci	6.44E-07	1.11E-05	6.94E-07	4.37E-06	1.68E-05
Te-131	Ci	0.00E+00	1.13E-06	0.00E+00	3.89E-07	1.52E-06
Ag-108M	Ci	6.50E-06	1.27E-06	2.25E-06	0.00E+00	1.00E-05
Y-91	Ci	2.15E-04	0.00E+00	0.00E+00	0.00E+00	2.15E-04
Y-88	Ci	0.00E+00	4.46E-07	0.00E+00	0.00E+00	4.46E-07
Br-84	Ci	0.00E+00	0.00E+00	2.30E-06	0.00E+00	2.30E-06
Eu-154	Ci	0.00E+00	0.00E+00	0.00E+00	1.38E-06	1.38E-06
Te-125M	Ci	8.34E-04	0.00E+00	0.00E+00	0.00E+00	8.34E-04
Nb-95	Ci	0.00E+00	5.58E-04	3.54E-04	6.63E-04	1.58E-03
Rb-88	Ci	0.00E+00	0.00E+00	0.00E+00	4.65E-06	4.65E-06
Nd-147	Ci	0.00E+00	0.00E+00	2.39E-06	0.00E+00	2.39E-06
Ru-106	Ci	0.00E+00	1.57E-05	0.00E+00	0.00E+00	1.57E-05
Zr-95	Ci	0.00E+00	3.00E-04	1.30E-04	3.40E-04	7.70E-04
Zn-65	Ci	0.00E+00	5.09E-05	1.85E-05	2.75E-05	9.69E-05
Zr-97	Ci	3.96E-07	0.00E+00	0.00E+00	2.42E-07	6.38E-07
Sr-90	Ci	0.00E+00	9.86E-06	0.00E+00	0.00E+00	9.86E-06
Te-132	Ci	1.37E-06	6.17E-07	0.00E+00	0.00E+00	1.99E-06
Eu-155	Ci	0.00E+00	0.00E+00	6.01E-07	0.00E+00	6.01E-07
Cs-134	Ci	0.00E+00	0.00E+00	1.89E-06	0.00E+00	1.89E-06
Tc-101	Ci	0.00E+00	0.00E+00	3.31E-07	0.00E+00	3.31E-07
Te-134	Ci	0.00E+00	0.00E+00	3.05E-06	0.00E+00	3.05E-06
Ba-133	Ci	0.00E+00	0.00E+00	5.57E-07	0.00E+00	5.57E-07
Te-129M	Ci	0.00E+00	2.22E-04	0.00E+00	0.00E+00	2.22E-04
Ba-140	Ci	0.00E+00	0.00E+00	1.98E-06	0.00E+00	1.98E-06
Sb-124	Ci	0.00E+00	3.19E-04	0.00E+00	0.00E+00	3.19E-04
Ni-56	Ci	8.50E-07	0.00E+00	0.00E+00	1.63E-06	2.48E-06
Co-60	Ci	2.46E-03	5.59E-03	7.37E-03	2.21E-03	1.76E-02
Co-58	Ci	1.17E-04	2.87E-03	2.38E-03	1.83E-03	7.20E-03
Hg-203	Ci	1.95E-06	4.34E-07	0.00E+00	0.00E+00	2.38E-06
Cd-109	Ci	1.99E-05	0.00E+00	0.00E+00	0.00E+00	1.99E-05

Table 29, Batch Mode Liquid Effluents (Site)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Rh-106	Ci	0.00E+00	1.57E-05	0.00E+00	0.00E+00	1.57E-05
Rb-86	Ci	0.00E+00	0.00E+00	0.00E+00	2.78E-06	2.78E-06
Mn-56	Ci	3.82E-07	0.00E+00	0.00E+00	0.00E+00	3.82E-07
Sb-126	Ci	0.00E+00	1.13E-05	0.00E+00	0.00E+00	1.13E-05
Ru-103	Ci	0.00E+00	0.00E+00	0.00E+00	4.86E-06	4.86E-06
Cs-137	Ci	9.95E-07	3.66E-05	2.14E-05	6.92E-06	6.59E-05
Te-129	Ci	4.14E-06	3.49E-06	5.97E-06	0.00E+00	1.36E-05
Sb-125	Ci	1.28E-02	7.69E-03	6.90E-04	4.80E-04	2.17E-02
Y-90M	Ci	0.00E+00	0.00E+00	1.56E-07	0.00E+00	1.56E-07
Nb-97	Ci	1.30E-05	2.72E-06	3.62E-06	0.00E+00	1.93E-05
Pr-144	Ci	0.00E+00	1.57E-04	0.00E+00	0.00E+00	1.57E-04
Y-94	Ci	0.00E+00	0.00E+00	0.00E+00	5.58E-07	5.58E-07
Cr-51	Ci	1.03E-04	2.27E-03	2.74E-04	2.33E-03	4.98E-03
Ag-110M	Ci	5.32E-06	0.00E+00	2.45E-06	0.00E+00	7.77E-06
Cs-136	Ci	0.00E+00	0.00E+00	4.77E-07	0.00E+00	4.77E-07
Te-127M	Ci	0.00E+00	1.04E-04	0.00E+00	0.00E+00	1.04E-04
Y-93	Ci	0.00E+00	0.00E+00	1.09E-05	0.00E+00	1.09E-05
Pm-149	Ci	9.13E-06	0.00E+00	0.00E+00	0.00E+00	9.13E-06
Co-57	Ci	8.88E-07	2.69E-06	6.34E-06	9.62E-07	1.09E-05
Rh-105	Ci	0.00E+00	6.61E-04	1.12E-04	4.98E-04	1.27E-03
I-133	Ci	1.09E-05	1.74E-06	0.00E+00	0.00E+00	1.26E-05
Fe-59	Ci	0.00E+00	5.78E-06	0.00E+00	0.00E+00	5.78E-06
Sb-122	Ci	0.00E+00	4.63E-06	0.00E+00	0.00E+00	4.63E-06
I-131	Ci	1.31E-05	1.62E-06	0.00E+00	0.00E+00	1.47E-05
Total for Period	Ci	1.73E-02	2.11E-02	1.18E-02	8.53E-03	5.87E-02
Tritium						
H-3	Ci	9.98E+02	5.16E+02	6.60E+02	2.15E+02	2.39E+03
Gross Alpha						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Entrained Gases						
Xe-133M	Ci	0.00E+00	0.00E+00	1.11E-04	0.00E+00	1.11E-04
Xe-131M	Ci	0.00E+00	0.00E+00	1.12E-05	0.00E+00	1.12E-05
Kr-89	Ci	2.25E-04	0.00E+00	0.00E+00	0.00E+00	2.25E-04
Ar-41	Ci	9.71E-07	0.00E+00	0.00E+00	4.09E-07	1.38E-06
Xe-127	Ci	7.28E-07	0.00E+00	2.10E-07	0.00E+00	9.38E-07

Table 29, Batch Mode Liquid Effluents (Site)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Xe-133	Ci	5.35E-04	1.11E-03	1.50E-02	1.52E-04	1.68E-02
Xe-135	Ci	3.66E-06	3.23E-06	2.93E-04	0.00E+00	3.00E-04
Kr-88	Ci	0.00E+00	0.00E+00	6.00E-06	0.00E+00	6.00E-06
Total for Period	Ci	7.65E-04	1.12E-03	1.54E-02	1.52E-04	1.74E-02
If Not Detected, Nuclide is Not Reported. Zeroes in this table indicate that no radioactivity was present at detectable levels. See Table 30, Minimum Detectable Concentrations-Liquid Sample Analyses for typical minimum detectable concentrations.						

Table 30, Minimum Detectable Concentrations-Liquid Sample Analyses

The values in this table represent a priori Minimum Detectable Concentrations (MDC) that are typically achieved in laboratory analyses of liquid radwaste samples.

Nuclide	MDC (µCi/mL)
Mn-54	3.54E-08
Co-58	3.72E-08
Fe-59	6.53E-08
Co-60	3.93E-08
Zn-65	8.76E-08
Mo-99	2.65E-07
I-131	2.89E-08
Cs-134	3.02E-08
Cs-137	3.76E-08
Ce-141	3.88E-08
Ce-144	1.70E-07

Attachment 2, Solid Waste Information

1.0 SOLID RADIOACTIVE WASTE SHIPPED FOR PROCESSING OR DISPOSAL

FNP-0-M-30, PROCESS CONTROL PROGRAM, step B.3.1 states that the radwaste solidification system shall be OPERABLE and used, as applicable in accordance with a PROCESS CONTROL PROGRAM, for the SOLIDIFICATION and packaging of radioactive wastes to ensure meeting the requirements of 10 CFR Part 20 and 10 CFR Part 71 prior to shipment of radioactive wastes from the site.

FNP-0-M-30, PROCESS CONTROL PROGRAM, step B.5.1 states that the Annual Radioactive Effluent Release Report, submitted in accordance with Technical Specifications 5.6.2 and 5.6.3, shall include a summary of the quantities of solid radwaste released from the units as outlined in Regulatory Guide 1.21, “Measuring, Evaluating, and Reporting Radioactive Material in Liquid and Gaseous Effluents and Solid Waste,” Revision 2, issued June 2009 , with data summarized on an annual basis following the format of Table A-3 thereof.

Table 31, Resins, Filters, and Evaporator Bottoms

Resins, Filters, and Evaporator Bottoms	**Volume**		**Curies Shipped**
Waste Class	ft^3	m^3	
A	2.42E+02	6.85E+00	3.52E+00
B	2.85E+02	8.07E+00	3.10E+02
C	0.00E+00[1]	0.00E+00	0.00E+00
Unclassified	0.00E+00	0.00E+00	0.00E+00
ALL	5.27E+02	1.49E+01	3.13E+02

Major Nuclides for the Above Table:
Waste Class "A": C-14 1.23%, Fe-55 2.88%, Co-60 49.25%, Ni-63 44.19%
Waste Class "B": Mn-54 1.25%, Fe-55 22.99%, Co-60 41.63%, Ni-63 30.59%, Zn-65 1.08%
Waste Class "C": N/A
Unclassified: N/A
ALL: Mn-54 1.24%, Fe-55 22.77%, Co-60 41.71%, Ni-63 30.74%, Zn-65 1.08%

Table 32, Dry Active Waste

Dry Active Waste	**Volume**		**Curies Shipped**
Waste Class	ft^3	m^3	
A	1.85E+04	5.23E+02	3.66E-01
B	0.00E+00	0.00E+00	0.00E+00
C	0.00E+00	0.00E+00	0.00E+00
Unclassified	0.00E+00	0.00E+00	0.00E+00
ALL	1.85E+04	5.23E+02	3.66E-01

Major Nuclides for the Above Table:
Waste Class "A": H-3 22.89%, Cr-51 2.74%, Fe-55 22.64%, Co-58 9.48%, Co-60 15.4%, Ni-63 13.47%
Zr-95 3.17%, Nb-95 5.97%, Sb-125 2.03%
Waste Class "B": N/A
Waste Class "C": N/A
Unclassified: N/A
ALL: ": H-3 22.89%, Cr-51 2.74%, Fe-55 22.64%, Co-58 9.48%, Co-60 15.4%, Ni-63 13.47%
Zr-95 3.17%, Nb-95 5.97%, Sb-125 2.03%

[1] 0.00E+00 indicate that no shipments were made for the respective waste class

Table 33, Irradiated Components

Irradiated Components	**Volume**		**Curies Shipped**
Waste Class	ft^3	m^3	
A	0.00E+00[1]	0.00E+00	0.00E+00
B	0.00E+00	0.00E+00	0.00E+00
C	0.00E+00	0.00E+00	0.00E+00
Unclassified	0.00E+00	0.00E+00	0.00E+00
ALL	0.00E+00	0.00E+00	0.00E+00

All: N/A

Table 34, Other Waste

Other Waste	**Volume**		**Curies Shipped**
Waste Class	ft^3	m^3	
A	0.00E+00	0.00E+00	0.00E+00
B	0.00E+00	0.00E+00	0.00E+00
C	0.00E+00	0.00E+00	0.00E+00
Unclassified	0.00E+00	0.00E+00	0.00E+00
ALL	0.00E+00	0.00E+00	0.00E+00

All: N/A

Table 35, Sum of All Low Level Waste Shipped from Site

Sum of All Low Level Waste Shipped from Site	**Volume**		**Curies Shipped**
Waste Class	ft^3	m^3	
A	1.87E+04	5.30E+02	3.89E+00
B	2.85E+02	8.07E+00	3.10E+02
C	0.00E+00	0.00E+00	0.00E+00
Unclassified	0.00E+00	0.00E+00	0.00E+00
ALL	1.90E+04	5.38E+02	3.14E+02

Major Nuclides for the Above Table:
Waste Class: "A" H-3 2.41%, C-14 1.18%, Fe-55 4.75%, Co-60 46.06%, Ni-63 41.29%
Waste Class: "B" Mn-54 1.25%, Fe-55 22.99%, Co-60 41.63%, Ni-63 30.59%, Zn-65 1.08%
Waste Class: "C" N/A
Unclassified: N/A
All Mn-54 1.24%, Fe-55 22.77%, Co-60 41.68%, Ni-63 30.72%, Zn-65 1.08%

[1] 0.00E+00 indicate that no shipments were made for the respective waste class

Attachment 3, NEI 07-07 Onsite Radiological Groundwater Monitoring Program

Farley Nuclear Plant
Appendix C

Groundwater Protection Program

To ensure compliance with NEI 07-07 (Industry Ground Water Protection Initiative – Final Guidance Document), Southern Nuclear implemented a groundwater protection program which is proceduralized in Nuclear Management Procedure, Radiological Groundwater Protection Program. The procedure contains detailed site-specific monitoring plans, program technical bases, and communications protocol (to ensure that radioactive leaks and spills are addressed and communicated appropriately). In an effort to prevent future leaks of radioactive material to groundwater, SNC plants have established buried piping and tanks inspection programs.

Plant Farley maintained the following wells (Table C-1), which were sampled at a frequency that satisfied the requirements of NEI 07-07. The analytical results for 2022 were all within regulatory limits specified within this report. Table C-2 contains the results of the Groundwater Protection Program results for tritium (in pCi/L). See Figure C-1 for well locations.

Table C-1. Groundwater Protection Program Locations

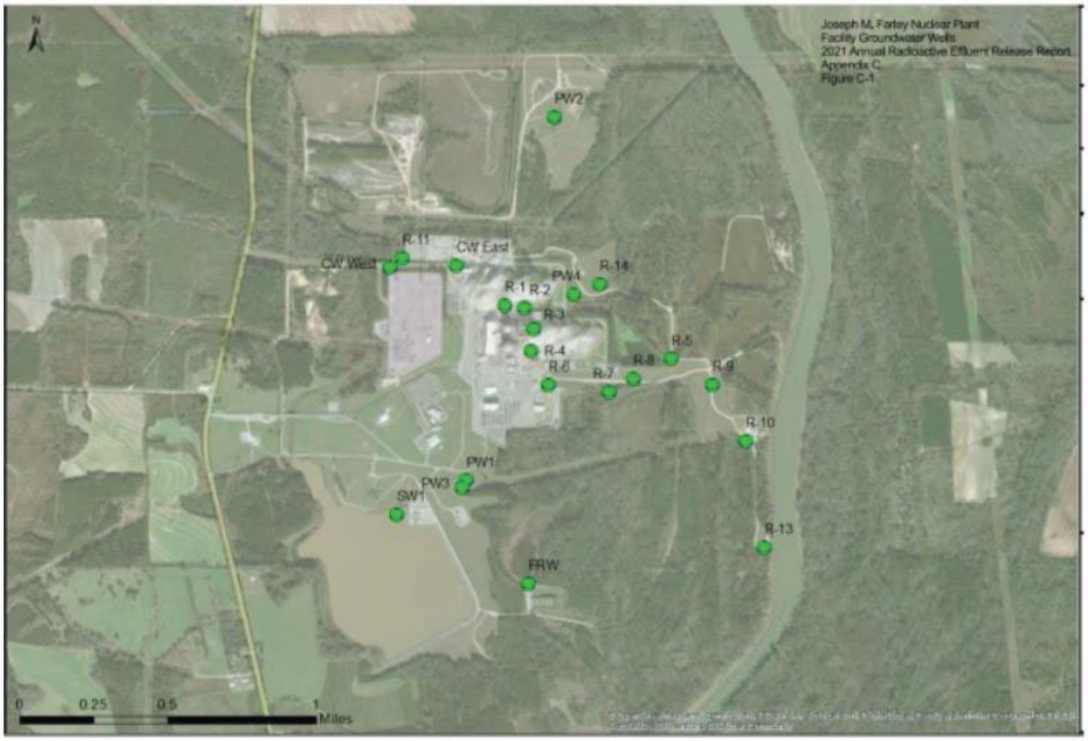
Well	Aquifer	Monitoring Purpose
R1	Major Shallow aquifer	Dilution line
R2	Major Shallow aquifer	Dilution line
R3	Major Shallow aquifer	Unit 2 RWST
R4	Major Shallow aquifer	Unit 1 RWST
R5	Major Shallow aquifer	Dilution line
R6r	Major Shallow aquifer	Dilution line
R7	Major Shallow aquifer	Dilution line
R8	Major Shallow aquifer	Dilution line
R9	Major Shallow aquifer	Dilution line
R10	Major Shallow aquifer	Dilution line
R11	Major Shallow aquifer	Background 1
R13	Major Shallow aquifer	Dilution line
R14	Major Shallow aquifer	Background 2
PW#2	Drinking water	Production Well #2 Supply
PW#3	Drinking water	Production Well #3 Supply
PW#4	Drinking water	Production Well #4 Supply
CW West	Drinking water	Construction Well West Supply
CW East	Drinking water	Construction Well East Supply
FRW	Drinking water	Firing Range Well Supply
SW-1	N/A	Background 3, Service Water Pond

Table C-2. Groundwater Protection Program Results

Well	May - June 2022	November 2022
R-1	NDM	NDM
R-2	NDM	NDM
R-3	434	388
R-4	NDM	NDM
R-5	NDM	237
R-6r	NDM	NDM
R-7	NDM	NDM
R-8	NDM	379
R-9	NDM	NDM
R-10	NDM	NDM
R-11	NDM	NDM
R-13	NDM	NDM
R-14	NDM	NDM
SW-1	NDM	NDM
E YARD	NDM	325
WSW-FR	NDM	NDM
WSW-CE	NDM	NDM
WSW-CW	NDM	NDM
WSW-4	NS	NDM
SE YARD	NDM	NDM
WSW-2	NDM	NDM

Units in pCi/L
NDM - No Detectable Measurements
NS - Not Sampled

Figure C-1
Joseph M. Farley Nuclear Plant
Map of Facility Groundwater Wells



Edwin I. Hatch Nuclear Plant – Units 1&2
Joseph M. Farley Nuclear Plant – Units 1&2
Vogtle Electric Generating Plant – Units 1&2
Vogtle Electric Generating Plant – Unit 3
Annual Non-Radiological Environmental Operating Reports and Annual Radioactive Effluent Release Reports for 2022

Enclosure 6

Vogtle Electric Generating Plant – Units 1&2
Annual Radioactive Effluent Release Report for 2022

Southern Nuclear

Vogtle Electric Generating Plant

2022

Annual Radioactive Effluent Release Report

Document Number: 50-424 & 50-425
Facility Operating License Nos. NPF-68 & NPF-81

Prepared By: R.J. Thomas / R.J. Thomas Nuclear Chemist   Date: 04-14-2023

Reviewed By: Jessica Osborne / Chemistry Manager   Date: 4/14/2023

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TABLE OF CONTENTS

TABLES

FIGURES

ATTACHMENTS

1.0 LIST OF ACRONYMS AND DEFINITIONS

1. *a priori*: Before the fact limit representing the capability of a measurement system and not as an after the fact (a posteriori) limit for a particular measurement.

2. Airborne Activity Sampling: Sampling of air through the collection of particulates and radionuclides on filter media, collection of noble gases in a container, and collection of water vapor containing tritium.

3. Alpha Particle (α): A charged particle emitted from the nucleus of an atom having a mass and charge equal in magnitude of a helium nucleus.

4. BWR: Boiling Water Reactor

5. Composite Sample: A series of single collected portions (aliquots) analyzed as one sample. The aliquots making up the sample are collected at time intervals that are very short compared to the composite period.

6. Control: A sampling station in a location not likely to be affected by plant effluents due to its distance and/or direction from the Plant.

7. Counting Error: An estimate of the two-sigma uncertainty associated with the sample results based on total counts accumulated.

8. Curie (Ci): A measure of radioactivity; equal to 3.7×10^{10} disintegrations per second, or 2.22×10^{12} disintegrations per minute.

9. Direct Radiation Monitoring: The measurement of radiation dose at various distances from the plant is assessed using thermoluminescent dosimeters (TLDs), optically stimulated luminescent dosimeters (OSLDs), and/or pressurized ionization chambers.

10. ECL: Effluent Concentration Limit

11. Grab Sample: A single discrete sample drawn at one point in time.

12. Indicator: A sampling location that is likely to be affected by plant effluents due to its proximity and/or direction from the plant.

13. Ingestion Pathway: The ingestion pathway includes milk, fish, and garden produce. Meat or other food products may also be included.

14. ISFSI: Independent Spent Fuel Storage Installation

15. Lower Limit of Detection (LLD): The smallest concentration of radioactive material in a sample that will yield a net count (above system background) that will be detected with 95% probability with a 5% probability of a false conclusion that a blank observation represents "real" signal.

16. MDA: Minimum Detectable Activity. - For radiochemistry instruments, the MDA is the a posteriori minimum concentration that a counting system detects. The smallest concentration or activity of radioactive material in a sample that will yield a net count above instrument background and that is detected with 95% probability, with only five % probability of falsely concluding that a blank observation represents a true signal.

17. MDC: Minimum Detectable Concentration, essentially synonymous with MDA for the purposes of radiological monitoring.

18. Mean: The average, i.e., the sum of results divided by the number of results.

19. Microcurie (µCi): 3.7×10^4 disintegrations per second, or 2.22×10^6 disintegrations per minute.

20. millirem (mrem): 1/1000 rem; a unit of radiation dose equivalent in tissue.

21. Milliroentgen (mR): 1/1000 Roentgen; a unit of exposure to X- or gamma radiation.

22. MWe: Megawatts Electric

23. MWTh: Megawatts Thermal

24. NA: Not Applicable

25. NEI: Nuclear Energy Institute

26. NRC: Nuclear Regulatory Commission

27. ODCM: Offsite Dose Calculation Manual

28. OSLD: Optically Stimulated Luminescence Dosimeter

29. Protected Area: The fenced area immediately surrounding the Plant. Access to the protected area requires a security badge or escort.

30. PWR: Pressurized Water Reactor

31. REC: Radiological Effluent Control

32. REMP: Radiological Environmental Monitoring Program

33. Restricted Area: Any area where access is controlled for the purpose of protecting individuals from exposure to radiation or radioactive materials.

34. SLCs: Selected Licensee Commitments

35. TEDE: Total Effective Dose Equivalent (TEDE) means the sum of the effective dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

36. TLD: Thermoluminescent Dosimeter

37. TRM: Technical Requirements Manual

38. TS: Technical Specification

2.0 EXECUTIVE SUMMARY

Vogtle Electric Generating Plant (VEGP) Radiological Effluent Control (REC) Program was established to limit the quantities of radioactive material that may be released based on calculated radiation doses or dose rates. Dose to Members of the Public due to radioactive materials released from the plant is limited by Appendix I of 10 CFR 50 and by 40 CFR 190. Operational doses to the public during 2022 were calculated to be very small compared to the limits required by regulation and compared to other sources of radiation dose and pose no health hazard. These doses are summarized and compared to the regulatory limits in Section 2.1, Comparison to Regulatory Limits, below.

The Annual Radioactive Effluent Release Report (ARERR) is published per REC requirements and provides data related to plant operation, including: quantities of radioactive materials released in liquid and gaseous effluents; radiation doses to members of the public; solid radioactive waste shipped offsite for disposal; and other information as required by site licensing documents.

In 2022 the Land Use Census dose assessments due to radioactive gaseous effluents showed that the critical receptor for Vogtle Electric Generating Plant is Child, due to exposure pathways of inhalation, ground plane, cow meat and garden, at location 1.2 miles, WSW. The maximum Annual Organ Dose calculated for this receptor was 2.60E-03 mrem (Units 1 and 2), to the thyroid. This annual dose is a small fraction of the 10 CFR 50, Appendix I guideline of 30 mrem to the Maximum Organ (15 mrem per reactor unit).

Solid radioactive waste shipped offsite for disposal included 6.18E+02 Curies and 2.72E+02 m^3, shipped in 10 shipments.

In addition to monitoring radioactive effluents, VEGP has a Radiological Environmental Monitoring Program (REMP) that monitors for buildup of radioactivity in the offsite environment. Data from the REMP is published in the Annual Radiological Environmental Operating Report (AREOR).

2.1 Comparison to Regulatory Limits

During 2022 all solid, liquid, and gaseous radioactive effluents from Vogtle Electric Generating Plant were well below regulatory limits, as summarized in Table 1, Table 2 and Table 4. Table 3 is a summary of the cumulative dose from both units.

Table 1, Vogtle Electric Generating Plant (Unit 1) Dose Summary[1]

		Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual
Liquid Effluent Dose Limit, Total Body	**Limit**	**1.5 mrem**	**1.5 mrem**	**1.5 mrem**	**1.5 mrem**	**3 mrem**
	Total Body Dose	1.60E-05	6.55E-06	9.05E-04	5.11E-03	6.04E-03
	% of Limit	1.07E-03	4.37E-04	6.04E-02	3.41E-01	2.01E-01
Liquid Effluent Dose Limit, Any Organ	**Limit**	**5 mrem**	**5 mrem**	**5 mrem**	**5 mrem**	**10 mrem**
	Max Organ Dose	1.60E-05	6.56E-06	9.10E-04	5.55E-03	6.48E-03
	% of Limit	3.21E-04	1.31E-04	1.82E-02	1.11E-01	6.48E-02
Gaseous Effluent Dose Limit, Gamma Air (Noble Gas)	**Limit**	**5 mrad**	**5 mrad**	**5 mrad**	**5 mrad**	**10 mrad**
	Gamma Air Dose	1.11E-05	1.22E-05	1.41E-05	1.57E-05	5.32E-05
	% of Limit	2.23E-04	2.44E-04	2.82E-04	3.14E-04	5.32E-04
Gaseous Effluent Dose Limit, Beta Air (Noble Gas)	**Limit**	**10 mrad**	**10 mrad**	**10 mrad**	**10 mrad**	**20 mrad**
	Beta Air Dose	3.92E-06	4.30E-06	4.99E-06	5.54E-06	1.88E-05
	% of Limit	3.92E-05	4.30E-05	4.99E-05	5.54E-05	9.38E-05
Gaseous Effluent Organ Dose Limit (Iodine, Tritium, Particulates with > 8-day half-life)	**Limit**	**7.5 mrem**	**7.5 mrem**	**7.5 mrem**	**7.5 mrem**	**15 mrem**
	Max Organ Dose	3.27E-04	4.72E-04	5.87E-04	5.27E-04	1.91E-03
	% of Limit	4.36E-03	6.30E-03	7.82E-03	7.03E-03	1.28E-02

[1] Table 1 demonstrates compliance with 10 CFR Part 50, App. I Limits.

Table 2, Vogtle Electric Generating Plant (Unit 2) Dose Summary[1]

		Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual
Liquid Effluent Dose Limit, Total Body	**Limit**	**1.5 mrem**	**1.5 mrem**	**1.5 mrem**	**1.5 mrem**	**3 mrem**
	Total Body Dose	2.65E-02	1.04E-02	7.96E-03	4.78E-03	4.97E-02
	% of Limit	1.76E+00	6.96E-01	5.31E-01	3.19E-01	1.66E+00
Liquid Effluent Dose Limit, Any Organ	**Limit**	**5 mrem**	**5 mrem**	**5 mrem**	**5 mrem**	**10 mrem**
	Max Organ Dose	2.72E-02	1.06E-02	8.35E-03	5.08E-03	5.06E-02
	% of Limit	5.44E-01	2.12E-01	1.67E-01	1.02E-01	5.06E-01
Gaseous Effluent Dose Limit, Gamma Air (Noble Gas)	**Limit**	**5 mrad**	**5 mrad**	**5 mrad**	**5 mrad**	**10 mrad**
	Gamma Air Dose	2.60E-04	1.01E-05	2.02E-05	5.88E-06	2.96E-04
	% of Limit	5.19E-03	2.02E-04	4.04E-04	1.18E-04	2.96E-03
Gaseous Effluent Dose Limit, Beta Air (Noble Gas)	**Limit**	**10 mrad**	**10 mrad**	**10 mrad**	**10 mrad**	**20 mrad**
	Beta Air Dose	1.50E-04	3.56E-06	2.22E-05	2.08E-06	1.78E-04
	% of Limit	1.50E-03	3.56E-05	2.22E-04	2.08E-05	8.89E-04
Gaseous Effluent Organ Dose Limit (Iodine, Tritium, Particulates with > 8-day half-life)	**Limit**	**7.5 mrem**	**7.5 mrem**	**7.5 mrem**	**7.5 mrem**	**15 mrem**
	Max Organ Dose	3.74E-04	9.97E-05	7.89E-05	1.37E-04	6.89E-04
	% of Limit	4.99E-03	1.33E-03	1.05E-03	1.82E-03	4.60E-03

[1] Table 2 demonstrates compliance with 10 CFR Part 50, App. I Limits.

Table 3, Vogtle Electric Generating Plant (Site) Dose Summary[1]

		Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual
Liquid Effluent Dose Limit, Total Body	**Limit**	**3 mrem**	**3 mrem**	**3 mrem**	**3 mrem**	**6 mrem**
	Total Body Dose	2.65E-02	1.05E-02	8.87E-03	9.89E-03	5.57E-02
	% of Limit	8.83E-01	3.50E-01	2.96E-01	3.30E-01	9.28E-01
Liquid Effluent Dose Limit, Any Organ	**Limit**	**10 mrem**	**10 mrem**	**10 mrem**	**10 mrem**	**20 mrem**
	Max Organ Dose	2.72E-02	1.06E-02	9.25E-03	1.06E-02	5.71E-02
	% of Limit	2.72E-01	1.06E-01	9.25E-02	1.06E-01	2.86E-01
Gaseous Effluent Dose Limit, Gamma Air (Noble Gas)	**Limit**	**10 mrad**	**10 mrad**	**10 mrad**	**10 mrad**	**20 mrad**
	Gamma Air Dose	2.71E-04	2.23E-05	3.43E-05	2.16E-05	3.49E-04
	% of Limit	2.71E-03	2.23E-04	3.43E-04	2.16E-04	1.75E-03
Gaseous Effluent Dose Limit, Beta Air (Noble Gas)	**Limit**	**20 mrad**	**20 mrad**	**20 mrad**	**20 mrad**	**40 mrad**
	Beta Air Dose	1.54E-04	7.87E-06	2.72E-05	7.61E-06	1.97E-04
	% of Limit	7.70E-04	3.94E-05	1.36E-04	3.81E-05	4.93E-04
Gaseous Effluent Organ Dose Limit (Iodine, Tritium, Particulates with > 8-day half-life)	**Limit**	**15 mrem**	**15 mrem**	**15 mrem**	**15 mrem**	**30 mrem**
	Max Organ Dose	7.01E-04	5.72E-04	6.65E-04	6.64E-04	2.60E-03
	% of Limit	4.67E-03	3.81E-03	4.43E-03	4.43E-03	8.67E-03

[1] Compliance to 10 CFR Part 50, Appendix I Limits is demonstrated from Tables 1 and 2 for each unit. Table 3 is a summary of the cumulative dose from both units.

ODCM 5.1 states in part that the annual (calendar year) dose or dose commitment to any MEMBER OF THE PUBLIC due to releases of radioactivity and to radiation from uranium fuel cycle sources shall be limited to less than or equal to 25 mrem to the whole body or to any organ, except the thyroid, which shall be limited to less than or equal to 75 mrem.

No dose limits stated in ODCM Sections 2.1.3, 3.1.3, and 3.1.4 were exceeded. Therefore, compliance with 40 CFR 190 dose limits was demonstrated in accordance with the requirements of ODCM Section 5.1.3. However, Table 4 was included to demonstrate compliance with 40 CFR 190.

Table 4, Total Annual Offsite-Dose Comparison to 40 CFR 190 Limits for VEGP[1]

	Whole Body	**Thyroid**	**Max Other Organ**
Gaseous[2]	5.53E-03	2.60E-03	2.60E-03
Carbon-14	3.38E-02	3.38E-02	1.69E-01
Liquid	5.57E-02	5.35E-02	5.71E-02
Direct Shine*	N/A	N/A	N/A
Total Site Dose	9.50E-02	8.99E-02	2.29E-01
Total w/Other Nearby Facility[3]	N/A	N/A	N/A
Limit	**25 mrem**	**75 mrem**	**25 mrem**
% of Limit	3.80E-01	1.20E-01	9.16E-01

* Based on data from the Radiological Environmental Monitoring Program, direct radiation at the site boundary is indistinguishable from background.at the plant perimeter.

[1] Table 4 is a summation of Units to show compliance with 40 CFR Part 190 Limits.
[2] Gaseous dose values in Table 4 includes organ dose from Noble Gas, Iodine, Tritium, and particulates.
[3] Other fuel cycle sources within 5 miles of the site are considered in this analysis.

3.0 INTRODUCTION

3.1 About Nuclear Power

Commercial nuclear power plants are generally classified as either Boiling Water Reactors (BWRs) or Pressurized Water Reactors (PWRs), based on their design. A BWR includes a single coolant system where water used as reactor coolant boils as it passes through the core and the steam generated is used to turn the turbine generator for power production. A PWR, in contrast, includes two separate water systems: radioactive reactor coolant and a secondary system. Reactor coolant is maintained under high pressure, preventing boiling. The high-pressure coolant is passed through a heat exchanger called a steam generator where the secondary system water is boiled, and the steam is used to turn the turbine generator for power production.

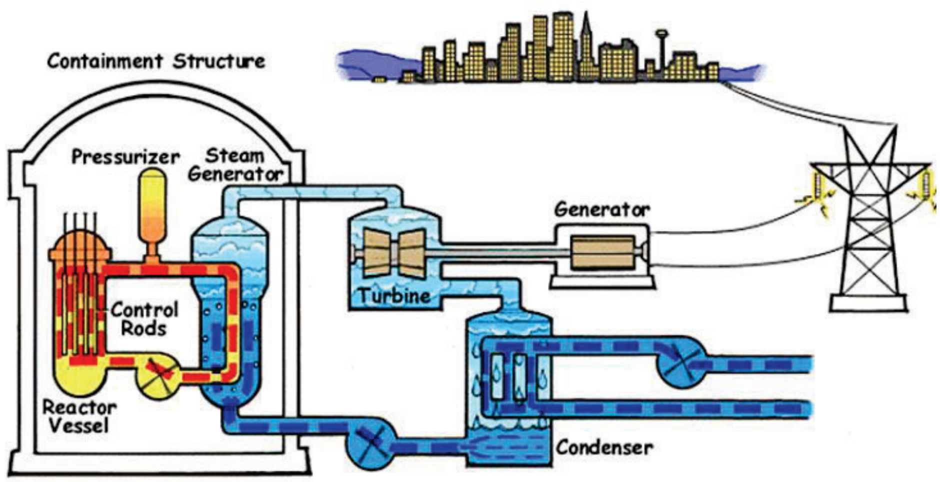

Figure 1, Pressurized Water Reactor (PWR) **[1]**

3.1 (Continued)

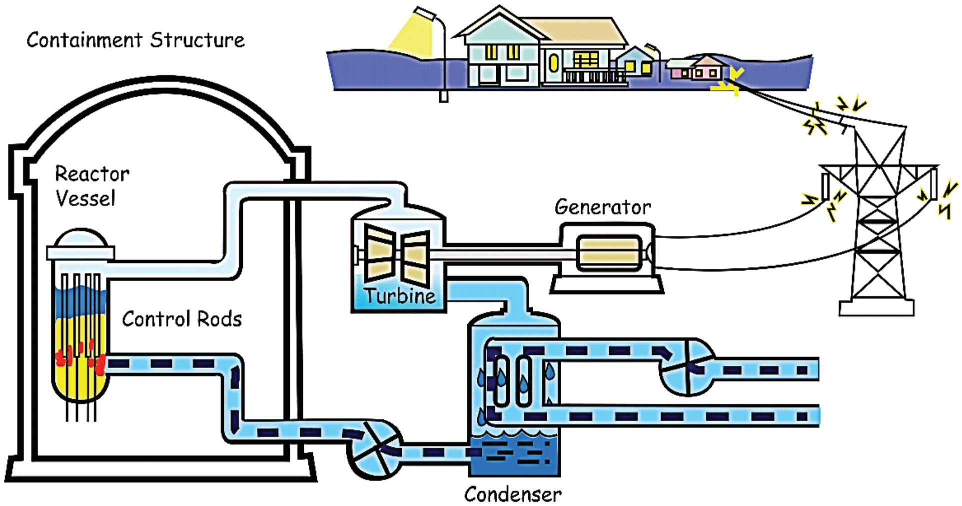

Figure 2, Boiling Water Reactor (BWR) **[2]**

Electricity is generated by a nuclear power plant similarly to the way that electricity is generated at other conventional types of power plants, such as those driven by coal or natural gas. Water is boiled to generate steam; the steam turns a turbine that is attached to a generator and the steam is condensed back into water to be returned to the boiler. What makes nuclear power different from these other types of power plants is that the heat is generated by fission and decay reactions occurring within and around the core containing fissionable uranium (U-235).

Nuclear fission occurs when certain nuclides (primarily U-233, U-235, or Pu-239) absorb a neutron and break into several smaller nuclides (called fission products) as well as some additional neutrons.

Fission results in production of radioactive materials including gases and solids that must be contained to prevent release or treated prior to release. These effluents are generally treated by filtration and/or hold-up prior to release. Releases are generally monitored by sampling and by continuously indicating radiation monitors. The effluent release data is used to calculate doses in order to ensure that dose to the public due to plant operation remains within required limits.

3.2 About Radiation Dose

Ionizing radiation, including alpha, beta, and gamma radiation from radioactive decay, has enough energy to break chemical bonds in tissues and result in damage to tissue or genetic material. The amount of ionization that will be generated by a given exposure to ionizing radiation is quantified as dose. Radiation dose is generally reported in units of millirem (mrem) in the US.

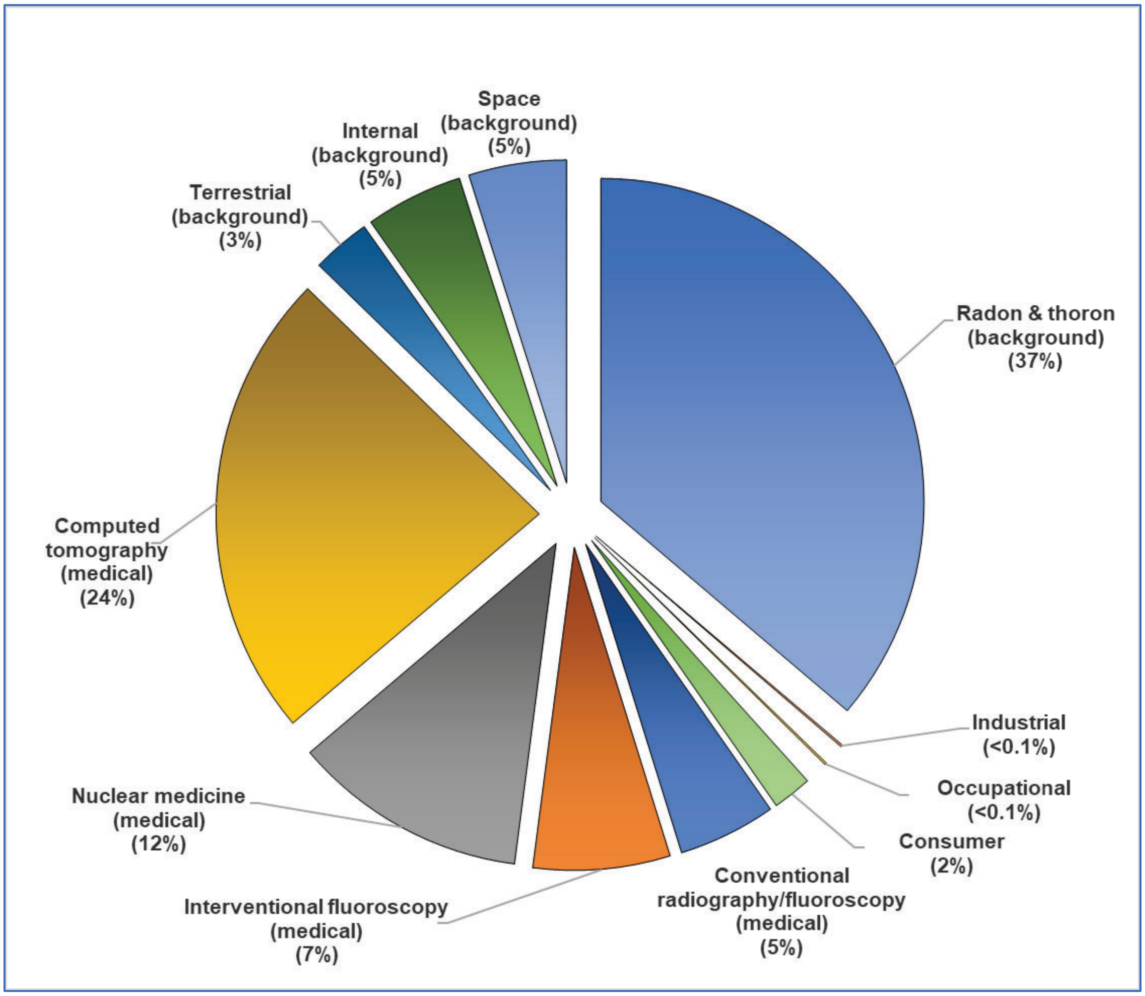

Figure 3, Sources of Radiation Exposure (NCRP Report No. 160) **[3]**

3.2 (Continued)

The National Council on Radiation Protection (NCRP) has evaluated the population dose for the US and determined that the average individual is exposed to approximately 620 mrem per year [3]. There are many sources for radiation dose, ranging from natural background sources to medical procedures, air travel, and industrial processes. Approximately half (310 mrem) of the average exposure is due to natural sources of radiation including exposure to Radon, cosmic radiation, and internal radiation and terrestrial due to naturally occurring radionuclides. The remaining 310 mrem of exposure is due to man-made sources of exposure, with the most significant contributors being medical (48%) due to radiation used in various types of medical scans and treatments. Of the remaining 2% of dose, most is due to consumer activities such as air travel, smoking cigarettes, and building materials. A small fraction of this 2% is due to industrial activities including generation of nuclear power.

Readers that are curious about common sources and effects of radiation dose that they may encounter can find excellent sources of information from the Health Physics Society, including the Radiation Fact Sheets [4], and from the US Nuclear Regulatory Commission website [5].

3.3 About Dose Calculation

Concentrations of radioactive material in the environment resulting from plant operations are very small and it is not possible to determine doses directly using measured activities of environmental samples. To overcome this, Dose Calculations based on measured activities of effluent streams are used to model the dose impact for Members of the Public due to plant operation and effluents. There are several mechanisms that can result in dose to Members of the Public, including: Ingestion of radionuclides in food or water; Inhalation of radionuclides in air; Immersion in a plume of noble gases; and Direct Radiation from the ground, the plant or from an elevated plume.

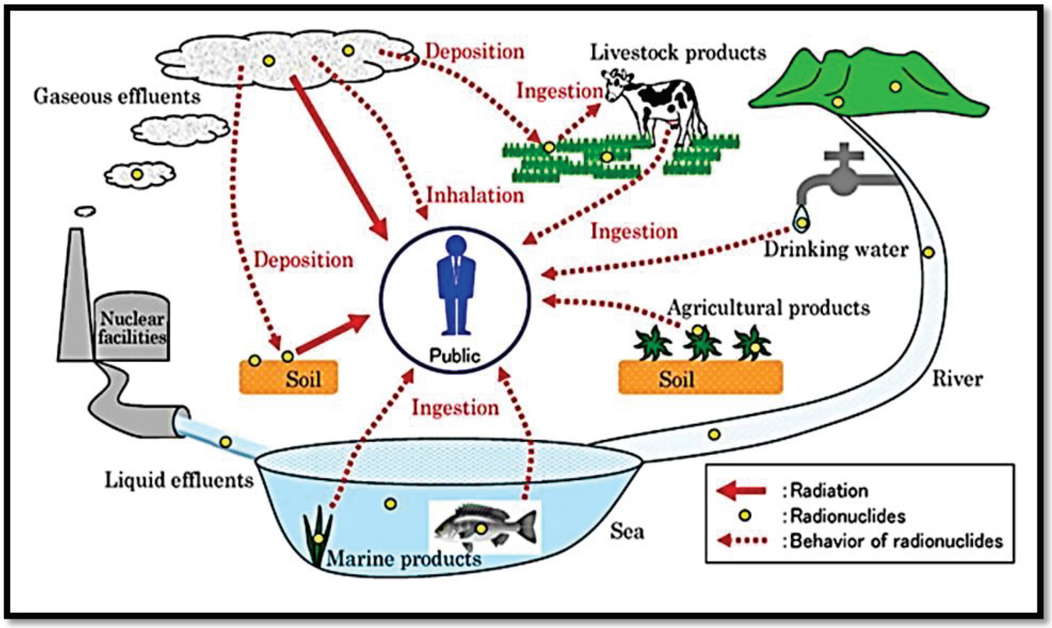

Figure 4, Potential exposure pathways to Members of the Public due to Plant Operations **[6]**

The Offsite Dose Calculation Manual (ODCM) specifies the methodology used to obtain the doses in the Dose Assessment section of this report. The methodology in the ODCM is based on NRC Regulatory Guide 1.109 [7] and NUREG-0133 [8]. Doses are calculated by determining what the nuclide concentration will be in air, water, on the ground, or in food products based on plant effluent releases. Release points are continuously monitored to quantify what concentrations of nuclides are being released. For gaseous releases meteorological data is used to determine how much of the released activity will be present at a given location outside of the plant either deposited onto the ground or in gaseous form. Intake patterns and nuclide bio-concentration factors are used to determine how much activity will be transferred into animal milk or meat. Finally, human ingestion factors and dose factors are used to determine how much activity will be consumed and how much dose the consumer will receive. Inhalation dose is calculated by determining the concentration of nuclides and how much air is breathed by the individual.

3.3 (Continued)

For liquid releases, dilution and mixing factors are used to model the environmental concentrations in water. Drinking water pathways are modeled by determining the concentration of nuclides in the water at the point where the drinking water is sourced. Fish and invertebrate pathways are determined by using concentration at the release point, bioaccumulation factors for the fish or invertebrate and an estimate of the quantity of fish consumed.

Each year a Land Use Census is performed to determine what potential dose pathways currently exist within a five-mile radius around the plant, the area most affected by plant operations. The Annual Land Use Census identifies the locations of vegetable gardens, nearest residences, milk animals and meat animals. The data from the census is used to determine who is the likely to be most exposed to radiation dose as a result of plant operation.

There is significant uncertainty in dose calculation results, due to modeling dispersion of material released and bioaccumulation factors, as well as assumptions associated with consumption and land-use patterns. Even with these sources of uncertainty, the calculations do provide a reasonable estimate of the order of magnitude of the exposure. Conservative assumptions are made in the calculation inputs such as the number of various foods and water consumed, the amount of air inhaled, and the amount of direct radiation exposure from the ground or plume, such that the actual dose received are likely lower than the calculated dose. Even with the built-in conservatism, doses calculated for the highest hypothetical exposed individual due to plant operation are a very small fraction of the annual dose that is received due to other sources. The low calculated doses due to plant effluents, along with REMP results, serve to provide assurance that the site is not having a negative impact on the environment or people living near the plant.

4.0 DOSE ASSESSMENT FOR PLANT OPERATIONS

4.1 Regulatory Limits

Regulatory limits are detailed in Station Licensing documents such as the Offsite Dose Calculation Manual (ODCM) and Technical Specifications 5.5.1, 5.5.4, 5.5.12 and 5.6.3. These documents contain the limits to which VEGP must adhere. VEGP drives to maintain the philosophy to keep dose "as low as reasonably achievable" (ALARA) and actions are taken to reduce the amount of radiation released to the environment. Liquid and gaseous release data show that the dose from VEGP is well below the ODCM limits. The concentration of liquid radioactive material released shall be limited to ten times the concentration specified in 10 CFR 20, Appendix B, Table 2, Column 2, for radionuclides other than dissolved or entrained noble gases. For dissolved or entrained noble gases, the total concentration released shall be limited to 1.0×10^{-4} microcuries/ml. For gross alpha in liquid radwaste, the ECL is 2E-09 uCi/ml. These data reveals that the radioactive effluents have an overall minimal dose contribution to the surrounding environment.

The annual whole body, skin and organ dose was computed using the 2022 source term using the dose calculation methodology provided in the ODCM. The calculated doses due to gaseous effluents to demonstrate compliance with offsite dose limits are presented in Table 1, Vogtle Electric Generating Plant (Unit 1) Dose Summary, Table 2, Vogtle Electric Generating Plant (Unit 2) Dose Summary and Table 4, Total Annual Offsite-Dose Comparison to 40 CFR 190 Limits for VEGP.

4.2 Regulatory Limits for Gaseous Effluent Doses:

1. Fission and activation gases:

   a. Noble gases dose rate due to radioactive materials released in gaseous effluents from the site to areas at and beyond the site boundary shall be limited to the following:

      1) Less than or equal to 500 mrem/year to the total body

      2) Less than or equal to 3000 mrem/year to the skin

   b. Noble gas air dose due to noble gases released in gaseous effluents, from each reactor unit to areas at and beyond the site boundary shall be limited to the following:

      1) Quarterly

         a) Less than or equal to 5 mrads gamma

         b) Less than or equal to 10 mrads beta

4.2 (Continued)

2) Yearly

a) Less than or equal to 10 mrads gamma

b) Less than or equal to 20 mrads beta

2. Iodine, tritium, and all radionuclides in particulate form with half-lives greater than 8 days.

a. The dose rate for iodine-131, iodine-133, tritium, and all radionuclides in particulate form with half-lives greater than 8 days in gaseous effluents released from the site to areas at and beyond the site boundary shall be limited to the following:

1) Less than or equal to 1500 mrem/yr to any organ

b. The dose to a MEMBER OF THE PUBLIC from iodine-131, iodine-133, tritium, and all radionuclides in particulate form with half-lives greater than 8 DAYS in gaseous effluents released, from each reactor unit to areas at and beyond the site boundary shall be limited to the following:

1) Quarterly

a) Less than or equal to 7.5 mrem to any organ

2) Yearly

a) Less than or equal to 15 mrem to any organ

4.3 Regulatory Limits for Liquid Effluent Doses

1. The dose or dose commitment to a MEMBER OF THE PUBLIC from radioactive materials in liquid effluents released, from each reactor unit to unrestricted areas shall be limited to the following:

a. Quarterly

1) Less than or equal to 1.5 mrem total body

2) Less than or equal to 5 mrem critical organ

b. Yearly

1) Less than or equal to 3 mrem total body

2) Less than or equal to 10 mrem critical organ

4.4 40 CFR 190 Regulatory Dose Limits for a Member of the Public

1. Total Dose (40 CFR 190)

   a. The annual (calendar year) dose or dose commitment to any MEMBER OF THE PUBLIC in the unrestricted area due to releases of radioactivity and to radiation from uranium fuel cycle sources shall be limited to the following:

      1) Less than or equal to 25 mrem, Total Body or any Organ except Thyroid.

      2) Less than or equal to 75 mrem, Thyroid.

4.5 Onsite Doses (Within Site Boundary)

ODCM 7.2.2.3 states in part:

"The report shall also include assessment of the radiation doses from radioactive liquid and gaseous effluents to MEMBERS OF THE PUBLIC due to their activities inside the SITE BOUNDARY during the report period; this assessment must be performed in accordance with Chapter 6. All assumptions used in making these assessments (i.e., specific activity, exposure time, and location) shall be included in the report".

This section evaluates dose to non-occupationally exposed workers and members of the public that may be onsite for various reasons. The report must include any other information as may be required by the Commission to estimate maximum potential annual radiation doses to the public resulting from effluent releases as required by 10 CFR 50.36a(a)(2). While within controlled or restricted areas, the limits from Sections 4.1 through 4.4 do not apply; however, 10 CFR 20.1301 dose limit of 100 mrem per year TEDE and dose rate limit of 2 mrem per hour from external sources continue to apply. Occupancy times within the controlled areas are generally sufficiently low to compensate for increase in the atmospheric dispersion factor above the site boundary. Groups of concern and occupancy factors (number of hours/year spent inside the site boundary), are listed in Table 5. These groups conservatively represent the most-exposed individual.

The locations of concern within the site boundary are the Visitors Center and Vogtle 3&4 Construction Site. The activities at the Visitor Center consist of occasional attendance at meetings and/or short visits for informational purposes. The activities at Vogtle 3&4 consist of construction and administrative work.

There will be no radiation dose at these locations due to radioactive liquid effluents. Delineated in Table 5 for these locations are the values of the basic data assumed in the dose assessment due to radioactive gaseous effluents. Listed in this table are distance, direction from a point midway between the center of Unit 1 and the Unit 2 reactors and the estimated maximum occupancy factor for an individual.

Table 5, Onsite Doses (Within Site Boundary)

Location	Sector	Occupancy Hours	Approx. Distance (Meters	Dose (mrem)	
				Total Body	Organ
Visitor's Center	SE	4	447	1.40E-08	1.40E-08
Units 3&4 Construction	SW	2076	483	1.12E-05	1.12E-05

5.0 SUPPLEMENTAL INFORMATION

5.1 Gaseous Batch Releases

5.1.1 VEGP (Unit 1)

	Units	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual
1. Number of Batch Releases		89	91	95	94	369
2. Total duration of batch releases	minutes	6.20E+03	6.04E+03	6.91E+03	6.26E+03	2.54E+04
3. Maximum batch release duration	minutes	1.45E+02	1.28E+02	6.32E+02	2.15E+02	6.32E+02
4. Average batch release duration	minutes	6.97E+01	6.63E+01	7.27E+01	6.66E+01	6.88E+01
5. Minimum batch release duration	minutes	2.70E+01	2.20E+01	1.50E+01	2.00E+01	1.50E+01

5.1.2 VEGP (Unit 2)

	Units	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual
1. Number of Batch Releases		81	90	94	93	358
2. Total duration of batch releases	minutes	4.90E+04	4.77E+03	2.86E+03	2.05E+03	5.86E+04
3. Maximum batch release duration	minutes	6.03E+03	2.04E+03	5.18E+02	5.00E+01	6.03E+03
4. Average batch release duration	minutes	6.05E+02	5.29E+01	3.04E+01	2.20E+01	1.64E+02
5. Minimum batch release duration	minutes	7.00E+00	1.00E+01	1.00E+01	1.00E+01	7.00E+00

5.2 Liquid Batch Releases

5.2.1 VEGP (Unit 1)

VEGP (Unit 1)	Units	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual
1. Number of Batch Releases		0	0	1	4	5
2. Total duration of batch releases	minutes	0.00E+00	0.00E+00	2.49E+02	2.00E+03	2.25E+03
3. Maximum batch release duration	minutes	0.00E+00	0.00E+00	2.49E+02	5.80E+02	5.80E+02
4. Average batch release duration	minutes	0.00E+00	0.00E+00	2.49E+02	5.00E+02	4.49E+02
5. Minimum batch release duration	minutes	0.00E+00	0.00E+00	2.49E+02	4.50E+02	2.49E+02
6. Average stream flow during periods of release of liquid effluent into a flowing stream[1]	CFS	1.13E+04	1.14E+04	6.86E+03	5.21E+03	8.69E+03

5.2.2 VEGP (Unit 2)

	Units	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual
1. Number of Batch Releases		18	13	11	5	47
2. Total duration of batch releases	minutes	6.18E+03	4.57E+03	3.83E+03	2.23E+03	1.68E+04
3. Maximum batch release duration	minutes	6.08E+02	5.07E+02	4.70E+02	6.12E+02	6.12E+02
4. Average batch release duration	minutes	3.43E+02	3.51E+02	3.48E+02	4.45E+02	3.57E+02
5. Minimum batch release duration	minutes	1.90E+02	2.50E+02	4.50E+01	2.79E+02	4.50E+01
6. Average stream flow during periods of release of liquid effluent into a flowing stream[1]	CFS	1.13E+04	1.14E+04	6.86E+03	5.21E+03	8.69E+03

5.3 Abnormal Releases

5.3.1 Gaseous Abnormal Releases (Unit 1)

	Units	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual
1. Number of Releases		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Total Time For All Releases	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3. Maximum Time For A Release	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4. Average Time For A Release	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5. Minimum Time For A Release	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
6. Total activity for all releases	Curies	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

[1] Average river flowrate taken from USGS Monitoring Station 02197500, Savannah River at Burton's Ferry Bridge near Millhaven, GA. 32 miles

5.3.2 Gaseous Abnormal Releases (Unit 2)

	Units	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual
1. Number of Releases		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Total Time For All Releases	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3. Maximum Time For A Release	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4. Average Time For A Release	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5. Minimum Time For A Release	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
6. Total activity for all releases	Curies	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

There were no abnormal gaseous releases during 2022.

5.3.3 Liquid Abnormal Releases (Unit 1)

	Units	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual
1. Number of Releases		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Total Time For All Releases	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3. Maximum Time For A Release	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4. Average Time For A Release	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5. Minimum Time For A Release	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
6. Total activity for all releases	Curies	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

5.3.4 Liquid Abnormal Releases (Unit 2)

	Units	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual
1. Number of Releases		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. Total Time For All Releases	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3. Maximum Time For A Release	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4. Average Time For A Release	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5. Minimum Time For A Release	minutes	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
6. Total activity for all releases	Curies	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

There were no abnormal liquid releases during 2022

5.4 Land Use Census Changes

There were no changes to receptors, receptor locations, sample media availability, or new (or changed) routes of exposure as determined by the 2022 Land Use Census.

5.5 Meteorological Data

ODCM 7.2.2.2 states in part:

The Radioactive Effluent Release Report shall include an annual summary of hourly meteorological data collected over the previous year. This annual summary may be either in the form of an hour-by-hour listing of wind speed, wind direction, atmospheric stability, and precipitation (if measured) on magnetic tape; or in the form of joint frequency distributions of wind speed, wind direction and atmospheric stability.

In lieu of submission with the Radioactive Effluent Release Report, the licensee has the option of retaining this summary of required meteorological data on site in a file that shall be provided to the NRC upon request.

Meteorological data accumulation was greater than 97.8% for all variables required by Regulatory Guide 1.23. At least a 90% data recovery is required by the Regulatory Guide.

5.6 Effluent Radiation Monitors Out of Service Greater Than 30 Days

ODCM 7.2.2.6 states in part that the report shall include deviations from the liquid and gaseous effluent monitoring instrumentation operability requirements included in Sections 2.1.1 and 3.1.1, respectively. The report shall include an explanation as to why the inoperability of liquid or gaseous effluent monitoring instrumentation was not corrected within the specified time requirement.

1. The inoperability of liquid and gaseous effluent monitors not corrected within the specified time for this reporting period is detailed below. When applicable, compensatory measures were utilized per ODCM Action Statements:

    a. 1RE-0018 (Liquid Waste Effluent Rad Monitor) -This monitor was out greater than 30 days due to a high background. It was taken out of service on 01-03-2022. The detector was decontaminated and continued to have high background. The detector was replaced under SNC1357687. The monitor was returned to service on 08-22-2022.

    b. 1RE-12839 A, B, C, D, E, F, 1FT-12839 and 1FIT-13211 (SJAE & STM Packing Exhaust Rad monitor) - This monitor was out of service for greater than 30 days. It was taken out of service on 04-17-2022 for an installation of the new General Atomics RM-2000. This work is being performed under Design Change Package (DCP) SNC1046507 and is tracking installation into 2023.

    c. 1RE-12442 A, B, C, D, E, F and 1FT-12442 (Plant Vent Radiation Monitor) - This monitor was out of service for greater than 30 days. On 10-21-2022 it was taken out of service due to a board failure on 1FT-12442 which took out the monitor. The installation of the new board is being tracked into 2023 on SNC1396347.

5.6 (Continued)

d. 1RE-12444 A, B, C, D, E, F and 1FT-12835 (Plant Vent Post Accident Radiation Monitor) - This monitor was out of service for greater than 30 days. On 09-16-2021 the monitor was taken out of service due to the 1FT-12835 flow transmitter failing. The work for a new flow transmitter is being tracked under DCP SNC1414233 into 2023.

e. ARE-16980 (Radiation Processing Facility Radiation Monitor) - This monitor was out of service for more than 30 days. On 02-09-2022 the monitor was taken out of service due to heat trace issues and returned to service on 04-21-2022. The investigation and adjustments made to heat trace were tracked under SNC1225090.

f. 2RE-12839 A, B, C, D, E, F, 2FT-12839, and 2FIT-13211 (SJAE & STM Packing Exhaust Rad monitor) - This monitor was out of service for greater than 30 days. It was taken out of service on 07-18-2022 for an installation of the new General Atomics RM-2000. This work is being performed under Design Change Package (DCP) SNC1046514 and is tracking installation into 2023.

g. 2RE-12444 A, B, C, E, F and 2FT-12835 (Plant Vent Post Accident Radiation Monitor) - This monitor was out of service for greater than 30 days. It was taken out of service on 03-15-2021 for an installation of the new General Atomics RM-2000. This work was performed under Design Change Package (DCP) SNC131179 and successfully put into service on 04-03-2022.

5.7 Offsite Dose Calculation Manual (ODCM) Changes

ODCM 7.2.2.5 states in part that changes to the ODCM shall be submitted with the Radioactive Effluent Release Report. These changes may be due to changes in the radiological environmental monitoring program sampling locations as required by ODCM 4.1.1.2.3 or changes to dose calculation locations as required by ODCM 4.1.2.2.2. Land uses and dose calculation locations within five miles of VEGP must be determined by a land use census as required by ODCM 4.1.2

Date of Change	Revision	Section in ODCM	Description of Change
October 2022	36	4.2	The ODCM was changed to update the control dairy. Version 35 had the control dairy as Milky Way Dairy, which closed down in September of 2022 and was changed to Harmony Grove Dairy. Harmony Grove Dairy was listed as the new control dairy for Version 36. This work was performed under LDCR2022031.

5.8 Process Control Program (PCP) Changes

PCP 12.1 states in part:

Licensee major initiated changes to the solid radioactive waste treatment system shall be reported to the Nuclear Regulatory Commission in the Radioactive Effluent Release Report for the period in which the change was implemented.

There were no major changes to the solid radwaste systems in the 2022 assessment period.

5.9 Radioactive Waste Treatment System Changes

ODCM 7.2.2.7 states in part:

As required by Sections 2.1.5 and 3.1.6, licensee initiated MAJOR CHANGES TO RADIOACTIVE WASTE TREATMENT SYSTEMS (liquid and gaseous) shall be reported to the Nuclear Regulatory Commission in the Radioactive Effluent Release Report covering the period in which the change was reviewed and accepted for implementation.

Note 1: In lieu of inclusion in the Radioactive Effluents Release Report, this same information may be submitted as part of the annual FSAR update.

There were no major changes to the gaseous or liquid radwaste systems in the 2022 assessment period.

5.10 Other Supplemental Information

5.10.1 Measurements and Approximation of Total Radioactivity Gaseous Effluents

1. Sample Collection and Analysis

Gaseous Effluents at the Vogtle Electric Generating Plant are currently confined to five paths: plant vents (Unit 1 and Unit 2), the condenser air ejector, the steam packing exhauster systems (Unit 1 and Unit 2), and the Radwaste Processing Facility (RPF).

Waste gas decay tanks are batch released through the Unit 1 plant vent. The containment purges are released through their respective plant vents.

Containment atmosphere is also released via the containment equipment hatch during periods when the equipment hatch is open with containment purge/vent being stopped. Approval was granted by the NRC to open the equipment hatch during fuel movement; a release permit is generated when the equipment hatch is opened, and the containment exhaust fan is not discharging to the plant vent. Any detected activity in the containment equipment hatch permit is included in the Ground Release Table of the effluent report.

5.10.1 (Continued)

All of the paths with the exception of the RPF can be continuously monitored for gaseous radioactivity. The RPF is equipped with an integrated-type sample collection device for collecting particulates. Plant vent, containment, steam jet air ejector, steam-packing exhauster are equipped with an integrated-type sample collection device for collecting particulates and iodines. During this reporting period, there were no continuous radioactive releases through the condenser air ejector and the steam packing exhauster system vents. Batch Waste Gas Decay Tank releases are analyzed for noble gases before each release. The containment atmosphere is analyzed for noble gases prior to each release and for tritium at least on a monthly basis.

Sample analysis results and release flow rates form the basis for calculating released quantities of radionuclide specific radioactivity, dose rates associated with gaseous releases, and cumulative doses for the current quarter and year.

With each release period and batch release, radioactivity, dose rates, and cumulative doses are calculated. Cumulative dose results are tabulated, along with the percent of the ODCM limits for each release for the current quarter and year.

Typically achieved minimum detectable concentrations for gaseous effluent sample analyses are reported in Table 21, Minimum Detectable Concentrations Gaseous Sample Analysis.

2. Total Quantities of Radioactivity, Dose Rates, and Cumulative Doses

   a. Fission and Activation Gases

      The released radioactivity is determined from sample analysis results collected as described above and average release flow rates over the period represented by the collected sample. Dose rates due to noble gases, radioiodines, tritium, and particulates are calculated. Calculated dose rates are compared to the dose rate limits specified in ODCM 3.1.2 for noble gases, radioiodines, tritium, and particulates. Dose rate calculation methodology is presented in the ODCM.

      Beta and gamma air doses due to noble gases are calculated for the location in the unrestricted area with the potential for the highest exposure due to gaseous releases. Air doses are calculated for each release period and cumulative totals are kept for each unit for the calendar quarter and year. Cumulative air doses are compared with the dose limits specified in ODCM 3.1.3. Current percent of the ODCM limits are shown on the printout for each release period. Air dose calculation methodology is presented in the ODCM.

5.10.1 (Continued)

b. Radioiodines, Tritium and Particulate Releases

The released quantities of radioiodines, tritium and particulates are determined using the weekly samples and release flow rates for the two plant vent release points.

After each quarter, the particulate filters from each plant vent are combined, for strontium analysis. Strontium concentrations are input to the composite file of the computer to be used for release dose rate and individual dose calculations.

Doses to a Member of the Public due to radioiodines, tritium and particulates are calculated for the controlling receptor, which is described in Table 3-7of the ODCM. Doses are calculated for each release period, and cumulative totals are kept for each unit for the current calendar quarter and year. Cumulative doses are compared to the dose limits specified in ODCM 3.1.4.

Current percent of ODCM limits are shown in this report for each release period

c. Gross Alpha Release

The gross alpha release is calculated each month by counting the particulate filters for each week for gross alpha activity. The four or five weeks' numbers are then recorded on a data sheet and the activity is summed at the end of the month. This concentration is used for release calculations.

3. Total Error Estimation

The total or maximum error associated with the effluent measurement will include the cumulative errors resulting from the total operation of sampling and measurement. Because it may be very difficult to assign error terms for each parameter affecting the final measurement, detailed statistical evaluation of error are not suggested. The objective should be to obtain an overall estimate of the error associated with measurements of radioactive materials released in liquid and gaseous effluents and solid waste.

Estimated errors are based on errors in counting equipment calibration, counting statistics, vent-flow rates, vent sample flow rates, non-steady release rates, chemical yield factors, and sample losses for such items as charcoal cartridges. Total Error is calculated by the root mean square method. The root mean square value is the square root of the arithmetic mean (average) of the squares of the original values.

5.10.1 (Continued)

a. Fission and activation total release was calculated from sample analysis results and release point flow rates with one sigma counting error.

Sampling and statistical error in counting	10%
Counting equipment calibration	10%
Vent flow rates	10%
Non-steady release rates	20%
TOTAL ERROR	26.5

b. I-131 releases were calculated from each weekly sample:

Statistical error in counting	10%
Counting equipment calibration	10%
Vent flow rates	10%
Vent sample flow rates	50%
Non-steady release rates	10%
Losses from charcoal cartridges	10%
TOTAL ERROR	55%

c. Particulates with half-lives greater than 8 day releases were calculated from sample and analysis results and release point flow rates.

Statistical error at MDC concentration	10%
Counting equipment calibration	10%
Vent flow rates	10%
Vent sample flow rates	50%
Non steady release rates	10%
TOTAL ERROR	54%

5.10.1 (Continued)

d. Total tritium releases were calculated from sample analysis results and release point flow rates.

Water vapor in sample stream determination	10%
Vent flow rates	10%
Counting calibration and statistics	10%
Non-steady release rates	10%
TOTAL ERROR	20%

e. Gross Alpha radioactivity was calculated from sample analysis results and release point flow rates.

Statistical error at MDC concentration	10%
Counting equipment calibration	10%
Vent flow rates	10%
Vent sample flow rates	50%
Non steady release rates	10%
TOTAL ERROR	55%

5.10.2 Measurements and Approximation of Total Radioactivity Liquid Effluents

1. Total Radioactivity Determination

Prior to the release of any tank containing liquid radwaste, and following the required recirculation, samples are collected and analyzed in accordance with the Vogtle Electric Generating Plant Offsite Dose Calculation Manual (ODCM) Table 2-3 “Radioactive Liquid Waste Sampling and Analysis Program”. A sample from each tank which is planned for release is analyzed for principal gamma emitters, I-131, and dissolved and entrained noble gases by gamma spectroscopy. Monthly and quarterly composites are prepared for analysis by extracting aliquots from each sample taken from the tanks, which are released. Liquid radwaste sample analyses are performed as follows:

	Measurement	Frequency	Method
1.	Gamma Isotopic	Each Batch	Gamma Spectroscopy with computerized data reduction.
2.	Dissolved or entrained noble gases	Each Batch	Gamma Spectroscopy with computerized data reduction
3.	Tritium	Monthly Composite	Distillation and liquid scintillation counting
4.	Gross Alpha	Monthly Composite	Gas flow proportional counting (1)
5.	Sr-89 & Sr-90	Quarterly Composite	Chemical separation and gas flow proportional or scintillation counting (1)
6.	Fe-55	Quarterly Composite	Chemical separation and liquid scintillation Counting (1)
7.	Ni-63	Quarterly Composite	Chemical separation and liquid scintillation Counting (1)

(1) Analysis performed by an offsite laboratory

5.10.2 (Continued)

Gamma isotopic measurements are performed using germanium detectors with a resolution of 2.1 keV or lower. A peak search of the resulting gamma ray spectrum is performed by the computer system. Energy and net count data for all significant peaks are determined, and a quantitative reduction or MDC calculation is performed. This ensures that the MDC's are met for the nuclides specified in ODCM Chapter 10 (i.e., Mn-54, Fe-59, Co-58, Co-60, Zn-65, Mo-99, Cs-134, Cs-137, Ce-141 and Ce-144). The quantitative calculations, corrections for counting time, decay time, sample volume, sample geometry, detector efficiency, baseline counts, branching ratio and MDC calculations, are made based on the counts at the location in the spectrum where the peak for that radionuclide would be located, if present.

ECL fraction is determined using radionuclide concentrations of a tank planned for release, the most current results available for tritium, gross alpha, Sr-89, Sr-90, Fe-55 and Ni-63 and the corresponding ECL values. This ECL fraction is used, with appropriate safety factors, tolerance factors, and the minimum assured dilution stream flow to calculate maximum permissible release rates and a liquid effluent monitor setpoint. The monitor setpoint is calculated to assure that the limits of the Offsite Dose Calculation Manual (ODCM) are not exceeded.

A monitor reading in excess of the calculated setpoint results in an automatic termination of the liquid radwaste discharge. Liquid effluent discharge is also automatically terminated if the dilution stream flow rate falls below the minimum assured dilution flow rate used in the setpoint calculations and established as a setpoint on the dilution stream flow monitor.

Radionuclide concentrations, safety factors, dilution stream flow rate, and liquid effluent radiation monitor calibrations are entered into the computer and a pre-release printout is generated. If the release is not permissible, appropriate warnings will be displayed on the computer screen. If the release is permissible, it is approved by the Chemistry Department and sent to the Operations Department for release. When the release is completed, the necessary data from the release (i.e., release volume, etc.) is provided by the Operations Department to the Chemistry Department. This data is inputted to the computer and a post-release printout is generated. The post release printout contains the actual release rates, release concentrations and quantities, actual dilution flow, and calculated doses to an individual.

Typically achieved liquid effluent sample analyses minimum detectable concentrations are reported in Table 31, Minimum Detectable Concentrations-Liquid Sample Analyses.

5.10.2 (Continued)

2. Total Error Estimation

The total or maximum error associated with the effluent measurement includes the cumulative errors resulting from the total operation of sampling and measurement. Because it may be very difficult to assign error terms for each parameter affecting the final measurement, detailed statistical evaluation of error is not suggested. The objective should be to obtain an overall estimate of the error associated with measurements of radioactive materials released in effluents (Reference Reg. Guide 1.21 Rev 1). Total Error is calculated by the root mean square method. The root mean square value is the square root of the arithmetic mean (average) of the squares of the original values.

a. Fission and activation total release was calculated from sample analysis results and release point flow rates with one sigma counting error.

Sampling and statistical error	10%
Counting equipment calibration	10%
Tank volumes and system flow rate	20%
TOTAL ERROR	24.5%

b. Total Tritium release was calculated from sample analysis results and release point volumes.

Sampling and statistical error	10%
Counting equipment calibration	10%
Tank volumes and system flow rate	20%
TOTAL ERROR	24.5%

c. Dissolved and entrained gases were calculated from sample analysis results and release point volumes.

Sampling and statistical error	20%
Counting equipment calibration	10%
Tank volumes and system flow rate	20%
TOTAL ERROR	30%

5.10.2 (Continued)

d. Gross alpha radioactivity was calculated from sample analysis results and release point volumes.

Sampling and statistical error	10%
Counting equipment calibration	10%
Tank volumes and system flow rate	20%
TOTAL ERROR	24.5%

e. Volume of waste prior to dilution was calculated from level indicators on the tanks and pump discharge flow rates and times.

Level Indicator error	10%
Operator Interpretation of gauge	10%
TOTAL ERROR	14%

f. Volume of dilution water used was calculated from flow totalizers and pump discharge flow rates and times.

Flow totalizer error	10%
Operator Interpretation of gauge	10%
TOTAL ERROR	14%

g. Gross alpha, Sr-89, Sr-90, Fe-55, Ni-63 and H-3 radioactivity has an additional error associated with sample compositing.

Compositing sample error	5%

5.10.3 Outside Temporary Tanks

ODCM 7.2.2.6 states in part that the report shall include a description of the events leading to liquid holdup tanks or gas storage tanks exceeding the limits of Technical Specifications 5.5.12.

Limits for outdoor liquid hold-up tanks used for radioactive liquids were not exceeded during this reporting period.

Limits for the gas storage tanks were not exceeded during this reporting period.

5.10.4 Carbon-14

Carbon-14 (C-14) is a naturally-occurring radionuclide with a 5730 year half-life. Nuclear weapons testing in the 1950s and 1960s significantly increased the amount of C-14 in the atmosphere. Nuclear power plants also produce C-14, but the amount is infinitesimal compared to what has been distributed in the environment due to weapons testing and what is produced by natural cosmic ray interactions.

As nuclear plants have improved gaseous waste processing systems and improved fuel performance, the percentages of “principal radionuclides” in gaseous effluents have changed, and C-14 has become a larger percentage. “Principal radionuclides” are determined based on public dose contribution or the amount of activity discharged compared to other radionuclides of the same effluent type. In Revision 2 (June 2009) of Regulatory Guide 1.21 (RG 1.21), “Measuring, Evaluating, and Reporting Radioactive Material in Liquid and Gaseous Effluents and Solid Waste,” the NRC recommended re-evaluating “principal radionuclides” and reporting C-14 as appropriate. In 2010 Radioactive Effluent Release Reports, virtually all U. S. nuclear power plants started reporting C-14 amounts released and resulting doses to the maximally exposed member of the public.

Because C-14 is considered a hard-to-detect radionuclide which must be chemically separated from the effluent stream before it can be measured, RG 1.21 provides the option of calculating the C-14 source term based on power generation. The Electric Power Research Institute (EPRI) developed an accepted methodology for calculating C-14, and published the results in Technical Report 1021106 (December 2010), “Estimation of Carbon-14 in Nuclear Power Plant Gaseous Effluents.” Evaluation of C-14 in radioactive liquid effluents is not required because the quantity and dose contribution has been determined to be insignificant.

At Plant Vogtle, the annual quantity of C-14 released in gaseous effluents was estimated to be 12.08 Curies (per unit). Approximately 30% of the C-14 released is in the form of $^{14}CO_2$ and is incorporated into plants through photosynthesis. Ingestion dose results from this pathway. The remaining 70% is estimated to be organic. Both the organic and inorganic forms of C-14 contribute to inhalation dose. A child is the maximally exposed individual, and bone dose is the highest organ dose. Using the dose calculation methodology from the Vogtle ODCM, the resulting bone dose to a child located at the controlling receptor location would be 8.46E-02 mrem in a year which is 0.56% of the regulatory limit of 15 mrem per year (per unit) to any organ due to gaseous effluents. The resulting total body dose to a child located at the controlling receptor location would be 1.69E-02 mrem in a year which is 0.11% of the regulatory limit of 15 mrem per year (per unit) total body dose due to Table 1 and Table 2)

5.10.5 Errata/Corrections to Previous ARERRs

In 2021 it was reported 1RE-12444 A, B, C, D, E, FT and 1FT-12835 were OOS for greater than 30 days from 09/15/2020 to 02/26/2021 from being upgraded to a new monitor. It went back out of service on 09/16/2021, which was not reported in 2021, due to a failure of 1FT-12835. This work is being tracked under DCP SNC1414233 and remains OOS presently. All action statements were performed during this time to ensure compliance with the ODCM

6.0 NEI 07-07 ONSITE RADIOLOGICAL GROUNDWATER MONITORING PROGRAM

Vogtle Electric Generating Plant has developed a Groundwater Protection Initiative (GPI) program in accordance with NEI 07-07, Industry Ground Water Protection Initiative – Final Guidance Document [9]. The purpose of the GPI is to ensure timely detection and an effective response to situations involving inadvertent radiological releases to groundwater in order to prevent migration of licensed radioactive material off-site and to quantify impacts on decommissioning. The summary of results of 2022, VEGP GPI is located in Attachment 3, NEI 07-07 Onsite Radiological Groundwater Monitoring Program.

6.1 Voluntary Notification

During 2022, Vogtle Electric Generating Plant did not make a voluntary NEI 07-07 notification to State/Local officials, NRC, and to other stakeholders required by site procedures.

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Attachment 1, ARERR Release Summary Tables (RG-1.21 Tables)

1.0 GASEOUS EFFLUENTS

Table 6, Gaseous Effluents Summation of All Releases (Unit 1)

A. Fission & Activation Gases	**Unit**	**Quarter 1**	**Quarter 2**	**Quarter 3**	**Quarter 4**	**Annual**	**Est. Total Error %**
1. Total Release	Ci	8.17E-02	8.96E-02	1.04E-01	1.15E-01	3.90E-01	2.65E+01
2. Average release rate for the period	μCi/sec	1.04E-02	1.14E-02	1.32E-02	1.46E-02	1.24E-02	
B. Iodine-131							
1. Total Release	Ci	00E+00	00E+00	00E+00	00E+00	00E+00	5.50E+01
2. Average release rate for the period	μCi/sec	N/A	N/A	N/A	N/A	N/A	
C. Particulates							
1. Total Release	Ci	00E+00	00E+00	6.85E-07	00E+00	6.85E-07	5.40E+01
2. Average release rate for the period	μCi/sec	N/A	N/A	8.69E-08	N/A	2.17E-08	
D. Tritium							
1. Total Release	Ci	1.51E+01	2.18E+01	2.71E+01	2.44E+01	8.84E+01	2.00E+01
2. Average release rate for the period	μCi/sec	1.92E+00	2.77E+00	3.44E+00	3.09E+00	2.80E+00	
E. Gross Alpha							
1. Total Release	Ci	7.43E-07	1.49E-07	5.90E-07	2.51E-06	3.99E-06	5.50E+01
2. Average release rate for the period	μCi/sec	9.43E-08	1.89E-08	7.49E-08	3.19E-07	1.27E-07	
F. Carbon-14							
1. Total Release	Ci	3.02E+00	3.02E+00	3.02E+00	3.02E+00	1.21E+01	
2. Average release rate for the period	μCi/sec	3.88E-01	3.84E-01	3.80E-01	3.80E-01	3.83E-01	

% of limit is on Table 1, Vogtle Electric Generating Plant (Unit 1) Dose Summary

Table 7, Gaseous Effluents – Mixed Level Release Continuous Mode (Unit 1)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission & Activation Gases						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Iodines						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates						
Sr-89	Ci	0.00E+00	0.00E+00	6.85E-07	0.00E+00	6.85E-07
Total for Period	**Ci**	0.00E+00	0.00E+00	6.85E-07	0.00E+00	6.85E-07
Tritium						
H-3	Ci	1.51E+01	2.18E+01	2.71E+01	2.44E+01	8.84E+01
Gross Alpha						
Alpha	Ci	7.43E-07	1.49E-07	5.90E-07	2.51E-06	3.99E-06
If Not Detected, Nuclide is Not Reported. Zeroes in this table indicate that no radioactivity was present at detectable levels. See Table 21, Minimum Detectable Concentrations Gaseous Sample Analysis for typical minimum detectable concentrations.						

Table 8, Gaseous Effluents – Mixed Level Release Batch Mode (Unit 1)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission & Activation Gases						
Ar-41	Ci	8.17E-02	8.96E-02	1.04E-01	1.15E-01	3.90E-01
Xe-133	Ci	0.00E+00	0.00E+00	3.56E-04	0.00E+00	3.56E-04
Total for Period	**Ci**	8.17E-02	8.96E-02	1.04E-01	1.15E-01	3.90E-01
Iodines						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tritium						
H-3	Ci	2.97E-02	3.73E-02	4.50E-02	1.61E-02	1.28E-01
Gross Alpha						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
If Not Detected, Nuclide is Not Reported. Zeroes in this table indicate that no radioactivity was present at detectable levels. See Table 21, Minimum Detectable Concentrations Gaseous Sample Analysis for typical minimum detectable concentrations.						

Table 9, Gaseous Effluents – Ground Level Release Continuous Mode (Unit 1)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission & Activation Gases						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Iodines						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tritium						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gross Alpha						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
If Not Detected, Nuclide is Not Reported. Zeroes in this table indicate that no radioactivity was present at detectable levels. See Table 21, Minimum Detectable Concentrations Gaseous Sample Analysis for typical minimum detectable concentrations.						

Table 10, Gaseous Effluents – Ground Level Release Batch Mode (Unit 1)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission & Activation Gases						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Iodines						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tritium						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gross Alpha						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
If Not Detected, Nuclide is Not Reported. Zeroes in this table indicate that no radioactivity was present at detectable levels. See Table 21, Minimum Detectable Concentrations Gaseous Sample Analysis for typical minimum detectable concentrations.						

Table 11, Gaseous Effluents Summation of All Releases (Unit 2)

A. Fission & Activation Gases	**Unit**	**Quarter 1**	**Quarter 2**	**Quarter 3**	**Quarter 4**	**Annual**	**Est. Total Error %**
1. Total Release	Ci	3.85E+00	7.41E-02	6.42E-01	4.32E-02	4.61E+00	2.65E+01
2. Average release rate for the period	μCi/sec	4.89E-01	9.40E-03	8.15E-02	5.48E-03	1.46E-01	
B. Iodine-131							
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.50E+01
2. Average release rate for the period	μCi/sec	N/A	N/A	N/A	N/A	N/A	
C. Particulates							
1. Total Release	Ci	0.00E+00	1.47E-07	6.23E-07	4.00E-07	1.17E-06	5.40E+01
2. Average release rate for the period	μCi/sec	N/A	1.87E-08	7.91E-08	5.07E-08	3.71E-08	
D. Tritium							
1. Total Release	Ci	1.73E+01	4.61E+00	3.65E+00	6.32E+00	3.19E+01	2.00E+01
2. Average release rate for the period	μCi/sec	2.19E+00	5.85E-01	4.63E-01	8.01E-01	1.01E+00	
E. Gross Alpha							
1. Total Release	Ci	2.02E-06	1.36E-07	3.80E-07	2.63E-07	2.80E-06	5.50E+01
2. Average release rate for the period	μCi/sec	2.56E-07	1.72E-08	4.82E-08	3.33E-08	8.88E-08	
F. Carbon-14							
1. Total Release	Ci	3.02E+00	3.02E+00	3.02E+00	3.02E+00	1.21E+01	
2. Average release rate for the period	μCi/sec	3.88E-01	3.84E-01	3.80E-01	3.80E-01	3.83E-01	

% of limit is on Table 2, Vogtle Electric Generating Plant (Unit 2) Dose Summary

Table 12, Gaseous Effluents – Mixed Level Release Continuous Mode (Unit 2)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission & Activation Gases						
Xe-135	Ci	2.04E+00	0.00E+00	5.43E-01	0.00E+00	2.58E+00
Total for Period	**Ci**	2.04E+00	0.00E+00	5.43E-01	0.00E+00	2.58E+00
Iodines						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates						
Sr-89	Ci	0.00E+00	1.47E-07	6.23E-07	4.00E-07	1.17E-06
Total for Period	**Ci**	0.00E+00	1.47E-07	6.23E-07	4.00E-07	1.17E-06
Tritium						
H-3	Ci	1.69E+01	4.60E+00	3.64E+00	6.31E+00	3.15E+01
Gross Alpha						
Alpha	Ci	2.02E-06	1.36E-07	3.80E-07	2.63E-07	2.80E-06
If Not Detected, Nuclide is Not Reported. Zeroes in this table indicate that no radioactivity was present at detectable levels. See Table 21, Minimum Detectable Concentrations Gaseous Sample Analysis for typical minimum detectable concentrations.						

Table 13, Gaseous Effluents – Mixed Level Release Batch Mode (Unit 2)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission & Activation Gases						
Ar-41	Ci	1.45E+00	7.41E-02	3.35E-02	4.32E-02	1.60E+00
Kr-85M	Ci	8.84E-04	0.00E+00	0.00E+00	0.00E+00	8.84E-04
Kr-88	Ci	3.47E-03	0.00E+00	0.00E+00	0.00E+00	3.47E-03
Xe-133M	Ci	4.60E-03	0.00E+00	0.00E+00	0.00E+00	4.60E-03
Xe-133	Ci	3.19E-01	0.00E+00	6.57E-02	0.00E+00	3.85E-01
Xe-135	Ci	3.27E-02	0.00E+00	0.00E+00	0.00E+00	3.27E-02
Total for Period	**Ci**	1.81E+00	7.41E-02	9.93E-02	4.32E-02	2.03E+00
Iodines						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tritium						
H-3	Ci	3.89E-01	7.20E-03	6.42E-03	3.09E-03	4.06E-01
Gross Alpha						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
If Not Detected, Nuclide is Not Reported. Zeroes in this table indicate that no radioactivity was present at detectable levels. See Table 21, Minimum Detectable Concentrations Gaseous Sample Analysis for typical minimum detectable concentrations.						

Table 14, Gaseous Effluents – Ground Level Release Continuous Mode (Unit 2)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission & Activation Gases						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Iodines						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tritium						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gross Alpha						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
If Not Detected, Nuclide is Not Reported. Zeroes in this table indicate that no radioactivity was present at detectable levels. See Table 21, Minimum Detectable Concentrations Gaseous Sample Analysis for typical minimum detectable concentrations.						

Table 15, Gaseous Effluents – Ground Level Release Batch Mode (Unit 2)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission & Activation Gases						
Ar-41	Ci	1.38E-03	0.00E+00	0.00E+00	0.00E+00	1.38E-03
Xe-133	Ci	1.01E-03	0.00E+00	0.00E+00	0.00E+00	1.01E-03
Total for Period	**Ci**	2.40E-03	0.00E+00	0.00E+00	0.00E+00	2.40E-03
Iodines						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tritium						
H-3	Ci	3.99E-03	0.00E+00	0.00E+00	0.00E+00	3.99E-03
Gross Alpha						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
If Not Detected, Nuclide is Not Reported. Zeroes in this table indicate that no radioactivity was present at detectable levels. See Table 21, Minimum Detectable Concentrations Gaseous Sample Analysis for typical minimum detectable concentrations.						

Table 16, Gaseous Effluents Summation of All Releases (Site)

A. Fission & Activation Gases	**Unit**	**Quarter 1**	**Quarter 2**	**Quarter 3**	**Quarter 4**	**Annual**	**Est. Total Error %**
1. Total Release	Ci	3.94E+00	1.64E-01	7.46E-01	1.58E-01	5.01E+00	2.65E+01
2. Average release rate for the period	μCi/sec	4.99E-01	2.08E-02	9.47E-02	2.01E-02	1.59E-01	
B. Iodine-131							
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.50E+01
2. Average release rate for the period	μCi/sec	N/A	N/A	N/A	N/A	N/A	
C. Particulates							
1. Total Release	Ci	0.00E+00	1.47E-07	1.31E-06	4.00E-07	1.86E-06	5.40E+01
2. Average release rate for the period	μCi/sec	N/A	1.87E-08	1.66E-07	5.07E-08	5.89E-08	
D. Tritium							
1. Total Release	Ci	3.24E+01	2.65E+01	3.08E+01	3.07E+01	1.20E+02	2.00E+01
2. Average release rate for the period	μCi/sec	4.11E+00	3.36E+00	3.90E+00	3.90E+00	3.82E+00	
E. Gross Alpha							
1. Total Release	Ci	2.76E-06	2.84E-07	9.71E-07	2.77E-06	6.79E-06	5.50E+01
2. Average release rate for the period	μCi/sec	3.51E-07	3.61E-08	1.23E-07	3.52E-07	2.15E-07	
F. Carbon-14							
1. Total Release	Ci	6.04E+00	6.04E+00	6.04E+00	6.04E+00	2.42E+01	
2. Average release rate for the period	μCi/sec	7.77E-01	7.68E-01	7.60E-01	7.60E-01	7.66E-01	

Table 17, Gaseous Effluents – Mixed Level Release Continuous Mode (Site)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission & Activation Gases						
Xe-135	Ci	2.04E+00	0.00E+00	5.43E-01	0.00E+00	2.58E+00
Total for Period	**Ci**	2.04E+00	0.00E+00	5.43E-01	0.00E+00	2.58E+00
Iodines						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates						
Sr-89	Ci	0.00E+00	1.47E-07	1.31E-06	4.00E-07	1.86E-06
Total for Period	**Ci**	0.00E+00	1.47E-07	1.31E-06	4.00E-07	1.86E-06
Tritium						
H-3	Ci	3.20E+01	2.64E+01	3.07E+01	3.07E+01	1.20E+02
Gross Alpha						
Alpha	Ci	2.76E-06	2.84E-07	9.71E-07	2.77E-06	6.79E-06
If Not Detected, Nuclide is Not Reported. Zeroes in this table indicate that no radioactivity was present at detectable levels. See Table 21, Minimum Detectable Concentrations Gaseous Sample Analysis for typical minimum detectable concentrations.						

Table 18, Gaseous Effluents – Mixed Level Release Batch Mode (Site)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission & Activation Gases						
Ar-41	Ci	1.53E+00	1.64E-01	1.37E-01	1.58E-01	1.99E+00
Kr-85M	Ci	8.84E-04	0.00E+00	0.00E+00	0.00E+00	8.84E-04
Kr-88	Ci	3.47E-03	0.00E+00	0.00E+00	0.00E+00	3.47E-03
Xe-133M	Ci	4.60E-03	0.00E+00	0.00E+00	0.00E+00	4.60E-03
Xe-133	Ci	3.19E-01	0.00E+00	6.61E-02	0.00E+00	3.85E-01
Xe-135	Ci	3.27E-02	0.00E+00	0.00E+00	0.00E+00	3.27E-02
Total for Period	**Ci**	1.89E+00	1.64E-01	2.03E-01	1.58E-01	2.42E+00
Iodines						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tritium						
H-3	Ci	4.19E-01	4.45E-02	5.15E-02	1.92E-02	5.34E-01
Gross Alpha						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
If Not Detected, Nuclide is Not Reported. Zeroes in this table indicate that no radioactivity was present at detectable levels. See Table 21, Minimum Detectable Concentrations Gaseous Sample Analysis for typical minimum detectable concentrations.						

Table 19, Gaseous Effluents – Ground Level Release Continuous Mode (Site)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission & Activation Gases						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Iodines						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tritium						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gross Alpha						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
If Not Detected, Nuclide is Not Reported. Zeroes in this table indicate that no radioactivity was present at detectable levels. See Table 21, Minimum Detectable Concentrations Gaseous Sample Analysis for typical minimum detectable concentrations.						

Table 20, Gaseous Effluents – Ground Level Release Batch Mode (Site)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission & Activation Gases						
Ar-41	Ci	1.38E-03	0.00E+00	0.00E+00	0.00E+00	1.38E-03
Xe-133		1.01E-03	0.00E+00	0.00E+00	0.00E+00	1.01E-03
Total for Period	**Ci**	2.40E-03	0.00E+00	0.00E+00	0.00E+00	2.40E-03
Iodines						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Particulates						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tritium						
H-3	Ci	3.99E-03	0.00E+00	0.00E+00	0.00E+00	3.99E-03
Gross Alpha						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
If Not Detected, Nuclide is Not Reported. Zeroes in this table indicate that no radioactivity was present at detectable levels. See Table 21, Minimum Detectable Concentrations Gaseous Sample Analysis for typical minimum detectable concentrations.						

Table 21, Minimum Detectable Concentrations Gaseous Sample Analysis

The values in this table represent *a priori* Minimum Detectable Concentrations (MDC) that are typically achieved in laboratory analyses of gaseous effluent samples

RADIONUCLIDE	MDC	UNITS
Kr-87	1.82E-08	μCi/ml
Kr-88	2.53E-08	μCi/ml
Xe-133	2.05E-08	μCi/ml
Xe-133m	8.63E-08	μCi/ml
Xe-135	7.12E-08	μCi/ml
Xe-138	1.05E-07	μCi/ml
I-131	7.93E-15*	μCi/ml
Mn-54	3.94E-14*	μCi/ml
Fe-59	2.45E-14*	μCi/ml
Co-58	1.39E-14*	μCi/ml
Co-60	1.75E-14*	μCi/ml
Zn-65	2.82E-14*	μCi/ml
Mo-99	9.57E-14*	μCi/ml
Cs-134	1.12E-14*	μCi/ml
Cs-137	8.71E-15*	μCi/ml
Ce-141	8.62E-15*	μCi/ml
Ce-144	2.77E-14*	μCi/ml
Sr-89	1.00E-13	μCi/ml
Sr-90	1.00E-13	μCi/ml
H-3	9.00E-08	μCi/ml
Gross Alpha	1.00E-13	μCi/ml

* Based on an estimated sample volume of 5.7E+08 mL for particulate filters and charcoal cartridges

2.0 LIQUID EFFLUENTS

Table 22, Liquid Effluents – Summation of All Releases (Unit 1)

A. Fission & Activation Products	Unit	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual	Est. Total Error %
1. Total Release	Ci	0.00E+00	0.00E+00	8.48E-05	6.34E-04	7.19E-04	2.45E+01
2. Average diluted concentration	μCi/mL	N/A	N/A	2.27E-11	1.55E-10	3.73E-11	
B. Tritium							
1. Total Release	Ci	5.77E-01	1.08E-01	1.52E+01	1.25E+02	1.41E+02	2.45E+01
2. Average diluted concentration	μCi/mL	8.45E-08	2.34E-08	4.07E-06	3.04E-05	7.31E-06	
C. Dissolved & Entrained Gases							
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E+01
2. Average diluted concentration	μCi/mL	N/A	N/A	N/A	N/A	N/A	
D. Gross Alpha Activity							
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.45E+01
E. Volume of Waste Released (prior to dilution)	Liters	1.67E+08	2.05E+07	1.63E+07	1.56E+07	2.19E+08	
F. Volume of Dilution Water Used During Period	Liters	6.67E+09	4.59E+09	3.71E+09	4.08E+09	1.91E+10	

% of limit is on the Table 1, Vogtle Electric Generating Plant (Unit 1) Dose Summary

Table 23, Continuous Mode Liquid Effluents (Unit 1)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission and Activation Products						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tritium						
H-3	Ci	5.77E-01	1.08E-01	7.75E-02	6.41E-02	8.27E-01
Gross Alpha						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Entrained Gases						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
If Not Detected, Nuclide is Not Reported. Zeroes in this table indicate that no radioactivity was present at detectable levels. See Table 31, Minimum Detectable Concentrations-Liquid Sample Analyses for typical minimum detectable concentrations.						

Table 24, Batch Mode Liquid Effluents (Unit 1)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission and Activation Products						
Co-60	Ci	0.00E+00	0.00E+00	1.27E-05	4.36E-05	5.63E-05
Ni-63	Ci	0.00E+00	0.00E+00	3.35E-05	3.34E-04	3.68E-04
Co-58	Ci	0.00E+00	0.00E+00	3.48E-05	6.18E-05	9.66E-05
Cs-137	Ci	0.00E+00	0.00E+00	0.00E+00	1.18E-04	1.18E-04
Co-57	Ci	0.00E+00	0.00E+00	0.00E+00	1.58E-06	1.58E-06
Fe-55	Ci	0.00E+00	0.00E+00	3.68E-06	7.54E-05	7.91E-05
Total for Period	Ci	0.00E+00	0.00E+00	8.48E-05	6.34E-04	7.19E-04
Tritium						
H-3	Ci	0.00E+00	0.00E+00	1.51E+01	1.25E+02	1.40E+02
Gross Alpha						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Entrained Gases						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
If Not Detected, Nuclide is Not Reported. Zeroes in this table indicate that no radioactivity was present at detectable levels. See Table 31, Minimum Detectable Concentrations-Liquid Sample Analyses for typical minimum detectable concentrations.						

Table 25, Liquid Effluents – Summation of All Releases (Unit 2)

A. Fission & Activation Products	Unit	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual	Est. Total Error %
1. Total Release	Ci	8.44E-03	1.12E-02	7.20E-03	2.21E-03	2.91E-02	2.45E+01
2. Average diluted concentration	μCi/mL	1.00E-09	2.24E-09	1.79E-09	5.35E-10	1.35E-09	
B. Tritium							
1. Total Release	Ci	6.39E+02	2.85E+02	1.91E+02	1.35E+02	1.25E+03	2.45E+01
2. Average diluted concentration	μCi/mL	7.60E-05	5.70E-05	4.76E-05	3.28E-05	5.80E-05	
C. Dissolved & Entrained Gases							
1. Total Release	Ci	1.51E-04	7.96E-05	0.00E+00	0.00E+00	2.31E-04	3.00E+01
2. Average diluted concentration	μCi/mL	1.80E-11	1.59E-11	0.00E+00	0.00E+00	1.07E-11	
D. Gross Alpha Activity							
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.45E+01
E. Volume of Waste Released (prior to dilution)	Liters	1.86E+07	1.61E+07	1.79E+07	1.40E+07	6.66E+07	
F. Volume of Dilution Water Used During Period	Liters	8.39E+09	4.99E+09	4.00E+09	4.12E+09	2.15E+10	

% of limit is on the Table 2, Vogtle Electric Generating Plant (Unit 2) Dose Summary

Table 26, Continuous Mode Liquid Effluents (Unit 2)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission and Activation Products						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tritium						
H-3	Ci	7.07E-02	2.46E-02	1.03E-01	1.55E-01	3.53E-01
Gross Alpha						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Entrained Gases						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
If Not Detected, Nuclide is Not Reported. Zeroes in this table indicate that no radioactivity was present at detectable levels. See Table 31, Minimum Detectable Concentrations-Liquid Sample Analyses for typical minimum detectable concentrations.						

Table 27, Batch Mode Liquid Effluents (Unit 2)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission and Activation Products						
Nb-95	Ci	0.00E+00	0.00E+00	1.71E-05	3.25E-06	2.04E-05
Co-57	Ci	2.33E-06	1.03E-05	1.35E-05	4.09E-06	3.02E-05
Sb-125	Ci	0.00E+00	0.00E+00	1.91E-05	1.65E-06	2.08E-05
Sn-117M	Ci	9.92E-06	5.95E-06	1.04E-06	0.00E+00	1.69E-05
Ni-63	Ci	1.28E-03	5.20E-03	4.02E-03	1.30E-03	1.18E-02
Te-125M	Ci	4.46E-03	7.77E-04	0.00E+00	0.00E+00	5.24E-03
Cs-137	Ci	0.00E+00	0.00E+00	5.94E-05	7.69E-05	1.36E-04
Cr-51	Ci	1.61E-04	6.88E-04	0.00E+00	0.00E+00	8.49E-04
Fe-55	Ci	5.31E-04	5.90E-04	1.00E-04	1.42E-05	1.24E-03
Co-58	Ci	1.26E-03	3.08E-03	2.23E-03	5.40E-04	7.11E-03
Mn-54	Ci	1.64E-06	6.79E-06	6.32E-05	2.37E-05	9.53E-05
Co-60	Ci	7.34E-04	8.45E-04	6.67E-04	2.44E-04	2.49E-03
Total for Period	Ci	8.44E-03	1.12E-02	7.20E-03	2.21E-03	2.91E-02
Tritium						
H-3	Ci	6.39E+02	2.85E+02	1.91E+02	1.35E+02	1.25E+03
Gross Alpha						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Entrained Gases						
Xe-133	Ci	1.46E-04	0.00E+00	0.00E+00	0.00E+00	1.46E-04
Ar-41	Ci	0.00E+00	7.96E-05	0.00E+00	0.00E+00	7.96E-05
Xe-135	Ci	5.49E-06	0.00E+00	0.00E+00	0.00E+00	5.49E-06
Total for Period	Ci	1.51E-04	7.96E-05	0.00E+00	0.00E+00	2.31E-04
If Not Detected, Nuclide is Not Reported. Zeroes in this table indicate that no radioactivity was present at detectable levels. See Table 31, Minimum Detectable Concentrations-Liquid Sample Analyses for typical minimum detectable concentrations.						

Table 28, Liquid Effluents – Summation of All Releases (Site)

A. Fission & Activation Products	Unit	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual	Est. Total Error %
1. Total Release	Ci	8.44E-03	1.12E-02	7.28E-03	2.84E-03	2.98E-02	2.45E+01
2. Average diluted concentration	μCi/mL	5.54E-10	1.16E-09	9.40E-10	3.45E-10	7.28E-10	
B. Tritium							
1. Total Release	Ci	6.39E+02	2.85E+02	2.06E+02	2.60E+02	1.39E+03	2.45E+01
2. Average diluted concentration	μCi/mL	4.20E-05	2.97E-05	2.66E-05	3.16E-05	3.40E-05	
C. Dissolved & Entrained Gases							
1. Total Release	Ci	1.51E-04	7.96E-05	0.00E+00	0.00E+00	2.31E-04	3.00E+01
2. Average diluted concentration	μCi/mL	9.91E-12	8.28E-12	N/A	N/A	5.64E-12	
D. Gross Alpha Activity							
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.45E+01
E. Volume of Waste Released (prior to dilution)	Liters	1.86E+08	3.66E+07	3.42E+07	2.95E+07	2.86E+08	
F. Volume of Dilution Water Used During Period	Liters	1.51E+10	9.58E+09	7.71E+09	8.20E+09	4.06E+10	

% of limit is on the Table 3, Vogtle Electric Generating Plant (Site) Dose Summary

Table 29, Continuous Mode Liquid Effluents (Site)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission and Activation Products						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Tritium						
H-3	Ci	6.48E-01	1.33E-01	1.81E-01	2.19E-01	1.18E+00
Gross Alpha						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Entrained Gases						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	**Ci**	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
If Not Detected, Nuclide is Not Reported. Zeroes in this table indicate that no radioactivity was present at detectable levels. See Table 31, Minimum Detectable Concentrations-Liquid Sample Analyses for typical minimum detectable concentrations.						

Table 30, Batch Mode Liquid Effluents (Site)

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission and Activation Products						
Co-57	Ci	2.33E-06	1.03E-05	1.35E-05	5.66E-06	3.18E-05
Ni-63	Ci	1.28E-03	5.20E-03	4.06E-03	1.64E-03	1.22E-02
Fe-55	Ci	5.31E-04	5.90E-04	1.04E-04	8.97E-05	1.31E-03
Co-58	Ci	1.26E-03	3.08E-03	2.27E-03	6.02E-04	7.21E-03
Mn-54	Ci	1.64E-06	6.79E-06	6.32E-05	2.37E-05	9.53E-05
Co-60	Ci	7.34E-04	8.45E-04	6.80E-04	2.87E-04	2.55E-03
Sb-125	Ci	0.00E+00	0.00E+00	1.91E-05	1.65E-06	2.08E-05
Sn-117M	Ci	9.92E-06	5.95E-06	1.04E-06	0.00E+00	1.69E-05
Cs-137	Ci	0.00E+00	0.00E+00	5.94E-05	1.95E-04	2.54E-04
Te-125M	Ci	4.46E-03	7.77E-04	0.00E+00	0.00E+00	5.24E-03
Nb-95	Ci	0.00E+00	0.00E+00	1.71E-05	3.25E-06	2.04E-05
Cr-51	Ci	1.61E-04	6.88E-04	0.00E+00	0.00E+00	8.49E-04
Total for Period	Ci	8.44E-03	1.12E-02	7.28E-03	2.84E-03	2.98E-02
Tritium						
H-3	Ci	6.39E+02	2.85E+02	2.06E+02	2.60E+02	1.39E+03
Gross Alpha						
No Nuclides Found	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Entrained Gases						
Xe-133	Ci	1.46E-04	0.00E+00	0.00E+00	0.00E+00	1.46E-04
Ar-41	Ci	0.00E+00	7.96E-05	0.00E+00	0.00E+00	7.96E-05
Xe-135	Ci	5.49E-06	0.00E+00	0.00E+00	0.00E+00	5.49E-06
Total for Period	Ci	1.51E-04	7.96E-05	0.00E+00	0.00E+00	2.31E-04
If Not Detected, Nuclide is Not Reported. Zeroes in this table indicate that no radioactivity was present at detectable levels. See Table 31, Minimum Detectable Concentrations-Liquid Sample Analyses for typical minimum detectable concentrations.						

Table 31, Minimum Detectable Concentrations-Liquid Sample Analyses

The values in this table represent *a priori* Minimum Detectable Concentrations (MDC) that are typically achieved in laboratory analyses of liquid radwaste samples.

RADIONUCLIDE	MDC	UNITS
Mn-54	2.73E-08	μCi/ml
Fe-59	8.33E-08	μCi/ml
Co-58	3.78E-08	μCi/ml
Co-60	6.76E-08	μCi/ml
Zn-65	1.32E-07	μCi/ml
Mo-99	4.31E-07	μCi/ml
Cs-134	3.06E-08	μCi/ml
Cs-137	4.51E-08	μCi/ml
Ce-141	6.99E-08	μCi/ml
Ce-144	2.95E-07	μCi/ml
I-131	5.97E-08	μCi/ml
Xe-133	9.11E-08	μCi/ml
Xe-135	4.27E-08	μCi/ml
Fe-55	1.00E-06	μCi/ml
Sr-89	5.00E-08	μCi/ml
Sr-90	7.00E-09	μCi/ml
H-3	2.00E-06	μCi/ml
Gross Alpha	7.00E-08	μCi/ml

Attachment 2, Solid Waste Information

Table 32, Solid Waste Shipped Offsite January 1, 2022 Through June 30, 2022

A. Solid Waste Shipped Offsite For Burial Or Disposal (Not irradiated fuel)

1.Type of Waste: **NRC Waste Class A**	UNIT	6 month Period	Est. Total ERROR %
a) Spent resins, filter sludges, evaporator bottoms, etc.	m^3	4.81E+00	+/- 10
	Ci	4.19E+00	+/- 10
b) Dry compressible waste, contaminated equip., etc.	m^3	N/A	N/A
	Ci	N/A	N/A
c) Irradiated components, control rods, etc.	m^3	N/A	N/A
	Ci	N/A	N/A
d) Control Rod Drive Filters	m^3	N/A	N/A
	Ci	N/A	N/A
e) Other (describe)	m^3	N/A	N/A
	Ci	N/A	N/A

1.Type of Waste: **NRC Waste Class B**	UNIT	6 month Period	Est. Total ERROR %
a) Spent resins, filter sludges, evaporator bottoms, etc.	m^3	6.65E+00	+/- 10
	Ci	5.98E+02	+/- 10
b) Dry compressible waste, contaminated equip., etc.	m^3	N/A	N/A
	Ci	N/A	N/A
c) Irradiated components, control rods, etc.	m^3	N/A	N/A
	Ci	N/A	N/A
d) Control Rod Drive Filters	m^3	N/A	N/A
	Ci	N/A	N/A
e) Other (describe)	m^3	N/A	N/A
	Ci	N/A	N/A

2. Estimate of Major Nuclide Composition (by type of waste): **NRC Waste Class A**

	ISOTOPE	PERCENT	CURIES
a.	H-3	3.58	1.50E-01
	C-14	1.9	7.96E-02
	Fe-55	31.89	1.34E+00
	Co-58	3.1	1.30E-01
	Co-60	17.38	7.29E-01
	Ni-63	35.78	1.50E+00
	Sb-125	3.9	1.63E-01
b.	N/A	N/A	N/A
c.	N/A	N/A	N/A
d.	N/A	N/A	N/A
e.	N/A	N/A	N/A

Table 32 (Continued)

Estimate of Major Nuclide Composition (by type of waste): **NRC Waste Class B**

	ISOTOPE	PERCENT	CURIES
a.	Mn-54	1.51	9.00E+00
	Fe-55	8.85	5.29E+01
	Co-58	3.82	2.28E+01
	Co-60	19.55	1.17E+02
	Ni-63	60.63	3.63E+02
	Cs-134	1.47	8.81 E+00
	Cs-137	2.62	1.57E+01
b.	N/A	N/A	N/A
c.	N/A	N/A	N/A
d.	N/A	N/A	N/A
e.	N/A	N/A	N/A

3. Solid Waste Disposition

Number of Shipments	Mode of Transportation	Destination
1	Hittman Transport	Energy Solutions -- Bear Creek
2	Interstate Ventures	WCS

B. IRRADIATED FUEL SHIPMENTS

Number of Shipments	Mode of Transportation	Destination
N/A	N/A	N/A

Table 33, Solid Waste Shipped Offsite July 1, 2022 Through December 31, 2022

A. Solid Waste Shipped Offsite For Burial Or Disposal (Not irradiated fuel)

1.Type of Waste: **NRC Waste Class A**	UNIT	6 month Period	Est. Total ERROR %
a) Spent resins, filter sludges, evaporator bottoms, etc.	m^3	N/A	N/A
	Ci	N/A	N/A
b) Dry compressible waste, contaminated equip., etc.	m^3	2.55E+02	+/- 25
	Ci	1.81 E-01	+/- 25
c) Irradiated components, control rods, etc.	m^3	N/A	N/A
	Ci	N/A	N/A
d) Control Rod Drive Filters	m^3	N/A	N/A
	Ci	N/A	N/A
e) Other (describe)	m^3	N/A	N/A
	Ci	N/A	N/A

1.Type of Waste: **NRC Waste Class B**	UNIT	6 month Period	Est. Total ERROR %
a) Spent resins, filter sludges, evaporator bottoms, etc.	m^3	5.43E+00	+/- 10
	Ci	1.54E+01	+/- 10
b) Dry compressible waste, contaminated equip., etc.	m^3	N/A	N/A
	Ci	N/A	N/A
c) Irradiated components, control rods, etc.	m^3	N/A	N/A
	Ci	N/A	N/A
d) Control Rod Drive Filters	m^3	N/A	N/A
	Ci	N/A	N/A
e) Other (describe)	m^3	N/A	N/A
	Ci	N/A	N/A

2. Estimate of Major Nuclide Composition (by type of waste): **NRC Waste Class A**

	ISOTOPE	PERCENT	CURIES
a.	N/A	N/A	N/A
b.	H-3	3.68	6.67E-03
	Fe-55	18.14	3.28E-02
	Co-58	5.96	1.08E-02
	Co-60	25.10	4.55E-02
	Ni-63	44.21	8.01E-02
c.	N/A	N/A	N/A
d.	N/A	N/A	N/A
e.	N/A	N/A	N/A

Table 33 (Continued)

Estimate of Major Nuclide Composition (by type of waste): **NRC Waste Class B**

	ISOTOPE	PERCENT	CURIES
a.	Fe-55	1.53	2.35E-01
	Co-58	6.92	1.06E+00
	Co-60	9.78	1.50E+00
	Ni-63	59.40	9.12E+00
	Cs-134	3.29	5.05E-01
	Cs-137	17.17	2.64E+00
b.	N/A	N/A	N/A
c.	N/A	N/A	N/A
d.	N/A	N/A	N/A
e.	N/A	N/A	N/A

3. Solid Waste Disposition

Number of Shipments	Mode of Transportation	Destination
7	Hittman Transport	Energy Solutions -- Bear Creek

B. IRRADIATED FUEL SHIPMENTS

Number of Shipments	Mode of Transportation	Destination
N/A	N/A	N/A

Attachment 3, NEI 07-07 Onsite Radiological Groundwater Monitoring Program

Groundwater

To ensure compliance with NEI 07-07 (Industry Ground Water Protection Initiative – Final Guidance Document), Southern Nuclear implemented a groundwater protection program which is proceduralized in Nuclear Management Procedure, Radiological Groundwater Protection Program. The procedure contains detailed site-specific monitoring plans, program technical bases, and communications protocol (to ensure that radioactive leaks and spills are addressed and communicated appropriately). In an effort to prevent future leaks of radioactive material to groundwater, SNC plants have established buried piping and tanks inspection programs. No changes were made to the Groundwater Protection Program in 2022.

Plant Vogtle maintained the following wells (Table 34), which were sampled at a frequency that satisfied the requirements of NEI 07-07. The analytical results for 2022 were all within regulatory limits specified within this report. Table 35 contains the results of the Groundwater Protection Program tritium results (in pCi/L).

Table 34, Groundwater Protection Program Locations

Well	Aquifer	Monitoring Purpose
LT-1B	Water Table	NSCW related tank
LT-7A	Water Table	NSCW related tank
LT-12	Water Table	NSCW related tank
LT-13	Water Table	NSCW related tank
802A	Water Table	Southeastern potential leakage
806B	Water Table	Dilution line
808	Water Table	Up gradient; along Pen Branch Fault
R1	Water Table	NSCW related tank; western potential leakage
R2	Water Table	Southern potential leakage
R3	Water Table	Eastern potential leakage
R4	Water Table	Dilution line
R5	Water Table	Dilution line
R6	Water Table	Dilution line
R7	Water Table	Dilution line
R8	Water Table within Sav. River sediments	Dilution line
1014	Tertiary	Up gradient
1015	Water Table	Vertically up gradient
MU-1	Tertiary/Cretaceous	Facility water supply
River	N/A	Surface water
NSCW – Nuclear service cooling water		

Table 35, Groundwater Protection Program Tritium Results (pCi/L)

Well	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
LT-1B	NS	255	NS	283
LT-7A	NS	483	491	574
LT-12	2235	2211	2244	2290
LT-13	NS	273	278	348
802A	NS	NS	NS	NS
806B	NS	428	NS	328
808	NS	NDM	NS	NS
R1	NS	149	NS	NS
R2	NS	211	NS	NS
R3	NS	225	NS	NS
R4	NS	131	NS	NS
R5	NS	196	NS	NS
R6	NS	180	NS	NS
R7	NS	NDM	NS	NS
R8	NS	NDM	NS	NS
1014	NS	NDM	NS	NS
1015	NS	197	NS	NS
MU-1	NDM	575	NSM	NS
River	NS	NDM	NS	NS

NDM – No Detectable Measurement
NS – Not Sampled

Edwin I. Hatch Nuclear Plant – Units 1&2
Joseph M. Farley Nuclear Plant – Units 1&2
Vogtle Electric Generating Plant – Units 1&2
Vogtle Electric Generating Plant – Unit 3
Annual Non-Radiological Environmental Operating Reports and Annual Radioactive Effluent Release Reports for 2022

Enclosure 7

Vogtle Electric Generating Plant – Unit 3
Annual Radioactive Effluent Release Report for 2022

2022 Annual Radioactive Effluent Release Report

Document Number: 52-025
Facility Operating License No. NPF-91

Prepared By: Harvey Taylor [signature] Date: 4/25/23

Reviewed By: SYEF M. HOQUE / [signature] Date: 4-25-23

TABLE OF CONTENTS

TABLES

FIGURES

ATTACHMENTS

1.0 LIST OF ACRONYMS AND DEFINITIONS

1. Airborne Activity Sampling: Sampling of air through the collection of particulates and radionuclides on filter media, collection of noble gases in a container, and collection of water vapor containing tritium.

2. Alpha Particle (α): A charged particle emitted from the nucleus of an atom having a mass and charge equal in magnitude of a helium nucleus.

3. BWR: Boiling Water Reactor

4. Composite Sample: A series of single collected portions (aliquots) analyzed as one sample. The aliquots making up the sample are collected at time intervals that are very short compared to the composite period.

5. Control: A sampling station in a location not likely to be affected by plant effluents due to its distance and/or direction from the Plant.

6. Counting Error: An estimate of the two-sigma uncertainty associated with the sample results based on respective count times.

7. Curie (Ci): A measure of radioactivity; equal to 3.7×10^{10} disintegrations per second, or 2.22×10^{12} disintegrations per minute.

8. Direct Radiation Monitoring: The measurement of radiation dose at various distances from the plant is assessed using thermoluminescent dosimeters (TLDs), optically stimulated luminescent dosimeters (OSLDs), and/or pressurized ionization chambers.

9. Grab Sample: A single discrete sample drawn at one point in time.

10. Indicator: A sampling location that is likely to be affected by plant effluents due to its proximity and/or direction from the plant.

11. Ingestion Pathway: The ingestion pathway includes milk, fish, and garden produce. Meat or other food products may also be included

12. ISFSI: Independent Spent Fuel Storage Installation

13. Lower Limit of Detection (LLD): The smallest concentration of radioactive material in a sample that will yield a net count (above system background) that will be detected with 95% probability with a 5% probability of a false conclusion that a blank observation represents "real" signal.

14. MDA: Minimum Detectable Activity

15. MDC: Minimum Detectable Concentration, essentially synonymous with MDA for the purposes of radiological monitoring.

16. Mean: The average, i.e., the sum of results divided by the number of results.

17. Microcurie (µCi): 3.7 x 10^4 disintegrations per second, or 2.22 x10^6 disintegrations per minute.

18. millirem (mrem): 1/1000 rem; a unit of radiation dose equivalent in tissue.

19. Milliroentgen (mR): 1/1000 Roentgen; a unit of exposure to X- or gamma radiation.

20. MWe: Megawatts Electric

21. MWTh: Megawatts Thermal

22. NA: Not Applicable

23. NEI: Nuclear Energy Institute

24. NRC: Nuclear Regulatory Commission

25. ODCM: Offsite Dose Calculation Manual

26. OSLD: Optically Stimulated Luminescence Dosimeter

27. Protected Area: The fenced area immediately surrounding the Plant. Access to the protected area requires a security badge or escort.

28. PWR: Pressurized Water Reactor

29. REC: Radiological Effluent Control

30. REMP: Radiological Environmental Monitoring Program

31. Restricted Area: Any area where access is controlled for the purpose of protecting individuals from exposure to radiation or radioactive materials

32. SLCs: Selected Licensee Commitments

33. TLD: Thermoluminescent Dosimeter

34. TRM: Technical Requirements Manual

35. TS: Technical Specification

2.0 EXECUTIVE SUMMARY

Vogtle Electric Generating Plant Unit 3 Radiological Effluent Control (REC) Program was established to limit the quantities of radioactive material that may be released based on calculated radiation doses or dose rates. Dose to Members of the Public due to radioactive materials released from the plant is limited by Appendix I of 10 CFR 50 and by 40 CFR 190. Operational doses to the public during 2022 were calculated to be very small compared to the limits required by regulation and compared to other sources of radiation dose and pose no health hazard.

In 2022 Dose assessments showed the critical receptor for Vogtle Unit 3 is the Unit 4 construction workers, in the Child age group, due to the ingestion pathway, at NE sector at 0.25 miles. The maximum Annual Organ Dose calculated for this receptor was 1.850E-09 mrem per year, to the Liver. This annual dose is a minute fraction of the 10 CFR 50, Appendix I guideline of 15 mrem to the Maximum Organ.

2.1 Summary of Conclusions:

During 2022 all solid, liquid, and gaseous radioactive effluents from Unit 3. Vogtle Electric Generating Plant were well below regulatory limits. Initial Fuel load was on October 14, 2022 and initial criticality was not until March 6, 2023. For individual effluent streams, the quarterly limit most closely approached was:

Table 1, Vogtle Electric Generating Plant (Unit 3) Dose Summary[1]

		Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual
Liquid Effluent Dose Limit, Total Body	Limit	1.5 mrem	1.5 mrem	1.5 mrem	1.5 mrem	3 mrem
	Total Body Dose (mrem)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	% of Limit	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Liquid Effluent Dose Limit, Any Organ	Limit	5 mrem	5 mrem	5 mrem	5 mrem	10 mrem
	Maximum Organ Dose (mrem)	0.00E+00	0.00E+00	0.00E+00	1.85E-09	1.85E-09
	% of Limit	0.00E+00	0.00E+00	0.00E+00	3.7E-12	1.85E-12
Gaseous Effluent Dose Limit, Gamma Air	Limit	5 mrad	5 mrad	5 mrad	5 mrad	10 mrad
	Gamma Air Dose (mrad)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	% of Limit	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gaseous Effluent Dose Limit, Beta Air	Limit	10 mrad	10 mrad	10 mrad	10 mrad	20 mrad
	Beta Air Dose (mrad)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	% of Limit	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Gaseous Effluent Organ Dose Limit (Iodine, Tritium, Particulates with > 8-day half-life)	Limit	7.5 mrem	7.5 mrem	7.5 mrem	7.5 mrem	15 mrem
	Maximum Organ Dose (mrem)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	% of Limit	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

[1] Table 1 is meant to demonstrate 10 CFR Part 50, Appendix I Limits. Add more tables for each Rx. Unit.

Table 2, Total Annual Offsite-Dose Comparison to Regulatory Limits for Plant Vogtle[2]

	Whole Body	Thyroid	Max Organ
Limit	**25 mrem**	**75 mrem**	**25 mrem**
Gaseous (mrem)	0.00E+00	0.00E+00	0.00E+00
Liquid (mrem)	0.00E+00	0.00E+00	0.00E+00
Direct Shine (mrem)	0.00E+00	0.00E+00	0.00E+00
% of Limit	0.00E+00	0.00E+00	0.00E+00

3.0 INTRODUCTION

3.1 About Nuclear Power

Commercial nuclear power plants are generally classified as either Boiling Water Reactors (BWRs) or Pressurized Water Reactors (PWRs), based on their design. A BWR includes a single coolant system where water used as reactor coolant boils as it passes through the core and the steam generated is used to turn the turbine generator for power production. A PWR, in contrast, includes two separate water systems: radioactive reactor coolant and a secondary system. Reactor coolant is maintained under high pressure, preventing boiling. The high-pressure coolant is passed through a heat exchanger called a steam generator where the secondary system water is boiled, and the steam is used to turn the turbine generator for power production.

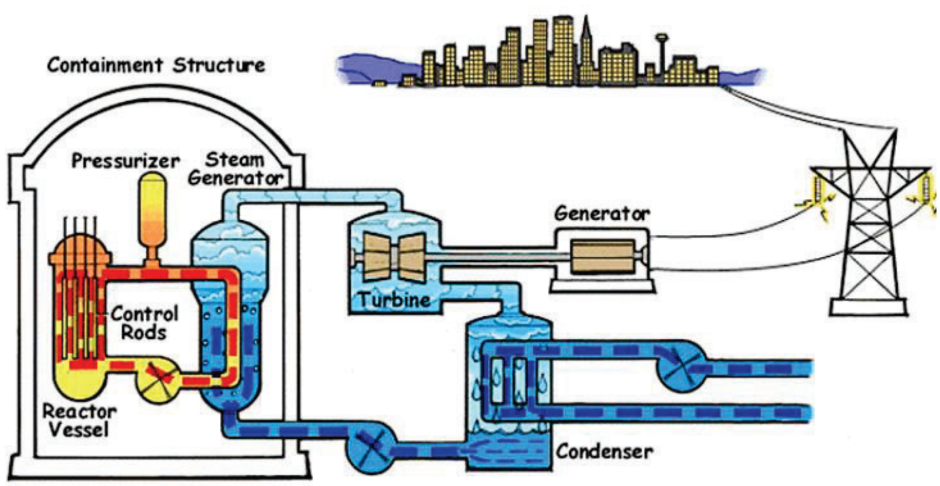

Figure 1, Pressurized Water Reactor (PWR) (1)

[2] Table 2 is a summation of Units to show compliance with 40 CFR Part 190 Limits.

3.1 (Continued)

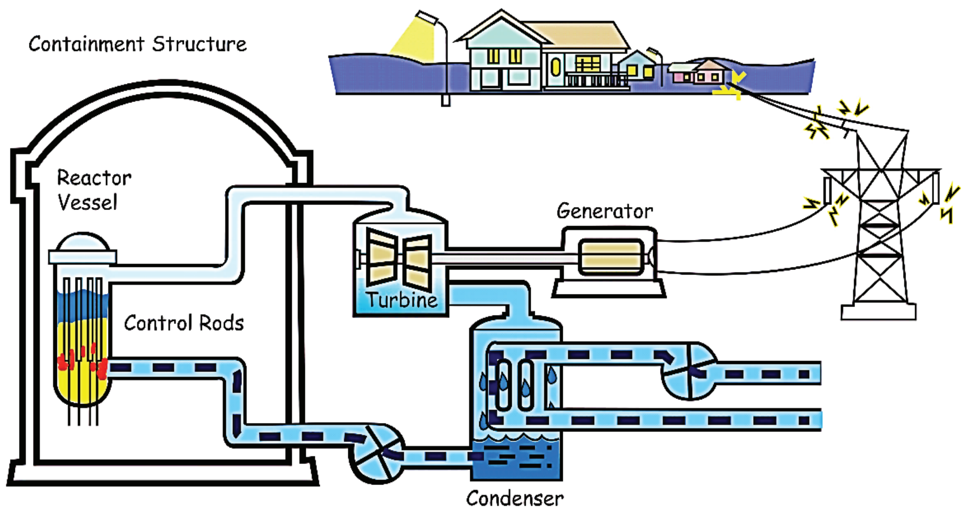

Figure 2, Boiling Water Reactor (BWR) (2)

Electricity is generated by a nuclear power plant similarly to the way that electricity is generated at other conventional types of power plants, such as those driven by coal or natural gas. Water is boiled to generate steam; the steam turns a turbine that is attached to a generator and the steam is condensed back into water to be returned to the boiler. What makes nuclear power different from these other types of power plants is that the heat is generated by fission and decay reactions occurring within and around the core containing fissionable uranium (U-235).

Nuclear fission occurs when certain nuclides (primarily U-233, U-235, or Pu-239) absorb a neutron and break into several smaller nuclides (called fission products) as well as some additional neutrons.

Fission results in production of radioactive materials including gases and solids that must be contained to prevent release or treated prior to release. These effluents are generally treated by filtration and/or hold-up prior to release. Releases are generally monitored by sampling and by continuously indicating radiation monitors. The effluent release data is used to calculate doses in order to ensure that dose to the public due to plant operation remains within required limits.

3.2 About Radiation Dose

Ionizing radiation, including alpha, beta, and gamma radiation from radioactive decay, has enough energy to break chemical bonds in tissues and result in damage to tissue or genetic material. The amount of ionization that will be generated by a given exposure to ionizing radiation is quantified as dose. The units for dose are generally given in millirem (mrem) in the US.

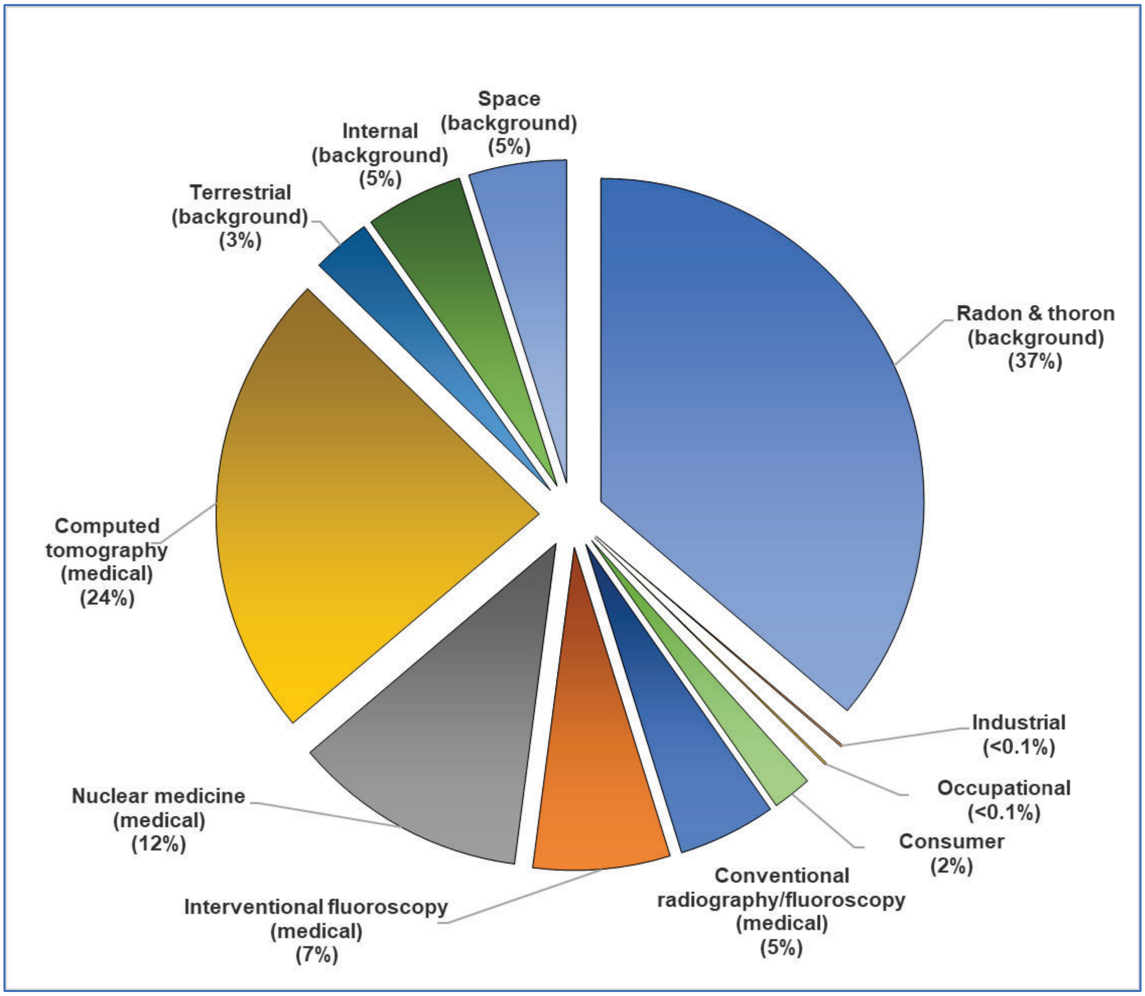

Figure 3, Sources of Radiation Exposure (NCRP Report No. 160) (3)

3.2 (Continued)

The National Council on Radiation Protection (NCRP) has evaluated the population dose for the US and determined that the average individual is exposed to approximately 620 mrem per year. There are many sources for radiation dose, ranging from natural background sources to medical procedures, air travel, and industrial processes. Approximately half (310 mrem) of the average exposure is due to natural sources of radiation including exposure to Radon, cosmic radiation, and internal radiation and terrestrial due to naturally occurring radionuclides. The remaining 310 mrem of exposure is due to man-made sources of exposure, with the most significant contributors being medical (48%) due to radiation used in various types of medical scans and treatments. Of the remaining 2% of dose, most is due to consumer activities such as air travel, smoking cigarettes, and building materials. A small fraction of this 2% is due to industrial activities including generation of nuclear power.

Readers that are curious about common sources and effects of radiation dose that they may encounter can find excellent sources of information from the Health Physics Society, including the Radiation Fact Sheets (4), and from the US Nuclear Regulatory Commission website (5).

3.3 About Dose Calculation

Concentrations of radioactive material in the environment resulting from plant operations are very small and it is not possible to determine doses directly using measured activities of environmental samples. To overcome this, Dose Calculations based on measured activities of effluent streams are used to model the dose impact for Members of the Public due to plant operation and effluents. There are several mechanisms that can result in dose to Members of the Public, including: Ingestion of radionuclides in food or water; Inhalation of radionuclides in air; Immersion in a plume of noble gases; and Direct Radiation from the ground, the plant or from an elevated plume.

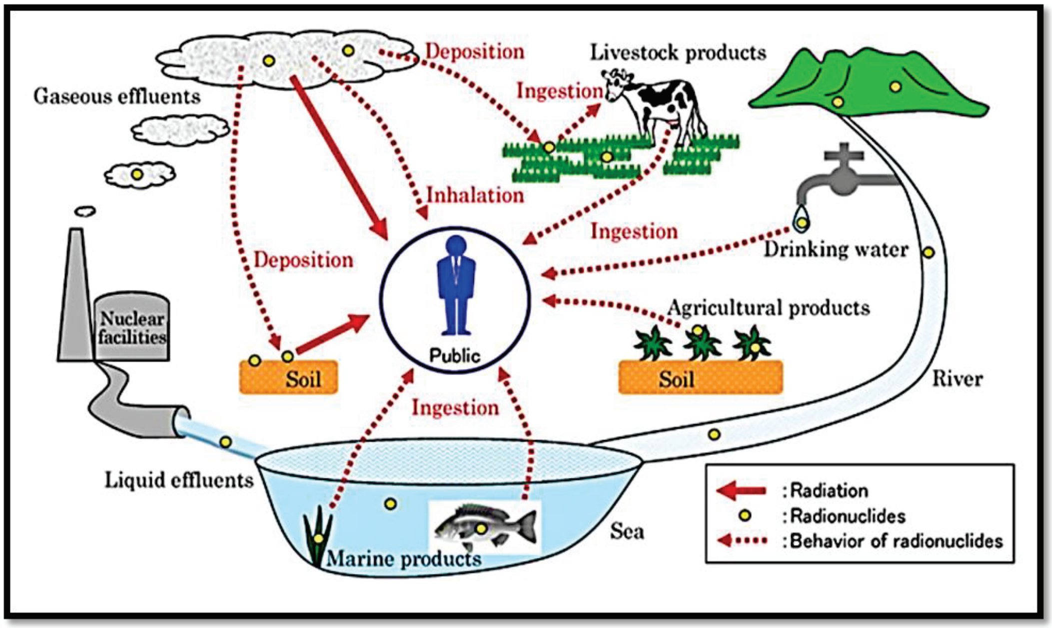

Figure 4, Potential exposure pathways to Members of the Public due to Plant Operations (6)

The Offsite Dose Calculation Manual (ODCM) specifies the methodology used to obtain the doses in the Dose Assessment section of this report. The methodology in the ODCM is based on NRC Regulatory Guide 1.109 (7) and NUREG-0133 (8). Doses are calculated by determining what the nuclide concentration will be in air, water, on the ground, or in food products based on plant effluent releases. Release points are continuously monitored to quantify what concentrations of nuclides are being released. For gaseous releases meteorological data is used to determine how much of the released activity will be present at a given location outside of the plant either deposited onto the ground or in gaseous form. Intake patterns and nuclide bio-concentration factors are used to determine how much activity will be transferred into animal milk or meat. Finally, human ingestion factors and dose factors are used to determine how much activity will be consumed and how much dose the consumer will receive. Inhalation dose is calculated by determining the concentration of nuclides and how much air is breathed by the individual.

For liquid releases, dilution and mixing factors are used to model the environmental concentrations in water. Drinking water pathways are modeled by determining the concentration of nuclides in the water at the point where the drinking water is sourced. Fish and invertebrate pathways are determined by using concentration at the release point, bioaccumulation factors for the fish or invertebrate and an estimate of the quantity of fish consumed.

Each year a Land Use Census is performed to determine what potential dose pathways currently exist within a five-mile radius around the plant, the area most affected by plant operations. The Annual Land Use Census identifies the locations of vegetable gardens, nearest residences, milk animals and meat animals. The data from the census is used to determine who is the likely to be most exposed to radiation dose as a result of plant operation.

There is significant uncertainty in dose calculation results, due to modeling dispersion of material released and bioaccumulation factors, as well as assumptions associated with consumption and land-use patterns. Even with these sources of uncertainty, the calculations do provide a reasonable estimate of the order of magnitude of the exposure. Conservative assumptions are made in the calculation inputs such as the number of various foods and water consumed, the amount of air inhaled, and the amount of direct radiation exposure from the ground or plume, such that the actual dose received are likely lower than the calculated dose. Even with the built-in conservatism, doses calculated for the highest hypothetical exposed individual due to plant operation are a very small fraction of the annual dose that is received due to other sources. The low calculated doses due to plant effluents, along with REMP results indicating no detectible radioactive material due to plant operations, serve to provide assurance that the site is not having a negative impact on the environment or people living near the plant.

4.0 DOSE ASSESSMENT FOR PLANT OPERATIONS

4.1 Regulatory Limits

Regulatory limits are detailed in Vogtle Licensing documents such as the Offsite Dose Calculation Manual (ODCM) and Selected Licensing Commitments. These documents contain the limits to which Plant Vogtle must adhere. Plant Vogtle drives to maintain the philosophy to keep dose "as low as reasonably achievable" (ALARA) and actions are taken to reduce the amount of radiation released to the environment. Liquid and gaseous release data show that the dose from Plant Vogtle is well below the ODCM limits. The concentration of liquid radioactive material released shall be limited to ten times the concentration specified in 10 CFR 20, Appendix B, Table 2, Column 2, for radionuclides other than dissolved or entrained noble gases. For dissolved or entrained noble gases, the total concentration released shall be limited to 2.0E-4 microcuries/ml. This data reveals that the radioactive effluents have an overall minimal dose contribution to the surrounding environment.

4.2 Regulatory Limits for Gaseous Effluent Doses:

1. Fission and activation gases:

    a. Noble gases dose rate due to radioactive materials released in gaseous effluents from the areas at and beyond the site boundary shall be limited to the following:

        1) Less than or equal to 500 mrem/year to the total body

        2) Less than or equal to 3000 mrem/year to the skin

    b. Noble gas air dose due to noble gases released in gaseous effluents to areas at and beyond the site boundary shall be limited to the following:

        1) Quarterly

            a) Less than or equal to 5 mrads gamma

            b) Less than or equal to 10 mrads beta

        2) Yearly

            a) Less than or equal to 10 mrads gamma

            b) Less than or equal to 20 mrads beta

2. Iodine, tritium, and all radionuclides in particulate form with half-lives greater than 8 days.

    a. The dose rate for iodine-131, iodine-133, tritium, and all radionuclides in particulate form with half-lives greater than 8 days in gaseous effluents released to areas at and beyond the site boundary shall be limited to the following:

        1) Less than or equal to 1500 mrem/yr to any organ

    b. The dose to a MEMBER OF THE PUBLIC from iodine-131, iodine-133, tritium, and all radionuclides in particulate form with half-lives greater than 8 DAYS in gaseous effluents released to areas at and beyond the site boundary shall be limited to the following:

        1) Quarterly

            a) Less than or equal to 7.5 mrem to any organ

        2) Yearly

            a) Less than or equal to 15 mrem to any organ

4.3 Regulatory Limits for Liquid Effluent Doses

1. The dose or dose commitment to a MEMBER OF THE PUBLIC from radioactive materials in liquid effluents released to unrestricted areas shall be limited to the following:

   a. Quarterly

      1) Less than or equal to 1.5 mrem total body

      2) Less than or equal to 5 mrem critical organ

   b. Yearly

      1) Less than or equal to 3 mrem total body

      2) Less than or equal to 10 mrem critical organ

4.4 40CFR190 Regulatory Dose Limits for a Member of the Public

1. Total Dose (40CFR190)

   a. The annual (calendar year) dose or dose commitment to any MEMBER OF THE PUBLIC due to releases of radioactivity and to radiation from uranium fuel cycle sources shall be limited to the following:

      1) Less than or equal to 25 mrem, Total Body or any Organ except Thyroid.

      2) Less than or equal to 75 mrem, Thyroid.

4.5 Onsite Doses (Within Site Boundary)

This section evaluates dose to non-occupationally exposed workers that may be onsite for various reasons. Groups of concern include the Unit 4 construction workers. These workers are considered not to be occupationally exposed because the work activities are only remotely related to plant-operational activities. Use of a conservative assumption of 2000 hours a year spent inside the site boundary by these groups conservatively represents the most-exposed individual.

The annual whole body, skin and organ dose was computed using the 2022 source term using the dose calculation methodology provided in the ODCM. The calculated doses due to gaseous effluents for non-rad workers onsite are presented in Table 1, Vogtle Electric Generating Plant (Unit 3) Dose Summary and Table 2, Total Annual Offsite-Dose Comparison to Regulatory Limits for Plant Vogtle.

.

5.0 SUPPLEMENTAL INFORMATION[3]

5.1 Gaseous Batch Releases

5.1.1 Plant Vogtle Unit 3

Number of batch releases: 0

Total time period for a batch release: 0.00E+00 minutes

Maximum time period for a batch release: 0.00E+00 minutes

Average time period for a batch release: 0.00E+00 minutes

Minimum time period for a batch release: 0.00E+00 minutes

5.2 Gaseous Continuous Release

5.2.1 Plant Vogtle Unit 3

Number of batch releases: 12

Total time period for a batch release: 1.21E+05 minutes

Maximum time period for a batch release: 1.01E+04 minutes

Average time period for a batch release: 1.01E+04 minutes

Minimum time period for a batch release: 1.01E+04 minutes

5.3 Liquid Batch Releases

5.3.1 Plant Vogtle Unit 3

Number of batch releases: 13

Total time period for a batch release: 2.41E+03 minutes

Maximum time period for a batch release: 1.94E+02 minutes

Average time period for a batch release: 1.85E+02 minutes

Minimum time period for a batch release: 1.27E+02 minutes

[3] If site does not utilize continuous or batch release points, then alter to desired result.

5.4 Liquid Continuous Releases

5.4.1 Plant Vogtle Unit 3

Number of batch releases: 0

Total time period for a batch release: 0.00E+00 minutes

Maximum time period for a batch release: 0.00E+00 minutes

Average time period for a batch release: 0.00E+00 minutes

Minimum time period for a batch release: 0.00E+00 minutes

5.5 Abnormal Releases

There were no Abnormal Releases that occurred during the reporting period.

5.6 Land Use Census Changes

There were no critical receptor changes affecting the environmental monitoring program such as receptor, receptor locations, sample media changes or availability, and routes of exposure.

5.7 Meteorological Data

Per VEGP Units 3 and 4 ODCM, Section 6.7.3.b:

In lieu of submission with the Radioactive Effluent Release Report, the licensee has the option of retaining this summary of required meteorological data on site in a file that shall be provided to the NRC upon request.

5.8 Effluent Radiation Monitors Out of Service Greater Than 30 Days

ODCM, Section 6.2.2.d.2 and 6.3.2.c.3 states in part that the Annual Radioactive Effluent Release Report shall include deviations from the liquid and gaseous effluent monitoring instrumentation functionality. The report must also include an explanation as to why the inoperability was not corrected in a timely manner.

1. Plant Vent normal-range radiation monitor 3-VFS-JE-RE101,102 and 103
   This radiation monitor was out of service greater than 30 days. It was taken out of service on 10/14/23 for installation of heat tracing on the plant vent stack sample lines. This was installed and the monitor successfully placed in service on 2/8/23.

2. Plant Vent high-range radiation monitor 3-VFS-JE-RE104A and 104B
   This radiation monitor was out of service greater than 30 days. It was taken out of service on 10/14/23 for installation of heat tracing on the plant vent stack sample lines. This was installed and the monitor successfully placed in service on 2/8/23.

5.9 Offsite Dose Calculation Manual (ODCM) Changes

ODCM 6.7.4 states in part that Changes will be documented in the Site's Annual Radioactive Effluent Release Report for the period in which the changes were implemented.

5.10 Process Control Program (PCP) Changes

PCP 3.2.2 states changes will be sent to the NRC. Changes will be documented in the Site's Annual Radioactive Effluent Release Report for the period in which the changes were implemented for Vogtle 3 and 4.

5.11 Radioactive Waste Treatment System Changes

There were no changes or modifications affecting any portion of the gaseous radioactive waste treatment system, the ventilation exhaust treatment system, or the liquid radioactive waste treatment.

6.0 OTHER SUPPLIMENTAL INFORMATION

None.

6.1 Outside Tanks

There are no outside tanks that exceeded ODCM or Technical Specification Limits.

6.2 Independent Spent Fuel Storage Installation (ISFSI) Monitoring Program

Provide plant specific information if reporting ISFSI as part of the ARERR.

6.3 Carbon-14

Carbon-14 (C-14) is a naturally occurring radionuclide with a 5730-year half-life. Nuclear weapons testing in the 1950s and 1960s significantly increased the amount of C-14 in the atmosphere. Nuclear power plants also produce C-14, but the amount is infinitesimal compared to what has been distributed in the environment due to weapons testing and what is produced by natural cosmic ray interactions.

In accordance with Regulatory Guide 1.21, "Measuring, Evaluating, and Reporting Radioactive Material in Liquid and Gaseous Effluents and Solid Waste," the NRC recommended re-evaluating "principal radionuclides" and reporting C-14 as appropriate. Carbon-14 production and release estimates were calculated using EPRI Report 1021106, "Estimation of Carbon-14 in Nuclear Plant Gaseous Effluents". This calculation uses active core coolant mass, average neutron flux by energy and reactor coolant nitrogen concentrations to determine Carbon-14 generation based upon an effective full power year. The estimated generation for Vogtle Unit 3 for 2022 was 0.00E+00 Curies.

Public dose estimates were performed using methodology from the ODCM which is based on Regulatory Guide 1.109 methodology. Carbon dioxide is assumed to make up 20-30% of the Carbon-14 gaseous emissions from the Vogtle Unit 3 based upon available references and on-site testing. Carbon-14 is the highest dose contributor of all radionuclides released in gaseous effluents. Annual dose resulting from Carbon-14 releases in gaseous effluents is estimated to be 0.00E+00 mrem in a year total body and 0.00E+00 mrem to any organ.

6.4 Corrections to Previous Reports

Plant Vogtle Unit 3 did not have a radioactive effluent release report for 2021 and no corrections to previous reports.

7.0 NEI 07-07 ONSITE RADIOLOGICAL GROUNDWATER MONITORING PROGRAM

Plant Vogtle has developed a Groundwater Protection Initiative (GPI) program in accordance with NEI 07-07, Industry Ground Water Protection Initiative – Final Guidance Document. The purpose of the GPI is to ensure timely detection and an effective response to situations involving inadvertent radiological releases to groundwater in order to prevent migration of licensed radioactive material off-site and to quantify impacts on decommissioning. During 2022, Vogtle Unit 3 collected and analyzed groundwater samples in accordance with the requirements of NMP-EN-002.

This section is included in this report to communicate results of NEI 07-07 Radiological Groundwater Monitoring Program. Monitoring wells installed as part of Groundwater Protection Initiative (GPI) (NEI 07-07) program are sampled and analyzed Quarterly. In addition to reporting results from NEI 07-07monitoring wells, new voluntary communications made for onsite leaks or spills per NEI 07-07 Objective 2.2, are also reported as part of this report. It is important to note, samples and results taken in support of NEI 07-07 groundwater monitoring program are not part of the Radiological Environmental Monitoring Program (REMP) but should be reported as part of AREOR or ARERR.

Licensee may include all NEI groundwater sample results or a summary table of results as part of this report this report. At a minimum include a summary table that includes the following information for 2022.

- Number of positive detections
- Number of analyses
- Average concentration
- Maximum concentration

Table 3, Groundwater Protection Program Monitoring Well Results (Tritium)

Well Name	Number of Positive Detections	Number of Analysis	Average Concentration	Maximum Concentration
GWPP-01	2	4	168	199
GWPP-02	2	4	102	107
GWPP-03	4	4	150	242
GWPP-04	1	4	253	253
GWPP-05	1	4	124	124
GWPP-06	4	4	138	189
GWPP-07	0	3	0	0
GWPP-08R	2	4	91	93
GWPP-09	3	4	161	217
GWPP-10	2	4	118	124
GWPP-11	4	4	271	344
GWPP-12F	3	4	174	214
GWPP-13	3	4	156	198
GWPP-15	1	4	146	146
GWPP-16	4	4	125	138
GWPP-18	3	4	213	368
GWPP-19	2	4	183	216
GWPP-20	2	4	164	193
Note: There were no gamma radionuclides identified in GWPP samples in 2022 (with the exception of K-40).				

8.0 VOLUNTARY NOTIFICATION

During 2022, Plant Vogtle did not make a voluntary NEI 07-07 notification to State/Local officials, NRC, and to other stakeholders required by site procedures.

9.0 BIBLIOGRAPHY

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12. *NUREG-0324, "XOQDOQ, Program for the Meteorological Evaluation of Routine Effluent Releases at Nuclear Power Stations,".* s.l. : Nuclear Regulatory Commission, September, 1977.

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15. *Regulatory Guide 4.13, Performance, Testing, and Procedural Specifications for Thermoluminescence Dosimetry: Environmental Applications, Revision 2.* s.l. : Nuclear Regulatory Commision, June, 2019. ML19044A595.

16. *Regulatory Guide 4.15, Quality Assurance for Radiological Monitoring Programs (Inception through Normal Operations to License Termination) -- Effluent Streams and the Environment.* s.l. : Nuclear Regulatory Commission, July, 2007. ML071790506.

Attachment 1, ARERR Release Summary Tables (RG-1.21 Tables)

1.0 GASEOUS EFFLUENTS

Table 4, Gaseous Effluents Summation of All Releases (Vogtle Unit 3)

A.	Fission & Activation Gases	Unit	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Est. Total Error %
1.	Total Release	Ci	N/A	N/A	N/A	0.00E+00	26.5%
2.	Average release rate for the period	μCi/sec	N/A	N/A	N/A	0.00E+00	
B.	Iodine						
1.	Total Iodine – 131	Ci	N/A	N/A	N/A	0.00E+00	55%
2.	Average release rate for the period	μCi/sec	N/A	N/A	N/A	0.00E+00	
C.	Particulates						
1.	Particulates with half-lives > 8 days	Ci	N/A	N/A	N/A	0.00E+00	54%
2.	Average release rate for the period	μCi/sec	N/A	N/A	N/A	0.00E+00	
D.	Tritium						
1.	Total Release	Ci	N/A	N/A	N/A	0.00E+00	20%
2.	Average release rate for the period	μCi/sec	N/A	N/A	N/A	0.00E+00	
E.	Gross Alpha						
1.	Total Release	Ci	N/A	N/A	N/A	0.00E+00	55%
2.	Average release rate for the period	μCi/sec	N/A	N/A	N/A	0.00E+00	
F.	Carbon-14						
1.	Total Release	Ci	N/A	N/A	N/A	0.00E+00	
2.	Average release rate for the period	μCi/sec	N/A	N/A	N/A	0.00E+00	

% of limit is on Table 1, Vogtle Electric Generating Plant (Unit 3) Dose Summary

Table 5, Gaseous Effluents – Ground Level Release Batch Mode (Vogtle Unit 3)

Radionuclide Released	Unit	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission Gases						
Ar-41	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Kr-85	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Kr-85m	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Kr-87	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Kr-88	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Xe-133	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Xe-135	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Xe-135m	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Xe-138	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
(List Others)	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Total for Period	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Iodines						
I-131	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
I-133	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
I-135	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Total for Period	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Particulates						
Co-58	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Co-60	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Sr-89	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Sr-90	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Cs-134	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
(List Others)	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Total for Period	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Tritium						
H-3	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Gross Alpha						
Alpha	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Carbon-14						
C-14	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00

Table 6, Gaseous Effluents – Ground Level Release Continuous Mode (Vogtle Unit 3)

Radionuclide Released	Unit	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission Gases						
Ar-41	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Kr-85	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Kr-85m	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Kr-87	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Kr-88	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Xe-133	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Xe-135	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Xe-135m	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Xe-138	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
(List Others)	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Total for Period	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Iodines						
I-131	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
I-133	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
I-135	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Total for Period	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Particulates						
Co-58	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Co-60	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Sr-89	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Sr-90	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Cs-134	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
(List Others)	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Total for Period	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Tritium						
H-3	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Gross Alpha						
Alpha	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Carbon-14						
C-14	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00

Table 7, Gaseous Effluents – Mixed Level Release Batch Mode (Vogtle Unit 3)

Radionuclide Released	Unit	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission Gases						
Ar-41	Ci	N/A	N/A	N/A	N/A	N/A
Kr-85	Ci	N/A	N/A	N/A	N/A	N/A
Kr-85m	Ci	N/A	N/A	N/A	N/A	N/A
Kr-87	Ci	N/A	N/A	N/A	N/A	N/A
Kr-88	Ci	N/A	N/A	N/A	N/A	N/A
Xe-133	Ci	N/A	N/A	N/A	N/A	N/A
Xe-135	Ci	N/A	N/A	N/A	N/A	N/A
Xe-135m	Ci	N/A	N/A	N/A	N/A	N/A
Xe-138	Ci	N/A	N/A	N/A	N/A	N/A
(List Others)	Ci	N/A	N/A	N/A	N/A	N/A
Total for Period	Ci	N/A	N/A	N/A	N/A	N/A
Iodines						
I-131	Ci	N/A	N/A	N/A	N/A	N/A
I-133	Ci	N/A	N/A	N/A	N/A	N/A
I-135	Ci	N/A	N/A	N/A	N/A	N/A
Total for Period	Ci	N/A	N/A	N/A	N/A	N/A
Particulates						
Co-58	Ci	N/A	N/A	N/A	N/A	N/A
Co-60	Ci	N/A	N/A	N/A	N/A	N/A
Sr-89	Ci	N/A	N/A	N/A	N/A	N/A
Sr-90	Ci	N/A	N/A	N/A	N/A	N/A
Cs-134	Ci	N/A	N/A	N/A	N/A	N/A
(List Others)	Ci	N/A	N/A	N/A	N/A	N/A
Total for Period	Ci	N/A	N/A	N/A	N/A	N/A
Tritium						
H-3	Ci	N/A	N/A	N/A	N/A	N/A
Gross Alpha						
Alpha	Ci	N/A	N/A	N/A	N/A	N/A
Carbon-14						
C-14	Ci	N/A	N/A	N/A	N/A	N/A

Table 8, Gaseous Effluents – Mixed Level Release Continuous Mode (Vogtle Unit 3)

Radionuclide Released	Unit	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission Gases						
Ar-41	Ci	N/A	N/A	N/A	N/A	N/A
Kr-85	Ci	N/A	N/A	N/A	N/A	N/A
Kr-85m	Ci	N/A	N/A	N/A	N/A	N/A
Kr-87	Ci	N/A	N/A	N/A	N/A	N/A
Kr-88	Ci	N/A	N/A	N/A	N/A	N/A
Xe-133	Ci	N/A	N/A	N/A	N/A	N/A
Xe-135	Ci	N/A	N/A	N/A	N/A	N/A
Xe-135m	Ci	N/A	N/A	N/A	N/A	N/A
Xe-138	Ci	N/A	N/A	N/A	N/A	N/A
(List Others)	Ci	N/A	N/A	N/A	N/A	N/A
Total for Period	Ci	N/A	N/A	N/A	N/A	N/A
Iodines						
I-131	Ci	N/A	N/A	N/A	N/A	N/A
I-133	Ci	N/A	N/A	N/A	N/A	N/A
I-135	Ci	N/A	N/A	N/A	N/A	N/A
Total for Period	Ci	N/A	N/A	N/A	N/A	N/A
Particulates						
Co-58	Ci	N/A	N/A	N/A	N/A	N/A
Co-60	Ci	N/A	N/A	N/A	N/A	N/A
Sr-89	Ci	N/A	N/A	N/A	N/A	N/A
Sr-90	Ci	N/A	N/A	N/A	N/A	N/A
Cs-134	Ci	N/A	N/A	N/A	N/A	N/A
(List Others)	Ci	N/A	N/A	N/A	N/A	N/A
Total for Period	Ci	N/A	N/A	N/A	N/A	N/A
Tritium						
H-3	Ci	N/A	N/A	N/A	N/A	N/A
Gross Alpha						
Alpha	Ci	N/A	N/A	N/A	N/A	N/A
Carbon-14						
C-14	Ci	N/A	N/A	N/A	N/A	N/A

Table 9, Gaseous Effluents – Elevated Level Release Batch Mode (Vogtle Unit 3)

Radionuclide Released	Unit	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission Gases						
Ar-41	Ci	N/A	N/A	N/A	N/A	N/A
Kr-85	Ci	N/A	N/A	N/A	N/A	N/A
Kr-85m	Ci	N/A	N/A	N/A	N/A	N/A
Kr-87	Ci	N/A	N/A	N/A	N/A	N/A
Kr-88	Ci	N/A	N/A	N/A	N/A	N/A
Xe-133	Ci	N/A	N/A	N/A	N/A	N/A
Xe-135	Ci	N/A	N/A	N/A	N/A	N/A
Xe-135m	Ci	N/A	N/A	N/A	N/A	N/A
Xe-138	Ci	N/A	N/A	N/A	N/A	N/A
(List Others)	Ci	N/A	N/A	N/A	N/A	N/A
Total for Period	Ci	N/A	N/A	N/A	N/A	N/A
Iodines						
I-131	Ci	N/A	N/A	N/A	N/A	N/A
I-133	Ci	N/A	N/A	N/A	N/A	N/A
I-135	Ci	N/A	N/A	N/A	N/A	N/A
Total for Period	Ci	N/A	N/A	N/A	N/A	N/A
Particulates						
Co-58	Ci	N/A	N/A	N/A	N/A	N/A
Co-60	Ci	N/A	N/A	N/A	N/A	N/A
Sr-89	Ci	N/A	N/A	N/A	N/A	N/A
Sr-90	Ci	N/A	N/A	N/A	N/A	N/A
Cs-134	Ci	N/A	N/A	N/A	N/A	N/A
(List Others)	Ci	N/A	N/A	N/A	N/A	N/A
Total for Period	Ci	N/A	N/A	N/A	N/A	N/A
Tritium						
H-3	Ci	N/A	N/A	N/A	N/A	N/A
Gross Alpha						
Alpha	Ci	N/A	N/A	N/A	N/A	N/A
Carbon-14						
C-14	Ci	N/A	N/A	N/A	N/A	N/A

Table 10, Gaseous Effluents – Elevated Level Release Continuous Mode (Vogtle Unit 3)

Radionuclide Released	Unit	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission Gases						
Ar-41	Ci	N/A	N/A	N/A	N/A	N/A
Kr-85	Ci	N/A	N/A	N/A	N/A	N/A
Kr-85m	Ci	N/A	N/A	N/A	N/A	N/A
Kr-87	Ci	N/A	N/A	N/A	N/A	N/A
Kr-88	Ci	N/A	N/A	N/A	N/A	N/A
Xe-133	Ci	N/A	N/A	N/A	N/A	N/A
Xe-135	Ci	N/A	N/A	N/A	N/A	N/A
Xe-135m	Ci	N/A	N/A	N/A	N/A	N/A
Xe-138	Ci	N/A	N/A	N/A	N/A	N/A
(List Others)	Ci	N/A	N/A	N/A	N/A	N/A
Total for Period	Ci	N/A	N/A	N/A	N/A	N/A
Iodines						
I-131	Ci	N/A	N/A	N/A	N/A	N/A
I-133	Ci	N/A	N/A	N/A	N/A	N/A
I-135	Ci	N/A	N/A	N/A	N/A	N/A
Total for Period	Ci	N/A	N/A	N/A	N/A	N/A
Particulates						
Co-58	Ci	N/A	N/A	N/A	N/A	N/A
Co-60	Ci	N/A	N/A	N/A	N/A	N/A
Sr-89	Ci	N/A	N/A	N/A	N/A	N/A
Sr-90	Ci	N/A	N/A	N/A	N/A	N/A
Cs-134	Ci	N/A	N/A	N/A	N/A	N/A
(List Others)	Ci	N/A	N/A	N/A	N/A	N/A
Total for Period	Ci	N/A	N/A	N/A	N/A	N/A
Tritium						
H-3	Ci	N/A	N/A	N/A	N/A	N/A
Gross Alpha						
Alpha	Ci	N/A	N/A	N/A	N/A	N/A
Carbon-14						
C-14	Ci	N/A	N/A	N/A	N/A	N/A

2.0 LIQUID EFFLUENTS

Table 11, Liquid Effluents – Summation of All Releases (Vogtle Unit 3)

A.	**Fission & Activation Products**	**Unit**	**Quarter 1**	**Quarter 2**	**Quarter 3**	**Quarter 4**	**Est. Total Error %**
1.	Total Release	Ci	N/A	N/A	N/A	0.00E+00	24.5%
2.	Average diluted concentration	µCi/mL	N/A	N/A	N/A	0.00E+00	
B.	**Tritium**						
1.	Total Release	Ci	N/A	N/A	N/A	3.32E-05	24.5%
2.	Average diluted concentration	µCi/mL	N/A	N/A	N/A	1.75E-07	
C.	**Dissolved & Entrained Gases**						
1.	Total Release	Ci	N/A	N/A	N/A	0.00E+00	30%
2.	Average diluted concentration	µCi/mL	N/A	N/A	N/A	0.00E+00	
D.	**Gross Alpha Activity**						
1.	Total Release	Ci	N/A	N/A	N/A	0.00E+00	24.5%
E.	**Volume of Waste Released (prior to dilution)(gal)**	Liters	N/A	N/A	N/A	1.95E+05	
F.	**Volume of Dilution Water Used During Period (gal)**	Liters	N/A	N/A	N/A	3.24E+06	

% of limit is on the Table 1, Vogtle Electric Generating Plant (Unit 3) Dose Summary

Table 12, Batch Mode Liquid Effluents (Vogtle Unit 3)

Radionuclide Released	Unit	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Cr-51	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Mn-54	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Fe-55	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Fe-59	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Co-57	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Co-58	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Co-60	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Sr-89	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Sr-90	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Nb-95	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
I-131	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Zn-65	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Ag-110m	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
I-131	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
I-133	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Cs-134	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Cs-137	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
H-3	Ci	N/A	N/A	N/A	3.32E-05	3.32E-05
(List Others)	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Total for Period	Ci	N/A	N/A	N/A	0.00E+00	3.32E-05
Entrained Gases						
Xe-133	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Xe-135	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
(List Others)		N/A	N/A	N/A	0.00E+00	0.00E+00
Total for Period		N/A	N/A	N/A	0.00E+00	0.00E+00

Table 13, Continuous Mode Liquid Effluents (Vogtle Unit 3)

Radionuclide Released	Unit	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Cr-51	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Mn-54	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Fe-55	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Fe-59	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Co-57	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Co-58	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Co-60	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Sr-89	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Sr-90	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Nb-95	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
I-131	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Zn-65	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Ag-110m	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
I-131	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
I-133	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Cs-134	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Cs-137	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
H-3	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
(List Others)	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Total for Period	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Entrained Gases						
Xe-133	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Xe-135	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
(List Others)	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00
Total for Period	Ci	N/A	N/A	N/A	0.00E+00	0.00E+00

Attachment 2, Solid Waste Information

1.0 SOLID WASTE SHIPPED OFFSITE FOR BURIAL OR DISPOSAL (NOT IRRADIATED FUEL)

Table 14, Types of Solid Waste Summary (Vogtle Unit 3)

Types of Waste	Total Quantity (m^3)	Total Activity (Ci)	Est. Total Error (%)
a. Spent resins, filter sludges, evaporator bottoms, etc.	0.00E+00	0.00E+00	25
b. Dry compressible waste, contaminated equip, etc.	0.00E+00	0.00E+00	25
c. Irradiated components, control rods, etc.	0.00E+00	0.00E+00	25
d. Other (describe)	0.00E+00	0.00E+00	25

2.0 ESTIMATE OF MAJOR NUCLIDE COMPOSITION (BY WASTE TYPE) ONLY >1% ARE REPORTED. [NOTE 1]

Table 15, Major Nuclides (Vogtle Unit 3)

Major Nuclide Composition	%	Curies
a. Spent resins, filter sludges, evaporator bottoms, etc.	0.00E+00	0.00E+00
b. Dry compressible waste, contaminated equip, etc.	0.00E+00	0.00E+00
c. Irradiated components, control rods, etc.	0.00E+00	0.00E+00
d. Other (describe)	0.00E+00	0.00E+00

3.0 SOLID WASTE DISPOSITION

Table 16, Solid Waste Disposition (Vogtle Unit 3)

Number of Shipments	Mode of Transportation	Destination
0	N/A	N/A

4.0 IRRADIATED FUEL DISPOSITION

Table 17, Irradiated Fuel Shipments Disposition (Vogtle Unit 3)

Number of Shipments	Mode of Transportation	Destination
0	N/A	N/A

Attachment 3, Meteorological Data

Per VEGP Units 3 and 4 ODCM, Section 6.7.3.b:

In lieu of submission with the Radioactive Effluent Release Report, the licensee has the option of retaining this summary of required meteorological data on site in a file that shall be provided to the NRC upon request.

Edwin I. Hatch Nuclear Plant – Units 1&2
Joseph M. Farley Nuclear Plant – Units 1&2
Vogtle Electric Generating Plant – Units 1&2
Vogtle Electric Generating Plant – Unit 3
Annual Non-Radiological Environmental Operating Reports and Annual Radioactive Effluent Release Reports for 2022

Enclosure 8

Vogtle Electric Generating Plant – Units 1&2
Offsite Dose Calculation Manual – Version 35

OFFSITE DOSE CALCULATION MANUAL

FOR

SOUTHERN NUCLEAR OPERATING COMPANY

VOGTLE ELECTRIC GENERATING PLANT

Version 35

JUNE 2021

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

PAGE

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF FIGURES

REFERENCES

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CHAPTER 1

INTRODUCTION

The Offsite Dose Calculation Manual is a supporting document of the Technical Specifications. As such, it describes the methodology and parameters to be used in the calculation of offsite doses due to radioactive liquid and gaseous effluents, and in the calculation of liquid and gaseous effluent monitoring instrumentation alarm setpoints. In addition, it contains the following:

- The controls required by the Technical Specifications, governing the radioactive effluent and radiological environmental monitoring programs.
- Schematics of liquid and gaseous radwaste effluent treatment systems, which include designation of release points to UNRESTRICTED AREAS.
- A list and maps indicating the specific sample locations for the Radiological Environmental Monitoring Program.
- Specifications and descriptions of the information that must be included in the Annual Radiological Environmental Operating Report and the Radioactive Effluent Release Report required by the Technical Specifications.

The ODCM will be maintained at the plant for use as a reference guide and training document of accepted methodologies and calculations. Changes in the calculational methods or parameters will be incorporated into the ODCM in order to ensure that it represents current methodology in all applicable areas. Any computer software used to perform the calculations described will be maintained current with the ODCM.

Equations and methods used in the ODCM are based on those presented in NUREG–0133 (Reference 1), in Regulatory Guide 1.109 (References 2 and 3), in Regulatory Guide 1.111 (References 4 and 5), and in Regulatory Guide 1.113 (Reference 6).

CHAPTER 2

LIQUID EFFLUENTS

2.1 LIMITS OF OPERATION

The following Liquid Effluent Controls implement requirements established by Technical Specifications Section 5.0. Terms printed in all capital letters are defined in Chapter 10.

2.1.1 Liquid Effluent Monitoring Instrumentation Control

In accordance with Technical Specification 5.5.4.a, the radioactive liquid effluent monitoring instrumentation channels shown in Table 2-1 shall be FUNCTIONAL with their alarm/trip setpoints set to ensure that the limits specified in Section 2.1.2 are not exceeded. The alarm/trip setpoints of these channels shall be determined in accordance with Section 2.3.

2.1.1.1 Applicability

This limit applies at all times.

2.1.1.2 Actions

With a radioactive liquid effluent monitoring instrumentation channel alarm/trip setpoint less conservative than required by the above control, immediately suspend the release of radioactive liquid effluents monitored by the affected channel, declare the channel NON-FUNCTIONAL, or change the setpoint to a conservative value.

With less than the minimum number of radioactive liquid effluent monitoring instrumentation channels FUNCTIONAL, take the ACTION shown in Table 2-1. Restore the NON-FUNCTIONAL instrumentation to FUNCTIONAL status within 30 days, or if unsuccessful, explain in the next Radioactive Effluent Release Report, per Technical Specification 5.6.3, why this NON-FUNCTIONALITY was not corrected in a timely manner.

This control does not affect shutdown requirements or MODE changes.

2.1.1.3 Surveillance Requirements

Each radioactive liquid effluent monitoring instrumentation channel shall be demonstrated FUNCTIONAL by performance of the CHANNEL CHECK, SOURCE CHECK, CHANNEL CALIBRATION, and CHANNEL FUNCTIONALITY TEST operations at the frequencies shown in Table 2-2. Specific instrument numbers are provided in parentheses for information only. The numbers apply to each unit. These numbers will help to identify associated channels or loops and are not intended to limit the requirements to the specific instruments associated with the number.

2.1.1.4 Basis

The radioactive liquid effluent instrumentation is provided to monitor and control, as applicable, the releases of radioactive materials in liquid effluents during actual or potential releases of liquid effluents. The Alarm/Trip Setpoints for these instruments shall be calculated and adjusted in accordance with the methodology and parameters in Section 2.3 to ensure that the alarm/trip will occur prior to exceeding the limits of Section 2.1.2. The FUNCTIONALITY and use of this instrumentation is consistent with the requirements of General Design Criteria 60, 63, and 64 of Appendix A to 10 CFR Part 50.

Table 2-1. Radioactive Liquid Effluent Monitoring Instrumentation

Instrument	FUNCTIONALITY Requirements[a]	
	Minimum Channels FUNCTIONAL	ACTION
1. Radwaste Monitors Providing Alarm and Automatic Termination of Release		
a. Liquid Radwaste Effluent Line (RE–0018)	1	37
b. Steam Generator Blowdown Effluent Line (RE-0021)	1	38
c. Turbine Building Effluent Line (RE–0848)	1	38
2. Radwaste Monitors Providing Alarm, but Not Automatic Termination of Release		
NSCW Effluent Line (RE-0020 A)	1	39
NSCW Effluent Line (RE-0020 B)	1	39
3. Flowrate Measurement Devices		
a. Liquid Radwaste Effluent Line (FT–0018), (FT-1084A/B), or (FT-1085A/B)	1	40
b. Steam Generator Blowdown Effluent Line (FT-0021)	1	40
c. Flow to Blowdown Sump (AFQI-7620, FI7620A)	1	40

a. All requirements in this table apply to each unit.

Table 2-1 (contd). Notation for Table 2-1 — ACTION Statements

ACTION 37 — With the number of channels FUNCTIONAL less than required by the Minimum Channels FUNCTIONAL requirement, effluent releases may continue provided that prior to initiating a release:

a. The local radiation monitor reading (if functional) is recorded at least once per 12 hours during the release or at least two independent samples are analyzed in accordance with Section 2.1.2.3, and

b. At least two technically qualified members of the Facility Staff independently verify the discharge line valving and the release rate calculations.

Otherwise, suspend release of radioactive effluents via this pathway.

ACTION 38 — With the number of channels FUNCTIONAL less than required by the Minimum Channels FUNCTIONAL requirement, effluent releases via this pathway may continue provided the local radiation monitor reading (if functional) is recorded at least once per 12 hours or grab samples are analyzed for gross radioactivity at a MINIMUM DETECTABLE CONCENTRATION no higher than 1×10^{-7} μCi/mL using gross beta/gamma counting or 5×10^{-7} μCi/mL for the principal gamma emitters using gamma-ray spectroscopy.

a. At least once per 12 hours when the specific activity of the secondary coolant is greater than 0.01 μCi/gram DOSE EQUIVALENT I–131.

b. At least once per 24 hours when the specific activity of the secondary coolant is less than or equal to 0.01 μCi/gram DOSE EQUIVALENT I–131.

ACTION 39 — With the number of channels FUNCTIONAL less than required by the Minimum Channels FUNCTIONAL requirement, effluent releases via this pathway may continue provided that, at least once per 12 hours, the local radiation monitor reading (if functional) is recorded or grab samples are collected and analyzed for radioactivity at a MINIMUM DETECTABLE CONCENTRATION no higher than 1×10^{-7} μCi/mL using gross beta/gamma counting or 5×10^{-7} μCi/mL for the principal gamma emitters using gamma-ray spectroscopy.

ACTION 40 — With the number of channels FUNCTIONAL less than required by the Minimum Channels FUNCTIONAL requirement, effluent releases via this pathway may continue provided the flowrate is estimated at least once per 4 hours during actual releases. Pump curves generated in place may be used to estimate flow.

Table 2-2. Radioactive Liquid Effluent Monitoring Instrumentation Surveillance Requirements

Instrument	Surveillance Requirements[d]			
	CHANNEL CHECK	SOURCE CHECK	CHANNEL CALIBRA-TION	CHANNEL FUNCTIONAL TEST
1. Radwaste Monitors Providing Alarm and Automatic Termination of Release				
a. Liquid Radwaste Effluent Line (RE-0018)	P	P	R^{b}	$R^{a(1)}$
b. Steam Generator Blowdown Effluent Line (RE-0021)	M	SA	R^{b}	$R^{a(1)}$
c. Turbine Building Effluent Line (RE-0848)	M	SA	R^{b}	$R^{a(1)}$
2. Radwaste Monitors Providing Alarm, but Not Automatic Termination of Release				
NSCW Effluent Line (RE-0020 A&B)	M	SA	R^{b}	$R^{a(2)}$
3. Flowrate Measurement Devices				
a. Liquid Radwaste Effluent Line (FT-0018)	P^{c}	NA	R	NA
b. Liquid Radwaste Effluent Line (FT-1084A/B), or (FT-1085A/B)	M^{c}	NA	R	NA
b. Steam Generator Blowdown Effluent Line (FT-0021)	M^{c}	NA	R	NA
d. Flow to Blowdown Sump (AFQI-7620, FI7620A)	M^{c}	NA	R	Q

Table 2-2 (contd). Notation for Table 2-2

a. In addition to the basic functions of a CHANNEL FUNCTIONAL TEST (Section 10.2):

(1) The CHANNEL FUNCTIONAL TEST shall also demonstrate that automatic isolation of this pathway and control room annunciation occurs (for item a. below only); and control room CRT indication occurs (if any of the following conditions exist):

(a) Instrument indicates measured levels above the alarm/trip setpoint;

(b) Instrument indicates an “Equipment Trouble” alarm;

(c) Instrument indicates a “Low” alarm; or

(d) Instrument indicates channel “Deactivated”.

(2) The CHANNEL FUNCTIONAL TEST shall also demonstrate that control room annunciation occurs (for item a. below only); and that control room CRT indication occurs (if any of the following conditions exist):

(a) Instrument indicates measured levels above the alarm/trip setpoint;

(b) Instrument indicates an “Equipment Trouble” alarm;

(c) Instrument indicates a “Low” alarm; or

(d) Instrument indicates channel “Deactivated”.

b. The initial CHANNEL CALIBRATION shall be performed using one or more of the reference standards certified by the National Institute of Standards and Technology or using standards that have been obtained from suppliers that participate in measurements assurance activities with NIST. These standards shall permit calibrating the system over its intended range of energy and measurement range. For subsequent CHANNEL CALIBRATION, sources that have been related to the initial calibration shall be used.

c. CHANNEL CHECK shall consist of verifying indication of flow during periods of release. CHANNEL CHECK shall be made at least once per 24 hours on days on which continuous, periodic, or batch releases are made.

d. All requirements in this table apply to each unit.

2.1.2 Liquid Effluent Concentration Control

In accordance with Technical Specifications 5.5.4.b and 5.5.4.c, the concentration of radioactive material released in liquid effluents to UNRESTRICTED AREAS shall be limited at all times to ten times the concentrations specified in 10 CFR 20, Appendix B, Table 2, Column 2 for radionuclides other than dissolved or entrained noble gases. For dissolved or entrained noble gases, the concentration shall be limited to 1 x 10^{-4} μCi/mL total activity.

2.1.2.1 Applicability

This limit applies at all times.

2.1.2.2 Actions

With the concentration of radioactive material released in liquid effluents to UNRESTRICTED AREAS exceeding the limits stated in Section 2.1.2, immediately restore the concentration to within the stated limits.

This control does not affect shutdown requirements or MODE changes.

2.1.2.3 Surveillance Requirements

The radioactivity content of each batch of radioactive liquid waste shall be determined by sampling and analysis in accordance with Table 2-3. The results of radioactive analyses shall be used with the calculational methods in Section 2.3 to assure that the concentration at the point of release is maintained within the limits of Section 2.1.2.

2.1.2.4 Basis

This control is provided to ensure that the concentration of radioactive materials released in liquid waste effluents to UNRESTRICTED AREAS will be less than ten times the concentration levels specified in 10 CFR 20, Appendix B, Table 2, Column 2. This limitation provides additional assurance that the levels of radioactive materials in bodies of water in UNRESTRICTED AREAS will result in exposures within (1) the Section II.A design objectives of Appendix I, 10 CFR 50, to a MEMBER OF THE PUBLIC, and (2) the limits of 10 CFR 20.1301 to the population. The concentration limit for dissolved or entrained noble gases is based upon the assumption that Xe–135 is the controlling radioisotope and its MPC in air (submersion) was converted to an equivalent concentration in water using the methods described in International Commission on Radiological Protection (ICRP) Publication 2 (1959). The resulting concentration of 2 x 10^{-4} was then multiplied by the ratio of the effluent concentration limit for Xe-135, stated in Appendix B, Table 2, Column 1 of 10 CFR 20 (paragraphs 20.1001 to 20.2401), to the MPC for Xe-135, stated in Appendix B, Table II, Column 1 of 10 CFR 20 (paragraphs 20.1 to 20.601), to obtain the limiting concentration of 1 x 10^{-4} μCi/mL.

Table 2-3. Radioactive Liquid Waste Sampling and Analysis Program

Liquid Release Type	Sampling and Analysis Requirements[a,b]			
	Sampling FREQUENCY	Minimum Analysis FREQUENCY	Type of Activity Analysis	MINIMUM DETECTABLE CONCENTRATION (MDC) (μCi/mL)
A. BATCH RELEASES				
1. Waste Monitor Tank 2. Drainage of System	P Each BATCH	P Each BATCH	PRINCIPAL GAMMA EMITTERS I-131	5 E-7 1 E-6
	P One BATCH/M	M	Dissolved and Entrained Gases (Gamma Emitters)	1 E-5
	P Each BATCH	M COMPOSITE	H-3 Gross Alpha	1 E-5 1 E-7
	P Each BATCH	Q COMPOSITE	Sr-89, Sr-90 Fe-55	5 E-8 1 E-6
B. CONTINUOUS RELEASES				
Waste Water Retention Basin[c]	Continuous	W COMPOSITE	PRINCIPAL GAMMA EMITTERS I-131	5 E-7 1 E-6
	M Grab Sample	M	Dissolved and Entrained Gases (Gamma Emitters)	1 E-5
	Continuous	M COMPOSITE	H-3 Gross Alpha	1 E-5 1 E-7
	Continuous	Q COMPOSITE	Sr-89, Sr-90 Fe-55	5 E-8 1 E-6

Table 2-3 (contd). Notation for Table 2-3

a. All requirements in this table apply to each unit.

b. Terms printed in all capital letters are defined in Chapter 10.

c. The WWRB will not be considered a release point until there is a confirmed primary to secondary leak. Once a primary to secondary leak has been confirmed, this composite shall be analyzed as specified until the leak is repaired. This surveillance will continue until three consecutive weekly composite samples have shown no activity above the MDC.

2.1.3 Liquid Effluent Dose Control

In accordance with Technical Specifications 5.5.4.d and 5.5.4.e, the dose or dose commitment to a MEMBER OF THE PUBLIC from radioactive materials in liquid effluents released, from each unit, to UNRESTRICTED AREAS shall be limited:

a. During any calendar quarter to less than or equal to 1.5 mrem to the total body and to less than or equal to 5 mrem to any organ, and

b. During any calendar year to less than or equal to 3 mrem to the total body and to less than or equal to 10 mrem to any organ.

2.1.3.1 Applicability

These limits apply at all times.

2.1.3.2 Actions

With the calculated dose from the release of radioactive materials in liquid effluents exceeding any of the limits of Section 2.1.3., prepare and submit to the Nuclear Regulatory Commission within 30 days a special report which identifies the cause(s) for exceeding the limit(s); defines the corrective actions to be taken to reduce the releases; and defines the proposed corrective actions to be taken to assure that subsequent releases will be in compliance with the limits of Section 2.1.3.

This control does not affect shutdown requirements or MODE changes.

2.1.3.3 Surveillance Requirements

At least once per 31 days, cumulative dose contributions from liquid effluents for the current calendar quarter and the current calendar year shall be determined, for each unit, in accordance with Section 2.4.

2.1.3.4 Basis

This control is provided to implement the requirements of Sections II.A, III.A and IV.A of Appendix I, 10 CFR Part 50. The limits stated in Section 2.1.3 implement the guides set forth in Section II.A of Appendix I. The ACTIONS stated in Section 2.1.3.2 provide the required operating flexibility and at the same time implement the guides set forth in Section IV.A of Appendix I to assure that the releases of radioactive material in liquid effluents will be kept "as low as is reasonably achievable." Also, for fresh water sites with drinking water supplies that can be potentially affected by plant operations, there is reasonable assurance that the operation of the facility will not result in radionuclide concentrations in the finished drinking water that are in excess of the requirements of 40 CFR Part 141. The dose calculations in Section 2.4 implement the requirements in Section III.A of Appendix I, which state that conformance with the guides of Appendix I be shown by calculational procedures based on models and data, such that the actual exposure of a MEMBER OF THE PUBLIC through appropriate pathways is unlikely to be substantially underestimated. The equations specified in Section 2.4 for calculating the doses due to the actual release rates of radioactive materials in liquid effluents are consistent with the methodology provided in Regulatory Guide 1.109 (Reference 3) and Regulatory Guide 1.113 (Reference 6).

This control applies to the release of liquid effluents from each unit at the site. The liquid effluents from shared LIQUID RADWASTE TREATMENT SYSTEMs are to be proportioned between the units.

2.1.4 Liquid Radwaste Treatment System Control

In accordance with Technical Specification 5.5.4.f, the LIQUID RADWASTE TREATMENT SYSTEM shall be FUNCTIONAL. The appropriate portions of the system shall be used to reduce radioactivity in liquid wastes prior to their discharge when the projected doses due to the liquid effluent, from each unit, to UNRESTRICTED AREAS would exceed 0.06 mrem to the total body or 0.2 mrem to any organ of a MEMBER OF THE PUBLIC in 31 days.

2.1.4.1 Applicability

This limit applies at all times.

2.1.4.2 Actions

With radioactive liquid waste being discharged without treatment and in excess of the above limits and any portion of the LIQUID RADWASTE TREATMENT SYSTEM not in operation, prepare and submit to the Nuclear Regulatory Commission within 30 days a special report which includes the following information:

a. Explanation of why liquid radwaste was being discharged without treatment, identification of any NON-FUNCTIONAL equipment or subsystems and the reason for the NON-FUNCTIONALITY,

b. Action(s) taken to restore the NON-FUNCTIONAL equipment to FUNCTIONAL status, and

c. Summary description of action(s) taken to prevent a recurrence.

This control does not affect shutdown requirements or MODE changes.

2.1.4.3 Surveillance Requirements

Doses due to liquid releases to UNRESTRICTED AREAS shall be projected at least once per 31 days, in accordance with Section 2.5, during periods in which the LIQUID RADWASTE TREATMENT SYSTEMs are not being fully utilized.

The LIQUID RADWASTE TREATMENT SYSTEM shall be demonstrated FUNCTIONAL by meeting the controls of Sections 2.1.2 and 2.1.3.

2.1.4.4 Basis

The FUNCTIONALITY of the LIQUID RADWASTE TREATMENT SYSTEM ensures that this system will be available for use whenever liquid effluents require treatment prior to release to the UNRESTRICTED AREAS. The requirement that the appropriate portions of this system be used when specified provides assurance that the releases of radioactive materials in liquid effluents will be kept "as low as is reasonably achievable." This control implements the requirements of 10 CFR Part 50.36a, General Design Criterion 60 of Appendix A to 10 CFR Part 50, and the design objective given in Section II.D of Appendix I to 10 CFR Part 50. The specified limits governing the use of appropriate portions of the LIQUID RADWASTE TREATMENT SYSTEM were specified as a suitable fraction of the dose design objectives set forth in Section II.A of Appendix I, 10 CFR Part 50, for liquid effluents.

This control applies to the release of radioactive materials in liquid effluents from each unit at the site. For units with shared radwaste systems, the liquid effluents from the shared system are to be proportioned among the units sharing that system.

2.1.5 Major Changes to Liquid Radioactive Waste Treatment Systems

Licensee initiated MAJOR CHANGES TO LIQUID RADIOACTIVE WASTE TREATMENT SYSTEMS:

a. Shall be reported to the Nuclear Regulatory Commission in the Radioactive Effluent Release Report for the period in which the change was implemented. The discussion of each change shall contain the information described in Section 7.2.2.7.

b. Shall become effective upon review by the Plant Review Board and approval by the Plant Manager.

2.2 LIQUID RADWASTE TREATMENT SYSTEM

The Vogtle Electric Generating Plant is located on the west bank of the Savannah River approximately 151 river miles from the Atlantic Ocean. There are two pressurized water reactors on the site. Each unit is served by a separate LIQUID RADWASTE TREATMENT SYSTEM; however, certain components are shared between the two systems. Schematics of the LIQUID RADWASTE TREATMENT SYSTEMs are presented in Figure 2-1 and Figure 2-2. Liquid discharge pathways are shown in Figure 2-3.

All liquid radwastes treated by the LIQUID RADWASTE TREATMENT SYSTEM are collected in 5,000-gallon or 20,000-gallon waste monitor tanks. Releases from the waste monitor tanks are to the discharge line from the blowdown sump, and from there to the Savannah River. The blowdown sump also receives input from the waste water retention basins, turbine plant cooling water blowdown, and nuclear service cooling water blowdown. Additional dilution water is available from the cooling tower makeup water bypass line.

Although no significant quantities of radioactivity are expected in the nuclear service cooling water, the steam generator blowdown processing system, or the turbine building drain system, these effluent pathways are monitored as a precautionary measure. The monitors serving the latter two pathways provide for automatic termination of releases from these systems in the event that radio-activity is detected above predetermined levels. These two systems discharge to the waste water retention basin. Sampling and analysis of releases via all three of these pathways must be sufficient to ensure that the liquid effluent dose limits specified in the controls of Section 2.1.3 are not exceeded.

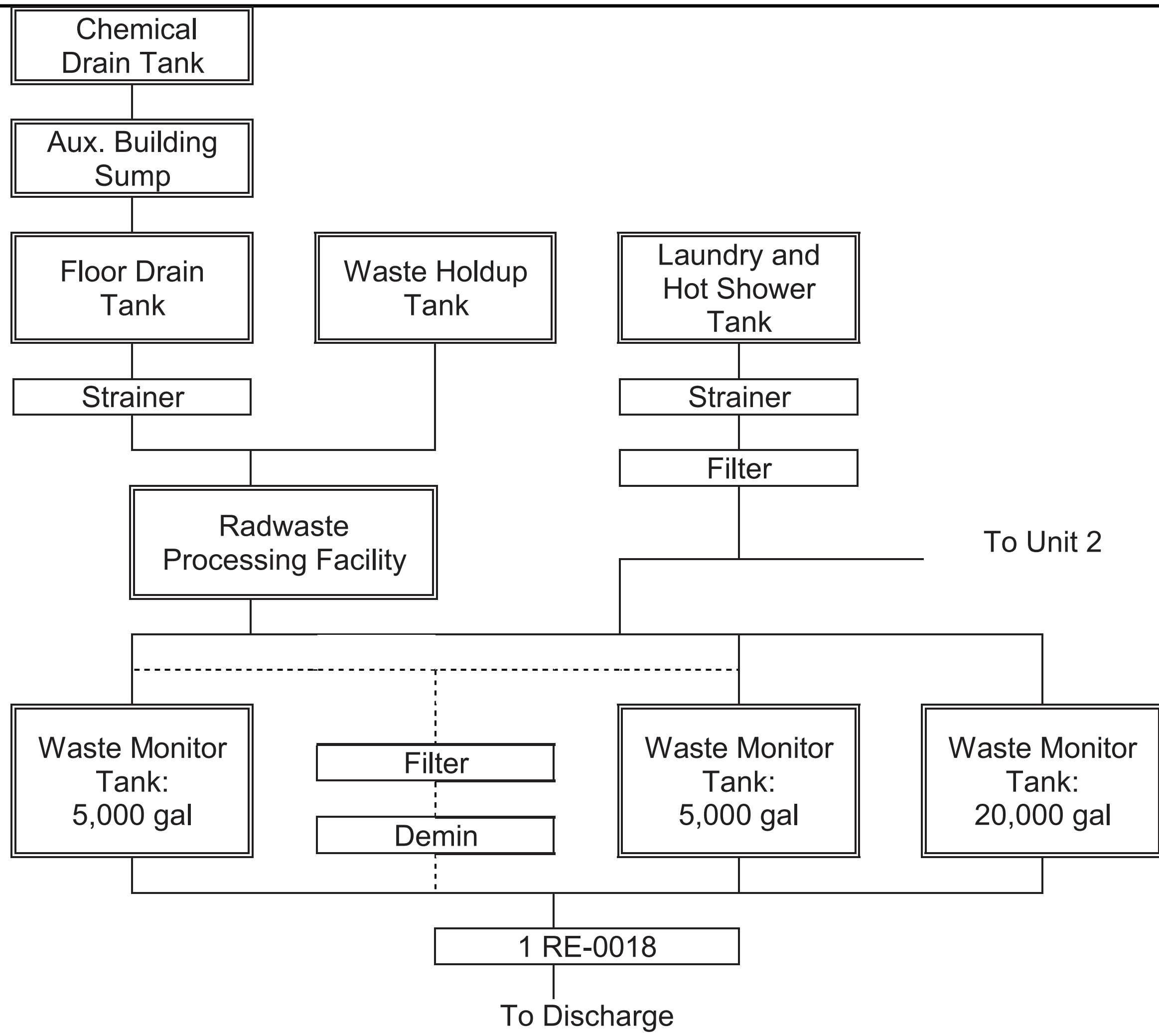


Figure 2-1. Unit 1 Liquid Radwaste Treatment System

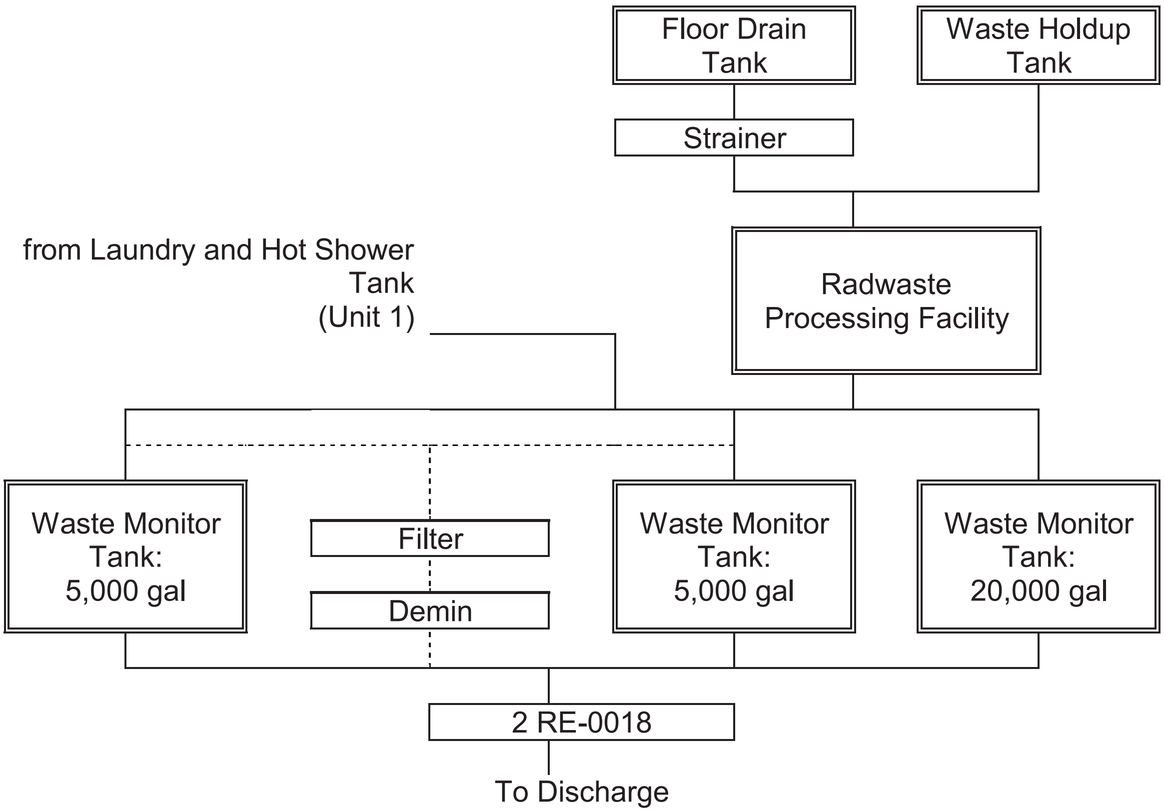


Figure 2-2. Unit 2 Liquid Radwaste Treatment System

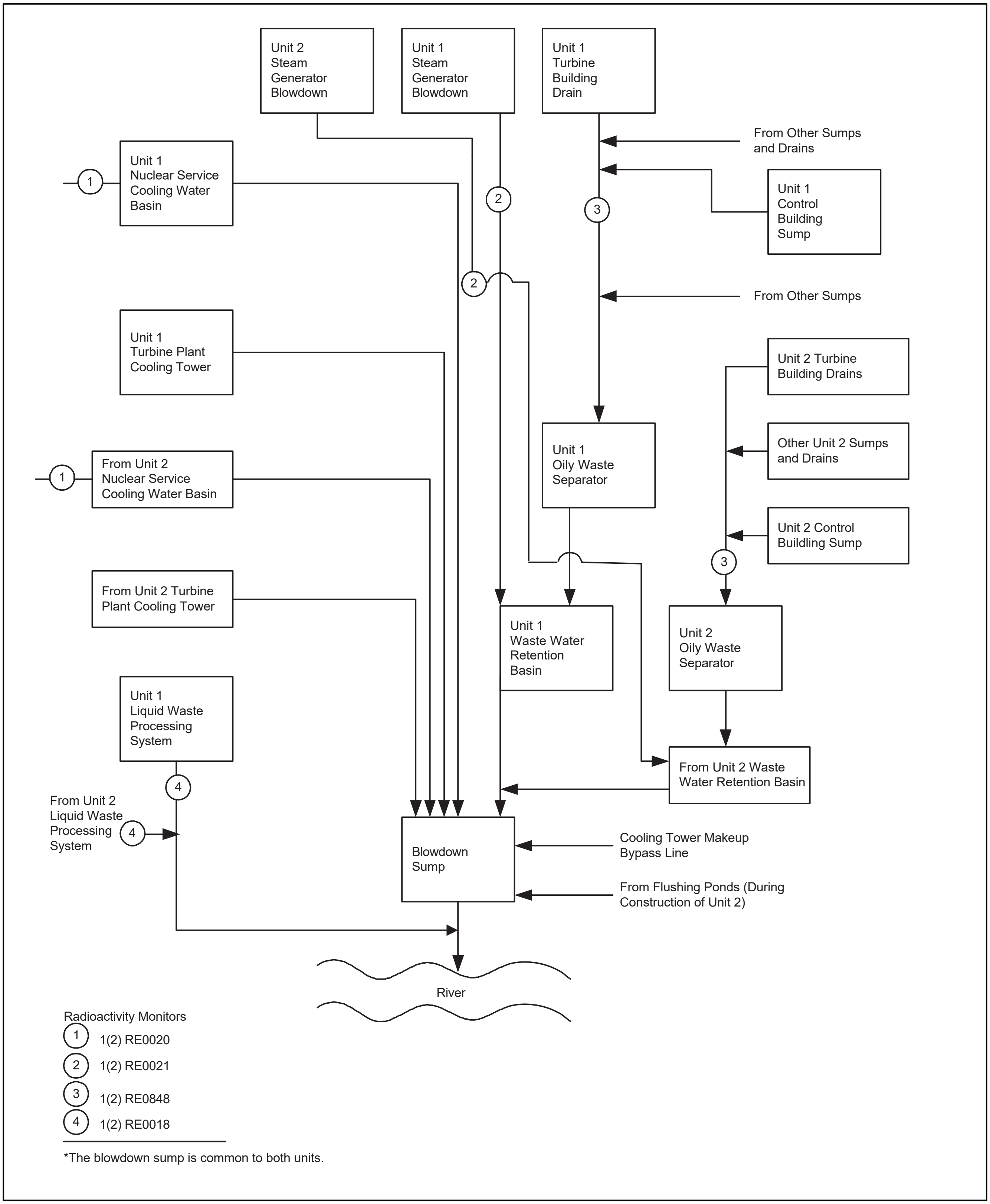


Figure 2-3. Liquid Radwaste Discharge Pathways

2.3 LIQUID EFFLUENT MONITOR SETPOINTS

2.3.1 General Provisions Regarding Setpoints

Liquid monitor setpoints calculated in accordance with the methodology presented in this section will be regarded as upper bounds for the actual high alarm setpoints. That is, a lower value for the high alarm setpoint may be established or retained on the monitor, if desired. Intermediate level setpoints should be established at an appropriate level to give sufficient warning prior to reaching the high alarm setpoint. If no release is planned for a particular pathway, or if there is no detectable activity in the planned release, the monitor setpoint should be established as close to background as practical to prevent spurious alarms, and yet alarm should an inadvertent release occur.

Two basic setpoint methodologies are presented below. For radwaste system discharge monitors, setpoints are determined to assure that the limits of Section 2.1.2 are not exceeded. For monitors on streams that are not expected to contain significant radioactivity, the purpose of the monitor setpoints is to cause an alarm on low levels of radioactivity, and to terminate the release where this is possible. Section 2.1.1 establishes the requirements for liquid effluent monitoring instrumentation. Table 2-4 lists the monitors for which each of the setpoint methodologies is applicable.

Table 2-4. Applicability of Liquid Monitor Setpoint Methodologies

Liquid Radwaste Discharge Monitors

Setpoint Method: Section 2.3.2

Release Type: BATCH

Unit 1 or Unit 2 Liquid Waste Treatment System Effluent
Monitor: 1RE-0018 / 2RE-0018

Normally Low-Radioactivity Streams with Termination or Diversion upon Alarm

Setpoint Method: Section 2.3.3

Release Type: CONTINUOUS

Unit 1 or Unit 2 Steam Generator Blowdown Effluent
Monitor: 1RE-0021 / 2RE-0021

Unit 1 or Unit 2 Turbine Building Drain Effluent
Monitor: 1RE-0848 / 2RE-0848

Normally Low-Radioactivity Streams with Alarm Only

Setpoint Method: Section 2.3.3

Release Type: CONTINUOUS

Unit 1 or Unit 2 Nuclear Service Cooling Water System Effluent
Monitors (2 per unit): 1RE-0020 A and B
2RE-0020 A and B

2.3.2 Setpoints for Radwaste System Discharge Monitors

2.3.2.1 Overview of Method

LIQUID RADWASTE TREATMENT SYSTEM effluent line radioactivity monitors are intended to provide alarm and automatic termination of release prior to exceeding the limits specified in Section 2.1.2 at the point of release of the diluted effluent into the UNRESTRICTED AREA. Therefore, their alarm/trip setpoints are established to ensure compliance with the following equation (equation adapted from Addendum to Reference 1):

$$\frac{c \cdot f}{F + f} \leq TF \cdot C_{ECL} \qquad \textbf{(2.1)}$$

where:

C_{ECL} = the Effluent Concentration Limit corresponding to the mix of radionuclides in the effluent being considered for discharge, in μCi/mL.

c = the setpoint, in μCi/mL, of the radioactivity monitor measuring the concentration of radioactivity in the effluent line prior to dilution and subsequent release. The setpoint represents a concentration which, if exceeded, could result in concentrations exceeding the limits of Section 2.1.2 in the UNRESTRICTED AREA.

f = the effluent flowrate at the location of the radioactivity monitor, in gpm.

F = the dilution stream flowrate which can be assured prior to the release point to the UNRESTRICTED AREA, in gpm. A predetermined dilution flowrate must be assured for use in the calculation of the radioactivity monitor setpoint.

TF = the tolerance factor selected to allow flexibility in the establishment of a practical monitor setpoint which could accommodate effluent releases at concentrations higher than the ECL values stated in 10 CFR 20, Appendix B, Table 2, Column 2; the tolerance factor must not exceed a value of 10.

While equation (2.1) shows the relationships of the critical parameters that determine the setpoint, it cannot be applied practically to a mixture of radionuclides with different Effluent Concentration Limits (ECLs). For a mixture of radionuclides, equation (2.1) is satisfied in a practicable manner based on the calculated ECL fraction of the radionuclide mixture and the dilution stream flowrate that can be assured for the duration of the release (F_d), by calculating the maximum permissible effluent flowrate (f_m) and the radioactivity monitor setpoint (c).

The setpoint method presented below is applicable to the release of only one tank of liquid radwaste per reactor unit at a given time. Liquid releases must be controlled administratively to ensure that this condition is met; otherwise, the setpoint method may not ensure that the limits of Section 2.1.2 are not exceeded.

2.3.2.2 Setpoint Calculation Steps

Step 1: Determine the radionuclide concentrations in the liquid waste being considered for release in accordance with the sampling and analysis requirements of Section 2.1.2.

All liquid radwastes treated by the LIQUID RADWASTE TREATMENT SYSTEM are collected in waste monitor tanks for sampling and analysis. The 5,000-gallon waste monitor tanks are recirculated for a minimum of 30 minutes, and the 20,000-gallon waste monitor tanks are recirculated for a minimum of 45 minutes. This mixing assures that a representative sample can be taken from the tank.

The total concentration of the liquid waste is determined by the results of all required analyses on the collected sample, as follows:

$$\sum_i C_i = C_a + \sum_s C_s + C_f + C_t + \sum_g C_g \qquad \textbf{(2.2)}$$

where:

C_a = the gross concentration of alpha emitters in the liquid waste, not less than that measured in the most recent applicable composite sample.

C_s = the concentration of strontium radioisotope s (Sr–89 or Sr–90) in the liquid waste, not less than that measured in the most recent applicable composite sample.

C_f = the concentration of Fe–55 in the liquid waste, not less than that measured in the most recent applicable composite sample.

C_t = the concentration of H–3 in the liquid waste, not less than that measured in the most recent applicable composite sample.

C_g = the concentration of gamma emitter g in the liquid waste as measured by gamma ray spectroscopy performed on the sample for the release under consideration.

The C_g term will be included in the analysis of each waste sample; terms for gross concentrations of alpha emitters, Sr-89, Sr-90, Fe-55, and tritium will be included in accordance with the sampling and analysis program required for the waste stream (see Section 2.1.2). For each analysis, only radionuclides identified and detected above background for the given measurement should be included in the calculation. When using the alternate setpoint methodology of step 5.b, the historical maximum values of C_a, C_s, C_f, and C_t shall be used.

Step 2: Determine the required dilution factor for the mix of radionuclides detected in the waste.

Measured radionuclide concentrations are used to calculate ECL fractions. The ECL fractions are used along with a safety factor to calculate the required dilution factor; this is the minimum ratio of dilution flowrate to waste flowrate that must be maintained throughout the release to ensure that the limits of Section 2.1.2 are not exceeded at the point of discharge into the UNRESTRICTED AREA. The required dilution factor, RDF, is calculated as the sum of the dilution factors required for gamma emitters (RDF_{γ}) and for non-gamma-emitters ($RDF_{n\gamma}$):

$$RDF = \left[\sum_i \frac{C_i}{ECL_i}\right] \div \left[(SF)(TF)\right]$$

$$= RDF_\gamma + RDF_{n\gamma} \qquad \textbf{(2.3)}$$

$$RDF_\gamma = \frac{\left[\sum_g \frac{C_g}{ECL_g}\right]}{(SF)(TF)} \qquad \textbf{(2.4)}$$

where:

$$RDF_{n\gamma} = \frac{\left[\frac{C_a}{ECL_a} + \sum_s \frac{C_s}{ECL_s} + \frac{C_f}{ECL_f} + \frac{C_t}{ECL_t}\right]}{(SF)(TF)} \qquad \textbf{(2.5)}$$

C_i = the measured concentration of radionuclide i as defined in step 1, in µCi/mL. The C_a, C_s, C_f, and C_t terms will be included in the calculation as appropriate.

ECL_i = the Effluent Concentration Limit for radionuclide i from 10 CFR Part 20, Appendix B, Table 2, Column 2 (except for noble gases as discussed below). In the absence of information regarding the solubility classification of a given radionuclide in the waste stream, the solubility class with the lowest ECL shall be assumed. For dissolved or entrained noble gases, the concentration shall be limited to $1x10^{-4}$ µCi/mL. For gross alpha, the ECL shall be $2x10^{-9}$ µCi/mL; if specific alpha-emitting radionuclides are measured, the ECL for the specific radionuclide(s) should be used.

SF = the safety factor selected to compensate for statistical fluctuations and errors of measurement. The value for the safety factor must be between 0 and 1. A value of 0.5 is reasonable for liquid releases; a more precise value may be developed if desired.

TF = the tolerance factor (as defined in Section 2.3.2.1).

<u>Step 3</u>: Determine the release-specific assured dilution stream flowrate.

Determine the dilution stream flowrate that can be assured during the release period, designated F_d; this value is the setpoint for the dilution stream flowrate measurement device.

If simultaneous radioactive releases are planned from the same or different reactor units, the dilution stream must be allocated among all the simultaneous releases. There will only be one such release per unit at a given time, unless there is detectable radioactivity in one of the normally low-radioactivity streams (see Section 2.3.3). Allocation of the dilution stream to multiple release paths is accomplished as follows:

$$F_{dp} = F_d\left(AF_p\right) \qquad \textbf{(2.6)}$$

where:

F_{dp} = the dilution flowrate allocated to release pathway p, in gpm.

AF_p = the dilution allocation factor for release pathway p. AF_p may be assigned any value between 0 and 1 for each active release pathway, under the condition that the sum of the AF_p for all active release pathways for the entire plant site does not exceed 1.

F_d = the assured minimum dilution flow for the unit, in gpm.

In the normal case in which the only release pathways with detectable radioactivity are the LIQUID RADWASTE TREATMENT SYSTEMs of each unit, AF_p for each unit may be assigned the value of 0.5 to permit releases from either unit to be made without regard to any releases from the other unit; if only one unit's LIQUID RADWASTE TREATMENT SYSTEM is releasing at a given time, its AF_p may be increased proportionately. If more precise allocation factor values are desired, they may be determined based on the relative radiological impact of each active release pathway; this may be approximated by multiplying the RDF of each effluent stream by its respective planned release flowrate, and comparing these values. If only one simultaneous release is being made, its AF_p may be assigned the value of 1, making F_{dp} equal to F_d.

For the case where RDF ≤ 1, the planned release meets the limits of Section 2.1.2 without dilution, and *could* be released with any desired effluent flowrate and dilution flowrate. However, in order to maintain individual doses due to liquid effluent releases as low as is reasonably achievable, no releases with detectable radioactivity *should* be made if the assured dilution flowrate, F_d, is less than 12,000 gpm.

Step 4: Determine the maximum allowable waste discharge flowrate.

For the case where RDF > 1, the maximum permissible effluent discharge flowrate for this release pathway, f_{mp} (in gpm), is calculated as follows:

$$f_{mp} = \frac{F_{dp}}{(RDF - 1)} \tag{2.7}$$

For the case RDF ≤ 1, equation (2.7) is not valid. However, as discussed above, when RDF ≤ 1, the release may be made at full discharge pump capacity; the radioactivity monitor setpoint must still be calculated in accordance with Step 5 below.

NOTE 1: Discharge flowrates are actually limited by the discharge pump capacity. When the calculated maximum permissible release flowrate exceeds the pump capacity, the release may be made at full capacity. Discharge flowrates less than the pump capacity must be achieved by throttling if this is available; if throttling is not available, the release may not be made as planned.

NOTE 2: If, at the time of the planned release, there is detectable radioactivity due to plant operations in the dilution stream, the diluting capacity of the dilution stream is diminished. (In addition, sampling and analysis of the other radioactive effluents affecting the dilution stream must be sufficient to ensure that the liquid effluent dose limits specified in the controls of Section 2.1.3 are not exceeded.) Under these conditions, equation (2.7) must be modified to account for the radioactivity present in the dilution stream prior to the introduction of the planned release:

$$f_{mp} = \frac{F_{dp}}{(RDF - 1)}\left(1 - \sum_r \left[\frac{f_r}{F_d} \sum_i \left(\frac{C_{ir}}{ECL_i}\right)\right]\right) \quad \textbf{(2.8)}$$

where:

C_{ir} = the measured concentration of radionuclide i in release pathway r that is contributing to radioactivity in the dilution stream.

f_r = the effluent discharge flowrate of release pathway r.

If the entire dilution stream contains detectable activity due to plant operations, whether or not its source is identified, $f_r = F_d$, and C_{ir} is the concentration in the total dilution system. This note does not apply: a) if the RDF of the planned release is ≤ 1; or b) if the release contributing radioactivity to the dilution stream has been accounted for by the assignment of an allocation factor.

Step 5: Determine the maximum radioactivity monitor setpoint concentration.

Based on the values determined in previous steps, the radioactivity monitor setpoint for the planned release is calculated to ensure that the limits of Section 2.1.2 will not be exceeded. Because the radioactivity monitor responds primarily to gamma radiation, the monitor setpoint c_p for release pathway p (in µCi/mL) is based on the concentration of gamma emitters in the waste stream, as follows:

$$c_p = A_p \sum_g c_g \quad \textbf{(2.9)}$$

where:

A_p = an adjustment factor which will allow the setpoint to be established in a practical manner to prevent spurious alarms while allowing a margin between measured concentrations and the limits of Section 2.1.2.

Step 5.a. If the concentration of gamma emitters in the effluent to be released is sufficient that the high alarm setpoint can be established at a level that will prevent spurious alarms, A_p should be calculated as follows:

$$A_p = \frac{1}{RDF} \times ADF$$

$$= \frac{1}{RDF} \times \frac{(F_{dp} + f_{ap})}{f_{ap}} \quad \textbf{(2.10)}$$

where:

ADF = the assured dilution factor.

f_{ap} = the anticipated actual discharge flowrate for the planned release (in gpm), a value less than f_{mp}. The release must then be controlled so that the actual effluent discharge flowrate does not exceed f_{ap} at any time.

Step 5.b. Alternatively, A_p may be calculated as follows:

$$A_p = \frac{ADF - RDF_{n\gamma}}{RDF_{\gamma}} \quad \textbf{(2.11)}$$

Step 5.c. Evaluate the computed value of A_p as follows:

If $A_p \geq 1$, calculate the monitor setpoint, c_p. However, if c_p is within about 10 percent of C_g, it may be impractical to use this value of c_p. This situation indicates that measured concentrations are approaching values which would cause limits of Section 2.1.2 to be exceeded. Therefore, steps should be taken to reduce potential concentrations at the point of discharge; these steps may include decreasing the planned effluent discharge flowrate, increasing the dilution stream flowrate, postponing simultaneous releases, and/or decreasing the effluent concentrations by further processing the liquid planned for release. Alternatively, allocation factors for the active liquid release pathways may be reassigned. When one or more of these actions has been taken, repeat Steps 1–5 to calculate a new radioactivity monitor setpoint.

If $A_p < 1$, the release may not be made as planned. Consider the alternatives discussed in the paragraph above, and calculate a new setpoint based on the results of the actions taken.

2.3.2.3 Use of the Calculated Setpoint

The setpoint calculated above is in the units μCi/mL. The monitor actually measures a count rate, subtracts a predetermined background count rate, and multiplies by a calibration factor to convert from count rate to μCi/mL.

Initial calibration of the monitors by the manufacturer and Georgia Power Company utilized NIST-traceable liquid solutions with gamma ray emissions over the range 0.08 to 1.33 MeV, in the exact geometry of each production monitor. The calibration factor is a function of the radionuclide mix in the liquid to be released, and will be calculated for the monitor based on the results of the pre-release sample results from the laboratory gamma-ray spectrometer system. The mix-dependent calibration factor will be used as the gain factor in the PERMS monitor, or used to modify the calculated base monitor setpoint so that the default calibration factor in the PERMS monitor can be left unchanged.

Notwithstanding the initial calibration, monitor calibration data for conversion between count rate and concentration *may* include operational data obtained from determining the monitor response to stream concentrations measured by liquid sample analysis. In all cases, monitor background must be controlled so that the monitor is capable of responding to concentrations in the range of the setpoint value.

2.3.3 Setpoints for Monitors on Normally Low-Radioactivity Streams

Radioactivity in these streams (listed in Table 2-4 above) is expected to be at very low levels, generally below detection limits. Accordingly, the purpose of these monitors is to alarm upon the occurrence of significant radioactivity in these streams, and to terminate or divert the release where this is possible.

2.3.3.1 Normal Conditions

When radioactivity in one of these streams is at its normal low level, its radioactivity monitor setpoint should be established as close to background as practical to prevent spurious alarms, and yet alarm should an inadvertent release occur.

2.3.3.2 Conditions Requiring an Elevated Setpoint

Under the following conditions, radionuclide concentrations must be determined and an elevated radioactivity monitor setpoint determined for these pathways:

- For streams that can be diverted or isolated, a new monitor setpoint must be established when it is desired to discharge the stream directly to the dilution water even though the radioactivity in the stream exceeds the level which would normally be diverted or isolated.

- For streams that cannot be diverted or isolated, a new monitor setpoint must be established whenever: the radioactivity in the stream becomes detectable above the background levels of the applicable laboratory analyses; or the associated radioactivity monitor detects activity in the stream at levels above the established alarm setpoint.

When an elevated monitor setpoint is required for any of these effluent streams, it should be determined in the same manner as described in Section 2.3.2. However, special consideration must be given to Step 3. An allocation factor must be assigned to the normally low-radioactivity release pathway under consideration, and allocation factors for other release pathways discharging simultaneously must be adjusted downward (if necessary) to ensure that the sum of the allocation factors does not exceed 1. Sampling and analysis of the normally low-radioactivity streams must be sufficient to ensure that the liquid effluent dose limits specified in the controls of Section 2.1.3 are not exceeded.

2.4 LIQUID EFFLUENT DOSE CALCULATIONS

The following sub-sections present the methods required for liquid effluent dose calculations, in deepening levels of detail. Applicable site-specific pathways and parameter values for the calculation of D_τ, $A_{i\tau}$, and CF_{iv} are summarized in Table 2-5.

2.4.1 Calculation of Dose

The dose limits for a MEMBER OF THE PUBLIC specified in Section 2.1.3 are on a per-unit basis. Therefore, the doses calculated in accordance with this section must be determined and recorded on a per-unit basis, including apportionment of releases shared between the two units.

For the purpose of implementing Section 2.1.3, the dose to the maximum exposed individual due to radionuclides identified in liquid effluents released from each unit to UNRESTRICTED AREAS will be calculated as follows (equation from Reference 1, page 15):

$$D_\tau = \sum_i A_{i\tau}\left[\sum_{l=1}^{m}\left(\Delta t_l C_{il} F_l\right)\right] \qquad \textbf{(2.12)}$$

where:

D_τ = the cumulative dose commitment to the total body or to any organ τ, in mrem, due to radioactivity in liquid effluents released during the total of the m time periods Δt_l.

$A_{i\tau}$ = the site-related adult ingestion dose commitment factor, for the total body or for any organ τ, due to identified radionuclide i, in (mrem·mL)/(h·µCi). Methods for the calculation of $A_{i\tau}$ are presented below in Section 2.4.2. The values of $A_{i\tau}$ to be used in dose calculations for releases from the plant site are listed in Table 2-8.

Δt_l = the length of time period l, over which C_{il} and F_l are averaged for liquid releases, in h.

C_{il} = the average concentration of radionuclide i in undiluted liquid effluent during time period l, in µCi/mL. Only radionuclides identified and detected above background in their respective samples should be included in the calculation.

F_l = the near-field average dilution factor in the receiving water of the UNRESTRICTED AREA:

$$F_l = \frac{f_t}{F_t \times Z} \qquad \textbf{(2.13)}$$

where:

f_t = the average undiluted liquid waste flowrate actually observed during the period of radioactivity release, in gpm.

F_t = the average dilution stream flowrate actually observed during the period of radioactivity release, in gpm. If simultaneous releases from both units occur, the dilution stream flowrate F_t must be allocated between them. In such cases, F_l is unit-specific.

Z = the applicable dilution factor for the receiving water body, in the near field of the discharge structure, during the period of radioactivity release, from Table 2-5.

NOTE: In equation (2.13), the product (F_t x Z) is limited to 1000 cfs (= 448,000 gpm) or less. (Reference 1, Section 4.3.)

2.4.2 Calculation of $A_{i\tau}$

The site-related adult ingestion dose commitment factor, $A_{i\tau}$, is calculated as follows (equation adapted from Reference 1, page 16, by addition of the irrigated garden vegetation pathway):

$$A_{i\tau} = 1.14 \times 10^5 \left(\frac{U_w}{D_w} e^{-\lambda_i t_w} + U_f BF_i \, e^{-\lambda_i t_f} + U_v CF_{iv} \right) DF_{i\tau} \qquad \textbf{(2.14)}$$

where:

1.14×10^5 = a units conversion factor, determined by:

10^6 pCi/μCi x 10^3 mL/L ÷ 8760 h/y.

U_w = the adult drinking water consumption rate applicable to the plant site (L/y).

D_w = the dilution factor from the near field of the discharge structure for the plant site to the potable water intake location.

λ_i = the decay constant for radionuclide i (h^{-1}). Values of λ_i used in effluent calculations should be based on decay data from a recognized and current source, such as Reference 20.

t_w = the transit time from release to receptor for potable water consumption (h).

U_f = the adult rate of fish consumption applicable to the plant site (kg/y).

BF_i = the bioaccumulation factor for radionuclide i applicable to freshwater fish in the receiving water body for the plant site, in (pCi/kg)/(pCi/L) = (L/kg). For specific values applicable to the plant site, see Table 2-6.

t_f = the transit time from release to receptor for fish consumption (h).

U_v = the adult consumption rate for irrigated garden vegetation applicable to the plant site (kg/y).

CF_{iv} = the concentration factor for radionuclide i in irrigated garden vegetation, as applicable to the vicinity of the plant site, in (pCi/kg)/(pCi/L). Methods for calculation of CF_{iv} are presented below in Section 2.4.3.

$DF_{i\tau}$ = the dose conversion factor for radionuclide i for adults, in organ τ (mrem/pCi). For specific values, see Table 2-7.

2.4.3 Calculation of Cf_{iv}

The concentration factor for radionuclide i in irrigated garden vegetation, CF_{iv} in (L/kg), is calculated as follows:

- For radionuclides other than tritium (equation adapted from Reference 3, equations A–8 and A–9):

$$CF_{iv} = M \cdot I \left[\frac{r\left(1 - e^{-\lambda_{Ei} t_e}\right)}{Y_v \lambda_{Ei}} + \frac{f_I B_{iv}\left(1 - e^{-\lambda_i t_b}\right)}{P \lambda_i} \right] e^{-\lambda_i t_h} \qquad \textbf{(2.15)}$$

- For tritium (equation adapted from Reference 3, equations A–9 and A–10):

$$CF_{iv} = M \cdot L_v \qquad \textbf{(2.16)}$$

where:

M = the additional river dilution factor from the near field of the discharge structure for the plant site to the point of irrigation water usage.

I = the average irrigation rate during the growing season (L)/($m^2 \cdot h$).

r = the fraction of irrigation-deposited activity retained on the edible portions of leafy garden vegetation.

Y_v = the areal density (agricultural productivity) of leafy garden vegetation (kg/m^2)

f_I = the fraction of the year that garden vegetation is irrigated.

B_{iv} = the crop to soil concentration factor applicable to radionuclide i (pCi/kg garden vegetation)/(pCi/kg soil).

P = the effective surface density of soil (kg/m^2).

λ_i = the decay constant for radionuclide i (h^{-1}). Values of λ_i used in effluent calculations should be based on decay data from a recognized and current source, such as Reference 20.

λ_w = the rate constant for removal of activity from plant leaves by weathering (h^{-1}).

λ_{Ei} = the effective removal rate for activity deposited on crop leaves (h^{-1}) calculated as: $\lambda_{Ei} = \lambda_i + \lambda_w$.

t_e = the period of leafy garden vegetation exposure during the growing season (h).

t_b = the period of long-term buildup of activity in soil (h).

t_h = the time between harvest of garden vegetation and human consumption (h).

L_v = the water content of leafy garden vegetation edible parts (L/kg).

Table 2-5. Parameters for Calculation of Doses Due to Liquid Effluent Releases

Dose Calculation Receptor Locations:

Fish: Vicinity of plant discharge

Drinking Water: 112 miles downstream, at Beaufort, SC (Reference 12)

Irrigated Garden Vegetation: None (Reference 12)

Numerical Parameters:

Parameter	Value	Reference
Z	10, for May through December 20, for January through April	Ref. 11
U_w	730 L/y	Ref 3
D_w	8	Ref. 7
t_w	48 h	Ref. 3, Sec. A.2; Ref. 8
U_f	21 kg/y	Ref. 3, Table E-5
t_f	24 h	Ref. 3, Sec. A.2
U_v	0 kg/y *	Ref. 12
M	1.0 +	
I	No value **	
r	0.25	Ref. 3, Table E-15.
Y_v	2.0 kg/m^2	Ref. 3, Table E-15
f_l	1.0 +	
P	240 kg/m^2	Ref. 3, Table E-15
λ_w	0.0021 h^{-1} (i.e., half-life of 14 d)	Ref. 3, Table E-15
t_e	1440 h (= 60 d)	Ref. 3, Table E-15
t_b	1.31 x 10^5 h (= 15 y)	Ref. 3, Table E-15
t_h	24 h	Ref. 3, Table E-15
L_v	0.92 L/kg	Based on Ref. 21, Table 5.16 (for lettuce, cabbage, etc.)

* - Because there is no irrigated garden vegetation pathway downstream of the plant site, the consumption of irrigated garden vegetation is set to zero, and the other pathway parameters are defaults.

\+ - There is no established default value for this parameter. The most conservative physically realistic value is 1.0.

Table 2-6. Element Transfer Factors

Element	Freshwater Fish BF_i*
H	9.0 E-01
C	4.6 E+03
Na	1.0 E+02
P	3.0 E+03
Cr	2.0 E+02
Mn	4.0 E+02
Fe	1.0 E+02
Co	5.0 E+01
Ni	1.0 E+02
Cu	5.0 E+01
Zn	2.0 E+03
Br	4.2 E+02
Rb	2.0 E+03
Sr	3.0 E+01
Y	2.5 E+01
Zr	3.3 E+00
Nb	5.5 E+02
Mo	1.0 E+01
Tc	1.5 E+01
Ru	1.0 E+01
Rh	1.0 E+01
Ag	2.3 E+00
Sb	2.0 E+02
Te	4.0 E+02
I	1.5 E+01
Cs	2.0 E+03
Ba	4.0 E+00
La	2.5 E+01
Ce	1.0 E+00
Pr	2.5 E+01
Nd	2.5 E+01
W	1.2 E+03
Np	1.0 E+01

* - Bioaccumulation Factors for freshwater fish, in (pCi/kg)/(pCi/L). They are obtained from Reference 3 (Table A-1), except as follows: Reference 9 for P; Reference 2 (Table A-8) for Ag; and Reference 10 for Nb and Sb.

Table 2-7. Adult Ingestion Dose Factors

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	1.05E-07	1.05E-07	1.05E-07	1.05E-07	1.05E-07	1.05E-07
C-14	2.84E-06	5.68E-07	5.68E-07	5.68E-07	5.68E-07	5.68E-07	5.68E-07
Na-24	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06
P-32	1.93E-04	1.20E-05	7.46E-06	No Data	No Data	No Data	2.17E-05
Cr-51	No Data	No Data	2.66E-09	1.59E-09	5.86E-10	3.53E-09	6.69E-07
Mn-54	No Data	4.57E-06	8.72E-07	No Data	1.36E-06	No Data	1.40E-05
Mn-56	No Data	1.15E-07	2.04E-08	No Data	1.46E-07	No Data	3.67E-06
Fe-55	2.75E-06	1.90E-06	4.43E-07	No Data	No Data	1.06E-06	1.09E-06
Fe-59	4.34E-06	1.02E-05	3.91E-06	No Data	No Data	2.85E-06	3.40E-05
Co-58	No Data	7.45E-07	1.67E-06	No Data	No Data	No Data	1.51E-05
Co-60	No Data	2.14E-06	4.72E-06	No Data	No Data	No Data	4.02E-05
Ni-63	1.30E-04	9.01E-06	4.36E-06	No Data	No Data	No Data	1.88E-06
Ni-65	5.28E-07	6.86E-08	3.13E-08	No Data	No Data	No Data	1.74E-06
Cu-64	No Data	8.33E-08	3.91E-08	No Data	2.10E-07	No Data	7.10E-06
Zn-65	4.84E-06	1.54E-05	6.96E-06	No Data	1.03E-05	No Data	9.70E-06
Zn-69	1.03E-08	1.97E-08	1.37E-09	No Data	1.28E-08	No Data	2.96E-09
Br-83	No Data	No Data	4.02E-08	No Data	No Data	No Data	5.79E-08
Br-84	No Data	No Data	5.21E-08	No Data	No Data	No Data	4.09E-13
Br-85	No Data	No Data	2.14E-09	No Data	No Data	No Data	No Data
Rb-86	No Data	2.11E-05	9.83E-06	No Data	No Data	No Data	4.16E-06
Rb-88	No Data	6.05E-08	3.21E-08	No Data	No Data	No Data	8.36E-19
Rb-89	No Data	4.01E-08	2.82E-08	No Data	No Data	No Data	2.33E-21
Sr-89	3.08E-04	No Data	8.84E-06	No Data	No Data	No Data	4.94E-05
Sr-90	7.58E-03	No Data	1.86E-03	No Data	No Data	No Data	2.19E-04
Sr-91	5.67E-06	No Data	2.29E-07	No Data	No Data	No Data	2.70E-05

All values are in (mrem/pCi ingested). They are obtained from Reference 3 (Table E-11), except as follows: Reference 2 (Table A–3) for Rh-105, Sb-124, and Sb-125.

Table 2-7 (contd). Adult Ingestion Dose Factors

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Sr-92	2.15E-06	No Data	9.30E-08	No Data	No Data	No Data	4.26E-05
Y-90	9.62E-09	No Data	2.58E-10	No Data	No Data	No Data	1.02E-04
Y-91m	9.09E-11	No Data	3.52E-12	No Data	No Data	No Data	2.67E-10
Y-91	1.41E-07	No Data	3.77E-09	No Data	No Data	No Data	7.76E-05
Y-92	8.45E-10	No Data	2.47E-11	No Data	No Data	No Data	1.48E-05
Y-93	2.68E-09	No Data	7.40E-11	No Data	No Data	No Data	8.50E-05
Zr-95	3.04E-08	9.75E-09	6.60E-09	No Data	1.53E-08	No Data	3.09E-05
Zr-97	1.68E-09	3.39E-10	1.55E-10	No Data	5.12E-10	No Data	1.05E-04
Nb-95	6.22E-09	3.46E-09	1.86E-09	No Data	3.42E-09	No Data	2.10E-05
Mo-99	No Data	4.31E-06	8.20E-07	No Data	9.76E-06	No Data	9.99E-06
Tc-99m	2.47E-10	6.98E-10	8.89E-09	No Data	1.06E-08	3.42E-10	4.13E-07
Tc-101	2.54E-10	3.66E-10	3.59E-09	No Data	6.59E-09	1.87E-10	1.10E-21
Ru-103	1.85E-07	No Data	7.97E-08	No Data	7.06E-07	No Data	2.16E-05
Ru-105	1.54E-08	No Data	6.08E-09	No Data	1.99E-07	No Data	9.42E-06
Ru-106	2.75E-06	No Data	3.48E-07	No Data	5.31E-06	No Data	1.78E-04
Rh-105	1.22E-07	8.86E-08	5.83E-08	No Data	3.76E-07	No Data	1.41E-05
Ag-110m	1.60E-07	1.48E-07	8.79E-08	No Data	2.91E-07	No Data	6.04E-05
Sb-124	2.81E-06	5.30E-08	1.11E-06	6.79E-09	No Data	2.18E-06	7.95E-05
Sb-125	2.23E-06	2.40E-08	4.48E-07	1.98E-09	No Data	2.33E-04	1.97E-05
Te-125m	2.68E-06	9.71E-07	3.59E-07	8.06E-07	1.09E-05	No Data	1.07E-05
Te-127m	6.77E-06	2.42E-06	8.25E-07	1.73E-06	2.75E-05	No Data	2.27E-05
Te-127	1.10E-07	3.95E-08	2.38E-08	8.15E-08	4.48E-07	No Data	8.68E-06
Te-129m	1.15E-05	4.29E-06	1.82E-06	3.95E-06	4.80E-05	No Data	5.79E-05
Te-129	3.14E-08	1.18E-08	7.65E-09	2.41E-08	1.32E-07	No Data	2.37E-08
Te-131m	1.73E-06	8.46E-07	7.05E-07	1.34E-06	8.57E-06	No Data	8.40E-05
Te-131	1.97E-08	8.23E-09	6.22E-09	1.62E-08	8.63E-08	No Data	2.79E-09

Table 2-7 (contd). Adult Ingestion Dose Factors

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Te-132	2.52E-06	1.63E-06	1.53E-06	1.80E-06	1.57E-05	No Data	7.71E-05
I-130	7.56E-07	2.23E-06	8.80E-07	1.89E-04	3.48E-06	No Data	1.92E-06
I-131	4.16E-06	5.95E-06	3.41E-06	1.95E-03	1.02E-05	No Data	1.57E-06
I-132	2.03E-07	5.43E-07	1.90E-07	1.90E-05	8.65E-07	No Data	1.02E-07
I-133	1.42E-06	2.47E-06	7.53E-07	3.63E-04	4.31E-06	No Data	2.22E-06
I-134	1.06E-07	2.88E-07	1.03E-07	4.99E-06	4.58E-07	No Data	2.51E-10
I-135	4.43E-07	1.16E-06	4.28E-07	7.65E-05	1.86E-06	No Data	1.31E-06
Cs-134	6.22E-05	1.48E-04	1.21E-04	No Data	4.79E-05	1.59E-05	2.59E-06
Cs-136	6.51E-06	2.57E-05	1.85E-05	No Data	1.43E-05	1.96E-06	2.92E-06
Cs-137	7.97E-05	1.09E-04	7.14E-05	No Data	3.70E-05	1.23E-05	2.11E-06
Cs-138	5.52E-08	1.09E-07	5.40E-08	No Data	8.01E-08	7.91E-09	4.65E-13
Ba-139	9.70E-08	6.91E-11	2.84E-09	No Data	6.46E-11	3.92E-11	1.72E-07
Ba-140	2.03E-05	2.55E-08	1.33E-06	No Data	8.67E-09	1.46E-08	4.18E-05
Ba-141	4.71E-08	3.56E-11	1.59E-09	No Data	3.31E-11	2.02E-11	2.22E-17
Ba-142	2.13E-08	2.19E-11	1.34E-09	No Data	1.85E-11	1.24E-11	3.00E-26
La-140	2.50E-09	1.26E-09	3.33E-10	No Data	No Data	No Data	9.25E-05
La-142	1.28E-10	5.82E-11	1.45E-11	No Data	No Data	No Data	4.25E-07
Ce-141	9.36E-09	6.33E-09	7.18E-10	No Data	2.94E-09	No Data	2.42E-05
Ce-143	1.65E-09	1.22E-06	1.35E-10	No Data	5.37E-10	No Data	4.56E-05
Ce-144	4.88E-07	2.04E-07	2.62E-08	No Data	1.21E-07	No Data	1.65E-04
Pr-143	9.20E-09	3.69E-09	4.56E-10	No Data	2.13E-09	No Data	4.03E-05
Pr-144	3.01E-11	1.25E-11	1.53E-12	No Data	7.05E-12	No Data	4.33E-18
Nd-147	6.29E-09	7.27E-09	4.35E-10	No Data	4.25E-09	No Data	3.49E-05
W-187	1.03E-07	8.61E-08	3.01E-08	No Data	No Data	No Data	2.82E-05
Np-239	1.19E-09	1.17E-10	6.45E-11	No Data	3.65E-10	No Data	2.40E-05

Table 2-8. Site-Related Ingestion Dose Factors, $A_{i\tau}$

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00	1.32E+00	1.32E+00	1.32E+00	1.32E+00	1.32E+00	1.32E+00
C-14	3.13E+04	6.26E+03	6.26E+03	6.26E+03	6.26E+03	6.26E+03	6.26E+03
Na-24	1.36E+02	1.36E+02	1.36E+02	1.36E+02	1.36E+02	1.36E+02	1.36E+02
P-32	1.32E+06	8.22E+04	5.11E+04	0.00	0.00	0.00	1.49E+05
Cr-51	0.00	0.00	1.27E+00	7.58E-01	2.79E-01	1.68E+00	3.19E+02
Mn-54	0.00	4.41E+03	8.42E+02	0.00	1.31E+03	0.00	1.35E+04
Mn-56	0.00	1.74E-01	3.08E-02	0.00	2.21E-01	0.00	5.55E+00
Fe-55	6.86E+02	4.74E+02	1.11E+02	0.00	0.00	2.65E+02	2.72E+02
Fe-59	1.07E+03	2.51E+03	9.61E+02	0.00	0.00	7.01E+02	8.36E+03
Co-58	0.00	9.59E+01	2.15E+02	0.00	0.00	0.00	1.94E+03
Co-60	0.00	2.78E+02	6.14E+02	0.00	0.00	0.00	5.23E+03
Ni-63	3.25E+04	2.25E+03	1.09E+03	0.00	0.00	0.00	4.70E+02
Ni-65	1.72E-01	2.23E-02	1.02E-02	0.00	0.00	0.00	5.66E-01
Cu-64	0.00	2.75E+00	1.29E+00	0.00	6.94E+00	0.00	2.35E+02
Zn-65	2.32E+04	7.37E+04	3.33E+04	0.00	4.93E+04	0.00	4.64E+04
Zn-69	7.88E-07	1.51E-06	1.05E-07	0.00	9.79E-07	0.00	2.26E-07
Br-83	0.00	0.00	3.83E-02	0.00	0.00	0.00	5.52E-02
Br-84	0.00	0.00	1.22E-12	0.00	0.00	0.00	9.61E-18
Br-85	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rb-86	0.00	9.75E+04	4.54E+04	0.00	0.00	0.00	1.92E+04
Rb-88	0.00	1.29E-22	6.82E-23	0.00	0.00	0.00	1.78E-33
Rb-89	0.00	1.61E-26	1.14E-26	0.00	0.00	0.00	0.00
Sr-89	2.49E+04	0.00	7.16E+02	0.00	0.00	0.00	4.00E+03
Sr-90	6.23E+05	0.00	1.53E+05	0.00	0.00	0.00	1.80E+04
Sr-91	7.25E+01	0.00	2.93E+00	0.00	0.00	0.00	3.45E+02
Sr-92	3.33E-01	0.00	1.44E-02	0.00	0.00	0.00	6.60E+00
Y-90	5.04E-01	0.00	1.35E-02	0.00	0.00	0.00	5.34E+03
Y-91m	1.04E-11	0.00	4.01E-13	0.00	0.00	0.00	3.04E-11
Y-91	9.77E+00	0.00	2.61E-01	0.00	0.00	0.00	5.38E+03
Y-92	4.61E-04	0.00	1.35E-05	0.00	0.00	0.00	8.07E+00
Y-93	3.19E-02	0.00	8.82E-04	0.00	0.00	0.00	1.01E+03
Zr-95	5.47E-01	1.75E-01	1.19E-01	0.00	2.75E-01	0.00	5.56E+02
Zr-97	7.40E-03	1.49E-03	6.83E-04	0.00	2.26E-03	0.00	4.62E+02
Nb-95	8.09E+00	4.50E+00	2.42E+00	0.00	4.45E+00	0.00	2.73E+04
Mo-99	0.00	1.07E+02	2.04E+01	0.00	2.43E+02	0.00	2.49E+02
Tc-99m	5.70E-04	1.61E-03	2.05E-02	0.00	2.44E-02	7.89E-04	9.53E-01

All values are in (mrem·mL)/(h·μCi). They are calculated using equation (2.14), and data from Table 2-5, Table 2-6, and Table 2-7. When "No Data" is shown for a radionuclide-organ combination in Table 2-7, $A_{i\tau}$ factors in this table are presented as zero.

Table 2-8 (contd). Site-Related Ingestion Dose Factors, $A_{i\tau}$

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Tc-101	2.71E-33	3.91E-33	3.83E-32	0.00	7.03E-32	2.00E-33	0.00
Ru-103	6.21E+00	0.00	2.68E+00	0.00	2.37E+01	0.00	7.25E+02
Ru-105	8.79E-03	0.00	3.47E-03	0.00	1.14E-01	0.00	5.38E+00
Ru-106	9.42E+01	0.00	1.19E+01	0.00	1.82E+02	0.00	6.10E+03
Rh-105	2.32E+00	1.69E+00	1.11E+00	0.00	7.15E+00	0.00	2.68E+02
Ag-110m	2.53E+00	2.34E+00	1.39E+00	0.00	4.61E+00	0.00	9.56E+02
Sb-124	1.36E+03	2.56E+01	5.37E+02	3.28E+00	0.00	1.05E+03	3.84E+04
Sb-125	1.09E+03	1.17E+01	2.19E+02	9.68E-01	0.00	1.14E+05	9.63E+03
Te-125m	2.56E+03	9.29E+02	3.43E+02	7.71E+02	1.04E+04	0.00	1.02E+04
Te-127m	6.51E+03	2.33E+03	7.93E+02	1.66E+03	2.64E+04	0.00	2.18E+04
Te-127	1.78E+01	6.40E+00	3.85E+00	1.32E+01	7.25E+01	0.00	1.41E+03
Te-129m	1.09E+04	4.07E+03	1.73E+03	3.74E+03	4.55E+04	0.00	5.49E+04
Te-129	1.78E-05	6.68E-06	4.33E-06	1.36E-05	7.47E-05	0.00	1.34E-05
Te-131m	9.57E+02	4.68E+02	3.90E+02	7.42E+02	4.74E+03	0.00	4.65E+04
Te-131	8.64E-17	3.61E-17	2.73E-17	7.10E-17	3.78E-16	0.00	1.22E-17
Te-132	1.97E+03	1.27E+03	1.19E+03	1.41E+03	1.23E+04	0.00	6.02E+04
I-130	7.60E+00	2.24E+01	8.85E+00	1.90E+03	3.50E+01	0.00	1.93E+01
I-131	1.73E+02	2.48E+02	1.42E+02	8.13E+04	4.25E+02	0.00	6.55E+01
I-132	5.27E-03	1.41E-02	4.93E-03	4.93E-01	2.24E-02	0.00	2.65E-03
I-133	2.59E+01	4.51E+01	1.37E+01	6.62E+03	7.86E+01	0.00	4.05E+01
I-134	2.18E-08	5.94E-08	2.12E-08	1.03E-06	9.44E-08	0.00	5.17E-11
I-135	1.31E+00	3.44E+00	1.27E+00	2.27E+02	5.52E+00	0.00	3.89E+00
Cs-134	2.98E+05	7.10E+05	5.80E+05	0.00	2.30E+05	7.62E+04	1.24E+04
Cs-136	2.96E+04	1.17E+05	8.42E+04	0.00	6.51E+04	8.92E+03	1.33E+04
Cs-137	3.82E+05	5.23E+05	3.43E+05	0.00	1.78E+05	5.90E+04	1.01E+04
Cs-138	9.12E-12	1.80E-11	8.92E-12	0.00	1.32E-11	1.31E-12	7.68E-17
Ba-139	5.64E-06	4.02E-09	1.65E-07	0.00	3.76E-09	2.28E-09	1.00E-05
Ba-140	3.74E+02	4.69E-01	2.45E+01	0.00	1.60E-01	2.69E-01	7.69E+02
Ba-141	8.47E-25	6.40E-28	2.86E-26	0.00	5.95E-28	3.63E-28	3.99E-34
Ba-142	0.00	0.00	0.00	0.00	0.00	0.00	0.00
La-140	1.10E-01	5.56E-02	1.47E-02	0.00	0.00	0.00	4.08E+03
La-142	2.19E-07	9.96E-08	2.48E-08	0.00	0.00	0.00	7.27E-04
Ce-141	1.15E-01	7.79E-02	8.84E-03	0.00	3.62E-02	0.00	2.98E+02
Ce-143	8.65E-03	6.39E+00	7.08E-04	0.00	2.81E-03	0.00	2.39E+02
Ce-144	6.22E+00	2.60E+00	3.34E-01	0.00	1.54E+00	0.00	2.10E+03
Pr-143	6.10E-01	2.44E-01	3.02E-02	0.00	1.41E-01	0.00	2.67E+03
Pr-144	1.48E-28	6.14E-29	7.51E-30	0.00	3.46E-29	0.00	2.13E-35
Nd-147	4.11E-01	4.75E-01	2.84E-02	0.00	2.78E-01	0.00	2.28E+03
W-187	1.47E+02	1.23E+02	4.31E+01	0.00	0.00	0.00	4.04E+04
Np-239	2.81E-02	2.76E-03	1.52E-03	0.00	8.62E-03	0.00	5.67E+02

2.5 LIQUID EFFLUENT DOSE PROJECTIONS

2.5.1 Thirty-One Day Dose Projections

In order to meet the requirements for operation of the LIQUID RADWASTE TREATMENT SYSTEM (see Section 2.1.4), dose projections must be made at least once each 31 days; this applies during periods in which a discharge to UNRESTRICTED AREAS of liquid effluents containing radioactive materials occurs or is expected.

Projected 31-day doses to individuals due to liquid effluents may be determined as follows:

$$D_{\tau p} = \left(\frac{D_{\tau c}}{t} \right) \times 31 + D_{\tau a} \qquad \textbf{(2.17)}$$

where:

$D_{\tau p}$ = the projected dose to the total body or organ τ, for the next 31 days of liquid releases.

$D_{\tau c}$ = the cumulative dose to the total body or organ τ, for liquid releases that have occurred in the elapsed portion of the current quarter, plus the release under consideration.

t = the number of whole or partial days elapsed into the current quarter, including the time to the end of the release under consideration (even if the release continues into the next quarter).

$D_{\tau a}$ = the anticipated dose contribution to the total body or any organ τ, due to any planned activities during the next 31-day period, if those activities will result in liquid releases that are in addition to routine liquid effluents. If only routine liquid effluents are anticipated, $D_{\tau a}$ may be set to zero.

2.5.2 Dose Projections for Specific Releases

Dose projections may be performed for a particular release by performing a prerelease dose calculation assuming that the planned release will proceed as anticipated. For individual dose projections due to liquid releases, follow the methodology of Section 2.4, using sample analysis results for the source to be released, and parameter values expected to exist during the release period.

2.6 DEFINITIONS OF LIQUID EFFLUENT TERMS

The following symbolic terms are used in the presentation of liquid effluent calculations in the subsections above.

Term	Definition	Section of Initial Use
A_p =	the adjustment factor used in calculating the effluent monitor setpoint for liquid release pathway p: the ratio of the assured dilution to the required dilution [unitless].	2.3.2.2
ADF =	the assured dilution factor for a planned release [unitless].	2.3.2.2
AF_p =	the dilution allocation factor for liquid release pathway p [unitless].	2.3.2.2
$A_{i\tau}$ =	the site-related adult ingestion dose commitment factor, for the total body or for any organ τ, due to identified radionuclide i [(mrem · mL)/(h · μCi)]. The values of $A_{i\tau}$ are listed in Table 2-8.	2.4.1
B_{iv} =	the crop to soil concentration factor applicable to radionuclide i, [(pCi/kg garden vegetation)/(pCi/kg soil)].	2.4.3
BF_i =	the bioaccumulation factor for radionuclide i for freshwater fish [(pCi/kg)/(pCi/L)]. Values are listed in Table 2-6.	2.4.2
c =	the setpoint of the radioactivity monitor measuring the concentration of radioactivity in the effluent line, prior to dilution and subsequent release [μCi/mL].	2.3.2.1
c_p =	the calculated effluent radioactivity monitor setpoint for liquid release pathway p [μCi/mL].	2.3.2.2
C_a =	the gross concentration of alpha emitters in the liquid waste as measured in the applicable composite sample [μCi/mL].	2.3.2.2
C_{ECL} =	the Effluent Concentration Limit stated in 10 CFR 20, Appendix B, Table 2, Column 2 [μCi/mL].	2.3.2.1
C_f =	the concentration of Fe–55 in the liquid waste as measured in the applicable composite sample [μCi/mL].	2.3.2.2

Term	Definition	Section of Initial Use
C_g =	the concentration of gamma emitter g in the liquid waste as measured by gamma ray spectroscopy performed on the applicable prerelease waste sample [μCi/mL].	2.3.2.2
C_i =	the measured concentration of radionuclide i in a sample of liquid effluent [μCi/mL].	2.3.2.2
C_{il} =	the average concentration of radionuclide i in undiluted liquid effluent during time period l [μCi/mL].	2.4.1
C_{ir} =	the measured concentration of radionuclide i in release pathway r that is contributing to radioactivity in the dilution stream [μCi/mL].	2.3.2.2
C_s =	the concentration of strontium radioisotope s (Sr–89 or Sr-90) in the liquid waste as measured in the applicable composite sample [μCi/mL].	2.3.2.2
C_t =	the concentration of H–3 in the liquid waste as measured in the applicable composite sample [μCi/mL].	2.3.2.2
CF_{iv} =	the concentration factor for radionuclide i in irrigated garden vegetation [(pCi/kg)/(pCi/L)].	2.4.2
D_w =	the dilution factor from the near field of the discharge structure to the potable water intake location [unitless].	2.4.2
D_τ =	the cumulative dose commitment to the total body or to any organ τ, due to radioactivity in liquid effluents released during a given time period [mrem].	2.4.1
$D_{\tau a}$ =	the anticipated dose contribution to the total body or any organ τ, due to any planned activities during the next 31-day period [mrem].	2.5.1
$D_{\tau c}$ =	the cumulative dose to the total body or organ τ, for liquid releases that have occurred in the elapsed portion of the current quarter, plus the release under consideration [mrem].	2.5.1
$D_{\tau p}$ =	the projected dose to the total body or organ τ, for the next 31 days of liquid releases [mrem].	2.5.1

Term	Definition	Section of Initial Use
$DF_{i\tau}$ =	the dose conversion factor for radionuclide i for adults, in organ τ [mrem/pCi]. Values are listed in Table 2-7.	2.4.2
ECL_i =	the liquid Effluent Concentration Limit for radionuclide i from 10 CFR Part 20, Appendix B, Table 2, Column 2 [μCi/mL].	2.3.2.2
f =	the effluent flowrate at the location of the radioactivity monitor [gpm].	2.3.2.1
f_{ap} =	the anticipated actual discharge flowrate for a planned release from liquid release pathway p [gpm].	2.3.2.2
f_l =	the fraction of the year that garden vegetation is irrigated [unitless].	2.4.3
f_{mp} =	the maximum permissible effluent discharge flowrate for release pathway p [gpm].	2.3.2.2
f_r =	the effluent discharge flowrate of release pathway r [gpm].	2.3.2.2
f_t =	the average undiluted liquid waste flowrate actually observed during the period of a liquid release [gpm].	2.4.1
F =	the dilution stream flowrate which can be assured prior to the release point to the UNRESTRICTED AREA [gpm].	2.3.2.1
F_d =	the entire assured dilution flowrate for the plant site during the release period [gpm].	2.3.2.2
F_{dp} =	the dilution flowrate allocated to release pathway p [gpm].	2.3.2.2
F_l =	the near-field average dilution factor in the receiving water of the UNRESTRICTED AREA [unitless].	2.4.1
F_t =	the average dilution stream flowrate actually observed during the period of a liquid release [gpm].	2.4.1
I =	the average irrigation rate during the growing season [L/(m^2 · h)].	2.4.3
L_v =	the water content of leafy garden vegetation edible parts [L/kg].	2.4.3

Term	Definition	Section of Initial Use
M =	the additional river dilution factor from the near field of the discharge structure for the plant site to the point of irrigation water usage [unitless].	2.4.3
P =	the effective surface density of soil [kg/m^2].	2.4.3
r =	the fraction of irrigation-deposited activity retained on the edible portions of leafy garden vegetation.	2.4.3
RDF =	the required dilution factor: the minimum ratio by which liquid effluent must be diluted before reaching the UNRESTRICTED AREA, in order to ensure that the limits of Section 2.1.2 are not exceeded [unitless].	2.3.2.2
RDF_{γ} =	the RDF for a liquid release due only to its concentration of gamma-emitting radionuclides [unitless].	2.3.2.2
$RDF_{n\gamma}$ =	the RDF for a liquid release due only to its concentration of non-gamma-emitting radionuclides [unitless].	2.3.2.2
SF =	the safety factor selected to compensate for statistical fluctuations and errors of measurement [unitless].	2.3.2.2
t =	the number of whole or partial days elapsed into the current quarter, including the time to the end of the release under consideration.	2.5.1
t_b =	the period of long-term buildup of activity in soil [h].	2.4.3
t_e =	the period of leafy garden vegetation exposure during the growing season [h].	2.4.3
t_f =	the transit time from release to receptor for fish consumption [h].	2.4.2
t_h =	the time between harvest of garden vegetation and human consumption [h].	2.4.3
t_w =	the transit time from release to receptor for potable water consumption [h].	2.4.2

Term	Definition	Section of Initial Use
TF =	the tolerance factor selected to allow flexibility in the establishment of a practical monitor setpoint which could accommodate effluent releases at concentrations higher than the ECL values stated in 10 CFR 20, Appendix B, Table 2, Column 2 [unitless]; the tolerance factor must not exceed a value of 10.	2.3.2.1
U_f =	the adult rate of fish consumption [kg/y].	2.4.2
U_v =	the adult consumption rate for irrigated garden vegetation [kg/y].	2.4.2
U_w =	the adult drinking water consumption rate applicable to the plant site [L/y].	2.4.2
Y_v =	the areal density (agricultural productivity) of leafy garden vegetation [kg/m^2].	2.4.3
Z =	the applicable dilution factor for the receiving water body, in the near field of the discharge structure, during the period of radioactivity release [unitless].	2.4.1
Δt_1 =	the length of time period 1, over which C_{i1} and F_1 are averaged for liquid releases [h].	2.4.1
λ_{Ei} =	the effective removal rate for activity deposited on crop leaves [h^{-1}].	2.4.3
λ_i =	the decay constant for radionuclide i [h^{-1}].	2.4.2
λ_w =	the rate constant for removal of activity from plant leaves by weathering [h^{-1}].	2.4.3

CHAPTER 3
GASEOUS EFFLUENTS

3.1 LIMITS OF OPERATION

The following Limits of Operation implement requirements established by Technical Specifications Section 5.0. Terms printed in all capital letters are defined in Chapter 10.

3.1.1 Gaseous Effluent Monitoring Instrumentation Control

In accordance with Technical Specification 5.5.4.a, the radioactive gaseous effluent monitoring instrumentation channels shown in Table 3-1 shall be FUNCTIONAL with their alarm/trip setpoints set to ensure that the limits of Section 3.1.2.a are not exceeded. The alarm/trip setpoints of these channels shall be determined in accordance with Section 3.3.

3.1.1.1 Applicability

These limits apply as shown in Table 3-1.

3.1.1.2 Actions

With a radioactive gaseous effluent monitoring instrumentation channel alarm/trip setpoint less conservative than required by the above control, immediately suspend the release of radioactive gaseous effluents monitored by the affected channel, declare the channel NON-FUNCTIONAL, or restore the setpoint to a value that will ensure that the limits of Section 3.1.2.a are met.

With less than the minimum number of radioactive gaseous effluent monitoring instrumentation channels FUNCTIONAL, take the ACTION shown in Table 3-1. Restore the NON-FUNCTIONAL instrumentation to FUNCTIONAL status within 30 days, or if unsuccessful, explain in the next Radioactive Effluent Release Report, per Technical Specification 5.6.3, why this NON-FUNCTIONALITY was not corrected in a timely manner.

This control does not affect shutdown requirements or MODE changes.

3.1.1.3 Surveillance Requirements

Each radioactive gaseous effluent monitoring instrumentation channel shall be demonstrated FUNCTIONAL by performance of the CHANNEL CHECK, SOURCE CHECK, CHANNEL CALIBRATION and CHANNEL FUNCTIONAL TEST operations at the frequencies shown in Table 3-2.

3.1.1.4 Basis

The radioactive gaseous effluent instrumentation is provided to monitor and control, as applicable, the releases of radioactive materials in gaseous effluents during actual or potential releases of gaseous effluents. The Alarm/Trip Setpoints for these instruments shall be calculated and adjusted in accordance with the methodology and parameters in Section 3.3 to ensure that the alarm/trip will occur prior to exceeding the limits of Section 3.1.2.a. The FUNCTIONALITY and use of this instrumentation is consistent with the requirements of General Design Criteria 60, 63, and 64 of Appendix A to 10 CFR Part 50.

Table 3-1. Radioactive Gaseous Effluent Monitoring Instrumentation

Instrument	FUNCTIONALITY Requirements		
	Minimum Channels FUNCTIONAL	Applicability	ACTION
1. GASEOUS RADWASTE TREATMENT SYSTEM (Common)			
a. Noble Gas Activity Monitor, with Alarm and Automatic Termination of Release (ARE-0014)	1	During releases[a]	45
b. Effluent System Flowrate Measuring Device (AFT-0014)	1	During releases[a]	46
2. Turbine Building Vent (Each Unit)			
a. Noble Gas Activity Monitor (RE-12839C)	1	During releases[a]	47
b. Iodine and Particulate Samplers (RE-12839A & B)	1	During releases[a]	51
c. Flowrate Monitor (FT-12839 or FIS-12862)[b]	1	During releases[a]	46
d. Sampler Flowrate Monitor (1FIT-13211, 2FIT-13211)	1	During releases[a]	46
3. Plant Vent (Each Unit)			
a. Noble Gas Activity Monitor (RE-12442C or RE-12444C)	1	At all times	47,48
b. Iodine Sampler/Monitor (RE-12442B or RE-12444B)	1	At all times	51
c. Particulate Sampler/Monitor (RE-12442A or RE-12444A)	1	At all times	51
d. Flowrate Monitor (FT-12442 or 12835)	1	At all times	46
e. Sampler Flowrate Monitor (FI-12442 or FI-12444N)	1	At all times	46
4. Radwaste Processing Facility Vent (Common)			
a. Particulate Monitor (ARE-16980)	1	During releases[a]	51

a. "During releases" means "During radioactive releases via this pathway."

b. During emergency filtration.

Table 3-1 (contd). Notation for Table 3-1 — ACTION Statements

ACTION 45 — With the number of channels FUNCTIONAL less than required by the Minimum Channels FUNCTIONAL requirement, the contents of the tank(s) may be released to the environment for up to 14 days provided that prior to initiating the release:

a. The local radiation monitor reading (if functional) is recorded at least once per 12 hours or at least two independent samples of the tank's contents are analyzed, and

b. At least two technically qualified members of the Facility Staff independently verify the discharge line valving, and verify the release rate calculations.

Otherwise, suspend release of radioactive effluents via this pathway.

ACTION 46 — With the number of channels FUNCTIONAL less than required by the Minimum Channels FUNCTIONAL requirement, effluent releases via this pathway may continue provided the flowrate is estimated at least once per 4 hours.

ACTION 47 — With the number of channels FUNCTIONAL less than required by the Minimum Channels FUNCTIONAL requirement, effluent releases via this pathway may continue provided the local radiation monitor reading (if functional) is recorded at least once per 12 hours or grab samples are taken at least once per 12 hours and these samples are analyzed for radioactivity within 24 hours. With the plant vent radiation monitor iodine and particulate channels NON-FUNCTIONAL during the loss of sample line heat tracing, the noble gas channel of RE-12442 and RE-12444 would still be considered valid.

ACTION 48 — With the number of channels FUNCTIONAL less than required by the Minimum Channels FUNCTIONAL requirement, record the local radiation monitor reading (if functional) for RE-2565C at least once per 12 hours or immediately suspend containment purging of radioactive effluents via this pathway.

ACTION 49 — (Not Used)

ACTION 50 — (Not Used)

ACTION 51 — With the number of channels FUNCTIONAL less than required by the Minimum Channels FUNCTIONAL requirement, effluent releases via the affected pathway may continue provided one of the following options is available (1) the local radiation monitor reading (if functional) is recorded at least once per 12 hours (2) samples are continuously collected with the installed skid or (3) samples are continuously collected with auxiliary sampling equipment. RE-12444A and B may be verified functional by recording local radiation monitor skid flow once per 12 hours. With the plant vent radiation monitor particulate and iodine channels NON-FUNCTIONAL during the loss of sample line heat tracing, estimate radioactive releases for up to 48 hours while continuing to monitor noble gas activity from RE-12442 and RE-12444.

Table 3-2. Radioactive Gaseous Effluent Monitoring Instrumentation Surveillance Requirements

Instrument	Surveillance Requirements				
	CHANNEL CHECK	SOURCE CHECK	CHANNEL CALIBRATION	CHANNEL FUNCTIONAL TEST	MODES[c]
1. GASEOUS RADWASTE TREATMENT SYSTEM (Common)					
a. Noble Gas Activity Monitor, with Alarm and Automatic Termination of Release (ARE-0014)	P	P	R[b]	R[a(1)]	During Release
b. Effluent System Flowrate Measuring Device (AFT-0014)	P	NA	R	NA	During Release
2. Turbine Building Vent (Each Unit)					
a. Noble Gas Activity Monitor (RE-12839C)	M	SA	R[b]	R[a(2)]	During Release
b. Iodine and Particulate Samplers (RE-12839A&B)	M[d]	NA	NA	NA	During Release
c. Flowrate Monitor (FT-12839 or FIS-12862)	M	NA	R	NA	During Release
d. Sampler Flowrate Monitor (1FIT-13211, 2FIT-13211)	M	NA	R	Q	During Release
3. Plant Vent (Each Unit)					
a. Noble Gas Activity Monitor (RE-12442C or RE-12444C)	M	SA	R[b]	R[a(2)]	All
b. Particulate and Iodine Monitors (RE-12442A&B)	M[d]	NA	R	R[a(2)]	All
c. Particulate and Iodine Samplers (RE–12444A&B)	M[d]	NA	NA	NA	All
d. Flowrate Monitor (FT-12442 or 12835)	M	NA	R	NA	All
e. Sampler Flowrate Monitor (FI-12442 or FI–12444N)	M	NA	R	Q	All
4. Radwaste Processing Facility Vent (Common)					
a. Particulate Monitor (ARE-16980)	M[d]	SA	R[e]	N/A	During Release

Table 3-2 (contd). Notation for Table 3-2

a. In addition to the basic functions of a CHANNEL FUNCTIONAL TEST (Section 10.2):

(1) The CHANNEL FUNCTIONAL TEST shall also demonstrate that automatic isolation of this pathway and control room annunciation occurs (for item a. below only); and control room CRT indication occurs (if any of the following conditions exist):

(a) Instrument indicates measured levels above the alarm/trip setpoint;

(b) Instrument indicates an “Equipment Trouble” alarm;

(c) Instrument indicates a “Low” alarm; or

(d) Instrument indicates channel “Deactivated.”

(2) The CHANNEL FUNCTIONAL TEST shall also demonstrate that control room annunciation occurs (for item a. below only); and that control room CRT indication occurs (if any of the following conditions exist):

(a) Instrument indicates measured levels above the alarm/trip setpoint;

(b) Instrument indicates an “Equipment Trouble” alarm;

(c) Instrument indicates a “Low” alarm; or

(d) Instrument indicates channel “Deactivated.” ("Loss of counts" for ARE-16980 only)

b. The initial CHANNEL CALIBRATION shall be performed using one or more of the reference standards certified by the National Institute of Standards and Technology, or using standards that have been obtained from suppliers that participate in measurement assurance activities with NIST. These standards shall permit calibrating the system over its intended range of energy and measurement range. For any subsequent CHANNEL CALIBRATION, sources that have been related to the initial calibration shall be used.

c. MODES in which surveillance is required. “All” means “At all times.” “During release” means “During radioactive release via this pathway.”

d. The channel check shall consist of visually verifying that the collection device (i.e., particulate filter or charcoal cartridge, etc.) is in place for sampling.

e. The CHANNEL CALIBRATION verifies proper operation of the CHANNEL FUNCTIONAL TEST requirements described in Notation a(2) above.

3.1.2 Gaseous Effluent Dose Rate Control

In accordance with Technical Specifications 5.5.4.c and 5.5.4.g, the licensee shall conduct operations so that the dose rates due to radioactive materials released in gaseous effluents from the site to areas at and beyond the SITE BOUNDARY are limited as follows:

a. For noble gases: Less than or equal to a dose rate of 500 mrem/y to the total body and less than or equal to a dose rate of 3000 mrem/y to the skin, and

b. For Iodine-131, Iodine-133, tritium, and for all radionuclides in particulate form with half-lives greater than 8 days: Less than or equal to a dose rate of 1500 mrem/y to any organ.

3.1.2.1 Applicability

This limit applies at all times.

3.1.2.2 Actions

With a dose rate due to radioactive material released in gaseous effluents exceeding the limit stated in Section 3.1.2, immediately decrease the release rate to within the stated limit.

These limits do not affect shutdown requirements or MODE changes.

3.1.2.3 Surveillance Requirements

The dose rates due to radioactive materials in areas at or beyond the SITE BOUNDARY due to releases of gaseous effluents shall be determined to be within the above limits, in accordance with the methods and procedures in Section 3.4.1, by obtaining representative samples and performing analyses in accordance with the sampling and analysis program specified in Table 3-3.

3.1.2.4 Basis

This control is provided to ensure that gaseous effluent dose rates will be maintained within the limits that historically have provided reasonable assurance that radioactive material discharged in gaseous effluents will not result in a dose to a MEMBER OF THE PUBLIC in an UNRESTRICTED AREA, either within or outside the SITE BOUNDARY, exceeding the limits specified in Appendix I of 10 CFR Part 50, while allowing operational flexibility for effluent releases. For MEMBERS OF THE PUBLIC who may at times be within the SITE BOUNDARY, the occupancy of the MEMBER OF THE PUBLIC will be sufficiently low to compensate for any increase in the atmospheric diffusion factor above that for the SITE BOUNDARY.

The dose rate limit for Iodine-131, Iodine-133, tritium, and radionuclides in particulate form with half-lives greater than 8 days specifically applies to dose rates to a child via the inhalation pathway.

This control applies to the release of gaseous effluents from all reactors at the site.

Table 3-3. Radioactive Gaseous Waste Sampling and Analysis Program

Gaseous Release Type	Sampling and Analysis Requirements[a]			
	Sampling FREQUENCY	Minimum Analysis FREQUENCY	Type of Activity Analysis	MINIMUM DETECTABLE CONCENTRATION (MDC) (μCi/mL)
Waste Gas Decay Tank (Common)	P Each Tank Grab Sample	P Each Tank	Noble Gas PRINCIPAL GAMMA EMITTERS	1 E-4
Containment Purge 24" or 14" (Each Unit)	P[c] Each Purge Grab Sample	P[c] Each Purge	Noble Gas PRINCIPAL GAMMA EMITTERS	1 E-4
		M	H-3 (Oxide)	1 E-6
Plant Vent (Each Unit)	M[c,d,f] Grab Sample	M[c]	Noble Gas PRINCIPAL GAMMA EMITTERS	1 E-4
			H-3 (Oxide)	1 E-6
Condenser Air Ejector & Steam Packing Exhaust (Each Unit)[b]	M Grab Sample	M	Noble Gas PRINCIPAL GAMMA EMITTERS	1 E-4
			H-3 (Oxide)	1 E-6
Plant Vent, Condenser Air Ejector & Steam Packing Exhaust (Each Unit)[b]	CONTINUOUS[g]	W[e] Charcoal or Silver Zeolite Sample	I-131	1 E-12
	CONTINUOUS[g]	W[e] Particulate Sample	Particulate PRINCIPAL GAMMA EMITTERS	1 E-11
	CONTINUOUS[g]	M COMPOSITE Particulate Sample	Gross Alpha	1 E-11
	CONTINUOUS[g]	Q COMPOSITE Particulate Sample	Sr-89, Sr-90	1 E-11
Radwaste Processing Facility Vent (Common)	CONTINUOUS[g]	W[h] Particulate Sample	Particulate PRINCIPAL GAMMA EMITTERS	1 E-11

Table 3-3 (contd). Notation for Table 3-3

a. Terms printed in all capital letters are defined in Chapter 10.

b. The turbine building vent is the release point for the condenser air ejector and steam packing exhaust. All sampling and analyses may be omitted for this vent, provided the absence of a primary to secondary leak has been demonstrated, that is, if the gamma activity in the secondary water does not exceed background by more than 20%.

c. Sampling and analysis shall also be performed following shutdown, startup, or a THERMAL POWER change exceeding 15% of the RATED THERMAL POWER within a one-hour period. This requirement does not apply if (1) analysis shows that the DOSE EQUIVALENT I–131 concentration in the primary coolant has not increased more than a factor of 3; and (2) the noble gas monitor shows that effluent activity has not increased more than a factor of 3.

d. Tritium grab samples shall be taken at least once per 24 hours when the refueling cavity is flooded.

e. Samples shall be changed at least once per 7 days and analyses shall be completed within 48 hours after changing (or after removal from sampler). Sampling shall also be performed at least once per 24 hours for at least 7 days following each shutdown, startup, or THERMAL POWER change exceeding 15% of RATED THERMAL POWER in one hour, and analyses shall be completed within 48 hours of changing. When samples collected for 24 hours are analyzed, the corresponding MDC may be increased by a factor of 10. This requirement does not apply if (1) analysis shows that the DOSE EQUIVALENT I–131 concentration in the primary coolant has not increased more than a factor of 3; and (2) the noble gas monitor shows that effluent activity has not increased more than a factor of 3.

f. Tritium grab samples shall be taken at least once per 7 days from the Unit 1 plant vent, whenever spent fuel is in the spent fuel pool (Unit 1 plant vent only).

g. The ratio of the sample flowrate to the sampled stream flowrate shall be known for the time period covered by each dose or dose rate calculation made in accordance with controls specified in Sections 3.1.2, 3.1.3, and 3.1.4.

h. Samples shall be changed at least once per 7 days and analyses shall be completed within 48 hours after changing (or removal of sampler).

3.1.3 Gaseous Effluent Air Dose Control

In accordance with Technical Specifications 5.5.4.e and 5.5.4.h, the air dose due to noble gases released in gaseous effluents, from each reactor unit, to areas at and beyond the SITE BOUNDARY shall be limited to the following:

a. During any calendar quarter: Less than or equal to 5 mrad for gamma radiation and less than or equal to 10 mrad for beta radiation, and

b. During any calendar year: Less than or equal to 10 mrad for gamma radiation and less than or equal to 20 mrad for beta radiation.

3.1.3.1 Applicability

This limit applies at all times.

3.1.3.2 Actions

With the calculated air dose from radioactive noble gases in gaseous effluents exceeding any of the above limits, prepare and submit to the Nuclear Regulatory Commission within 30 days a special report which identifies the cause(s) for exceeding the limit(s); defines the corrective actions that have been taken to reduce the releases; and defines the proposed corrective actions to be taken to assure that subsequent releases of radioactive noble gases in gaseous effluents will be in compliance with the limits of Section 3.1.3.

This control does not affect shutdown requirements or MODE changes.

3.1.3.3 Surveillance Requirements

Cumulative air dose contributions from noble gas radionuclides released in gaseous effluents from each unit to areas at and beyond the SITE BOUNDARY, for the current calendar quarter and current calendar year, shall be determined in accordance with Section 3.4.2 at least once per 31 days.

3.1.3.4 Basis

This control is provided to implement the requirements of Sections II.B, III.A and IV.A of Appendix I, 10 CFR Part 50. Section 3.1.3 implements the guides set forth in Section II.B of Appendix I. The ACTION statements in Section 3.1.3.2 provide the required operating flexibility and at the same time implement the guides set forth in Section IV.A of Appendix I, assuring that the releases of radioactive material in gaseous effluents to UNRESTRICTED AREAS will be kept “as low as is reasonably achievable.” The Surveillance requirements in Section 3.1.3.3 implement the requirements in Section III.A of Appendix I, which require that conformance with the guides of Appendix I be shown by calculational procedures based on models and data such that the actual exposure of a MEMBER OF THE PUBLIC through appropriate pathways is unlikely to be substantially underestimated. The dose calculations established in Section 3.4.2 for calculating the doses due to the actual releases of noble gases in gaseous effluents are consistent with the methodology provided in Regulatory Guide 1.109 (Reference 3), and Regulatory Guide 1.111 (Reference 5). The equations in Section 3.4.2 provided for determining the air doses at the SITE BOUNDARY are based upon the historical annual average atmospheric conditions.

3.1.4 Control on Gaseous Effluent Dose to a Member of the Public

In accordance with Technical Specifications 5.5.4.e and 5.5.4.i, the dose to a MEMBER OF THE PUBLIC from I–131, I–133, tritium, and all radionuclides in particulate form with half-lives greater than 8 days in gaseous effluents released, from each reactor unit, to areas at and beyond the SITE BOUNDARY shall be limited to the following:

a. During any calendar quarter: Less than or equal to 7.5 mrem to any organ, and

b. During any calendar year: Less than or equal to 15 mrem to any organ.

3.1.4.1 Applicability

This limit applies at all times.

3.1.4.2 Actions

With the calculated dose from the release of I-131, I-133, tritium, or radionuclides in particulate form with half-lives greater than 8 days, in gaseous effluents exceeding any of the above limits, prepare and submit to the Nuclear Regulatory Commission within 30 days a special report which identifies the cause(s) for exceeding the limit; defines the corrective actions that have been taken to reduce the releases of radioiodines and radionuclides in particulate form with half-lives greater than 8 days in gaseous effluents; and defines proposed corrective actions to assure that subsequent releases will be in compliance with the limits stated in Section 3.1.4.

This control does not affect shutdown requirements or MODE changes.

3.1.4.3 Surveillance Requirements

Cumulative organ dose contributions to a MEMBER OF THE PUBLIC from I–131, I–133, tritium, and radionuclides in particulate form with half-lives greater than 8 days released in gaseous effluents from each unit to areas at and beyond the SITE BOUNDARY, for the current calendar quarter and current calendar year, shall be determined in accordance with Section 3.4.3 at least once per 31 days.

3.1.4.4 Basis

This control is provided to implement the requirements of Section II.C, III.A and IV.A of Appendix I, 10 CFR Part 50. The limits stated in Section 3.1.4 are the guides set forth in Section II.C of Appendix I. The ACTION statements in Section 3.1.4.2 provide the required operating flexibility and at the same time implement the guides set forth in Section IV.A of Appendix I to assure that the releases of radioactive materials in gaseous effluents to UNRESTRICTED AREAS will be kept "as low as is reasonably achievable." The calculational methods specified in the Surveillance Requirements of Section 3.1.4.3 implement the requirements in Section III.A of Appendix I that conformance with the guides of Appendix I be shown by calculational procedures based on models and data, such that the actual exposure of a MEMBER OF THE PUBLIC through appropriate pathways is unlikely to be substantially underestimated. The calculational methods in Section 3.4.3 for calculating the doses due to the actual releases of the subject materials are consistent with the methodology provided in Regulatory Guide 1.109 (Reference 3), and Regulatory Guide 1.111 (Reference 5). These equations provide for determining the actual doses based upon the historical annual average atmospheric conditions. The release specifications for radioiodines, radioactive materials in particulate form and radionuclides other than noble gases are dependent on the existing radionuclide pathways to man, in the areas at and beyond the SITE BOUNDARY. The pathways which were examined in the development of these calculations were: 1) individual inhalation of airborne radionuclides, 2) deposition of radionuclides onto green leafy garden vegetation with subsequent consumption by man, 3) deposition onto grassy areas where milk animals and meat producing animals graze with consumption of the milk and meat by man, and 4) deposition on the ground with subsequent exposure of man.

3.1.5 Gaseous Radwaste Treatment System Control

In accordance with Technical Specification 5.5.4.f, the GASEOUS WASTE PROCESSING SYSTEM and the VENTILATION EXHAUST TREATMENT SYSTEM shall be FUNCTIONAL. The appropriate portions of the GASEOUS WASTE PROCESSING SYSTEM and the VENTILATION EXHAUST TREATMENT SYSTEM shall be used to reduce radioactive materials in gaseous wastes prior to their discharge when the projected doses in 31 days due to gaseous effluent releases, from each reactor unit, to areas at and beyond the SITE BOUNDARY would exceed 0.2 mrad to air from gamma radiation, 0.4 mrad to air from beta radiation, or 0.3 mrem to any organ of a MEMBER OF THE PUBLIC.

3.1.5.1 Applicability

These limits apply at all times.

3.1.5.2 Actions

With gaseous waste being discharged without treatment and in excess of the limits in Section 3.1.5, prepare and submit to the Nuclear Regulatory Commission within 30 days a special report which includes the following information:

a. Identification of any NON-FUNCTIONAL equipment or subsystem and the reason for NON-FUNCTIONALITY,

b. Action(s) taken to restore the NON-FUNCTIONAL equipment to FUNCTIONAL status, and

c. Summary description of action(s) taken to prevent a recurrence.

This control does not affect shutdown requirements or MODE changes.

3.1.5.3 Surveillance Requirements

Doses due to gaseous releases from each unit to areas at and beyond the SITE BOUNDARY shall be projected at least once per 31 days, in accordance with Section 3.5.1, when the GASEOUS WASTE PROCESSING SYSTEM or the VENTILATION EXHAUST TREATMENT SYSTEM is not being fully utilized.

The GASEOUS WASTE PROCESSING SYSTEM and the VENTILATION EXHAUST TREATMENT SYSTEM shall be demonstrated FUNCTIONAL:

by meeting the controls of Sections 3.1.2, and either 3.1.3 (for the GASEOUS WASTE PROCESSING SYSTEM) or 3.1.4 (for the VENTILATION EXHAUST TREATMENT SYSTEM).

3.1.5.4 Basis

The FUNCTIONALITY of the GASEOUS WASTE PROCESSING SYSTEM ensures that the system will be available for use whenever gaseous effluents require treatment prior to release to the environment. The requirement that the appropriate portions of this system be used, when specified, provides reasonable assurance that the releases of radioactive materials in gaseous effluents will be kept "as low as is reasonably achievable." This control implements the requirements of 10 CFR Part 50.36a, General Design Criterion 60 of Appendix A to 10 CFR Part 50, and the design objectives given in Section II.D of Appendix I to 10 CFR Part 50. The specified limits governing the use of appropriate portions of the system were specified as a suitable fraction of the dose design objectives set forth in Section II.B and II.C of Appendix I, 10 CFR Part 50, for gaseous effluents.

This control applies to the release of radioactive materials in gaseous effluents from each unit at the site. For units with shared radwaste treatment systems, the gaseous effluents from the shared system are proportioned among the units sharing that system.

3.1.6 Major Changes to Gaseous Radioactive Waste Treatment Systems

Licensee initiated MAJOR CHANGES TO GASEOUS RADIOACTIVE WASTE TREATMENT SYSTEMS:

a. Shall be reported to the Nuclear Regulatory Commission in the Radioactive Effluents Release Report for the period in which the change was implemented. The discussion of each change shall contain the information described in Section 7.2.2.7.

b. Shall become effective upon review by the Plant Review Board and approval by the Plant Manager.

3.2 GASEOUS WASTE PROCESSING SYSTEM

At Plant Vogtle, there are five potential points where radioactivity may be released to the atmosphere in gaseous discharges. These five *potential* release pathways are the Unit 1 and Unit 2 Plant Vents; the Unit 1 and Unit 2 Turbine Building Vents; and the Radwaste Processing Facility Vent. However, the Turbine Building Vents are not normal release pathways unless a primary-to-secondary leak exists. The Radwaste Processing Facility Vent is not a normal release pathway unless a spill occurs. The figures on the following pages give schematic diagrams of the Gaseous Waste Treatment System and the Ventilation Exhaust Treatment Systems (Reference 11).

The Unit 1 Plant Vent release pathway includes two release sources that are common to the two units: ventilation air from the Fuel Handling Building, and discharges from the GASEOUS WASTE PROCESSING SYSTEM. Otherwise, discharges from the two reactor units are separated. Reactor Containment Building ventilation releases are through the respective plant vents. The Turbine Building Vent serves as the discharge point for both the condenser air ejector and the steam packing exhauster system. The Radwaste Processing Facility Vent includes sources from the Radwaste Processing Facility Process area.

Releases from the two Turbine Building Vents and the Radwaste Processing Facility Vent are considered to be ground-level releases, whereas releases from the two Plant Vents are considered mixed-mode releases. Chapter 8 discusses the calculation of atmospheric dispersion parameters using the ground-level and mixed-mode (i.e., split-wake) models. All five potential release pathways are considered to be continuous (as opposed to batch) in nature.

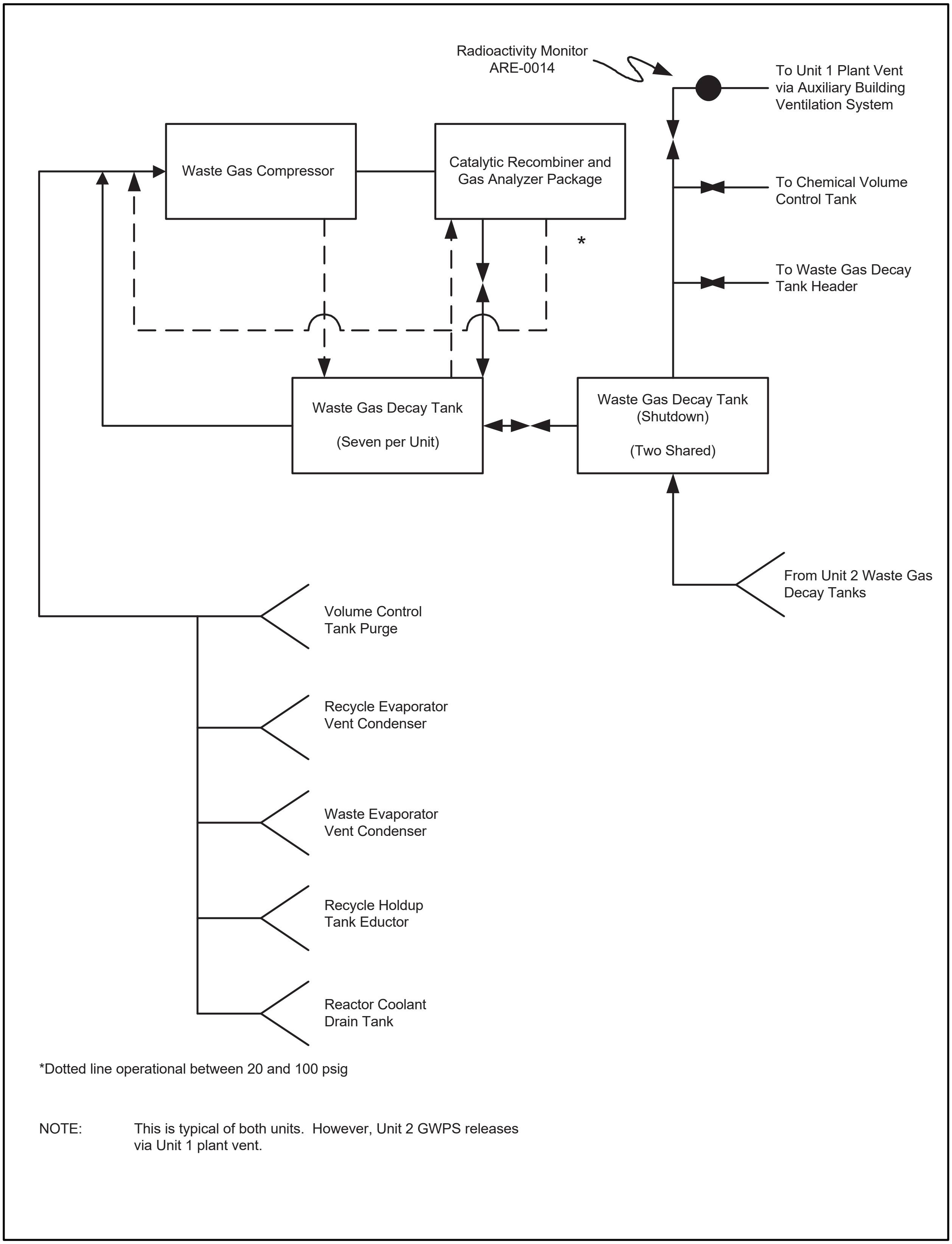
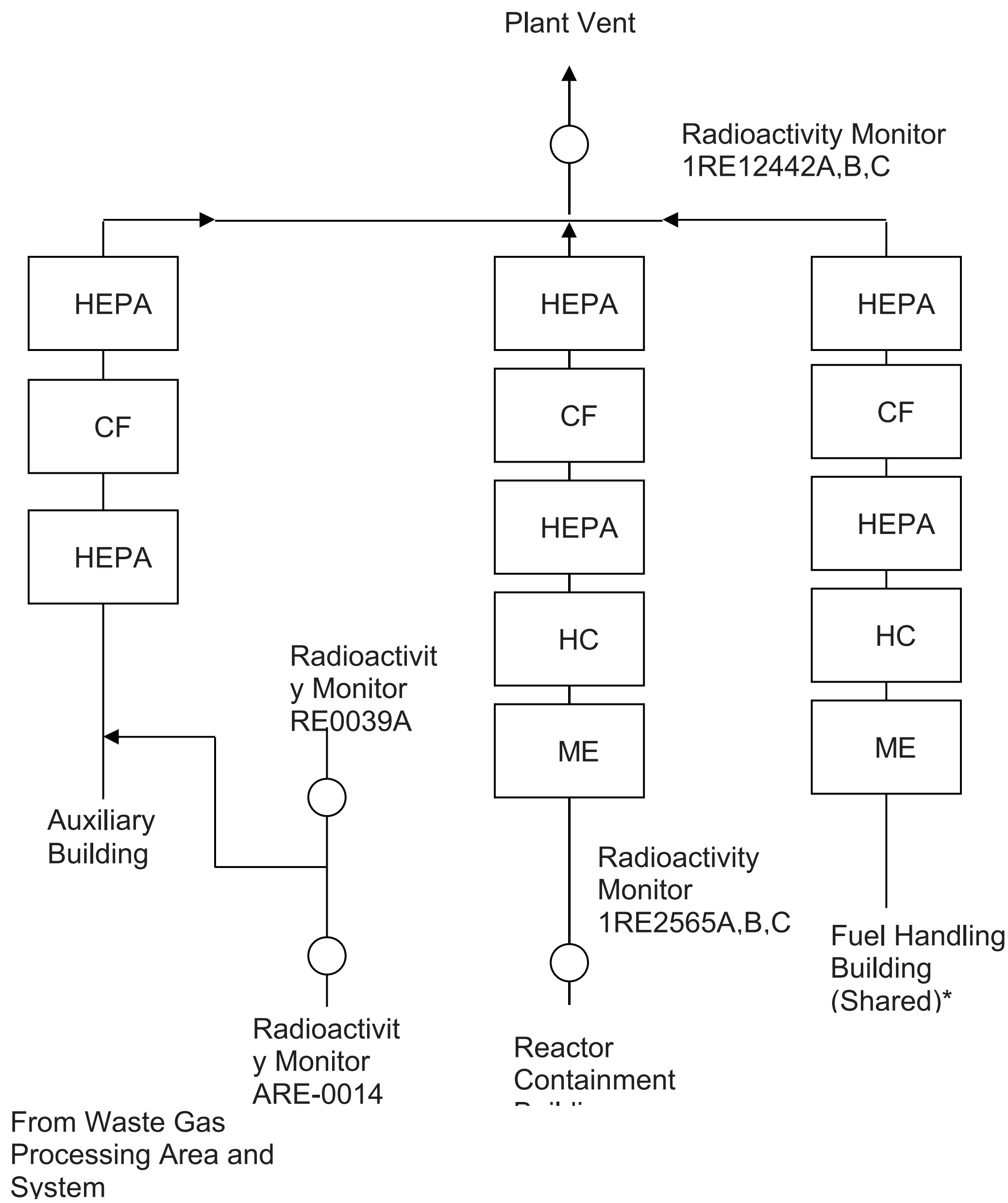


Figure 3-1. Schematic Diagram of the Gaseous Radwaste Treatment System



HEPA - High-Efficiency Particulate Air Filter
CF - Activated Charcoal Filter
HC - Heating Coil
ME - Moisture Eliminator

* Prior to treatment by the Fuel Handling Building Ventilation Exhaust Treatment System, Exhaust from Unit 1 Spent Fuel Pool Area is monitored by ARE2532B and ARE2533B; exhaust from Unit 2 Spent Fuel Pool Area is monitored by ARE2532A and ARE2533A.

Figure 3-2. Schematic Diagram of the Unit 1 Plant Vent Release Pathway

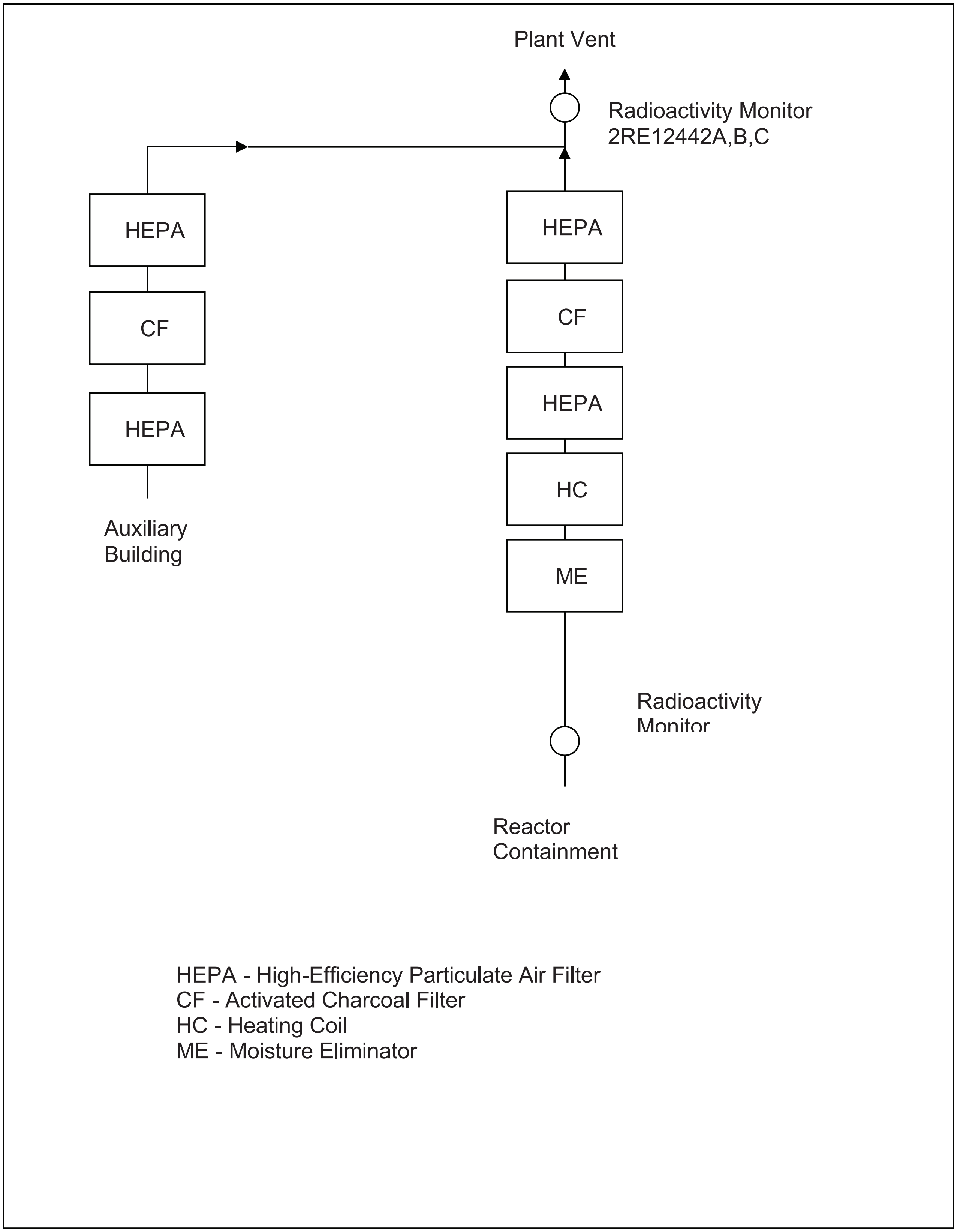
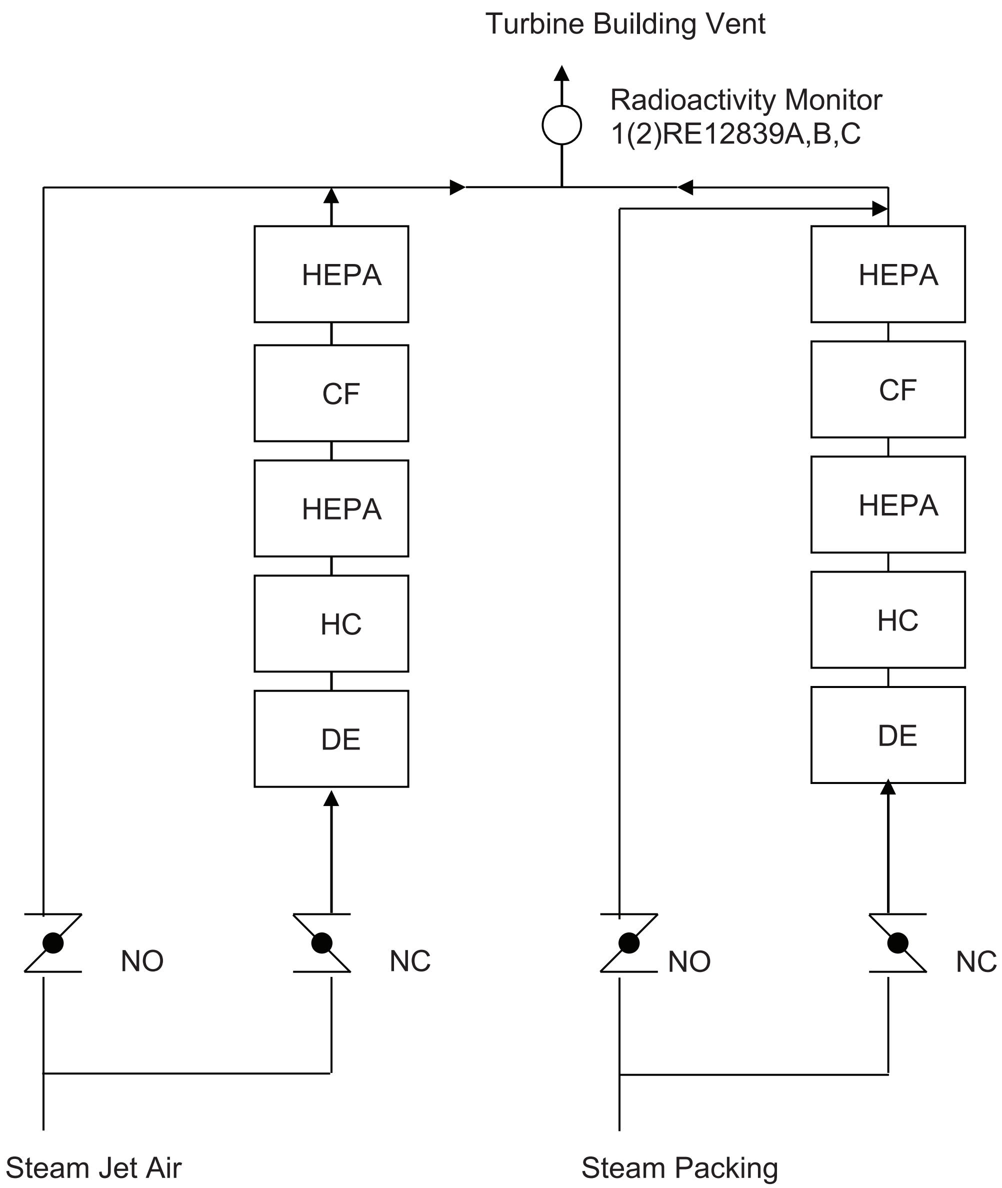


Figure 3-3. Schematic Diagram of the Unit 2 Plant Vent Release Pathway



HEPA - High-Efficiency Particulate Air Filter
CF - Activated Charcoal Filter
HC - Heating Coil
DE - Demister
NO - Normally Open
NC - Normally Closed

NOTE: This is typical of both units.

Figure 3-4. Schematic Diagram of the Turbine Building Vent Release Pathway (Typical of Both Units)

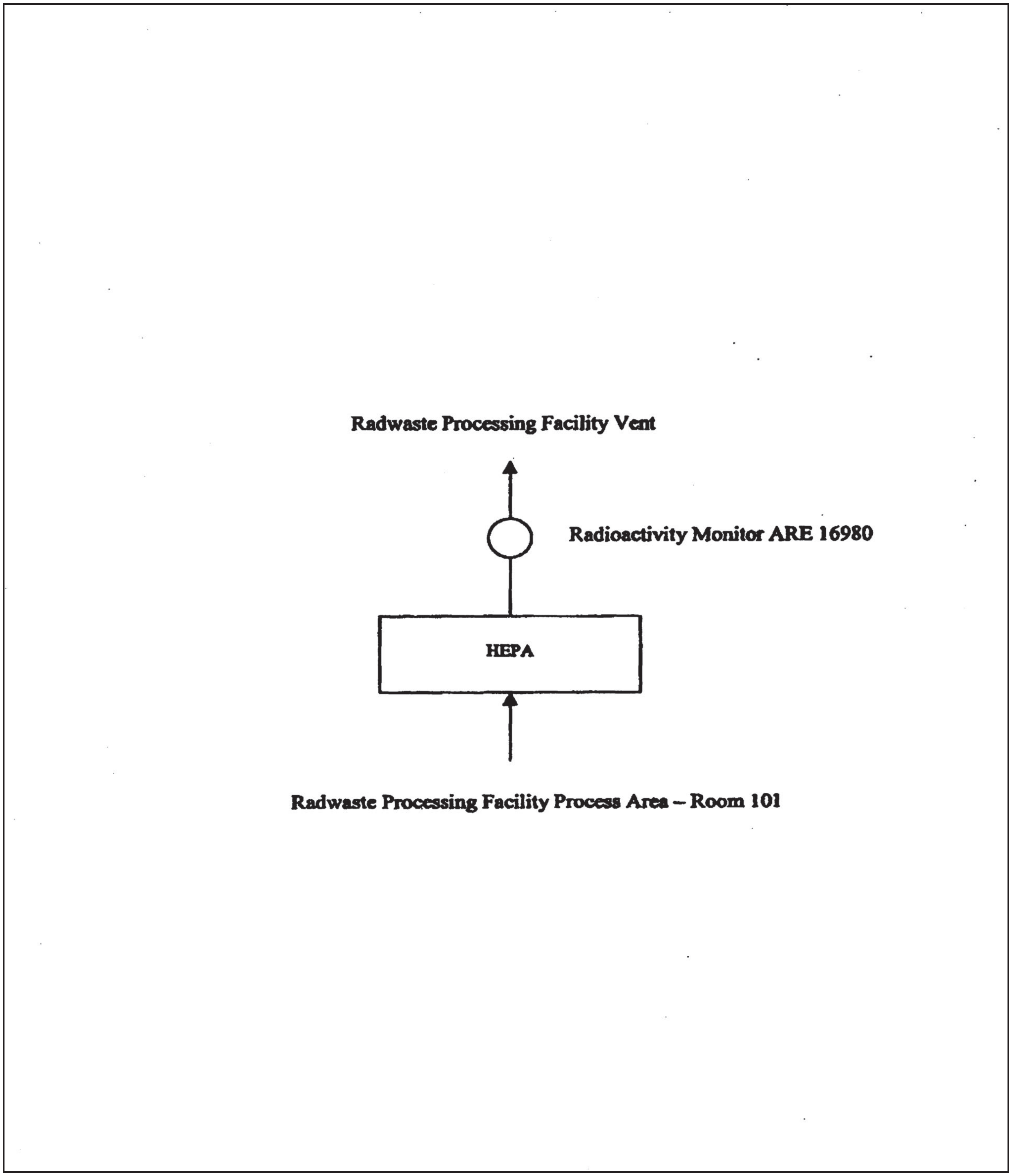


Figure 3-5. Schematic Diagram of the Radwaste Processing Facility Ventilation Release Pathway

3.3 GASEOUS EFFLUENT MONITOR SETPOINTS

3.3.1 General Provisions Regarding Noble Gas Monitor Setpoints

Noble gas radioactivity monitor setpoints calculated in accordance with the methodology presented in this section are intended to ensure that the limits of Section 3.1.2.a are not exceeded. They will be regarded as upper bounds for the actual high alarm setpoints. That is, a lower high alarm setpoint may be established or retained on the monitor, if desired. Intermediate level setpoints should be established at an appropriate level to give sufficient warning prior to reaching the high alarm setpoint.

If no release is planned for a given pathway, or if there is no detectable activity in the gaseous stream being evaluated for release, the setpoint should be calculated in accordance with the methods presented below, based on an assumed concentration of Kr-88 that leads to a practical setpoint. A practical setpoint in this context is one which prevents spurious alarms, and yet produces an alarm should a significant inadvertent release occur.

Section 3.1.1 establishes the requirements for gaseous effluent monitoring instrumentation, and Section 3.2 describes the VENTILATION EXHAUST TREATMENT SYSTEM and the GASEOUS WASTE PROCESSING SYSTEM. From those Sections, it can be seen that certain monitors are located on final release pathways, that is, streams that are being monitored immediately before being discharged from the plant; the setpoint methodology for these monitors is presented in Section 3.3.2. Other monitors are located on source streams, that is, streams that merge with other streams prior to passing a final monitor and being discharged; the setpoint methodology for these monitors is presented in Section 3.3.3. Table 3-4 identifies which of these setpoint methodologies applies to each monitor. Some additional monitors with special setpoint requirements are discussed in Section 3.3.5.

As established in Section 3.1.1, gaseous effluent monitor setpoints are *required* only for the noble gas monitors on certain potential release streams: the two Plant Vents, the two Turbine Building Vents, and the GASEOUS WASTE PROCESSING SYSTEM discharge. However, because of the potential significance of releases from other sources, Section 3.3 discusses setpoint methodologies for certain additional monitors, as well.

Table 3-4. Applicability of Gaseous Monitor Setpoint Methodologies

Final Release Pathways with no Monitored Source Streams

Setpoint Method: Section 3.3.2
Release Elevation: Ground-level

Unit 1 or Unit 2 Turbine Building Vent

Monitor: 1RE-12839C/2RE-12839C
Maximum Flowrate: 900 cfm (4.25 E+05 mL/s)

Final Release Pathways with One or More Monitored Source Streams

Release Elevation: Mixed-Mode

Unit 1 Plant Vent

Monitors: 1RE-12442C, 1RE-12444C
Maximum Flowrate: 187,000 cfm (8.83 E+07 mL/s)
Setpoint Method: Section 3.3.2
Release Type: CONTINUOUS

Source Stream: Unit 1 Reactor Containment Purge

Monitor: 1RE-2565C
Maximum Flowrate: release-dependent
Setpoint Method: Section 3.3.3
Release Type: BATCH

Source Stream: Gaseous Waste Treatment System

Monitor: ARE-0014
Maximum Flowrate: release-dependent
Setpoint Method: Section 3.3.3
Release Type: BATCH

Unit 2 Plant Vent

Monitors: 2RE-12442C, 2RE-12444C
Maximum Flowrate: 112,500 cfm (5.31 E+07 mL/s)
Setpoint Method: Section 3.3.2
Release Type: CONTINUOUS

Source Stream: Unit 2 Reactor Containment Purge

Monitor: 2RE-2565C
Maximum Flowrate: release-dependent
Setpoint Method: Section 3.3.3
Release Type: BATCH

$(\overline{X/Q})_{vb}$ Values for Use in Setpoint Calculations

Ground-Level Releases: 2.55×10^{-6} s/m^3 [NE Sector]

Mixed-Mode Releases: 4.62×10^{-7} s/m^3 [NE Sector]

Maximum flowrate values are from Reference 11, Table 11.5.2-1 and Table 11.5.5-1.

3.3.2 Setpoint for the Final Noble Gas Monitor on Each Release Pathway

3.3.2.1 Overview of Method

Gaseous effluent radioactivity monitors are intended to alarm prior to exceeding the limits of Section 3.1.2.a. Therefore, their alarm setpoints are established to ensure compliance with the following equation:

$$c = \text{the lesser of} \begin{cases} AG \cdot SF \cdot X \cdot R_t \\ AG \cdot SF \cdot X \cdot R_k \end{cases} \qquad \textbf{(3.1)}$$

where:

c = the setpoint, in μCi/mL, of the radioactivity monitor measuring the concentration of radioactivity in the effluent line prior to release. The setpoint represents a concentration which, if exceeded, could result in dose rates exceeding the limits of Section 3.1.2.a at or beyond the SITE BOUNDARY.

AG = an administrative allocation factor applied to divide the release limit among all the gaseous release pathways at the site.

SF = the safety factor selected to compensate for statistical fluctuations and errors of measurement.

X = the noble gas concentration for the release under consideration.

R_t = the ratio of the dose rate limit for the total body, 500 mrem/y, to the dose rate to the total body for the conditions of the release under consideration.

R_k = the ratio of the dose rate limit for the skin, 3000 mrem/y, to the dose rate to the skin for the conditions of the release under consideration.

Equation (3.1) shows the relationships of the critical parameters that determine the setpoint. However, in order to apply the methodology presented in the equation to a mixture of noble gas radionuclides, radionuclide-specific concentrations and dose factors must be taken into account under conditions of maximum flowrate for the release point and annual average meteorology.

The basic setpoint method presented below is applicable to the radioactivity monitor nearest the point of release for the release pathway. For monitors measuring the radioactivity in source streams that merge with other streams prior to subsequent monitoring and release, the modifications presented in Section 3.3.3 must be applied.

3.3.2.2 Setpoint Calculation Steps

Step 1: Determine the concentration, X_{iv}, of each noble gas radionuclide i in the gaseous stream v being considered for release, in accordance with the sampling and analysis requirements of Section 3.1.2. Then sum these concentrations to determine the total noble gas concentration, $\sum_i X_{iv}$.

Step 2: Determine R_t, the ratio of the dose rate limit for the total body, 500 mrem/y, to the total body dose rate due to noble gases detected in the release under consideration, as follows:

$$R_t = \frac{500}{\overline{(X/Q)}_{vb} \sum_i \left[K_i \cdot Q_{iv}\right]} \quad \textbf{(3.2)}$$

where:

500 = the dose rate limit for the total body, 500 mrem/y.

$\overline{(X/Q)}_{vb}$ = the highest annual average relative concentration at the SITE BOUNDARY for the discharge point of release pathway v. Table 3-4 includes an indication of what release elevation is applicable to each release pathway; release elevation determines the appropriate value of $\overline{(X/Q)}_{vb}$.

K_i = the total-body dose factor due to gamma emissions from noble gas radionuclide i, in (mrem/y)/(μCi/m^3), from Table 3-5.

Q_{iv} = the release rate of noble gas radionuclide i from the release pathway under consideration, in μCi/s, calculated as the product of X_{iv} and f_{av}, where:

X_{iv} = the concentration of noble gas radionuclide i for the particular release, in μCi/mL.

f_{av} = the maximum anticipated flowrate for release pathway v during the period of the release under consideration, in mL/s.

Step 3: Determine R_k, the ratio of the dose rate limit for the skin, 3000 mrem/y, to the skin dose rate due to noble gases detected in the release under consideration, as follows:

$$R_k = \frac{3000}{\overline{(X/Q)}_{vb} \sum_i \left[\left(L_i + 1.1M_i\right) \cdot Q_{iv}\right]} \quad \textbf{(3.3)}$$

where:

3000 = the dose rate limit for the skin, 3000 mrem/y.

L_i = the skin dose factor due to beta emissions from noble gas radionuclide i, in (mrem/y)/(μCi/m3), from Table 3-5.

M_i = the air dose factor due to gamma emissions from noble gas radionuclide i, in (mrad/y)/(μCi/m3), from Table 3-5.

1.1 = the factor to convert air dose in mrad to skin dose in mrem.

All other terms were defined previously.

Step 4: Determine the maximum noble gas radioactivity monitor setpoint concentration.

Based on the values determined in previous steps, the radioactivity monitor setpoint for the planned release is calculated to ensure that the limits of Section 3.1.2.a will not be exceeded. Because the radioactivity monitor responds primarily to radiation from noble gas radionuclides, the monitor setpoint c_{nv} (in μCi/mL) is based on the concentration of all noble gases in the waste stream, as follows:

where:

c_{nv} = the calculated setpoint, in μCi/mL, for the noble gas monitor serving gaseous release pathway v.

$$c_{nv} = the \quad lesser \quad of \begin{cases} AG_v \cdot SF \cdot \sum_i X_{iv} \cdot R_t \\ AG_v \cdot SF \cdot \sum_i X_{iv} \cdot R_k \end{cases} \qquad \textbf{(3.4)}$$

AG_v = the administrative allocation factor for gaseous release pathway v, applied to divide the release limit among all the gaseous release pathways at the site. The allocation factor may be assigned any value between 0 and 1, under the condition that the sum of the allocation factors for all simultaneously-active final release pathways at the entire plant site does not exceed 1. Alternative methods for determination of AG_v are presented in Section 3.3.4.

SF = the safety factor selected to compensate for statistical fluctuations and errors of measurement. The value for the safety factor must be between 0 and 1. A value of 0.5 is reasonable for gaseous releases; a more precise value may be developed if desired.

X_{iv} = the measured concentration of noble gas radionuclide i in gaseous stream v, as defined in Step 1, in μCi/mL.

The values of R_t and R_k to be used in the calculation are those which were determined in Steps 2 and 3 above.

Step 5: Determine whether the release is permissible, as follows:

If $c_{nv} \geq \sum_i X_{iv}$, the release is permissible. However, if c_{nv} is within about 10 percent of $\sum_i X_{iv}$, it may be impractical to use this value of c_{nv}. This situation indicates that measured concentrations are approaching values which would cause the limits of Section 3.1.2.a to be exceeded. Therefore, steps should be taken to reduce contributing source terms of gaseous radioactive material, or to adjust the allocation of the limits among the active release points. The setpoint calculations (steps 1–4) must then be repeated with parameters that reflect the modified conditions.

If $c_{nv} < \sum_i X_{iv}$, the release may not be made as planned. Consider the alternatives discussed in the paragraph above, and calculate a new setpoint based on the results of the actions taken.

3.3.2.3 Use of the Calculated Setpoint

The setpoint calculated above is in the units μCi/mL. The monitor actually measures a count rate, subtracts a predetermined background count rate, and multiplies by a calibration factor to convert from count rate to μCi/mL.

Initial calibration by the manufacturer and Georgia Power Company of the gaseous effluent monitors specified in Section 3.1.1 utilized at least one NIST-traceable gaseous radionuclide source in the exact geometry of each production monitor. The point and gaseous sources used covered the beta particle end point energy range from 0.293 MeV to at least 1.488 MeV. The calibration factor is a function of the radionuclide mix in the gas to be released, and normally will be calculated for the monitor based on the results of the sample results from the laboratory gamma-ray spectrometer system. The mix-dependent calibration factor will be used as the gain factor in the PERMS monitor, or used to modify the calculated base monitor setpoint so that the default calibration factor in the PERMS monitor can be left unchanged.

Notwithstanding the initial calibration, monitor calibration data for conversion between count rate and concentration *may* include operational data obtained from determining the monitor response to stream concentrations measured by sample analysis.

In all cases, monitor background must be controlled so that the monitor is capable of responding to concentrations in the range of the setpoint value. Contributions to the monitor background may include any or all of the following factors: ambient background radiation, plant-related radiation levels at the monitor location (which may change between shutdown and power conditions), and internal background due to contamination of the monitor's sample chamber.

3.3.3 Setpoints for Noble Gas Monitors on Effluent Source Streams

Table 3-4 lists certain gaseous release pathways as being source streams. As may be seen in the figures of Section 3.2, these are streams that merge with other streams, prior to passing a final radioactivity monitor and being released. Unlike the final monitors, the source stream monitors measure radioactivity in effluent streams for which flow can be terminated; therefore, the source stream monitors have control logic to terminate the source stream release at the alarm setpoint.

3.3.3.1 Setpoint of the Monitor on the Source Stream

Step 1: Determine the concentration X_{is} of each noble gas radionuclide i in source stream s (in μCi/mL) according to the results of its required sample analyses [see Section 3.1.2].

Step 2: Determine r_t, the ratio of the dose rate limit for the total body, 500 mrem/y, to the total body dose rate due to noble gases detected in the source stream under consideration. Use the X_{is} values and the maximum anticipated source stream flowrate f_{as} in equation (3.2) to determine the total body dose rate for the source stream, substituting r_t for R_t.

The SITE BOUNDARY relative dispersion value used in Steps 2 and 3 for the source stream is the same as the $\overline{(X/Q)}_{vb}$ that applies to the respective merged stream. This is because the $\overline{(X/Q)}$ value is determined by the meteorology of the plant site and the physical attributes of the release point, and is unaffected by whether or not a given source stream is operating.

Step 3: Determine r_k, the ratio of the dose rate limit for the skin, 3000 mrem/y, to the skin dose rate due to noble gases detected in the source stream under consideration. Use the X_{is} values and the maximum anticipated source stream flow rate f_{as} in equation (3.3) to determine the skin dose rate for the source stream, substituting r_k for R_k.

Step 4: Determine the maximum noble gas radioactivity monitor setpoint concentration, as follows:

$$c_{ns} = the \quad lesser \quad of \begin{cases} AG_s \cdot SF \cdot \sum_i X_{is} \cdot r_t \\ AG_s \cdot SF \cdot \sum_i X_{is} \cdot r_k \end{cases} \qquad \textbf{(3.5)}$$

where:

c_{ns} = the calculated setpoint (in μCi/mL) for the noble gas monitor serving gaseous source stream s.

AG_s = the administrative allocation factor applied to gaseous source stream s. For a given final release point v, the sum of all the AG_s values for source streams contributing to the final release point must not exceed the release point's allocation factor Ag_v.

X_{is} = the measured concentration of noble gas radionuclide i in gaseous source stream s, as defined in Step 1, in μCi/mL.

The values of r_t and r_k to be used in the calculation are those which were determined in Steps 2 and 3 above. The safety factor, SF, was defined previously.

Step 5: Determine whether the release is permissible, as follows:

If $c_{ns} \geq \sum_i X_{is}$, the release is permissible. However, if c_{ns} is within about 10 percent of $\sum_i X_{is}$, it may be impractical to use this value of c_{ns}. This situation indicates that measured concentrations are approaching values which would cause the limits of Section 3.1.2.a to be exceeded. Therefore, steps should be taken to reduce contributing source terms of gaseous radioactive material, or to adjust the allocation of the limits among the active release points. The setpoint calculations (steps 1–4) must then be repeated with parameters that reflect the modified conditions.

If $c_{ns} < \sum_i X_{is}$, the release may not be made as planned. Consider the alternatives discussed in the paragraph above, and calculate a new setpoint based on the results of the actions taken.

3.3.3.2 Effect on the Setpoint of the Monitor on the Merged Stream

Before beginning a release from a monitored source stream, a setpoint must be determined for the source stream monitor as presented in Section 3.3.3.1. In addition, whether or not the source stream has its own effluent monitor, the previously-determined maximum allowable setpoint for the downstream final monitor on the merged stream must be redetermined. This is accomplished by repeating the steps of Section 3.3.2, with the following modifications.

Modification 1: The new maximum anticipated flowrate of the merged stream is the sum of the old merged stream maximum flowrate, and the maximum flowrate of the source stream being considered for release.

$$\left(f_{av}\right)_{new} = \left(f_{av}\right)_{old} + f_{as} \tag{3.6}$$

Modification 2: The new concentration of noble gas radionuclide i in the merged stream includes both the contribution of the merged stream *without* the source stream, *and* the source stream being considered for release.

$$\left(X_{iv}\right)_{new} = \frac{\left(f_{av}\right)_{old} \cdot \left(X_{iv}\right)_{old} + f_{as} \cdot X_{is}}{\left(f_{av}\right)_{new}} \tag{3.7}$$

3.3.4 Determination of Allocation Factors, AG

When simultaneous gaseous releases are conducted, an administrative allocation factor must be applied to divide the release limit among the active gaseous release pathways. This is to assure that the dose rate limit for areas at and beyond the SITE BOUNDARY (see Section 3.1.2) will not be exceeded by simultaneous releases. The allocation factor for any pathway may be assigned any value between 0 and 1, under the following two conditions:

1. The sum of the allocation factors for all simultaneously-active *final* release paths at the plant site may not exceed 1.

2. The sum of the allocation factors for all simultaneously-active *source streams* merging into a given final release pathway may not exceed the allocation factor of that final release pathway.

Any of the following three methods may be used to assign the allocation factors to the active gaseous release pathways:

1. For ease of implementation, AG_v may be equal for all release pathways:

$$AG_v = \frac{1}{N} \tag{3.8}$$

where:

N = the number of simultaneously active gaseous release pathways.

2. AG_v for a given release pathway may be selected based on an *estimate* of the portion of the total SITE BOUNDARY dose rate (from all simultaneous releases) that is contributed

by the release pathway. During periods when a given building or release pathway is not subject to gaseous radioactive releases, it may be assigned an allocation factor of zero.

3. AG_v for a given release pathway may be selected based on a *calculation* of the portion of the total SITE BOUNDARY dose rate that is contributed by the release pathway, as follows:

$$AG_v = \frac{\left(\overline{X/Q}\right)_{vb} \sum_i \left(K_i Q_{iv}\right)}{\sum_{r=1}^{N} \left[\left(\overline{X/Q}\right)_{rb} \sum_i \left(K_i Q_{ir}\right)\right]} \qquad \textbf{(3.9)}$$

where:

$\left(\overline{X/Q}\right)_{vb}$ = the annual average SITE BOUNDARY relative concentration applicable to the gaseous release pathway v for which the allocation factor is being determined, in s/m^3.

K_i = the total-body dose factor due to gamma emissions from noble gas radionuclide i, in $(mrem/y)/(\mu Ci/m^3)$, from Table 3-5.

Q_{iv} = the release rate of noble gas radionuclide i from release pathway v, in μCi/s, calculated as the product of X_{iv} and f_{av}, where:

X_{iv} = the concentration of noble gas radionuclide i applicable to the gaseous release pathway v for which the allocation factor is being determined, in μCi/mL.

f_{av} = the discharge flowrate applicable to gaseous release pathway v for which the allocation factor is being determined, in mL/s.

$\left(\overline{X/Q}\right)_{rb}$ = the annual average SITE BOUNDARY relative concentration applicable to active gaseous release pathway r, in s/m^3.

Q_{ir} = the release rate of noble gas radionuclide i applicable to active release pathway r, in μCi/s, calculated as the product of X_{ir} and f_{ar}, where:

X_{ir} = the concentration of noble gas radionuclide i applicable to active gaseous release pathway r, in μCi/mL.

f_{ar} = the discharge flowrate applicable to active gaseous release pathway r, in mL/s.

N = the number of simultaneously active gaseous release pathways (including pathway v that is of interest).

NOTE: Although equations (3.8) and (3.9) are written to illustrate the assignment of the allocation factors for final release pathways, they may also be used to assign allocation factors to the source streams that merge into a given final release pathway.

3.3.5 Setpoints for Noble Gas Monitors with Special Requirements

At present, VEGP has no noble gas monitors for which setpoint methodologies are to be presented in the ODCM, and that require methods other than those in Section 3.3.2 or Section 3.3.3.

3.3.6 Setpoints for Particulate and Iodine Monitors

In accordance with Section 5.1.1 of NRC NUREG-0133 (Reference 1), the effluent controls of Section 3.1.1 do not require that the ODCM establish setpoint calculation methods for particulate and iodine monitors. Therefore, the following is provided for information only: Initial setpoints for the particulate channels of effluent monitors RE–12442 and RE–2565 were determined as described in Reference 13.

3.4 GASEOUS EFFLUENT COMPLIANCE CALCULATIONS

3.4.1 Dose Rates at and Beyond the Site Boundary

Because the dose rate limits for areas at and beyond the SITE specified in Section 3.1.2 are *site* limits applicable at any instant in time, the summations extend over all simultaneously active gaseous final release pathways at the *plant site*. Table 3-4 identifies the gaseous final release pathways at the plant site, and indicates the $\overline{(X/Q)}_{vb}$ value for each.

3.4.1.1 Dose Rates Due to Noble Gases

For the purpose of implementing the controls of Section 3.1.2.a, the dose rates due to noble gas radionuclides in areas at or beyond the SITE BOUNDARY, due to releases of gaseous effluents, shall be calculated as follows:

For total body dose rates:

$$DR_t = \sum_v \left\{ \overline{(X/Q)}_{vb} \sum_i \left[K_i Q_{iv} \right] \right\} \quad \textbf{(3.10)}$$

For skin dose rates:

$$DR_k = \sum_v \left\{ \overline{(X/Q)}_{vb} \sum_i \left[(L_i + 1.1 M_i) Q_{iv} \right] \right\} \quad \textbf{(3.11)}$$

where:

DR_t = the total body dose rate at the time of the release, in mrem/y.

DR_k = the skin dose rate at the time of the release, in mrem/y.

Q_{iv} = the release rate of noble gas radionuclide i, in μCi/s, equal to the product of f_{tv} and X_{iv}, where:

f_{tv} = the actual average flowrate for release pathway v during the period of the release, in mL/s.

All other terms were defined previously.

3.4.1.2 Dose Rates Due to Iodine-131, Iodine-133, Tritium, and Radionuclides in Particulate Form with Half-Lives Greater than 8 Days

For the purpose of implementing the controls of Section 3.1.2.b, the dose rates due to Iodine-131, Iodine-133, tritium, and all radionuclides in particulate form with half-lives greater than 8 days, in areas at or beyond the SITE BOUNDARY, due to releases of gaseous effluents, shall be calculated as follows:

$$DR_o = \sum_v \left\{ \overline{(X/Q)}_{vb} \sum_i \left[P_{io} \, Q'_{iv} \right] \right\} \quad \textbf{(3.12)}$$

where:

DR_o = the dose rate to organ o at the time of the release, in mrem/y.

P_{io} = the site-specific dose factor for radionuclide i and organ o, in (mrem/y)/(μCi/m^3). Since the dose rate limits specified in Section 3.1.2.b apply only to the child age group exposed to the inhalation pathway, the values of P_{io} may be obtained from Table 3-9, "R_{aipj} for Inhalation Pathway, Child Age Group."

Q'_{iv} = the release rate of radionuclide i from gaseous release pathway v, in μCi/s. For the purpose of implementing the controls of Section 3.1.2.b, only I–131, I–133, tritium, and all radionuclides in particulate form with half-lives greater than 8 days should be included in this calculation.

All other terms were defined previously.

3.4.2 Noble Gas Air Dose at or Beyond Site Boundary

For the purpose of implementing the controls of Section 3.1.3, air doses in areas at or beyond the SITE BOUNDARY due to releases of noble gases from each unit shall be calculated as follows (adapted from Reference 1, page 28, by including only long-term releases):

$$D_\beta = 3.17 \times 10^{-8} \sum_v \left\{ \left(\overline{X/Q}\right)_{vb} \sum_i \left[N_i \cdot \tilde{Q}_{iv} \right] \right\} \quad \textbf{(3.13)}$$

$$D_\gamma = 3.17 \times 10^{-8} \sum_v \left\{ \left(\overline{X/Q}\right)_{vb} \sum_i \left[M_i \cdot \tilde{Q}_{iv} \right] \right\} \quad \textbf{(3.14)}$$

where:

3.17×10^{-8} = a units conversion factor: 1 y/(3.15×10^7 s).

D_β = the air dose due to beta emissions from noble gas radionuclides, in mrad.

D_γ = the air dose due to gamma emissions from noble gas radionuclides, in mrad.

N_i = the air dose factor due to beta emissions from noble gas radionuclide i (mrad/y)/(μCi/m^3), from Table 3-5.

M_i = the air dose factor due to gamma emissions from noble gas radionuclide i (mrad/y)/(μCi/m^3), from Table 3-5.

$\tilde{Q}_{iv}$ = the cumulative release of noble gas radionuclide i from release pathway v (μCi), during the period of interest.

and all other terms are as defined above.

Because the air dose limit is on a per-reactor-unit basis, the summations extend over all gaseous final release pathways for a given *unit*. For a release pathway discharging materials originating in both reactor units, the activity discharged from the release point may be apportioned to the two units in any reasonable manner, provided that all activity released via the particular shared release pathway is apportioned to one or the other unit.

The gaseous final release pathways at the plant site, and the $\overline{(X/Q)}_{vb}$ for each, are identified in Table 3-4.

Table 3-5. Dose Factors for Exposure to a Semi-Infinite Cloud of Noble Gases

Nuclide	γ - Body (K) (mrem/y) per (μCi/m^3)	β - Skin (L) (mrem/y) per (μCi/m^3)	γ - Air (M) (mrad/y) per (μCi/m^3)	β - Air (N) (mrad/y) per (μCi/m^3)
Kr-83m	7.56 E-02	0.00 E+00	1.93 E+01	2.88 E+02
Kr-85m	1.17 E+03	1.46 E+03	1.23 E+03	1.97 E+03
Kr-85	1.61 E+01	1.34 E+03	1.72 E+01	1.95 E+03
Kr-87	5.92 E+03	9.73 E+03	6.17 E+03	1.03 E+04
Kr-88	1.47 E+04	2.37 E+03	1.52 E+04	2.93 E+03
Kr-89	1.66 E+04	1.01 E+04	1.73 E+04	1.06 E+04
Kr-90	1.56 E+04	7.29 E+03	1.63 E+04	7.83 E+03
Xe-131m	9.15 E+01	4.76 E+02	1.56 E+02	1.11 E+03
Xe-133m	2.51 E+02	9.94 E+02	3.27 E+02	1.48 E+03
Xe-133	2.94 E+02	3.06 E+02	3.53 E+02	1.05 E+03
Xe-135m	3.12 E+03	7.11 E+02	3.36 E+03	7.39 E+02
Xe-135	1.81 E+03	1.86 E+03	1.92 E+03	2.46 E+03
Xe-137	1.42 E+03	1.22 E+04	1.51 E+03	1.27 E+04
Xe-138	8.83 E+03	4.13 E+03	9.21 E+03	4.75 E+03
Ar-41	8.84 E+03	2.69 E+03	9.30 E+03	3.28 E+03

All values in this table were obtained from Reference 3 (Table B-1), with units converted.

Table 3-6. Dose Factors for Exposure to Direct Radiation from Noble Gases in an Elevated Finite Plume

The contents of this table are not applicable to VEGP.

3.4.3 Dose to a Member of the Public at or Beyond Site Boundary

The dose received by an individual due to gaseous releases from each reactor unit, to areas at or beyond the SITE BOUNDARY, depends on the individual's location, age group, and exposure pathways. The MEMBER OF THE PUBLIC expected to receive the highest dose in the plant vicinity is referred to as the controlling receptor. The dosimetrically-significant attributes of the currently-defined controlling receptor are presented in Table 3-7.

Doses to a MEMBER OF THE PUBLIC due to gaseous releases of I–131, I–133, tritium, and all radionuclides in particulate form from each unit shall be calculated as follows (equation adapted from Reference 1, page 29, by considering only long-term releases):

$$D_{ja} = 3.17 \times 10^{-8} \sum_{p} \left\{ \sum_{i} R_{aipj} \sum_{v} \left[W_{vip} \cdot \tilde{Q}'_{iv} \right] \right\} \qquad \textbf{(3.15)}$$

where:

D_{ja} = the dose to organ j of an individual in age group a, due to gaseous releases of I–131, I–133, tritium, and all radionuclides in particulate form with half-lives greater than 8 days, in mrem.

3.17×10^{-8} = a units conversion factor: 1 y/(3.15×10^{7} s).

R_{aipj} = the site-specific dose factor for age group a, radionuclide i, exposure pathway p, and organ j. For the purpose of implementing the controls of Section 3.1.4, the exposure pathways applicable to calculating the dose to the currently-defined controlling receptor are included in Table 3-7; values of R_{aipj} for each exposure pathway and radionuclide applicable to calculations of dose to the controlling receptor are included in Tables 3-8 through 3-12.

A detailed discussion of the methods and parameters used for calculating R_{aipj} for the plant site is presented in Chapter 9. That information may be used for recalculating the R_{aipj} values if the underlying parameters change, or for calculating R_{aipj} values for special radionuclides and age groups when performing the assessments discussed in Section 3.4.4 below.

W_{vip} = the annual average relative dispersion or deposition at the location of the controlling receptor, for release pathway v, as appropriate to exposure pathway p and radionuclide i.

For all tritium pathways, and for the inhalation of any radionuclide: W_{vip} is $\overline{(X/Q)}_{vp}$, the annual average relative dispersion factor for release pathway v, at the location of the controlling receptor (s/m^3). For the ground-plane exposure pathway, and for all ingestion-related pathways for radionuclides other than tritium: W_{vip} is $\overline{(D/Q)}_{vp}$, the annual average relative deposition factor for release pathway v, at the location of the controlling receptor (m^{-2}). Values of $\overline{(X/Q)}_{vp}$ and $\overline{(D/Q)}_{vp}$ for use in calculating the dose to the currently-defined controlling receptor are included in Table 3-7.

$\tilde{Q}'_{iv}$ = the cumulative release of radionuclide i from release pathway v, during the period of interest (μCi). For the purpose of implementing the controls of Section 3.1.4, only I–131, I–133, tritium, and all radionuclides in particulate form with half-lives greater than 8 days should be included in this calculation. In any dose assessment using the methods of this subsection, only radionuclides detectable above background in their respective samples should be included in the calculation.

Because the member of the public dose limit is on a per-unit basis, the summations extend over all gaseous final release pathways for a given *unit*. For a release pathway discharging materials originating in both reactor units, the activity discharged from the release point may be apportioned between the two units in any reasonable manner, provided that all activity released from the plant site is apportioned to one or the other unit.

The gaseous final release pathways at the plant site, and the release elevation for each, are identified in Table 3-4.

Table 3-7. Attributes of the Controlling Receptor

The locations of members of the public in the vicinity of the plant site, and the exposure pathways associated with those locations, are determined in the Annual Land Use Census. Dispersion and deposition values were calculated based on site meteorological data collected for the period January 1, 1985 through December 31, 1987.

Based on an analysis of this information, the current controlling receptor for the plant site is described as follows.

Sector: WSW

Distance: 1.2 miles

Age Group: Child

Exposure Pathways: Inhalation, ground plane, cow meat, and garden vegetation

Dispersion Factors $\overline{(X/Q)}_{vb}$:

Ground-Level release points:	6.20 E-7 s/m^3
Mixed-Mode release points:	1.27 E-7 s/m^3

Deposition Factors $\overline{(D/Q)}_{vb}$:

Ground-Level release points:	2.80 E-9 m^{-2}
Mixed-Mode release points:	9.90 E-10 m^{-2}

3.4.4 Dose Calculations to Support Other Requirements

Case 1: A radiological impact assessment may be required to support evaluation of a reportable event.

Dose calculations may be performed using the equations in Section 3.4.3, with the substitution of the dispersion and deposition parameters [(X/Q) and (D/Q)] for the period covered by the report, and using the appropriate pathway dose factors (R_{aipj}) for the receptor of interest. Methods for calculating (X/Q) and (D/Q) from meteorological data are presented in Chapter 8.

Values of R_{aipj} other than those presented in Tables 3-8 through 3-12 may need to be calculated. Methods and parameters for calculating values of R_{aipj} are presented in Chapter 9. When calculating R_{aipj} for evaluation of an event, pathway and usage factors specific to the receptor involved in the event may be used in place of the values in Chapter 9, if the specific values are known.

Case 2: A dose calculation is required to evaluate the results of the Land Use Census, under the provisions of Section 4.1.2.

In the event that the Land Use Census reveals that exposure pathways have changed at previously-identified locations, or if new locations are identified, it may be necessary to calculate doses at two or more locations to determine which should be designated as the controlling receptor. Such dose calculations may be performed using the equations in Section 3.4.3, with the substitution of the annual average dispersion and deposition values [$\overline{(X/Q)}$ and $\overline{(D/Q)}$] for the locations of interest, and using the appropriate pathway dose factors (R_{aipj}) for the receptors of interest.

Methods for calculating (X/Q) and (D/Q) from meteorological data are presented in Chapter 8. The values of R_{aipj} other than those presented in Tables 3-8 through 3-12 may need to be calculated. Methods and parameters for calculating values of R_{aipj} are presented in Chapter 9.

Case 3: Under Section 5.2, a dose calculation may be required to support the determination of a component of the total dose to a receptor other than that currently defined as the controlling receptor.

Dose calculations would be performed using the equations in Section 3.4.3, with the dispersion and deposition parameters and appropriate values of (R_{aipj}) for the receptor of interest.

Appropriate values of the dispersion and deposition parameters, if not found in Table 3-7, would need to be calculated. Methods for calculating (X/Q) and (D/Q) from meterological data are presented in Chapter 8.

Appropriate values of R_{aipj}, if not found in Tables 3-8 through 3-12, would need to be calculated. Methods and parameters for calculating values of R_{aipj} are presented in Chapter 9.

Table 3-8. R_{aipj} for Ground Plane Pathway, All Age Groups

Nuclide	T. Body	Skin
H-3	0.00	0.00
C-14	0.00	0.00
P-32	0.00	0.00
Cr-51	4.66E+06	5.51E+06
Mn-54	1.39E+09	1.63E+09
Fe-55	0.00	0.00
Fe-59	2.73E+08	3.21E+08
Co-58	3.79E+08	4.44E+08
Co-60	2.15E+10	2.53E+10
Ni-63	0.00	0.00
Zn-65	7.47E+08	8.59E+08
Rb-86	8.99E+06	1.03E+07
Sr-89	2.16E+04	2.51E+04
Sr-90	0.00	0.00
Y-91	1.07E+06	1.21E+06
Zr-95	2.45E+08	2.84E+08
Nb-95	1.37E+08	1.61E+08
Ru-103	1.08E+08	1.26E+08
Ru-106	4.22E+08	5.07E+08
Ag-110m	3.44E+09	4.01E+09
Sb-124	5.98E+08	6.90E+08
Sb-125	2.34E+09	2.64E+09
Te-125m	1.55E+06	2.13E+06
Te-127m	9.16E+04	1.08E+05
Te-129m	1.98E+07	2.31E+07
I-131	1.72E+07	2.09E+07
I-133	2.45E+06	2.98E+06
Cs-134	6.86E+09	8.00E+09
Cs-136	1.51E+08	1.71E+08
Cs-137	1.03E+10	1.20E+10
Ba-140	2.05E+07	2.35E+07
Ce-141	1.37E+07	1.54E+07
Ce-144	6.95E+07	8.04E+07
Pr-143	0.00	0.00
Nd-147	8.39E+06	1.01E+07

1. Units are $m^2 \cdot$(mrem/yr)/(μCi/s).
2. The values in the Total Body column also apply to the Bone, Liver, Thyroid, Kidney, Lung, and GI-LLI organs.
3. This table also supports the calculations of section 6.2.

Table 3-9. R_{aipj} for Inhalation Pathway, Child Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00	1.12E+03	1.12E+03	1.12E+03	1.12E+03	1.12E+03	1.12E+03
C-14	3.59E+04	6.73E+03	6.73E+03	6.73E+03	6.73E+03	6.73E+03	6.73E+03
P-32	2.60E+06	1.14E+05	9.88E+04	0.00	0.00	0.00	4.22E+04
Cr-51	0.00	0.00	1.54E+02	8.55E+01	2.43E+01	1.70E+04	1.08E+03
Mn-54	0.00	4.29E+04	9.51E+03	0.00	1.00E+04	1.58E+06	2.29E+04
Fe-55	4.74E+04	2.52E+04	7.77E+03	0.00	0.00	1.11E+05	2.87E+03
Fe-59	2.07E+04	3.34E+04	1.67E+04	0.00	0.00	1.27E+06	7.07E+04
Co-58	0.00	1.77E+03	3.16E+03	0.00	0.00	1.11E+06	3.44E+04
Co-60	0.00	1.31E+04	2.26E+04	0.00	0.00	7.07E+06	9.62E+04
Ni-63	8.21E+05	4.63E+04	2.80E+04	0.00	0.00	2.75E+05	6.33E+03
Zn-65	4.26E+04	1.13E+05	7.03E+04	0.00	7.14E+04	9.95E+05	1.63E+04
Rb-86	0.00	1.98E+05	1.14E+05	0.00	0.00	0.00	7.99E+03
Sr-89	5.99E+05	0.00	1.72E+04	0.00	0.00	2.16E+06	1.67E+05
Sr-90	1.01E+08	0.00	6.44E+06	0.00	0.00	1.48E+07	3.43E+05
Y-91	9.14E+05	0.00	2.44E+04	0.00	0.00	2.63E+06	1.84E+05
Zr-95	1.90E+05	4.18E+04	3.70E+04	0.00	5.96E+04	2.23E+06	6.11E+04
Nb-95	2.35E+04	9.18E+03	6.55E+03	0.00	8.62E+03	6.14E+05	3.70E+04
Ru-103	2.79E+03	0.00	1.07E+03	0.00	7.03E+03	6.62E+05	4.48E+04
Ru-106	1.36E+05	0.00	1.69E+04	0.00	1.84E+05	1.43E+07	4.29E+05
Ag-110m	1.69E+04	1.14E+04	9.14E+03	0.00	2.12E+04	5.48E+06	1.00E+05
Sb-124	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sb-125	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Te-125m	6.73E+03	2.33E+03	9.14E+02	1.92E+03	0.00	4.77E+05	3.38E+04
Te-127m	2.49E+04	8.55E+03	3.02E+03	6.07E+03	6.36E+04	1.48E+06	7.14E+04
Te-129m	1.92E+04	6.85E+03	3.04E+03	6.33E+03	5.03E+04	1.76E+06	1.82E+05
I-131	4.81E+04	4.81E+04	2.73E+04	1.62E+07	7.88E+04	0.00	2.84E+03
I-133	1.66E+04	2.03E+04	7.70E+03	3.85E+06	3.38E+04	0.00	5.48E+03
Cs-134	6.51E+05	1.01E+06	2.25E+05	0.00	3.30E+05	1.21E+05	3.85E+03
Cs-136	6.51E+04	1.71E+05	1.16E+05	0.00	9.55E+04	1.45E+04	4.18E+03
Cs-137	9.07E+05	8.25E+05	1.28E+05	0.00	2.82E+05	1.04E+05	3.62E+03
Ba-140	7.40E+04	6.48E+01	4.33E+03	0.00	2.11E+01	1.74E+06	1.02E+05
Ce-141	3.92E+04	1.95E+04	2.90E+03	0.00	8.55E+03	5.44E+05	5.66E+04
Ce-144	6.77E+06	2.12E+06	3.61E+05	0.00	1.17E+06	1.20E+07	3.89E+05
Pr-143	1.85E+04	5.55E+03	9.14E+02	0.00	3.00E+03	4.33E+05	9.73E+04
Nd-147	1.08E+04	8.73E+03	6.81E+02	0.00	4.81E+03	3.28E+05	8.21E+04

1. Units are (mrem/yr)/(μCi/m^3) for all radionuclides.
2. This table also supports the calculations of section 6.2.

Table 3-10. R_{aipj} for Inhalation Pathway, Adult Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00	1.26E+03	1.26E+03	1.26E+03	1.26E+03	1.26E+03	1.26E+03
C-14	1.82E+04	3.41E+03	3.41E+03	3.41E+03	3.41E+03	3.41E+03	3.41E+03
P-32	1.32E+06	7.71E+04	5.01E+04	0.00	0.00	0.00	8.64E+04
Cr-51	0.00	0.00	1.00E+02	5.95E+01	2.28E+01	1.44E+04	3.32E+03
Mn-54	0.00	3.96E+04	6.30E+03	0.00	9.84E+03	1.40E+06	7.74E+04
Fe-55	2.46E+04	1.70E+04	3.94E+03	0.00	0.00	7.21E+04	6.03E+03
Fe-59	1.18E+04	2.78E+04	1.06E+04	0.00	0.00	1.02E+06	1.88E+05
Co-58	0.00	1.58E+03	2.07E+03	0.00	0.00	9.28E+05	1.06E+05
Co-60	0.00	1.15E+04	1.48E+04	0.00	0.00	5.97E+06	2.85E+05
Ni-63	4.32E+05	3.14E+04	1.45E+04	0.00	0.00	1.78E+05	1.34E+04
Zn-65	3.24E+04	1.03E+05	4.66E+04	0.00	6.90E+04	8.64E+05	5.34E+04
Rb-86	0.00	1.35E+05	5.90E+04	0.00	0.00	0.00	1.66E+04
Sr-89	3.04E+05	0.00	8.72E+03	0.00	0.00	1.40E+06	3.50E+05
Sr-90	9.92E+07	0.00	6.10E+06	0.00	0.00	9.60E+06	7.22E+05
Y-91	4.62E+05	0.00	1.24E+04	0.00	0.00	1.70E+06	3.85E+05
Zr-95	1.07E+05	3.44E+04	2.33E+04	0.00	5.42E+04	1.77E+06	1.50E+05
Nb-95	1.41E+04	7.82E+03	4.21E+03	0.00	7.74E+03	5.05E+05	1.04E+05
Ru-103	1.53E+03	0.00	6.58E+02	0.00	5.83E+03	5.05E+05	1.10E+05
Ru-106	6.91E+04	0.00	8.72E+03	0.00	1.34E+05	9.36E+06	9.12E+05
Ag-110m	1.08E+04	1.00E+04	5.94E+03	0.00	1.97E+04	4.63E+06	3.02E+05
Sb-124	3.12E+04	5.89E+02	1.24E+04	7.55E+01	0.00	2.48E+06	4.06E+05
Sb-125	6.61E+04	7.13E+02	1.33E+04	5.87E+01	0.00	2.20E+06	1.01E+05
Te-125m	3.42E+03	1.58E+03	4.67E+02	1.05E+03	1.24E+04	3.14E+05	7.06E+04
Te-127m	1.26E+04	5.77E+03	1.57E+03	3.29E+03	4.58E+04	9.60E+05	1.50E+05
Te-129m	9.76E+03	4.67E+03	1.58E+03	3.44E+03	3.66E+04	1.16E+06	3.83E+05
I-131	2.52E+04	3.58E+04	2.05E+04	1.19E+07	6.13E+04	0.00	6.28E+03
I-133	8.64E+03	1.48E+04	4.52E+03	2.15E+06	2.58E+04	0.00	8.88E+03
Cs-134	3.73E+05	8.48E+05	7.28E+05	0.00	2.87E+05	9.76E+04	1.04E+04
Cs-136	3.90E+04	1.46E+05	1.10E+05	0.00	8.56E+04	1.20E+04	1.17E+04
Cs-137	4.78E+05	6.21E+05	4.28E+05	0.00	2.22E+05	7.52E+04	8.40E+03
Ba-140	3.90E+04	4.90E+01	2.57E+03	0.00	1.67E+01	1.27E+06	2.18E+05
Ce-141	1.99E+04	1.35E+04	1.53E+03	0.00	6.26E+03	3.62E+05	1.20E+05
Ce-144	3.43E+06	1.43E+06	1.84E+05	0.00	8.48E+05	7.78E+06	8.16E+05
Pr-143	9.36E+03	3.75E+03	4.64E+02	0.00	2.16E+03	2.81E+05	2.00E+05
Nd-147	5.27E+03	6.10E+03	3.65E+02	0.00	3.56E+03	2.21E+05	1.73E+05

1. Units are (mrem/yr)/(μCi/m^3) for all radionuclides.
2. This table is included to support the calculations of section 6.2.

Table 3-11. R_{aipj} for Cow Meat Pathway, Child Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00	2.34E+02	2.34E+02	2.34E+02	2.34E+02	2.34E+02	2.34E+02
C-14	5.29E+05	1.06E+05	1.06E+05	1.06E+05	1.06E+05	1.06E+05	1.06E+05
P-32	7.41E+09	3.47E+08	2.86E+08	0.00	0.00	0.00	2.05E+08
Cr-51	0.00	0.00	8.79E+03	4.88E+03	1.33E+03	8.91E+03	4.66E+05
Mn-54	0.00	8.01E+06	2.13E+06	0.00	2.25E+06	0.00	6.72E+06
Fe-55	4.57E+08	2.42E+08	7.51E+07	0.00	0.00	1.37E+08	4.49E+07
Fe-59	3.76E+08	6.09E+08	3.03E+08	0.00	0.00	1.77E+08	6.34E+08
Co-58	0.00	1.64E+07	5.02E+07	0.00	0.00	0.00	9.58E+07
Co-60	0.00	6.93E+07	2.04E+08	0.00	0.00	0.00	3.84E+08
Ni-63	2.91E+10	1.56E+09	9.91E+08	0.00	0.00	0.00	1.05E+08
Zn-65	3.75E+08	1.00E+09	6.22E+08	0.00	6.30E+08	0.00	1.76E+08
Rb-86	0.00	5.77E+08	3.55E+08	0.00	0.00	0.00	3.71E+07
Sr-89	4.82E+08	0.00	1.38E+07	0.00	0.00	0.00	1.87E+07
Sr-90	1.04E+10	0.00	2.64E+09	0.00	0.00	0.00	1.40E+08
Y-91	1.80E+06	0.00	4.82E+04	0.00	0.00	0.00	2.40E+08
Zr-95	2.66E+06	5.85E+05	5.21E+05	0.00	8.38E+05	0.00	6.11E+08
Nb-95	3.10E+06	1.21E+06	8.62E+05	0.00	1.13E+06	0.00	2.23E+09
Ru-103	1.55E+08	0.00	5.96E+07	0.00	3.90E+08	0.00	4.01E+09
Ru-106	4.44E+09	0.00	5.54E+08	0.00	5.99E+09	0.00	6.90E+10
Ag-110m	8.39E+06	5.67E+06	4.53E+06	0.00	1.06E+07	0.00	6.74E+08
Sb-124	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sb-125	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Te-125m	5.69E+08	1.54E+08	7.59E+07	1.60E+08	0.00	0.00	5.49E+08
Te-127m	1.77E+09	4.78E+08	2.11E+08	4.24E+08	5.06E+09	0.00	1.44E+09
Te-129m	1.79E+09	5.00E+08	2.78E+08	5.77E+08	5.26E+09	0.00	2.18E+09
I-131	1.65E+07	1.66E+07	9.46E+06	5.50E+09	2.73E+07	0.00	1.48E+06
I-133	5.67E-01	7.02E-01	2.66E-01	1.30E+02	1.17E+00	0.00	2.83E-01
Cs-134	9.22E+08	1.51E+09	3.19E+08	0.00	4.69E+08	1.68E+08	8.16E+06
Cs-136	1.62E+07	4.46E+07	2.88E+07	0.00	2.37E+07	3.54E+06	1.57E+06
Cs-137	1.33E+09	1.28E+09	1.88E+08	0.00	4.16E+08	1.50E+08	7.99E+06
Ba-140	4.38E+07	3.84E+04	2.56E+06	0.00	1.25E+04	2.29E+04	2.22E+07
Ce-141	2.22E+04	1.11E+04	1.64E+03	0.00	4.86E+03	0.00	1.38E+07
Ce-144	2.32E+06	7.26E+05	1.24E+05	0.00	4.02E+05	0.00	1.89E+08
Pr-143	3.34E+04	1.00E+04	1.66E+03	0.00	5.43E+03	0.00	3.60E+07
Nd-147	1.17E+04	9.47E+03	7.33E+02	0.00	5.19E+03	0.00	1.50E+07

Units are (mrem/yr)/(μCi/m^3) for tritium, and $m^2\cdot$(mrem/yr)/(μCi/s) for all other radionuclides.

Table 3-12. R_{aipj} for Garden Vegetation Pathway, Child Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00	4.01E+03	4.01E+03	4.01E+03	4.01E+03	4.01E+03	4.01E+03
C-14	8.89E+08	1.78E+08	1.78E+08	1.78E+08	1.78E+08	1.78E+08	1.78E+08
P-32	3.37E+09	1.58E+08	1.30E+08	0.00	0.00	0.00	9.31E+07
Cr-51	0.00	0.00	1.17E+05	6.50E+04	1.78E+04	1.19E+05	6.21E+06
Mn-54	0.00	6.65E+08	1.77E+08	0.00	1.86E+08	0.00	5.58E+08
Fe-55	8.01E+08	4.25E+08	1.32E+08	0.00	0.00	2.40E+08	7.87E+07
Fe-59	3.98E+08	6.43E+08	3.20E+08	0.00	0.00	1.86E+08	6.70E+08
Co-58	0.00	6.44E+07	1.97E+08	0.00	0.00	0.00	3.76E+08
Co-60	0.00	3.78E+08	1.12E+09	0.00	0.00	0.00	2.10E+09
Ni-63	3.95E+10	2.11E+09	1.34E+09	0.00	0.00	0.00	1.42E+08
Zn-65	8.13E+08	2.16E+09	1.35E+09	0.00	1.36E+09	0.00	3.80E+08
Rb-86	0.00	4.52E+08	2.78E+08	0.00	0.00	0.00	2.91E+07
Sr-89	3.60E+10	0.00	1.03E+09	0.00	0.00	0.00	1.39E+09
Sr-90	1.24E+12	0.00	3.15E+11	0.00	0.00	0.00	1.67E+10
Y-91	1.86E+07	0.00	4.99E+05	0.00	0.00	0.00	2.48E+09
Zr-95	3.86E+06	8.48E+05	7.55E+05	0.00	1.21E+06	0.00	8.85E+08
Nb-95	4.10E+05	1.60E+05	1.14E+05	0.00	1.50E+05	0.00	2.96E+08
Ru-103	1.53E+07	0.00	5.90E+06	0.00	3.86E+07	0.00	3.97E+08
Ru-106	7.45E+08	0.00	9.30E+07	0.00	1.01E+09	0.00	1.16E+10
Ag-110m	3.21E+07	2.17E+07	1.73E+07	0.00	4.04E+07	0.00	2.58E+09
Sb-124	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sb-125	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Te-125m	3.51E+08	9.50E+07	4.67E+07	9.84E+07	0.00	0.00	3.38E+08
Te-127m	1.32E+09	3.56E+08	1.57E+08	3.16E+08	3.77E+09	0.00	1.07E+09
Te-129m	8.41E+08	2.35E+08	1.31E+08	2.71E+08	2.47E+09	0.00	1.03E+09
I-131	1.43E+08	1.44E+08	8.17E+07	4.75E+10	2.36E+08	0.00	1.28E+07
I-133	3.53E+06	4.37E+06	1.65E+06	8.11E+08	7.28E+06	0.00	1.76E+06
Cs-134	1.60E+10	2.63E+10	5.55E+09	0.00	8.15E+09	2.93E+09	1.42E+08
Cs-136	8.24E+07	2.27E+08	1.47E+08	0.00	1.21E+08	1.80E+07	7.96E+06
Cs-137	2.39E+10	2.29E+10	3.38E+09	0.00	7.46E+09	2.68E+09	1.43E+08
Ba-140	2.77E+08	2.42E+05	1.61E+07	0.00	7.89E+04	1.45E+05	1.40E+08
Ce-141	6.56E+05	3.27E+05	4.86E+04	0.00	1.43E+05	0.00	4.08E+08
Ce-144	1.27E+08	3.98E+07	6.78E+06	0.00	2.21E+07	0.00	1.04E+10
Pr-143	1.46E+05	4.37E+04	7.23E+03	0.00	2.37E+04	0.00	1.57E+08
Nd-147	7.15E+04	5.79E+04	4.48E+03	0.00	3.18E+04	0.00	9.17E+07

Units are (mrem/yr)/(μCi/m^3) for tritium, and m^2·(mrem/yr)/(μCi/s) for all other radionuclides.

3.5 GASEOUS EFFLUENT DOSE PROJECTIONS

3.5.1 Thirty-One Day Dose Projections

In order to meet the requirements of the limit for operation of the gaseous radwaste treatment system (see Section 3.1.5), dose projections must be made at least once each 31 days; this applies during periods in which a discharge to areas at or beyond the SITE BOUNDARY of gaseous effluents containing radioactive materials occurs or is expected.

Projected 31–day air doses and doses to individuals due to gaseous effluents may be determined as follows:

For air doses:

$$D_{\beta p} = \left(\frac{D_{\beta c}}{t}\right) \times 31 + D_{\beta a}$$

$$D_{\gamma p} = \left(\frac{D_{\gamma c}}{t}\right) \times 31 + D_{\gamma a} \quad \textbf{(3.16)}$$

For individual doses:

$$D_{op} = \left(\frac{D_{oc}}{t}\right) \times 31 + D_{oa} \quad \textbf{(3.17)}$$

where:

$D_{\beta p}$ = the projected air dose due to beta emissions from noble gases, for the next 31 days of gaseous releases.

$D_{\beta c}$ = the cumulative air dose due to beta emissions from noble gas releases that have occurred in the elapsed portion of the current quarter, plus the release under consideration.

$D_{\beta a}$ = the anticipated air dose due to beta emissions from noble gas releases, contributed by any planned activities during the next 31–day period, if those activities will result in gaseous releases that are in addition to routine gaseous effluents. If only routine gaseous effluents are anticipated, $D_{\beta a}$ may be set to zero.

$D_{\gamma p}$ = the projected air dose due to gamma emissions from noble gases for the next 31 days of gaseous releases.

$D_{\gamma c}$ = the cumulative air dose due to gamma emissions from noble gas releases that have occurred in the elapsed portion of the current quarter, plus the release under consideration.

$D_{\gamma a}$ = the anticipated air dose due to gamma emissions from noble gas releases, contributed by any planned activities during the next 31–day period, if those activities will result in gaseous releases that are in addition to routine gaseous effluents. If only routine gaseous effluents are anticipated, $D_{\gamma a}$ may be set to zero.

D_{op} = the projected dose to the total body or organ o, due to releases of I–131, I-133, tritium, and particulates for the next 31 days of gaseous releases.

D_{oc} = the cumulative dose to the total body or organ o, due to releases of I–131, I-133, tritium, and particulates that have occurred in the elapsed portion of the current quarter, plus the release under consideration.

D_{oa} = the anticipated dose to the total body or organ o, due to releases of I–131, I-133, tritium, and particulates, contributed by any planned activities during the next 31–day period, if those activities will result in gaseous releases that are in addition to routine gaseous effluents. If only routine gaseous effluents are anticipated, D_{oa} may be set to zero.

t = the number of whole or partial days elapsed into the current quarter, including the time to the end of the release under consideration (even if the release continues into the next quarter).

3.5.2 Dose Projections for Specific Releases

Dose projections may be performed for a particular release by performing a pre-release dose calculation assuming that the planned release will proceed as anticipated. For air dose and individual dose projections due to gaseous effluent releases, follow the methodology of Section 3.4, using sample analysis results for the gaseous stream to be released, and parameter values expected to exist during the release period.

3.6 DEFINITIONS OF GASEOUS EFFLUENT TERMS

Term	Definition	Section of Initial Use
AG =	the administrative allocation factor for gaseous streams, applied to divide the gaseous release limit among all the release pathways [unitless].	3.3.2.1
AG_s =	the administrative allocation factor for gaseous source stream s, applied to divide the gaseous release limit among all the release pathways [unitless].	3.3.3
AG_v =	the administrative allocation factor for gaseous release pathway v, applied to divide the gaseous release limit among all the release pathways [unitless].	3.3.2.2
c =	the setpoint of the radioactivity monitor measuring the concentration of radioactivity in the effluent line prior to release [μCi/mL].	3.3.2.1
c_{ns} =	the calculated noble gas effluent monitor setpoint for gaseous source stream s [μCi/mL].	3.3.3
c_{nv} =	the calculated noble gas effluent monitor setpoint for release pathway v [μCi/mL].	3.3.2.2
D_{ja} =	the dose to organ j of an individual in age group a, due to gaseous releases of I–131, I–133, tritium, and radionuclides in particulate form with half-lives greater than 8 days [mrem].	3.4.3
D_{oa} =	the anticipated dose to organ o due to releases of non-noble-gas radionuclides, contributed by any planned activities during the next 31–day period [mrem].	3.5.1
D_{oc} =	the cumulative dose to organ o due to releases of non-noble-gas radionuclides that have occurred in the elapsed portion of the current quarter, plus the release under consideration [mrem].	3.5.1
D_{op} =	the projected dose to organ o due to the next 31 days of gaseous releases of non-noble-gas radionuclides [mrem].	3.5.1
D_β =	the air dose due to beta emissions from noble gas radionuclides [mrad].	3.4.2
$D_{\beta a}$ =	the anticipated air dose due to beta emissions from noble gas releases, contributed by any planned activities during the next 31–day period [mrad].	3.5.1

Term	Definition	Section of Initial Use
$D_{\beta c}$ =	the cumulative air dose due to beta emissions from noble gas releases that have occurred in the elapsed portion of the current quarter, plus the release under consideration [mrad].	3.5.1
$D_{\beta p}$ =	the projected air dose due to beta emissions from noble gases, for the next 31 days of gaseous releases [mrad].	3.5.1
D_{γ} =	the air dose due to gamma emissions from noble gas radionuclides [mrad].	3.4.2
$D_{\gamma a}$ =	the anticipated air dose due to gamma emissions from noble gas releases, contributed by any planned activities during the next 31–day period [mrad].	3.5.1
$D_{\gamma c}$ =	the cumulative air dose due to gamma emissions from noble gas releases that have occurred in the elapsed portion of the current quarter, plus the release under consideration [mrad].	3.5.1
$D\gamma_p$ =	the projected air dose due to gamma emissions from noble gases, for the next 31 days of gaseous releases [mrad].	3.5.1
$(\overline{D/Q})_{vp}$ =	the annual average relative deposition factor for release pathway v, at the location of the controlling receptor, from Table 3-7 [m^{-2}].	3.4.3
DR_k =	the skin dose rate at the time of the release [mrem/y].	3.4.1.1
DR_o =	the dose rate to organ o at the time of the release [mrem/y].	3.4.1.2
DR_t =	the total body dose rate at the time of the release [mrem/y].	3.4.1.1
f_{av} =	the maximum anticipated actual discharge flowrate for release pathway v during the period of the planned release [mL/s].	3.3.2.2
f_{as} =	the maximum anticipated actual discharge flowrate for gaseous source stream s during the period of the planned release [mL/s].	3.3.3
K_i =	the total body dose factor due to gamma emissions from noble gas radionuclide i, from Table 3-5 [(mrem/y)/(μCi/m^3)].	3.3.2.2
L_i =	the skin dose factor due to beta emissions from noble gas radionuclide i, from Table 3-5 [(mrem/y)/(μCi/m^3)].	3.3.2.2
M_i =	the air dose factor due to gamma emissions from noble gas radionuclide i, from Table 3-5 [(mrad/y)/(μCi/m^3)].	3.4.2

Term	Definition	Section of Initial Use
N =	the number of simultaneously active gaseous release pathways [unitless].	3.3.4
N_i =	the air dose factor due to beta emissions from noble gas radionuclide i, from Table 3-5 [(mrad/y)/(μCi/m^3)].	3.4.2
P_{io} =	the site-specific dose factor for radionuclide i (I–131, I–133, tritium, and radionuclides in particulate form with half-lives greater than 8 days) and organ o. The values of P_{io} are equal to the site-specific R_{aipj} values presented in Table 3-9 [(mrem/y)/(μCi/m^3)].	3.4.1.2
Q_{iv} =	the release rate of noble gas radionuclide i from release pathway v during the period of interest [μCi/s].	3.3.2.2
Q'_{iv}=	the release rate of radionuclide i (I–131, I–133, tritium, and radionuclides in particulate form with half-lives greater than 8 days) from gaseous release pathway v during the period of interest [μCi/s].	3.4.1.2
$\tilde{Q}_{iv}$ =	the cumulative release of noble gas radionuclide i from release pathway v during the period of interest [μCi].	3.4.2
$\tilde{Q}'_{iv}$=	the cumulative release of non-noble-gas radionuclide i from release pathway v, during the period of interest [μCi].	3.4.3
R_{aipj} =	the site-specific dose factor for age group a, radionuclide i, exposure pathway p, and organ j. Values and units of R_{aipj} for each exposure pathway, age group, and radionuclide that may arise in calculations for implementing Section 3.1.4 are listed in Table 3-8 through Table 3-9.	3.4.3
R_k =	the ratio of the skin dose rate limit for noble gases, to the skin dose rate due to noble gases in the release under consideration [unitless].	3.3.2.1
R_t =	the ratio of the total body dose rate limit for noble gases, to the total body dose rate due to noble gases in the release under consideration [unitless].	3.3.2.1
r_k =	the ratio of the skin dose rate limit for noble gases, to the skin dose rate due to noble gases in the source stream under consideration [unitless].	3.3.3.1
r_t =	the ratio of the total body dose rate limit for noble gases, to the total body dose rate due to noble gases in the source stream under consideration [unitless].	3.3.3.1

Term	Definition	Section of Initial Use
SF =	the safety factor used in gaseous setpoint calculations to compensate for statistical fluctuations and errors of measurement [unitless].	3.3.2.2
t =	the number of whole or partial days elapsed in the current quarter, including the period of the release under consideration.	3.5.1
W_{vip} =	the annual average relative dispersion [$\overline{(X/Q)}_{vp}$] or deposition [$\overline{(D/Q)}_{vp}$] at the location of the controlling receptor, for release pathway v, as appropriate to exposure pathway p and radionuclide i.	3.4.3
X =	the noble gas concentration for the release under consideration [μCi/mL].	3.3.2.1
X_{ir} =	the concentration of radionuclide i applicable to active gaseous release pathway r [μCi/mL].	3.3.4
X_{is} =	the measured concentration of radionuclide i in gaseous source stream s [μCi/mL].	3.3.3
X_{iv} =	the measured concentration of radionuclide i in gaseous stream v [μCi/mL].	3.3.2.2
(X/Q) =	the highest relative concentration at any point at or beyond the SITE BOUNDARY [s/m^3].	3.3.2.1
$\overline{(X/Q)}_{rb}$ =	the annual average SITE BOUNDARY relative concentration applicable to active gaseous release pathway r [s/m^3].	3.3.4
$\overline{(X/Q)}_{vb}$ =	the highest annual average relative concentration at the SITE BOUNDARY for the discharge point of release pathway v, from Table 3-4 [s/m^3].	3.3.2.2
$\overline{(X/Q)}_{vp}$ =	annual average relative dispersion factor for release pathway v, at the location of the controlling receptor, from Table 3-7 [s/m^3].	3.4.3

CHAPTER 4
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

4.1 LIMITS OF OPERATION

The following limits are the same for both units at the site. Thus, a single program including monitoring, land use survey, and quality assurance serves both units.

4.1.1 Radiological Environmental Monitoring

The Radiological Environmental Monitoring Program (REMP) shall be conducted as specified in Table 4-1.

4.1.1.1 Applicability

This control applies at all times.

4.1.1.2 Actions

4.1.1.2.1 With the REMP not being conducted as specified in Table 4-1, submit to the Nuclear Regulatory Commission (NRC), in the Annual Radiological Environmental Operating Report, a description of the reasons for not conducting the program as required and the plans for preventing a recurrence. Deviations from the required sampling schedule are permitted if specimens are unobtainable due to hazardous conditions, unavailability, inclement weather, equipment malfunction, or other just reasons. If deviations are due to equipment malfunction, efforts shall be made to complete corrective action prior to the end of the next sampling period.

4.1.1.2.2 With the confirmed[1] measured level of radioactivity as a result of plant effluents in an environmental sampling medium specified in Table 4-1 exceeding the reporting levels of Table 4-2 when averaged over any calendar quarter, submit within 30 days a special report to the NRC. The special report shall identify the cause(s) for exceeding the limit(s) and define the corrective action(s) to be taken to reduce radioactive effluents so that the potential annual dose to a MEMBER OF THE PUBLIC is less than the calendar year limits of Sections 2.1.3, 3.1.3, and 3.1.4. The methodology and parameters used to estimate the potential annual dose to a MEMBER OF THE PUBLIC shall be indicated in the special report.

When more than one of the radionuclides in Table 4-2 are detected in the sampling medium, this report shall be submitted if:

$$\frac{concentration\ (1)}{reporting\ level\ (1)} + \frac{concentration\ (2)}{reporting\ level\ (2)} + \cdots \geq 1.0$$

[1] Defined as confirmed by reanalysis of the original sample, or analysis of a duplicate or new sample, as appropriate. The results of the confirmatory analysis shall be completed at the earliest time consistent with the analysis.

When radionuclides other than those in Table 4-2 are detected and are the result of plant effluents, this special report shall be submitted if the potential annual dose to a MEMBER OF THE PUBLIC is equal to or greater than the calendar year limits stated in Sections 2.1.3, 3.1.3, and 3.1.4. This special report is not required if the measured level of radioactivity was not the result of plant effluents; however, in such an event, the condition shall be described in the Annual Radiological Environmental Operating Report. The levels of naturally-occurring radionuclides which are not included in the plant's effluent releases need not be reported.

4.1.1.2.3 If adequate samples of milk, or during the growing season, grass or leafy vegetation, can no longer be obtained from one or more of the sample locations required by Table 4-1, or if the availability is frequently or persistently wanting, efforts shall be made: to identify specific locations for obtaining suitable replacement samples; and to add any replacement locations to the REMP given in the ODCM within 30 days. The specific locations from which samples became unavailable may be deleted from the REMP. Pursuant to Technical Specification 5.5.1, documentation shall be submitted in the next Radioactive Effluent Release Report for the change(s) in the ODCM, including revised figure(s) and table(s) reflecting the changes to the location(s), with supporting information identifying the cause of the unavailability of samples and justifying the selection of any new location(s).

4.1.1.2.4 This control does not affect shutdown requirements or MODE changes.

4.1.1.3 Surveillance Requirements

The REMP samples shall be collected pursuant to Table 4-1 from the locations described in Section 4.2, and shall be analyzed pursuant to the requirements of Table 4-1 and Table 4-3. Required detection capabilities for thermoluminescent dosimeters used for environmental measurements shall be in accordance with the recommendations of Regulatory Guide 4.13. Program changes may be initiated based on operational experience.

Analyses shall be performed in such a manner that the stated MINIMUM DETECTABLE CONCENTRATIONs (MDCs) will be achieved under routine conditions. Occasionally background fluctuations, unavoidable small sample sizes, the presence of interfering radionuclides, or other uncontrollable circumstances may render these MDCs unachievable. In such cases, the contributing factors will be identified and described in the Annual Radiological Environmental Operating Report.

4.1.1.4 Basis

The REMP required by this control provides representative measurements of radiation and of radioactive materials in those exposure pathways, and for those radionuclides, which lead to the highest potential radiation exposures of MEMBERS OF THE PUBLIC resulting from the plant operation. The REMP implements Section IV.B.2, Appendix I, 10 CFR 50, and thereby supplements the radiological effluent monitoring program by measuring concentrations of radioactive materials and levels of radiation, which may then be compared with those expected on the basis of the effluent measurements and modeling of the environmental exposure pathways.

The detection capabilities required by Table 4-3 are within state-of-the-art for routine environmental measurements in industrial laboratories.

Table 4-1. Radiological Environmental Monitoring Program

Exposure Pathway and/or Sample	Number of Representative Samples and Sample Locations(1)	Sampling and Collection Frequency	Type and Frequency of Analysis
	1. DIRECT RADIATION		
Direct Radiation(2)	Thirty-six or more routine monitoring stations, either with two or more dosimeters, or with one instrument for measuring and recording dose rate continuously, placed as follows: An inner ring of stations, one in each meteorological sector in the general area of the site boundary. An outer ring of stations, one in each meteorological sector at approximately 5 miles from the site. The balance of the stations to be placed in special interest areas such as population centers, nearby residences, schools, and in one or more areas to serve as control stations.	Quarterly.	Gamma dose quarterly.
	2. AIRBORNE		
Radioiodine and Particulates	Samples from 5 or more locations as follows: Three or more samples from close to the three site boundary locations, in different sectors. One sample from the vicinity of a community having the highest calculated annual average ground-level D/Q. One sample from a control location, as, for example, a population center 10 to 20 miles distant and in the least prevalent wind direction.	Continuous sampler operation with sample collection weekly, or more frequently if required by dust loading.	Radioiodine Canister: I-131 analysis weekly. Particulate Sampler: Gross beta radioactivity analysis following filter change, and gamma isotopic analysis of composite (by location) quarterly.(3)(4)

Table 4-1. Radiological Environmental Monitoring Program

Exposure Pathway and/or Sample	Number of Representative Samples and Sample Locations(1)	Sampling and Collection Frequency	Type and Frequency of Analysis
3. WATERBORNE			
Surface(5)	One sample upstream. One sample downstream.	Composite sample over 1-month period.(6)	Gamma isotopic analysis monthly; composite for tritium analysis quarterly.(4)
Drinking	Two samples at each of the one to three nearest water treatment plants that could be affected by discharges from the facility. Two samples at a control location.	Composite sample of river water near intake at each water treatment plant over 2-week period when I-131 analysis is performed, monthly composite otherwise; and grab sample of finished water at each water treatment plant every 2 weeks or monthly, as appropriate.(6)	I-131 analysis on each sample when the dose calculated for the consumption of the water is greater than 1 mrem per year. Composite for gross beta and gamma isotopic analyses monthly. Composite for tritium analysis quarterly.(4)(7)
Sediment from Shoreline	One sample from downstream area with existing or potential recreational value. One sample from upstream area not influenced by plant discharge.	Semiannually.	Gamma isotopic analysis semi-annually.(4)
Groundwater	On-site groundwater monitoring is not required at Vogtle per NUREG 1301. Groundwater monitoring is performed under NMP-EN-002.	See NMP-EN-002.	See NMP-EN-002.

Table 4-1. Radiological Environmental Monitoring Program

Exposure Pathway and/or Sample	Number of Representative Samples and Sample Locations(1)	Sampling and Collection Frequency	Type and Frequency of Analysis
	4. INGESTION		
Milk	Samples from milking animals in three locations within 3 miles distance having the highest dose potential; if there are none, then one sample from milking animals in each of three areas between 3 and 5 miles distance where doses are calculated to be greater than 1 mrem per year.(7) One sample from milking animals at a control location about 10 miles distant or beyond, and preferably in a wind direction of low prevalence.	Semimonthly.	Gamma isotopic analysis semi-monthly.(4)(8)
Fish	At least one sample of any commercially and recreationally important species in vicinity of plant discharge area. At least one sample of any species in areas not influenced by plant discharge.	Semiannually.	Gamma isotopic analyses on edible portions.(4)
	At least one sample of any anadromous species in vicinity of plant discharge.	During spring spawning season.	Gamma isotopic analyses on edible portion.(4)
Grass or Leafy Vegetation	One sample from two onsite locations near the site boundary in different sectors.	Monthly during growing season.	Gamma isotopic.(4)(8)
	One sample from a control location about 15 miles distant.	Monthly during growing season.	Gamma isotopic.(4)(8)

Table 4-1. Radiological Environmental Monitoring Program

TABLE NOTATIONS

(1) For each sample location in this table, specific parameters of distance and direction sector from a point midway between the center of the two reactors, and additional description where pertinent, are provided in Table 4-4, and in Figure 4-1 through Figure 4-4 of this ODCM.

(2) One or more instruments, such as a pressurized ion chamber, for measuring and recording dose rate continuously, may be used in place of or in addition to integrating dosimeters. For the purpose of this table, a thermoluminescent dosimeter (TLD) is considered to be one phosphor; two or more phosphors in a packet are considered as two or more dosimeters. Film badges shall not be used as dosimeters for measuring direct radiation.

(3) Airborne particulate sample filters shall be analyzed for gross beta radioactivity 24 hours or more after sampling to allow for radon and thoron daughter decay. If gross beta activity in air particulate samples is greater than 10 times the yearly mean of control samples, gamma isotopic analysis shall be performed on the individual samples.

(4) Gamma isotopic analysis means the identification and quantification of gamma-emitting radionuclides that may be attributable to the effluents from the facility.

(5) The upstream sample shall be taken at a distance beyond significant influence of the discharge. The downstream sample shall be taken in an area beyond but near the mixing zone.

(6) Composite sample aliquots shall be collected at time intervals that are very short (e.g., hourly) relative to the compositing period (e.g., monthly) in order to assure obtaining a representative sample.

(7) The dose shall be calculated for the maximum organ and age group, using the methodology and parameters in the ODCM.

(8) If gamma isotopic analysis is not sensitive enough to meet the required MDC for I-131, a separate analysis for I-131 will be performed.

Table 4-2. Reporting Levels for Radioactivity Concentrations in Environmental Samples

Analysis	Water (pCi/L)	Airborne Particulate or Gases (pCi/m^3)	Fish (pCi/kg, wet)	Milk (pCi/L)	Grass or Leafy Vegetation (pCi/kg, wet)
H-3	2 E+4[a]				
Mn-54	1 E+3		3 E+4		
Fe-59	4 E+2		1 E+4		
Co-58	1 E+3		3 E+4		
Co-60	3 E+2		1 E+4		
Zn-65	3 E+2		2 E+4		
Zr-95	4 E+2				
Nb-95	7 E+2				
I-131	2 E+0[b]	9 E-1		3 E+0	1 E+2
Cs-134	3 E+1	1 E+1	1 E+3	6 E+1	1 E+3
Cs-137	5 E+1	2 E+1	2 E+3	7 E+1	2 E+3
Ba-140	2 E+2			3 E+2	
La-140	1 E+2			4 E+2	

a. This is the 40 CFR 141 value for drinking water samples. If no drinking water pathway exists, a value of 3 E+04 pCi/L may be used.

b. If no drinking water pathway exists, a value of 20 pCi/L may be used.

Table 4-3. Values for the Minimum Detectable Concentration (MDC)

Analysis	Minimum Detectable Concentration (MDC)[a]					
	Water (pCi/L)	Airborne Particulate or Gases (pCi/m^3)	Fish (pCi/kg, wet)	Milk (pCi/L)	Grass or Leafy Vegetation (pCi/kg, wet)	Sediment (pCi/kg, dry)
Gross Beta	4 E+0	1 E-2				
H-3	2 E+3[b]					
Mn-54	1.5 E+1		1.3 E+2			
Fe-59	3 E+1		2.6 E+2			
Co-58, Co-60	1.5 E+1		1.3 E+2			
Zn-65	3 E+1		2.6 E+2			
Zr-95	3 E+1					
Nb-95	1.5 E+1					
I-131	1 E+0[c]	7 E-2		1 E+0	6 E+1	
Cs-134	1.5 E+1	5 E-2	1.3 E+2	1.5 E+1	6 E+1	1.5 E+2
Cs-137	1.8 E+1	6 E-2	1.5 E+2	1.8 E+1	8 E+1	1.8 E+2
Ba-140	6 E+1			6 E+1		
La-140	1.5 E+1			1.5 E+1		

a. See the definition of MINIMUM DETECTABLE CONCENTRATION in Section 10.1. Other peaks which are measurable and identifiable as plant effluents, together with the radionuclides in this table, shall be analyzed and reported in accordance with Section 7.1.

b. If no drinking water pathway exists, a value of 3 E+3 pCi/L may be used.

c. If no drinking water pathway exists, a value of 1.5 E+1 pCi/L may be used.

4.1.2 Land Use Census

A land use census shall be conducted and shall identify the following within a distance of 5 miles in each of the 16 meteorological sectors: the location of the nearest milk animal,[1] the nearest permanent residence, and the nearest garden of greater than 500 square feet producing broad leafy vegetation. Land within the Savannah River Site is excluded from this census.

4.1.2.1 Applicability

This control applies at all times.

4.1.2.2 Actions

4.1.2.2.1 With a land use census identifying a location(s) which yields a calculated dose or dose commitment greater than values currently being calculated in accordance with Section 3.4.3, identify the new location(s) in the next Radioactive Effluent Release Report.

4.1.2.2.2 With a land use census identifying a location(s) which yields a calculated dose or dose commitment (via the same exposure pathway) 20 percent greater than at a location from which samples are currently being obtained in accordance with Section 4.1.1, add the new location(s) to the REMP within 30 days if samples are available. The sampling location, excluding control station location(s), having the lowest calculated dose or dose commitment (via the same exposure pathway) may be deleted from the REMP if new sampling locations are added. Pursuant to Technical Specification 5.5.1 submit in the next Radioactive Effluent Release Report any change(s) in the ODCM, including the revised figure(s) and table(s) reflecting any new location(s) and information supporting the change(s).

4.1.2.2.3 This control does not affect shutdown requirements or MODE changes.

4.1.2.3 Surveillance Requirements

The land use census shall be conducted annually, using that information which will provide good results, such as a door-to-door census, a visual census from automobile or aircraft, consultation with local agriculture authorities, or some combination of these methods, as feasible. Results of the land use census shall be included in the Annual Radiological Environmental Operating Report.

4.1.2.4 Basis

This control is provided to ensure that changes in the use of UNRESTRICTED AREAS are identified and that modifications to the REMP are made if required by the results of this census. This census satisfies the requirements of Section IV.B.3 of Appendix I to 10 CFR Part 50. Restricting the census to gardens of greater than 500 ft^2 provides assurance that significant exposure pathways via leafy vegetables will be identified and monitored since a garden of this size is the minimum required to produce the quantity (26 kg/y) of leafy vegetables assumed in Regulatory Guide 1.109 for consumption by a child. To determine this minimum garden size, the following assumptions were made: (1) 20 percent of the garden was used for growing broad leaf vegetation (i.e., similar to lettuce and cabbage) and (2) a vegetation yield of 2 kg/m^2 was obtained.

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[1] Defined as a cow or goat that is producing milk for human consumption.

4.1.3 Interlaboratory Comparison Program

Analyses shall be performed on radioactive materials supplied as part of an Interlaboratory Comparison Program which satisfies the requirements of Regulatory Guide 4.15, Revision 1, February, 1979.

4.1.3.1 Applicability

This control applies at all times.

4.1.3.2 Actions

With analyses not being performed as required by Section 4.1.3, report the corrective actions taken to prevent a recurrence in the Annual Radiological Environmental Operating Report.

This control does not affect shutdown requirements or MODE changes.

4.1.3.3 Surveillance Requirements

A summary of the results obtained as part of the required Interlaboratory Comparison Program shall be included in the Annual Radiological Environmental Operating Report.

4.1.3.4 Basis

The requirement for participation in an approved Interlaboratory Comparison Program is provided to ensure that independent checks on the precision and accuracy of the measurements of radioactive material in environmental sample matrices are performed as part of the quality assurance program for environmental monitoring, in order to demonstrate that the results are reasonably valid for the purposes of Section IV.B.2, Appendix I, 10 CFR 50.

4.2 RADIOLOGICAL ENVIRONMENTAL MONITORING LOCATIONS

Table 4-4 and Figure 4-1 through Figure 4-4 specify the locations at which the measurements and samples are taken for the REMP required by Section 4.1.1.

Table 4-4. Radiological Environmental Monitoring Locations

Location Number	Descriptive Location	Direction	Distance (miles)	Sample Type(1)
1	River Bank	N	1.1	D
2	River Bank	NNE	0.8	D
3*	Discharge Area	NE	0.6	A
3*	River Bank	NE	0.7	D
4	River Bank	ENE	0.8	D
5	River Bank	E	1.0	D
6	Plant Wilson	ESE	1.1	D
7	Simulator Building	SE	1.7	D,V,A
8	River Road	SSE	1.1	D
9	River Road	S	1.1	D
10*	Met Tower	SSW	0.9	A
10*	River Road	SSW	1.1	D
11	River Road	SW	1.2	D
12	River Road	WSW	1.2	D,A
13	River Road	W	1.3	D
14	River Road	WNW	1.8	D
15	Hancock Landing Road	NW	1.5	D,V
16	Hancock Landing Road	NNW	1.4	D,A
17	Savannah River Site, River Road	N	5.4	D
18	Savannah River Site, D Area	NNE	5.0	D
19	Savannah River Site, Road A.13	NE	4.6	D
20	Savannah River Site, Road A.13.1	ENE	4.8	D
21	Savannah River Site, Road A.17	E	5.3	D
22	River Bank Downstream of Buxton Landing	ESE	5.2	D
23	River Road	SE	4.6	D
24	Chance Road	SSE	4.9	D
25	Chance Road near Highway 23	S	5.2	D
26	Highway 23 and Ebenezer Church Rd.	SSW	4.6	D

*Two locations in the same sector and shown as a single sample station in Figure 4-1

Table 4-4 (contd). Radiological Environmental Monitoring Locations

Location Number	Descriptive Location	Direction	Distance (miles)	Sample Type[1]
27	Highway 23, opposite Boll Weevil Road	SW	4.7	D
28	Thomas Road	WSW	5.0	D
29	Claxton-Lively Road	W	5.1	D
30	Nathaniel Howard Road	WNW	5.0	D
31	River Road at Allen's Chapel Fork	NW	5.0	D
32	River Bank	NNW	4.7	D
35	Girard	SSE	6.6	D,A
36	GPC Waynesboro Operating Headquarters	WSW	13.9	D,A
37	Substation; Waynesboro, GA	WSW	16.7	D,V
43	Employees Recreation Area	SW	2.2	D
47	Oak Grove Church	SE	10.4	D
48	McBean Cemetery	NW	10.2	D
51	SGA School; Sardis, GA	S	11.0	D
52	Oglethorp Substation; Alexander, GA	SW	10.7	D
80	Augusta Water Treatment Plant	NNW	29.0	W[2]
81	Savannah River	N	2.5	F[3],S[4]
82	Savannah River (RM 151.2)	NNE	0.8	R
83	Savannah River (RM 150.4)	ENE	0.8	R,S[4]
84	Savannah River (RM 149.5)	ESE	1.6	R
85	Savannah River	ESE	4.3	F[3]
87	Beaufort - Jasper Water Treatment Plant; Beaufort, SC	SE	76.0	W[5] SEE NOTE 5
88	Cherokee Hill Water Treatment Plant; Port Wentworth, GA	SSE	72.0	W[6]
89	Purrysburg Water Treatment Plant; Purrysburg, SC	SSE	76.0	W[7]
101	Girard Dairy	S	5.5	M
102	Seven Oaks Dairy/Milky Way Dairy	w	7.5/16.0	M
110	Vogtle 1 & 2 River Intake	NE	0.6	V
111	Wilson Transmission Line ROW	E	0.7	V

Table 4-4 (cont.) Radiological Environmental Monitoring Locations

TABLE NOTATIONS

(1) Sample Types:

A - Airborne Radioactivity
D - Direct Radiation
F - Fish
M - Milk
R - River Water
S - River Shoreline Sediment
W - Drinking Water (at water treatment plant)
V - Vegetation

(2) The intake for the Augusta Water Treatment Plant is located on the Augusta Canal. The entrance to this canal is at river mile (RM) 207 on the Savannah River. The canal effectively parallels the river. The intake to the pumping station is about 4 miles down the canal and only 0.1 mile from the river (across land).

(3) About a 5-mile stretch of the river is generally needed to obtain adequate fish samples. Samples are normally gathered between RM 153 and 158 for upriver collections and between RMs 144 and 149.4 for downriver collections.

(4) Sediment is collected at locations with existing or potential recreational value. High water shifting of the river bottom or other reasons could cause a suitable location for sediment collection to become unavailable or unsuitable. Thus, a stretch of river between RM 148.5 and 150.5 is designated for downriver sediment collections, while a stretch between RM 153 and 154 is designated for upriver collections. In practice, collections are normally made at RM 150.2 for downriver collections and at RM 153.3 for upriver collections.

(5) DELETED THIS SAMPLE LOCATION IN 2014 (REF 34). Two additional indicator stations are available. Historical: The intake for the Beaufort-Jasper Water Treatment Plant is located at the end of a canal which begins at RM 39.3 on the Savannah River. This intake is about 16 miles by line of sight down the canal from its beginning on the Savannah River.

(6) The intake for the Cherokee Hill Water Treatment Plant is located on Abercorn Creek, which is about one and a quarter creek miles from its mouth on the Savannah River at RM 29.

(7) The intake for the Purrysburg Water Treatment Plant is located on the same canal as the Beaufort–Jasper Water Treatment Plant. The Purrysburg intake is nearer to the Savannah River at the beginning of the canal.

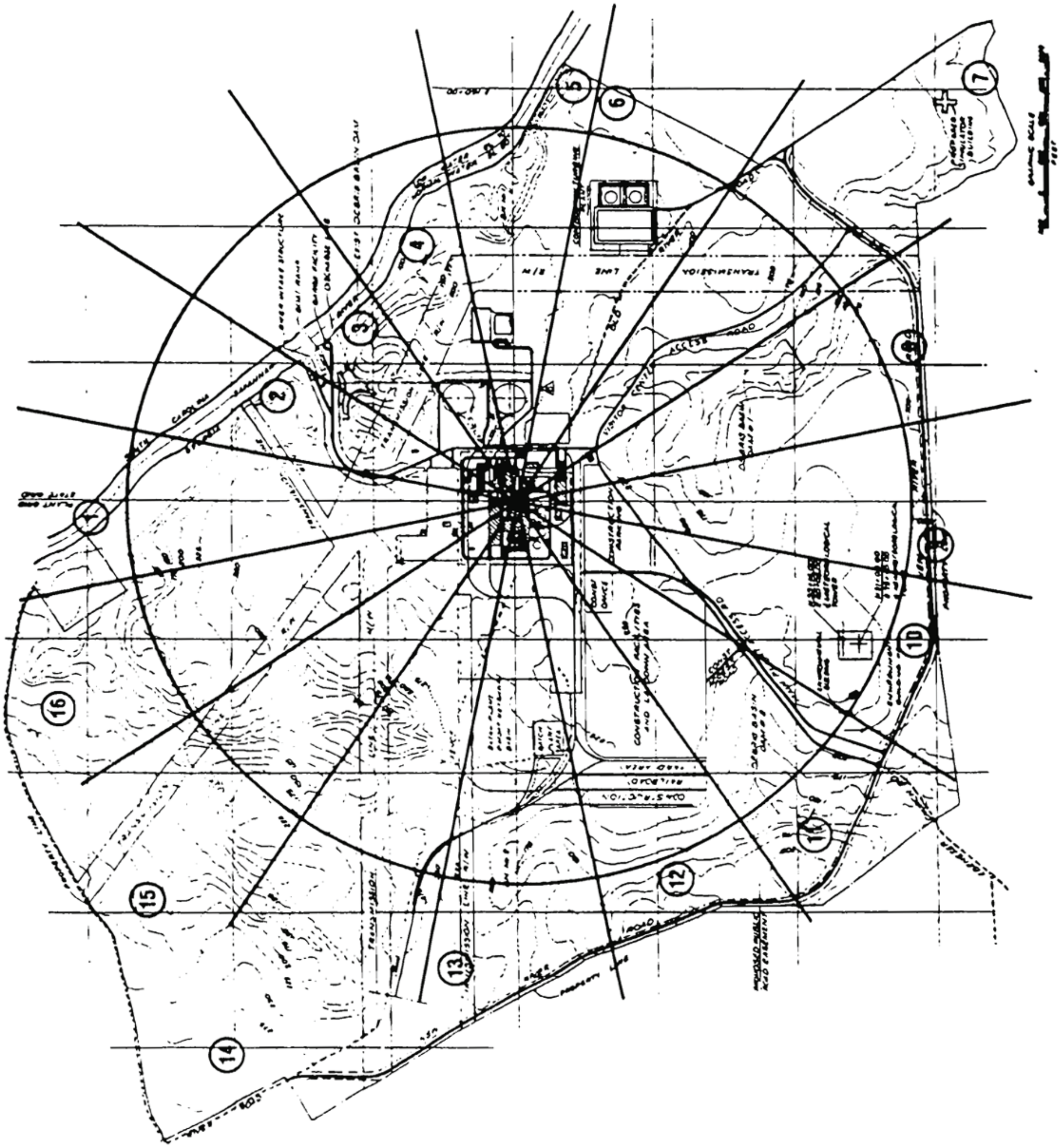

Figure 4-1. Terrestrial Stations Near Site Boundary

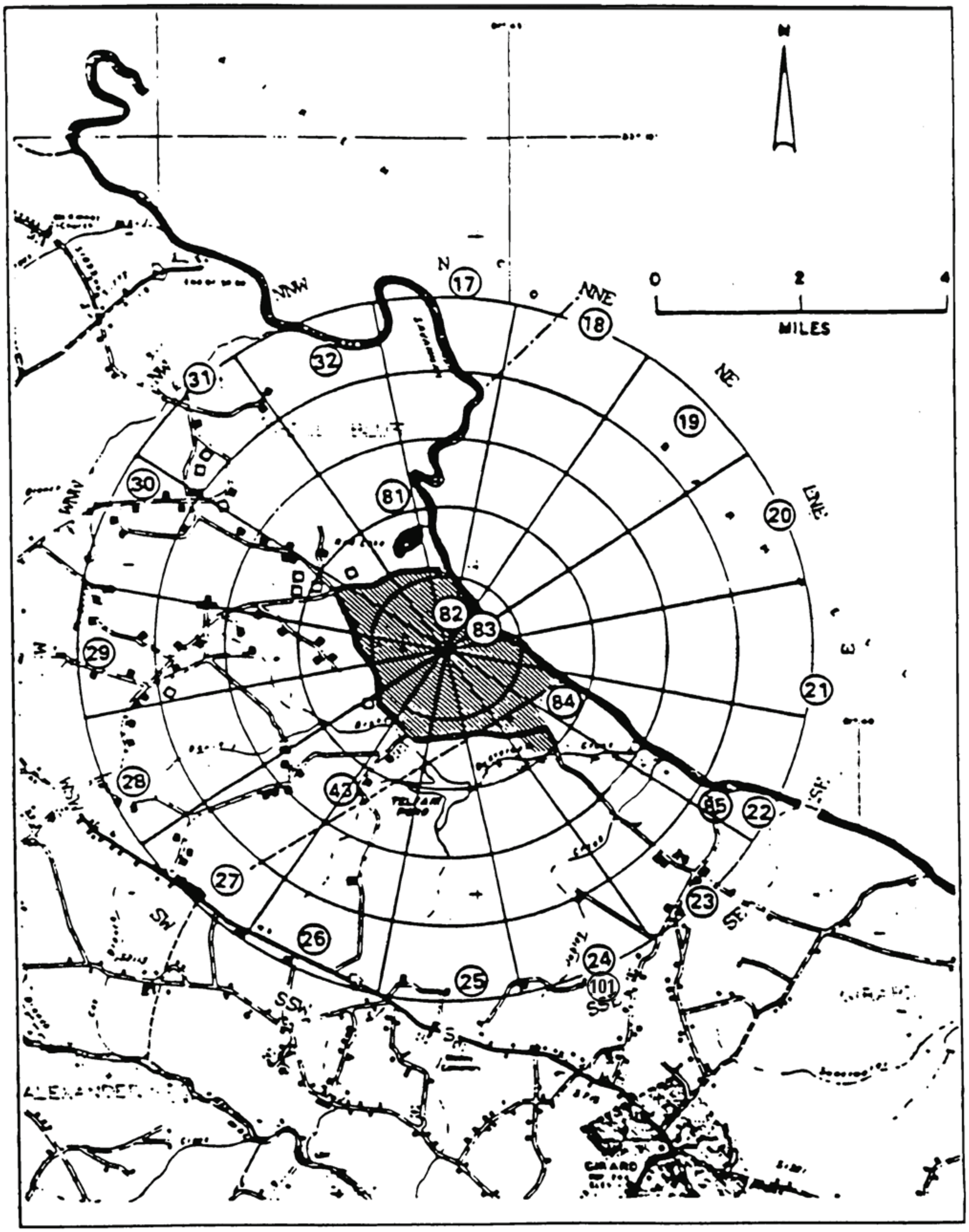

Figure 4-2. Terrestrial Stations and Aquatic Stations, 0-5 Miles

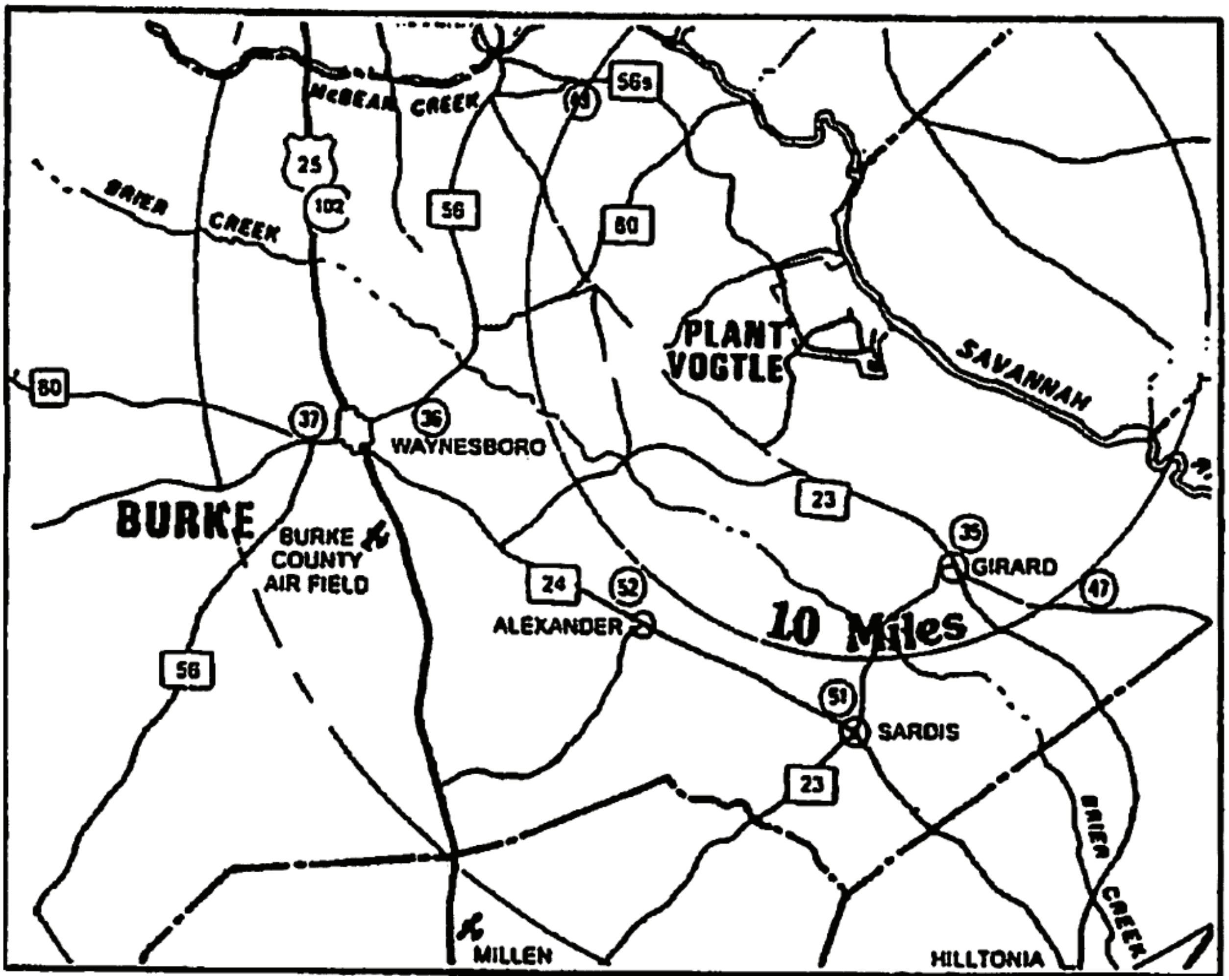

Figure 4-3. Terrestrial Stations Beyond 5 Miles

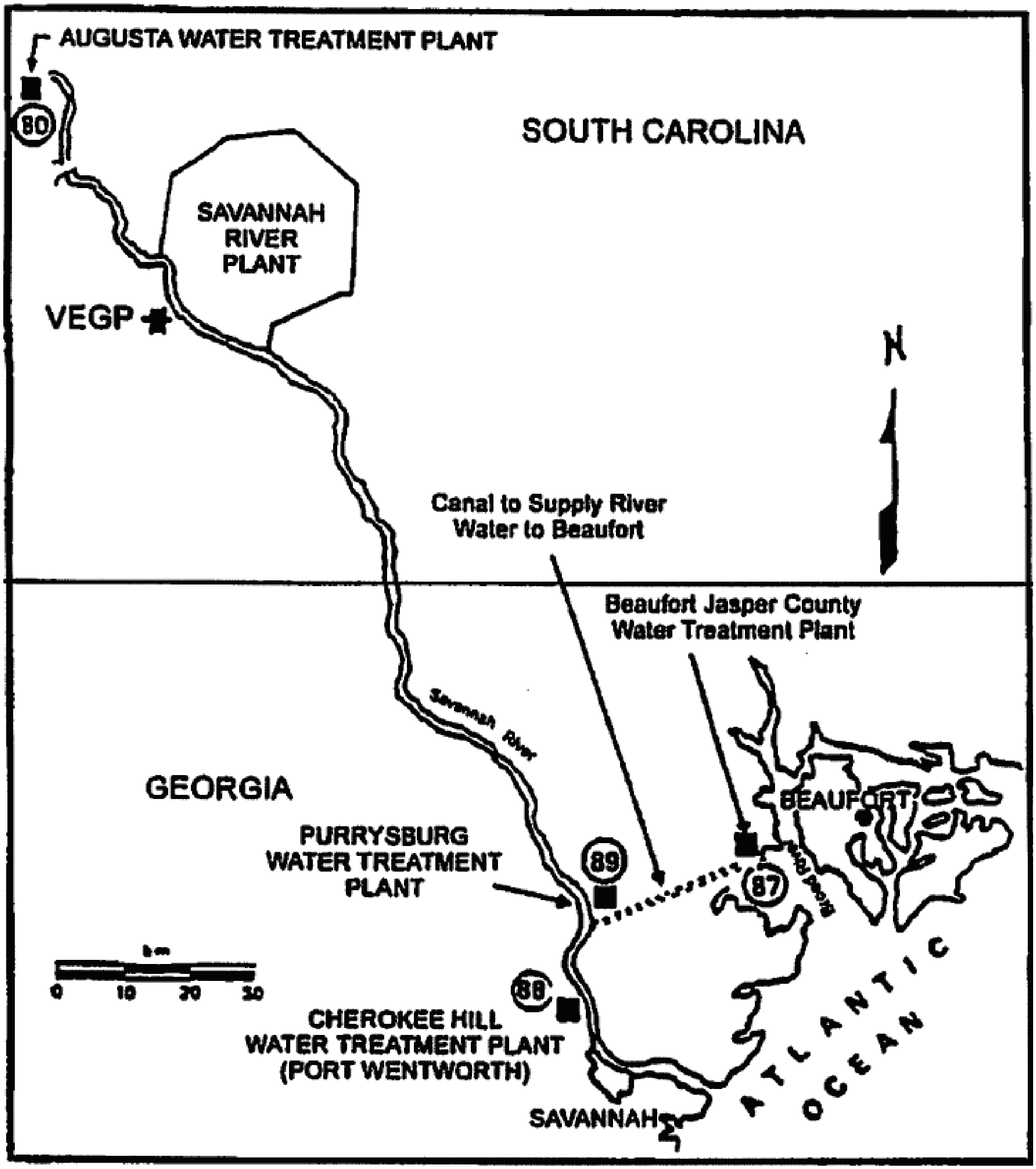

Figure 4-4. Drinking Water Stations

CHAPTER 5
TOTAL DOSE DETERMINATIONS

5.1 LIMIT OF OPERATION

In accordance with Technical Specification 5.5.4.j, the dose or dose commitment to any MEMBER OF THE PUBLIC over a calendar year, due to releases of radioactivity and to radiation from uranium fuel cycle sources, shall be limited to less than or equal to 25 mrem to the total body or any organ, except the thyroid, which shall be limited to less than or equal to 75 mrem.

5.1.1 Applicability

This limit applies at all times.

5.1.2 Actions

With the calculated doses from the release of radioactive materials in liquid or gaseous effluents exceeding twice the limits of Section 2.1.3, 3.1.3, or 3.1.4, calculations shall be made according to Section 5.2 methods to determine whether the limits of Section 5.1 have been exceeded. If these limits have been exceeded, prepare and submit a special report to the Nuclear Regulatory Commission within 30 days, which defines the corrective actions to be taken to reduce subsequent releases to prevent recurrence of exceeding the limits of Section 5.1 and includes the schedule for achieving conformance with the limits of Section 5.1. This special report, as defined in 10 CFR 20.2203, shall also include an analysis which estimates the radiation exposure (dose) to a MEMBER OF THE PUBLIC from uranium fuel cycle sources (including all effluent pathways and direct radiation) for the calendar year that includes the release(s) covered by this report. This special report shall also describe the levels of radiation and concentrations of radioactive material involved, and the cause of the exposure levels or concentrations. If the estimated dose(s) exceeds the limits of Section 5.1, and if the release condition resulting in violation of the provisions of 40 CFR 190 has not already been corrected, the special report shall include a request for variance in accordance with the provisions of 40 CFR 190 and including the specified information of 40 CFR 190.11(b). Submittal of the report is considered a timely request, and a variance is granted until staff action on the request is complete.

This control does not affect shutdown requirements or MODE changes.

5.1.3 Surveillance Requirements

Cumulative dose contributions from liquid and gaseous effluents and from direct radiation shall be determined in accordance with Section 5.2. This requirement is applicable only under the conditions set forth above in Section 5.1.2.

5.1.4 Basis

This control is provided to meet the dose limitations and reporting requirements of 40 CFR 190. The control requires the preparation and submittal of a special report whenever the calculated doses from plant radioactive effluents exceed the limits of Section 5.1. For sites containing up to 4 reactors, it is highly unlikely that the resultant dose to a MEMBER OF THE PUBLIC will exceed the dose limits of 40 CFR 190 if the individual reactors remain within twice the dose design objectives of Appendix I and if direct radiation doses from the units, such as direct exposure from outside storage tanks, are kept small. The special report will describe a course of action which should result in the limitation of dose to a MEMBER OF THE PUBLIC for a calendar year to within the 40 CFR 190 limits. For the purposes of the special report, it may be assumed that the dose commitment to the MEMBER OF THE PUBLIC from other uranium fuel cycle sources is negligible with the exception that dose contributions from other uranium fuel cycle facilities at the same site or within a radius of 5 miles must be considered. If the dose to any MEMBER OF THE PUBLIC is estimated to exceed the requirements of 40 CFR 190, the special report with a request for variance (provided the release conditions resulting in violation of 40 CFR 190 have not already been corrected), in accordance with the provisions of 40 CFR 190.11 and 10 CFR 20.2203(a)(4), is considered to be a timely request and fulfills the requirements of 40 CFR 190 until NRC staff action is completed. The variance only relates to the limits of 40 CFR 190, and does not apply in any way to the requirements for dose limitation as addressed in other sections of this ODCM. An individual is not considered a MEMBER OF THE PUBLIC during any period in which he/she is engaged in carrying out any operation which is part of the nuclear fuel cycle.

5.2 DEMONSTRATION OF COMPLIANCE

There are no other uranium fuel cycle facilities within 5 miles of the plant site. Therefore, for the purpose of demonstrating compliance with the limits of Section 5.1, the total dose to a MEMBER OF THE PUBLIC in the vicinity of the plant site due to uranium fuel cycle sources shall be determined as follows:

$$D_{Tk} = D_L + D_G + D_D + D_N \qquad \textbf{(5.1)}$$

where:

D_{Tk} = the total dose or dose commitment to the total body or organ k, in mrem.

D_L = the dose to the same organ due to radioactivity discharged from the plant site in liquid effluents, calculated in accordance with Section 2.4.1, in mrem.

D_G = the dose to the same organ due to non-noble-gas radionuclides discharged from the plant site in gaseous effluents, calculated for the controlling receptor in accordance with Section 3.4.3, in mrem.

D_D = the direct radiation dose to the whole body of an individual at the controlling receptor location, due to radioactive materials retained within the plant site, in mrem. Values of direct radiation dose may be determined by measurement, calculation, or a combination of the two.

D_N = the external whole body dose to an individual at the controlling receptor location, due to gamma ray emissions from noble gas radionuclides discharged from the plant site in gaseous effluents, in mrem. D_N is calculated as follows (equation adapted from Reference 1, page 22, by recasting in cumulative dose form):

$$D_N = 3.17 \times 10^{-8} \sum_v \left\{ \left(\overline{X/Q}\right)_{vp} \sum_i \left[K_i \cdot \tilde{Q}_{iv} \right] \right\} \qquad \textbf{(5.2)}$$

where:

3.17×10^{-8} = a units conversion factor: 1 y/(3.15×10^7 s).

$\tilde{Q}_{iv}$ = the cumulative release of noble gas radionuclide i from release pathway v (μCi), during the period of interest.

K_i = the total-body dose factor due to gamma emissions from noble gas radionuclide i (mrem/y)/(μCi/m^3), from Table 3-5.

$\left(\overline{X/Q}\right)_{vp}$ = annual average relative dispersion factor for release pathway v, at the location of the controlling receptor, from Table 3-7 [s/m^3].

As defined above, D_L and D_G are for different age groups, while D_D and D_N are not age group specific. When a more precise determination of D_{Tk} is desired, values of D_L and D_G may be calculated for all four age groups, and those values used in equation (5.1) to determine age group specific values of D_{Tk}; the largest value of D_{Tk} for any age group may then be compared to the limits of Section 5.1.

CHAPTER 6
POTENTIAL DOSES TO MEMBERS OF THE PUBLIC DUE TO THEIR ACTIVITIES INSIDE THE SITE BOUNDARY

6.1 REQUIREMENT FOR CALCULATION

To support the reporting requirements of Section 7.2.2.3, an assessment of the radiation doses from radioactive liquid and gaseous effluents to MEMBERS OF THE PUBLIC due to their activities inside the SITE BOUNDARY shall be performed as specified in Section 6.2, at least once per calendar year.

6.2 CALCULATIONAL METHOD

For the purpose of performing the calculations required in Section 6.1, the dose to a member of the public inside the SITE BOUNDARY shall be determined at the locations, and for the receptor age groups, defined in Table 6-1. The dose to such a receptor at any one of the defined locations shall be determined as follows:

$$D_{lk} = \left[D_A + D_S + D_P\right] \cdot F_o \qquad \textbf{(6.1)}$$

where:

D_{lk} = the total dose to the total body or organ k, in mrem.

D_A = the dose to the same organ due to <u>inhalation</u> of non-noble-gas radionuclides discharged from the plant site in gaseous effluents, calculated in accordance with Section 3.4.3, in mrem. The $\overline{(X/Q)}$ value to be used is given for each receptor location in Table 6-1; depleted $\overline{(X/Q)}$ values may be used in calculations for non-noble-gas radionuclides.

D_S = the dose to the same organ due to <u>ground plane deposition</u> of non-noble-gas radionuclides discharged from the plant site in gaseous effluents, calculated in accordance with Section 3.4.3, in mrem. The $\overline{(D/Q)}$ value to be used is given for each receptor location in Table 6-1.

D_P = the external whole body dose due to gamma ray emissions from noble gas radionuclides discharged from the plant site in gaseous effluents, calculated using equation (5.2), in mrem. The $\overline{(X/Q)}$ values that are to be used are given for each receptor location in Table 6-1.

F_o = the occupancy factor for the given location, which is the fraction of the year that one individual MEMBER OF THE PUBLIC is assumed to be present at the receptor location [unitless]. Values of F_o for each receptor location are included in Table 6-1.

Table 6-1. Attributes of Member of the Public Receptor Locations Inside the Site Boundary

Location: Visitors Center, SE at 447 meters

Age Group: Child

Occupancy Factor: 4.57×10^{-4} (based on 4 hours per year)

Dispersion and Deposition Parameters:

Parameter	Ground-Level	Mixed-Mode
Undepleted $\overline{(X/Q)}$, s/m^3	5.93 E-6	7.12 E-7
Depleted $\overline{(X/Q)}$, s/m^3	5.58 E-6	6.74 E-7
$\overline{(D/Q)}$, m^{-2}	2.28 E-8	5.77 E-9

CHAPTER 7
REPORTS

7.1 ANNUAL RADIOLOGICAL ENVIRONMENTAL OPERATING REPORT

7.1.1 Requirement for Report

In accordance with Technical Specification 5.6.2, the Annual Radiological Environmental Operating Report covering the REMP activities during the previous calendar year shall be submitted before May 15 of each year. (A single report fulfills the requirements for both units.) The material provided shall be consistent with the objectives outlined in section 4.1 and section 7.1.2 of the ODCM, and in Sections IV.B.2, IV.B.3, and IV.C of Appendix I to 10 CFR Part 50.

7.1.2 Report Contents

The materials specified in the following subsections shall be included in each Annual Radiological Environmental Operating Report:

7.1.2.1 Data

The report shall include summarized and tabulated results of all REMP samples required by Table 4-1 taken during the report period, in a format similar to that contained in Table 3 of the Radiological Assessment Branch Technical Position (Reference 19); the results for any additional samples shall also be reported. In the event that some results are not available for inclusion with the report, the report shall be submitted noting and explaining the reasons for the missing results; the missing data shall be submitted as soon as possible in a supplementary report. The results for naturally-occurring radionuclides not included in plant effluents need not be reported.

7.1.2.2 Evaluations

Interpretations and analyses of trends of the results shall be included in the report, including the following: (as appropriate) comparisons with preoperational studies, operational controls, and previous environmental reports; and an assessment of any observed impacts of the plant operation on the environment. If the measured level of radioactivity in an environmental sampling medium exceeding the reporting levels of Table 4-2 is not the result of plant effluents, the condition shall be described as required by Section 4.1.1.2.2.

7.1.2.3 Programmatic Information

Also to be included in each report are the following: a summary description of the REMP; a map(s) of all sampling locations keyed to a table giving distances and directions from a point midway between the centers of the two reactors; the results of land use censuses required by Section 4.1.2; and the results of licensee participation in the Interlaboratory Comparison Program required by Section 4.1.3.

7.1.2.4 Descriptions of Program Deviations

Discussions of deviations from the established program must be included in each report, as follows:

7.1.2.4.1 If the REMP is not conducted as required in Table 4-1, a description of the reasons for not conducting the program as required, and the plans for preventing a recurrence, must be included in the report.

7.1.2.4.2 If the MDCs required by Table 4-3 are not achieved, the contributing factors must be identified and described in the report.

7.1.2.4.3 If Interlaboratory Comparison Program analyses are not performed as required by Section 4.1.3, the corrective actions taken to prevent a recurrence must be included in the report.

7.2 RADIOACTIVE EFFLUENT RELEASE REPORT

7.2.1 Requirement for Report

In accordance with Technical Specification 5.6.3, the Radioactive Effluent Release Report covering the operation of the units during the previous calendar year of operation shall be submitted in accordance with 10 CFR Part 50.36a. (A single submittal may be made for Units 1 and 2. However, the submittal shall specify the releases of radioactive material in liquid and gaseous effluents from each unit and solid radioactive waste from the site.) The report shall include a summary of the quantities of radioactive liquid and gaseous effluents and solid waste released from the units. The material provided shall be consistent with the objectives outlined throughout this ODCM and the Process Control Program (PCP) and in conformance with 10 CFR Part 50.36a and Section IV.B.1 of Appendix I to 10 CFR Part 50.

7.2.2 Report Contents

The materials specified in the following subsections shall be included in each Radioactive Effluent Release Report:

7.2.2.1 Quantities of Radioactive Materials Released

The report shall include a summary of the quantities of radioactive liquid and gaseous effluents and solid waste released from the units as outlined in NRC Regulatory Guide 1.21, "Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants," Revision 1, June 1974, with liquid and gaseous effluent data summarized on a quarterly basis and solid radioactive waste data summarized on a semiannual basis following the format of Appendix B thereof. Unplanned releases of radioactive materials in gaseous and liquid effluents from the site to UNRESTRICTED AREAS shall be included in the report, tabulated either by quarter or by event. For gamma emitters released in liquid and gaseous effluents, in addition to the principal gamma emitters for which MDCs are specifically established in Table 2-3 and Table 3-3, other peaks which are measurable and identifiable also shall be identified and reported.

7.2.2.2 Meteorological Data

The report shall include an annual summary of hourly meteorological data collected over the previous year. This annual summary may be either in the form of an hour-by-hour listing of wind speed, wind direction, and atmospheric stability, and precipitation (if measured) on digital media; or in the form of joint frequency distributions of wind speed, wind direction, and atmospheric stability. In lieu of submission with the Radioactive Effluent Release Report, the licensee has the option of retaining this summary of required meteorological data on site in a file that shall be provided to the NRC upon request.

7.2.2.3 Dose Assessments

The report shall include an assessment of the radiation doses due to the radioactive liquid and gaseous effluents released from each unit during the previous calendar year. Historical annual average meteorology or the meteorological conditions concurrent with the time of release of radioactive materials in gaseous effluents (as determined by sampling frequency and measurement) shall be used for determining the gaseous pathway doses. This assessment of radiation doses shall be performed in accordance with Sections 2.1.3, 2.4, 3.1.3, 3.1.4, 3.4.2, 3.4.3, 5.1, and 5.2.

If a determination is required by Section 5.1.2, the report shall also include an assessment of radiation doses to the likely most exposed MEMBER OF THE PUBLIC from reactor releases and other nearby uranium fuel cycle sources (including doses from primary effluent pathways and direct radiation) for the previous calendar year to show conformance with 40 CFR 190, Environmental Radiation Protection Standards for Nuclear Power Operation; this dose assessment must be performed in accordance with Chapter 5. The report shall also include an assessment of the radiation doses from radioactive liquid and gaseous effluents to MEMBERS OF THE PUBLIC due to their activities inside the SITE BOUNDARY during the report period; this assessment must be performed in accordance with Chapter 6. All assumptions used in making these assessments (i.e., specific activity, exposure time, and location) shall be included in the report.

7.2.2.4 Solid Radwaste Data

For each type of solid waste shipped offsite during the report period, the following information shall be included:

a. Waste volume,
b. Total curie quantity (specify whether determined by measurement of estimate),
c. Principal radionuclides (specify whether determined by measurement or estimate),
d. Type of waste (e.g., spent resin, compacted dry waste, evaporator bottoms),
e. Type of container (e.g., LSA, Type A, Type B, Large Quantity),
f. Solidification agent (e.g., cement, urea formaldehyde)
and
g. Class of solid wastes (as defined by 10 CFR Part 61.)

7.2.2.5 Licensee Initiated Document Changes

Licensee initiated changes shall be submitted to the Nuclear Regulatory Commission as a part of or concurrent with the Radioactive Effluent Release Report for the period in which any changes were made. Such changes to the ODCM shall be submitted pursuant to Technical Specification 5.5.1. This requirement includes:

7.2.2.5.1 Any changes to the sampling locations in the radiological environmental monitoring program, including any changes made pursuant to Section 4.1.1.2.3. Documentation of changes made pursuant to Section 4.1.1.2.3 shall include supporting information identifying the cause of the unavailability of samples.

7.2.2.5.2 Any changes to dose calculation locations or pathways, including any changes made pursuant to Section 4.1.2.2.2.

7.2.2.6 Descriptions of Program Deviations

Discussions of deviations from the established program shall be included in each report, as follows:

7.2.2.6.1 The report shall include deviations from the liquid and gaseous effluent monitoring instrumentation FUNCTIONALITY requirements included in Sections 2.1.1 and 3.1.1, respectively. The report shall include an explanation as to why the NON-FUNCTIONALITY of the liquid or gaseous effluent monitoring instrumentation was not corrected within the specified time requirement.

7.2.2.6.2 The report shall include a description of the events leading to liquid holdup tanks or gas storage tanks exceeding the limits of Technical Specification 5.5.12.

7.2.2.7 Major Changes to Radioactive Waste Treatment Systems

As required by Sections 2.1.5 and 3.1.6, licensee initiated MAJOR CHANGES TO RADIOACTIVE WASTE TREATMENT SYSTEMS (liquid and gaseous) shall be reported to the Nuclear Regulatory Commission in the Radioactive Effluent Release Report covering the period in which the change was reviewed and accepted for implementation.[1] The discussion of each change shall contain:

a. A summary of the evaluation that led to the determination that the change could be made in accordance with 10 CFR 50.59;

b. Sufficient detailed information to totally support the reason for the change without benefit of additional supplemental information;

c. A detailed description of the equipment, components, and processes involved and the interfaces with other plant systems;

d. An evaluation of the change which shows the predicted releases of radioactive materials in liquid and gaseous effluents that differ from those previously predicted in the license applications and amendments thereto;

e. An evaluation of the change which shows the expected maximum exposures to individuals in the UNRESTRICTED AREA and to the general population that differ from those previously estimated in the license applications and amendments thereto;

f. A comparison of the predicted releases of radioactive materials, in liquid and gaseous effluents, to the actual releases for the period prior to when the changes are to be made;

g. An estimate of the exposure to plant operating personnel as a result of the change; and

h. Documentation of the fact that the change was reviewed and found acceptable by the PRB.

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[1] In lieu of inclusion in the Radioactive Effluents Release Report, this same information may be submitted as part of the annual FSAR update.

7.3 MONTHLY OPERATING REPORT

This ODCM establishes no requirements pertaining to the Monthly Operating Report.

7.4 SPECIAL REPORTS

Special reports shall be submitted to the Nuclear Regulatory Commission as required by Sections 2.1.3.2, 2.1.4.2, 3.1.3.2, 3.1.4.2, 3.1.5.2, 4.1.1.2.2, and 5.1.2.

CHAPTER 8
METEOROLOGICAL MODELS

The models presented in this chapter are those which were used to compute the specific values of meteorology-related parameters that are referenced throughout this ODCM. These models should also be used whenever it is necessary to calculate values of these parameters for new locations of interest.

Note: Although Plant Vogtle has no pure elevated releases, the sections on elevated-mode calculations (8.1.2 and 8.2.2) are included for convenience in calculating mixed-mode values, and to preserve section number compatibility with the ODCMs of the other Southern Company nuclear power plants.

8.1 ATMOSPHERIC DISPERSION

Atmospheric dispersion may be calculated using the appropriate form of the sector-averaged Gaussian model. Gaseous release elevations may be considered to be either at ground-level, elevated, or mixed-mode. Facility release elevations for each gaseous release point are as indicated in Table 3-4.

8.1.1 Ground-Level Releases

Relative concentration calculations for ground-level releases, or for the ground-level portion of mixed-mode releases, shall be made as follows:

$$\left(X/Q\right)_G = \frac{2.032\,\delta\,K_r}{N\ r} \sum_{jk} \left[\frac{n_{jk}}{u_j\, \Sigma_{zk}} \right] \qquad \textbf{(8.1)}$$

where:

$(X/Q)_G$ = the ground-level sector-averaged relative concentration for a given wind direction (sector) and distance (s/m^3).

2.032 = $(2/\pi)^{1/2}$ divided by the width in radians of a 22.5° sector, which is 0.3927 radians.

δ = the plume depletion factor for all radionuclides other than noble gases at a distance r shown in Figure 8-3. For noble gases, the depletion factor is unity. If an undepleted relative concentration is desired, the depletion factor is unity. Only depletion by deposition is considered since depletion by radioactive decay would be of little significance at the distances considered.

K_r = the terrain recirculation factor corresponding to a distance r, taken from Appendix A of Reference 15.

n_{jk} = the number of hours that wind of wind speed class j is directed into the given sector during the time atmospheric stability category k existed.

N = the total hours of valid meteorological data recorded throughout the period of interest for all sectors, wind speed classes, and stability categories.

u_j = the wind speed (mid-point of wind speed class j) at ground level (m/s).

r = the distance from release point to location of interest (m).

Σ_{zk} = the vertical standard deviation of the plume concentration distribution considering the initial dispersion within the building wake, calculated as follows:

$$\Sigma_{zk} = the \quad lesser \quad of \begin{cases} \left(\sigma_{zk}^2 + \dfrac{b^2}{2\pi} \right)^{1/2} \\ OR \\ \sqrt{3}(\sigma_{zk}) \end{cases} \qquad \textbf{(8.2)}$$

σ_{zk} = the vertical standard deviation of the plume concentration distribution (m) for a given distance and stability category k as shown in Figure 8-1. The stability category is determined by the vertical temperature gradient $\Delta T/\Delta z$ (°C/100 m).

π = 3.1416

b = the maximum height of adjacent plant structure (55 m).

8.1.2 Elevated Releases

Relative dispersion calculations for elevated releases, or for the elevated portion of mixed-mode releases, shall be made as follows:

$$(X/Q)_E = \frac{2.032K_r}{N\ r} \sum_{jk} \left[\frac{\delta_k n_{jk} exp\left(\dfrac{-h^2}{2\sigma_{zk}^2} \right)}{u_j \sigma_{zk}} \right] \qquad \textbf{(8.3)}$$

where:

$(X/Q)_E$ = the elevated release sector-averaged relative concentration for a given wind direction (sector) and distance (s/m^3).

δ_k = the plume depletion factor for all radionuclides other than noble gases at a distance r for elevated releases, as shown in Figure 8-4, Figure 8-5, and Figure 8-6. For an elevated release, this factor is stability dependent. For noble gases, the depletion factor is unity. If an undepleted relative concentration is desired, the depletion factor is unity. Only depletion by deposition is considered since depletion by radioactive decay would be of little significance at the distances considered.

n_{jk} = the number of hours that wind of wind speed class j is directed into the given sector during the time atmospheric stability category k existed.

u_j = the wind speed (mid-point of wind speed class j) at the effective release height h (m/s).

h = the effective height of the release (m), which is calculated as follows:

$$h = h_v + h_{pr} - h_t - c_v \tag{8.4}$$

h_v = the height of the release point (m).

h_t = the maximum terrain height between the release point and the point of interest (m), from Table 8-1.

h_{pr} = the additional height due to plume rise (m) which is calculated as follows and limited by $h_{pr(max)}$:

$$h_{pr} = 1.44\, d \left(\frac{W_o}{u}\right)^{2/3} \cdot \left(\frac{x}{d}\right)^{1/3} \tag{8.5}$$

$$h_{pr}(max) = the \quad lesser \quad of: \begin{cases} 3\left(\frac{W_o}{u}\right) \cdot d \\ OR \\ 1.5\left(\frac{F_m}{u}\right)^{1/3} \cdot s^{-1/6} \end{cases} \tag{8.6}$$

d = the inside diameter of the vent (m).

c_v = the correction for low vent exit velocity (m), which is calculated as follows:

$$c_v = \begin{cases} 3\left(1.5 - \frac{W_o}{u}\right) \cdot d & for \frac{W_o}{u} < 1.5 \\ OR & \\ 0 & for \frac{W_o}{u} \geq 1.5 \end{cases} \tag{8.7}$$

F_m = the momentum flux parameter (m^4/s^2), which is calculated as follows:

$$F_m = \left(W_o \cdot \frac{d}{2}\right)^2 \tag{8.8}$$

S = the stability parameter:

= $8.75 \times 10^{-4}\ s^{-2}$ for $-0.5 < \Delta T \leq 1.5$
= $1.75 \times 10^{-3}\ s^{-2}$ for $1.5 < \Delta T \leq 4.0$

= $2.45 \times 10^{-3}\ s^{-2}$ for $\Delta T > 4.0$

All other symbols are as previously defined in Section 8.1.1.

8.1.3 Mixed-Mode Releases

Relative dispersion calculations for mixed-mode releases shall be made as follows:

$$\left(X/Q\right)_M = (1 - E) \cdot (X/Q)_E + E \cdot (X/Q)_G \qquad \textbf{(8.9)}$$

where:

$(X/Q)_M$ = the mixed-mode release sector-averaged relative concentration for a given wind direction (sector) and distance (s/m^3).

E = the fraction of hours during which releases are considered as ground-level releases, calculated as follows:

$$E = \begin{cases} 1.0 & \text{for } \dfrac{W_o}{u_j} \leq 1.0 \\ 2.58 - 1.58 \cdot \left(\dfrac{W_o}{u_j}\right) & \text{for } 1.0 < \dfrac{W_o}{u_j} \leq 1.5 \\ 0.3 - 0.06 \cdot \left(\dfrac{W_o}{u_j}\right) & \text{for } 1.5 < \dfrac{W_o}{u_j} \leq 5.0 \\ 0 & \text{for } \dfrac{W_o}{u_j} > 5.0 \end{cases} \qquad \textbf{(8.10)}$$

All other symbols are as previously defined.

8.2 RELATIVE DEPOSITION

Plume depletion may be calculated using the appropriate form of the sector-averaged Gaussian model. Gaseous release elevations may be considered to be either at ground-level, elevated, or mixed-mode. Facility release elevations for each gaseous release points are as indicated in Table 3-4.

8.2.1 Ground-Level Releases

Relative deposition calculations for ground-level releases, or for the ground-level portion of mixed-mode releases, shall be made as follows:

$$(D/Q)_G = \frac{2.55 D_g \; K_r}{N \; r} \sum_k n_k \qquad \textbf{(8.11)}$$

where:

$(D/Q)_G$ = the ground-level sector-averaged relative deposition for a given wind direction (sector) and distance (m^{-2}).

2.55 = the inverse of the number of radians in a 22.5° sector [= $(2 \pi /16)^{-1}$].

D_g = the deposition rate at distance r, taken from Figure 8-7 for ground-level releases (m^{-1}).

n_k = the number of hours in which the wind is directed into the sector of interest, and during which stability category k exists.

All other symbols are as defined previously in Section 8.1.

8.2.2 Elevated Releases

Relative deposition calculations for elevated releases, or for the elevated portion of mixed-mode releases, shall be made as follows:

$$(D/Q)_E = \frac{2.55 K_r}{N \; r} \sum_k (n_k \; D_{ek}) \qquad \textbf{(8.12)}$$

where:

$(D/Q)_E$ = the elevated-plume sector-averaged relative deposition for a given wind direction (sector) and distance (m^{-2}).

D_{ek} = the elevated plume deposition rate at distance r, taken from Figure 8-8, Figure 8-9, or Figure 8-10, as appropriate to the plume effective release height h defined in Section 8.1.2, for stability class k (m^{-1}).

All other symbols are as defined previously.

8.2.3 Mixed-Mode Releases

Relative deposition calculations for mixed-mode releases shall be made as follows:

$$(D/Q)_M = (1 - E) \cdot (D/Q)_E + E \cdot (D/Q)_G \qquad \textbf{(8.13)}$$

where:

$(D/Q)_M$ = the mixed-mode release sector-averaged relative deposition for a given wind direction (sector) and distance (m^{-2}).

E = the fraction of hours during which releases are considered as ground-level releases, defined in Section 8.1.3.

All other symbols are as previously defined.

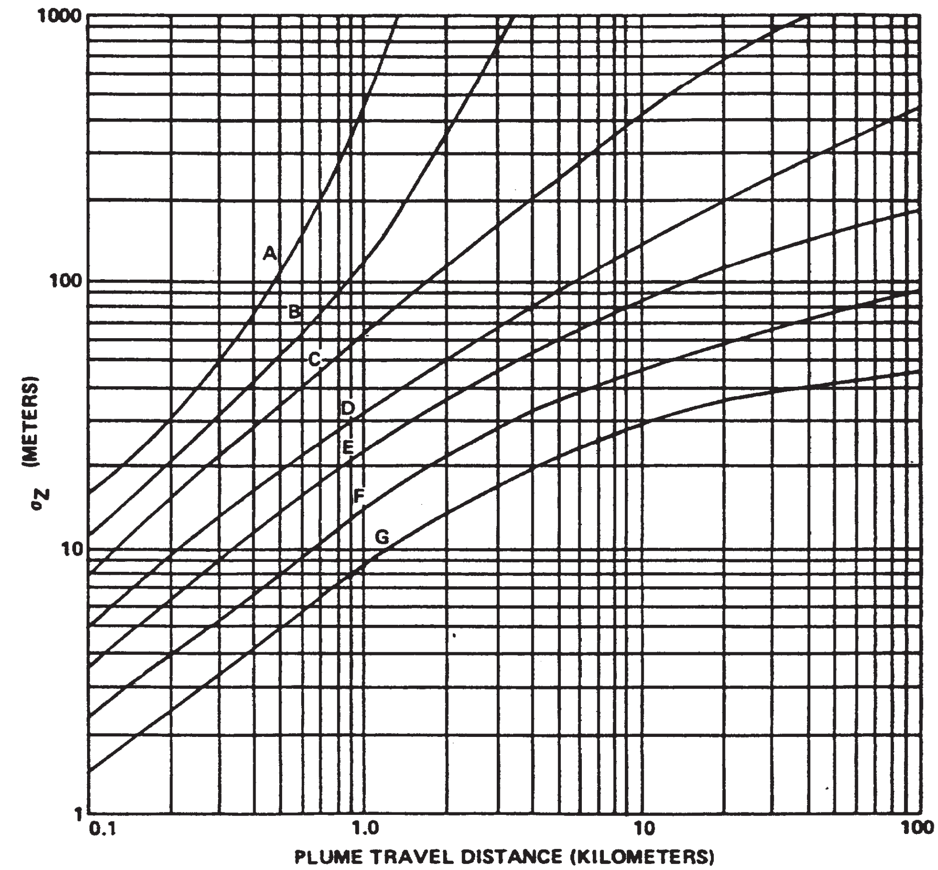
8.3 ELEVATED PLUME DOSE FACTORS

These factors are not required in effluent dose calculations for VEGP.

Table 8-1. Terrain Elevation Above Plant Site Grade

Dist. (m)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	8.7	5.7	1.4	5.8	5.7	3.5
1,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	16.7	13.4	3.3	10.4	11.8	6.8
1,500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	21.7	18.6	7.3	12.2	14.3	7.3
2,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	21.7	18.6	7.3	12.2	14.3	7.3
2,500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	21.7	18.6	7.3	12.2	14.3	7.3
3,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	23.7	18.6	7.3	12.2	14.3	7.3
3,500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	24.4	18.6	7.3	12.2	16.9	7.3
4,000	0.0	0.0	0.0	0.0	0.0	0.0	4.5	0.0	0.0	4.7	24.4	18.6	7.3	12.2	16.9	7.3
5,000	0.0	0.0	0.0	0.0	0.0	0.0	11.1	0.0	0.0	4.7	24.7	18.6	7.3	12.2	16.9	7.3
6,000	0.0	0.0	0.0	0.0	0.0	0.0	11.1	0.0	0.0	4.7	26.8	18.6	7.3	12.2	16.9	7.3
7,000	0.0	0.0	0.0	7.8	0.0	0.0	11.1	0.0	3.6	4.7	26.8	18.6	7.3	12.2	16.9	7.3
8,000	0.0	0.0	21.1	13.9	0.0	0.0	11.8	0.0	14.6	4.7	26.8	18.6	7.3	12.2	16.9	7.3
9,000	0.0	0.0	24.4	14.6	0.0	0.0	12.7	7.1	14.6	5.1	26.8	18.6	7.3	12.2	16.9	7.3
10,000	0.0	10.2	24.4	20.2	0.0	0.0	17.1	17.0	14.6	6.8	26.8	18.6	7.3	12.2	16.9	7.3
12,000	0.0	15.9	26.8	20.2	0.0	0.0	17.1	19.5	14.6	6.8	34.1	28.9	13.4	12.2	16.9	7.3
14,000	0.0	15.9	26.8	20.2	0.0	0.0	17.1	19.5	14.6	6.8	34.1	28.9	13.4	16.5	19.7	7.3
16,000	0.0	15.9	26.8	21.7	13.2	0.0	17.1	19.5	14.6	6.8	34.1	28.9	13.4	16.5	25.7	7.3

Data in this table are obtained from Reference 11.



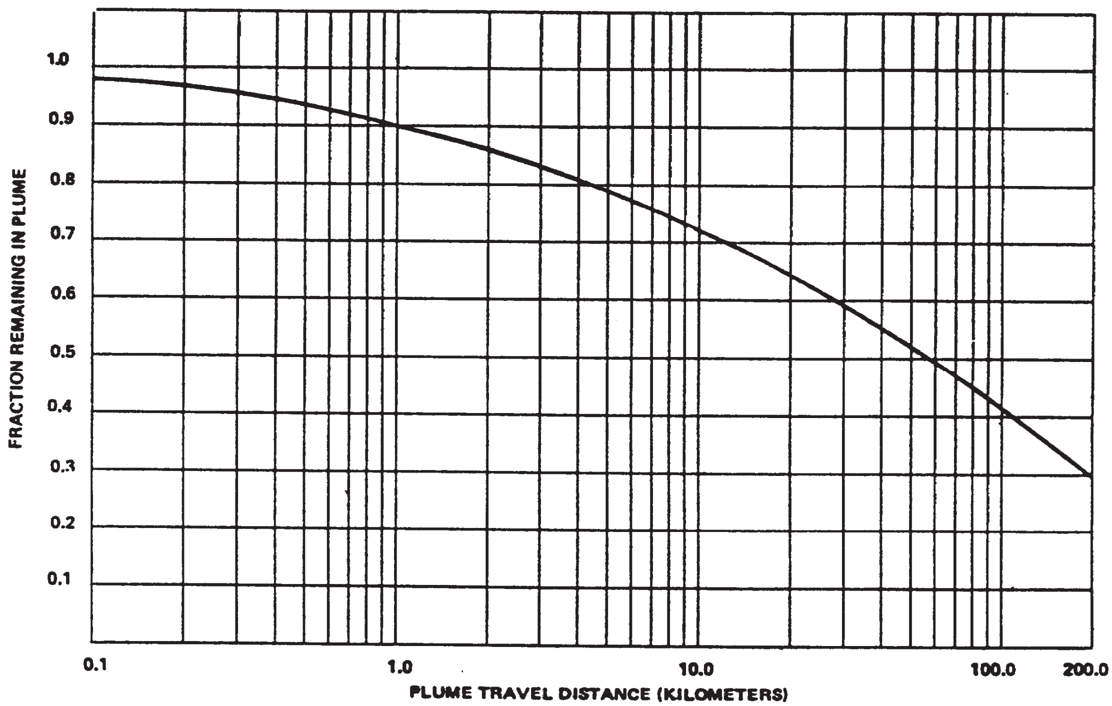
Category	Range of Vertical Temperature Gradient (°C/100 m)	Range of Vertical Temperature Gradient (°F/100 ft)
A	$\Delta T/\Delta Z < -1.9$	$\Delta T/\Delta Z < -1.0$
B	$-1.9 \le \Delta T/\Delta Z < -1.7$	$-1.0 \le \Delta T/\Delta Z < -0.9$
C	$-1.7 \le \Delta T/\Delta Z < -1.5$	$-0.9 \le \Delta T/\Delta Z < -0.8$
D	$-1.5 \le \Delta T/\Delta Z < -0.5$	$-0.8 \le \Delta T/\Delta Z < -0.3$
E	$-0.5 \le \Delta T/\Delta Z < 1.5$	$-0.3 \le \Delta T/\Delta Z < 0.8$
F	$1.5 \le \Delta T/\Delta Z < 4.0$	$0.8 \le \Delta T/\Delta Z < 2.2$
G	$4.0 \le \Delta T/\Delta Z$	$2.2 \le \Delta T/\Delta Z$

This graph is reproduced from Reference 5 (Figure 1).

Figure 8-1. Vertical Standard Deviation of Material in a Plume (σ_Z)

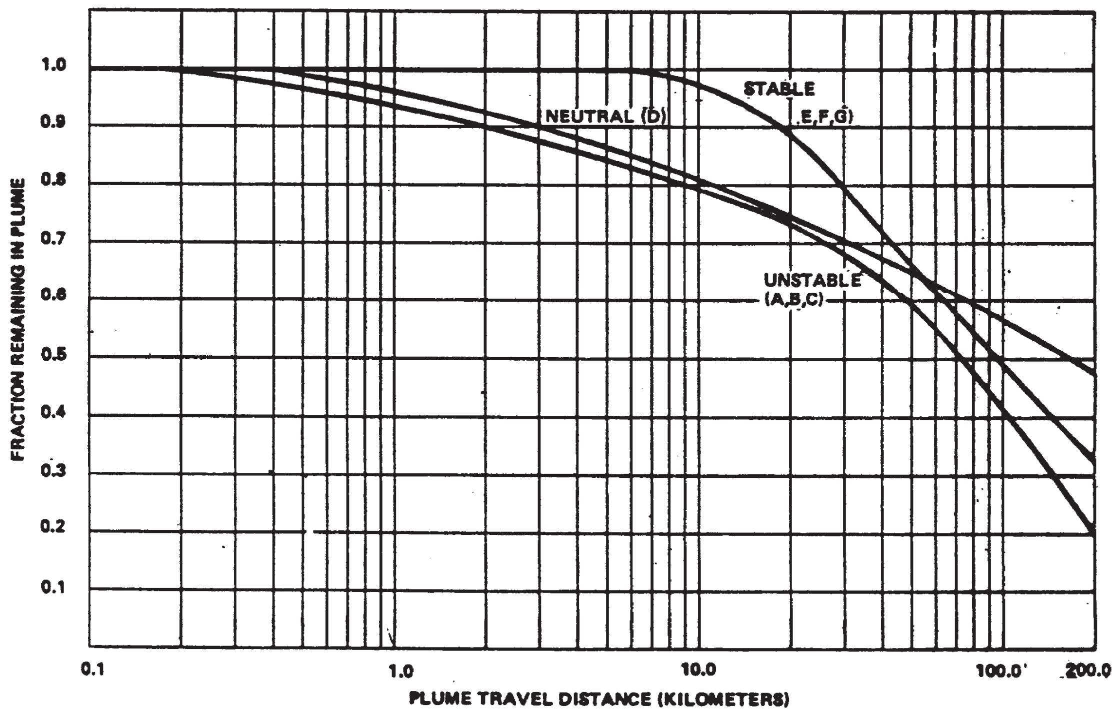
This figure intentionally left blank.
Refer to the definition for K_r (terrain recirculation factor) in section 8.1.1 for applicable plant data.

Figure 8-2. Terrain Recirculation Factor (K_r)



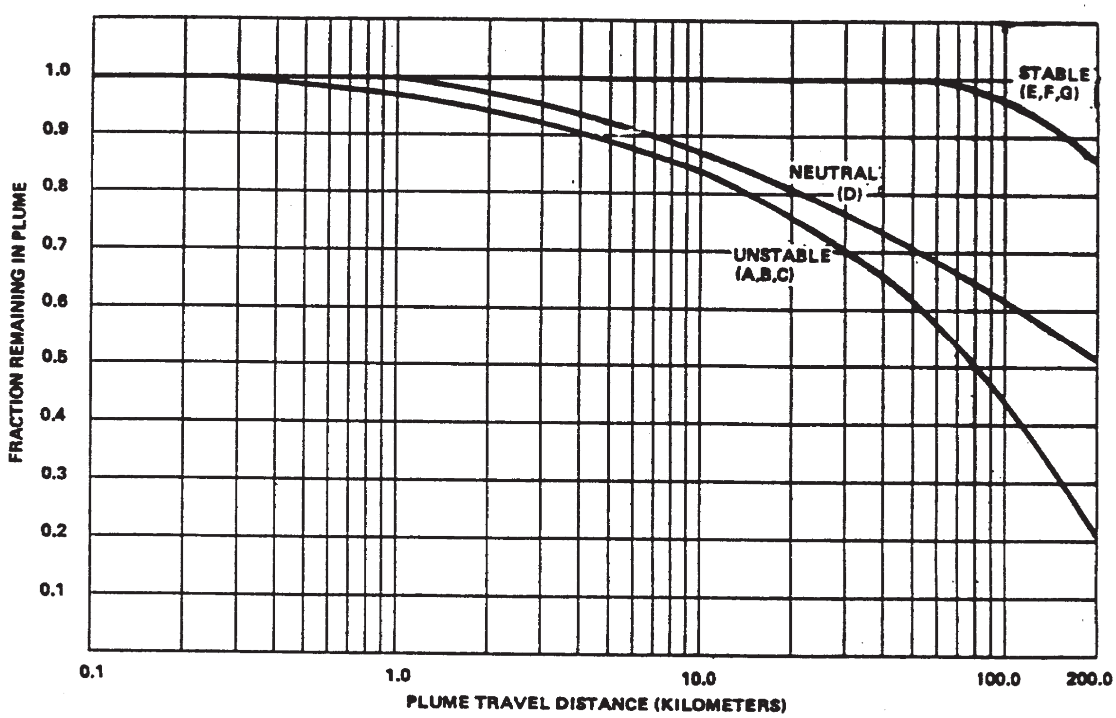
This graph is reproduced from Reference 5 (Figure 2).

Figure 8-3. Plume Depletion Effect for Ground Level Releases



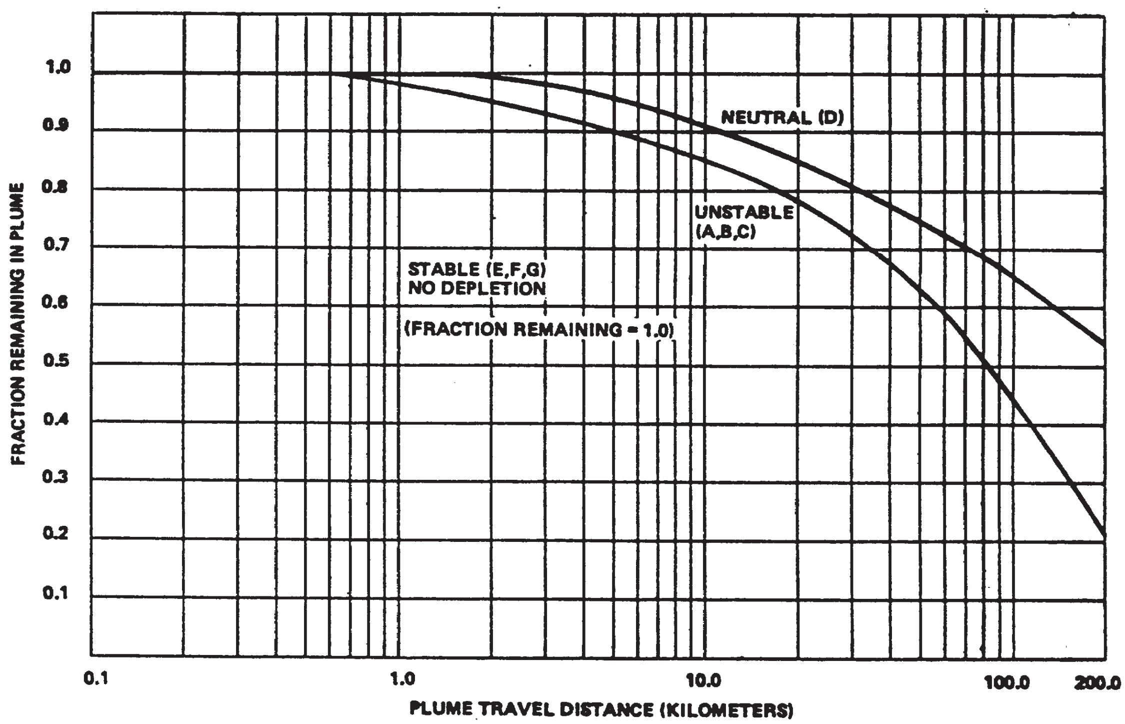
This graph is reproduced from Reference 5 (Figure 3).

Figure 8-4. Plume Depletion Effect for 30-Meter Releases



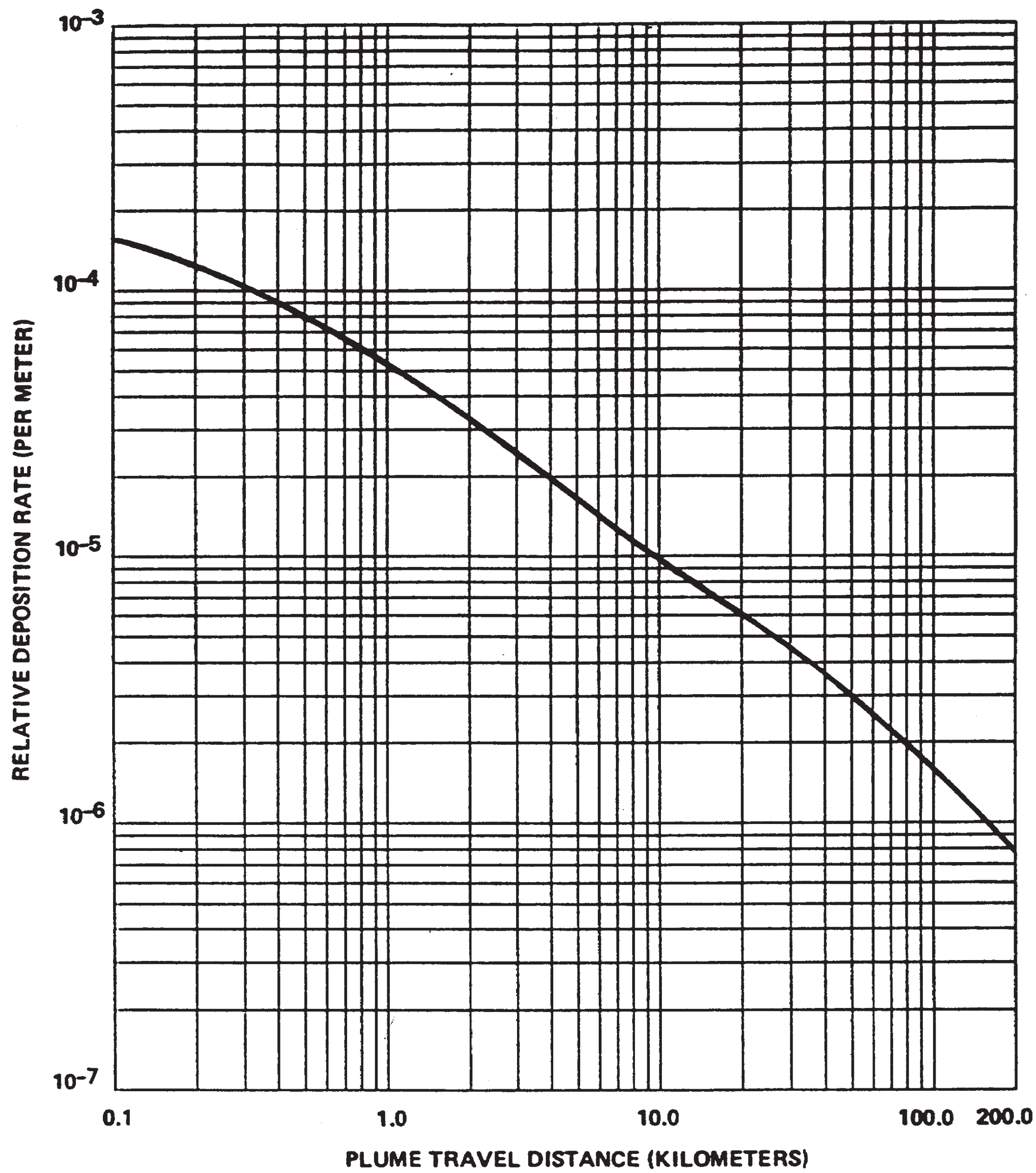
This graph is reproduced from Reference 5 (Figure 4).

Figure 8-5. Plume Depletion Effect for 60-Meter Releases



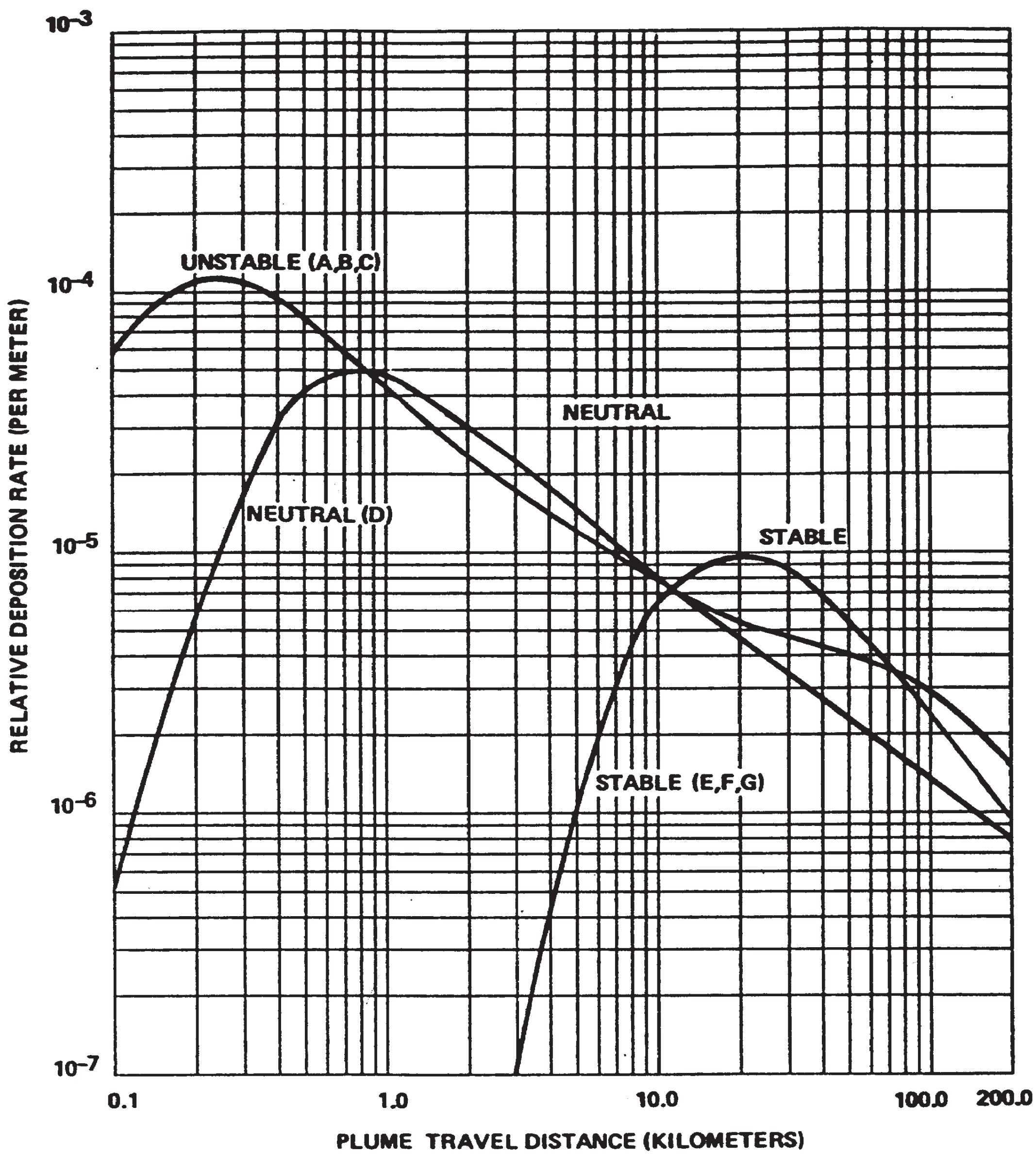
This graph is reproduced from Reference 5 (Figure 5).

Figure 8-6. Plume Depletion Effect for 100-Meter Releases



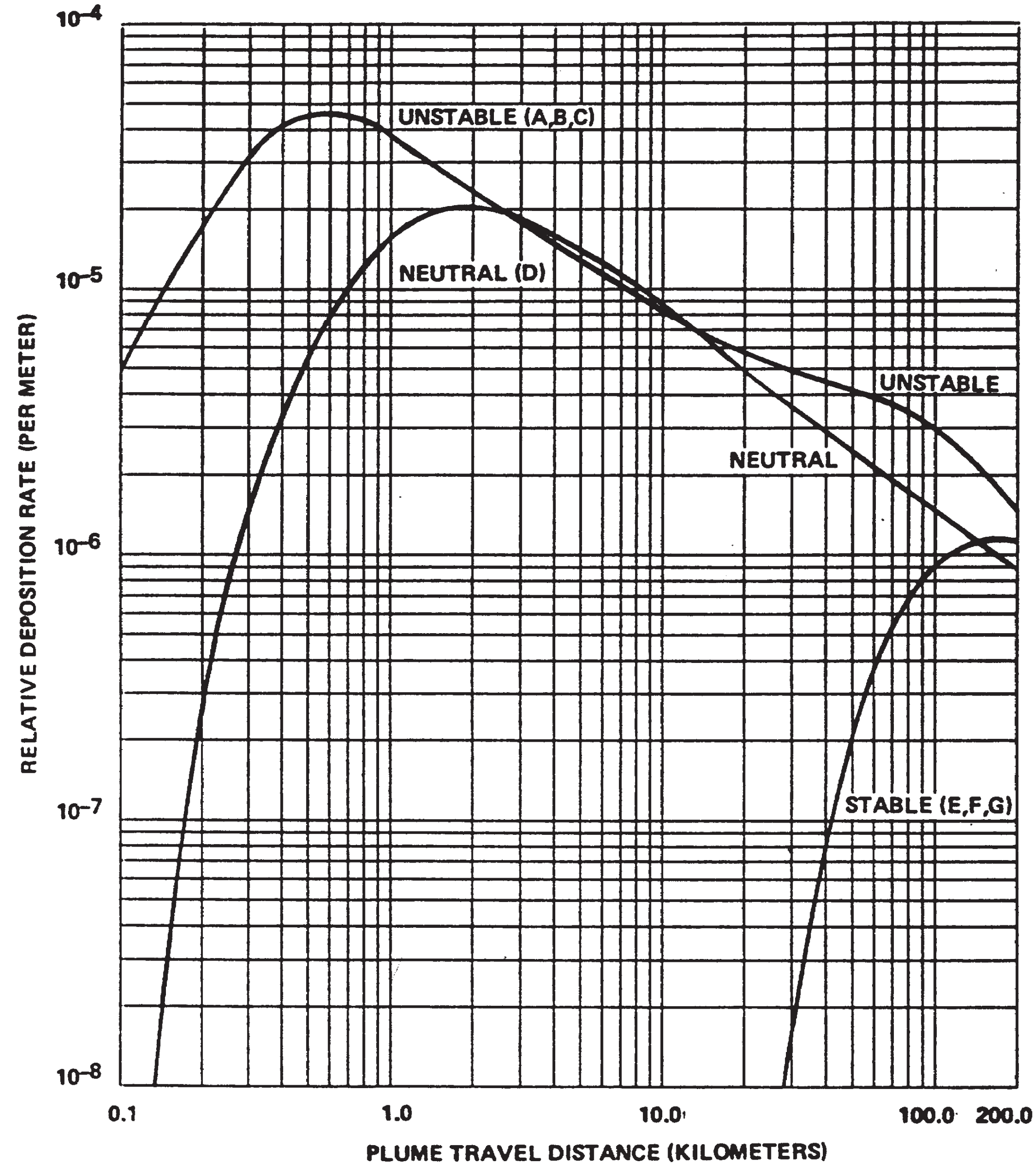
This graph is reproduced from Reference 5 (Figure 6).

Figure 8-7. Relative Deposition for Ground-Level Releases



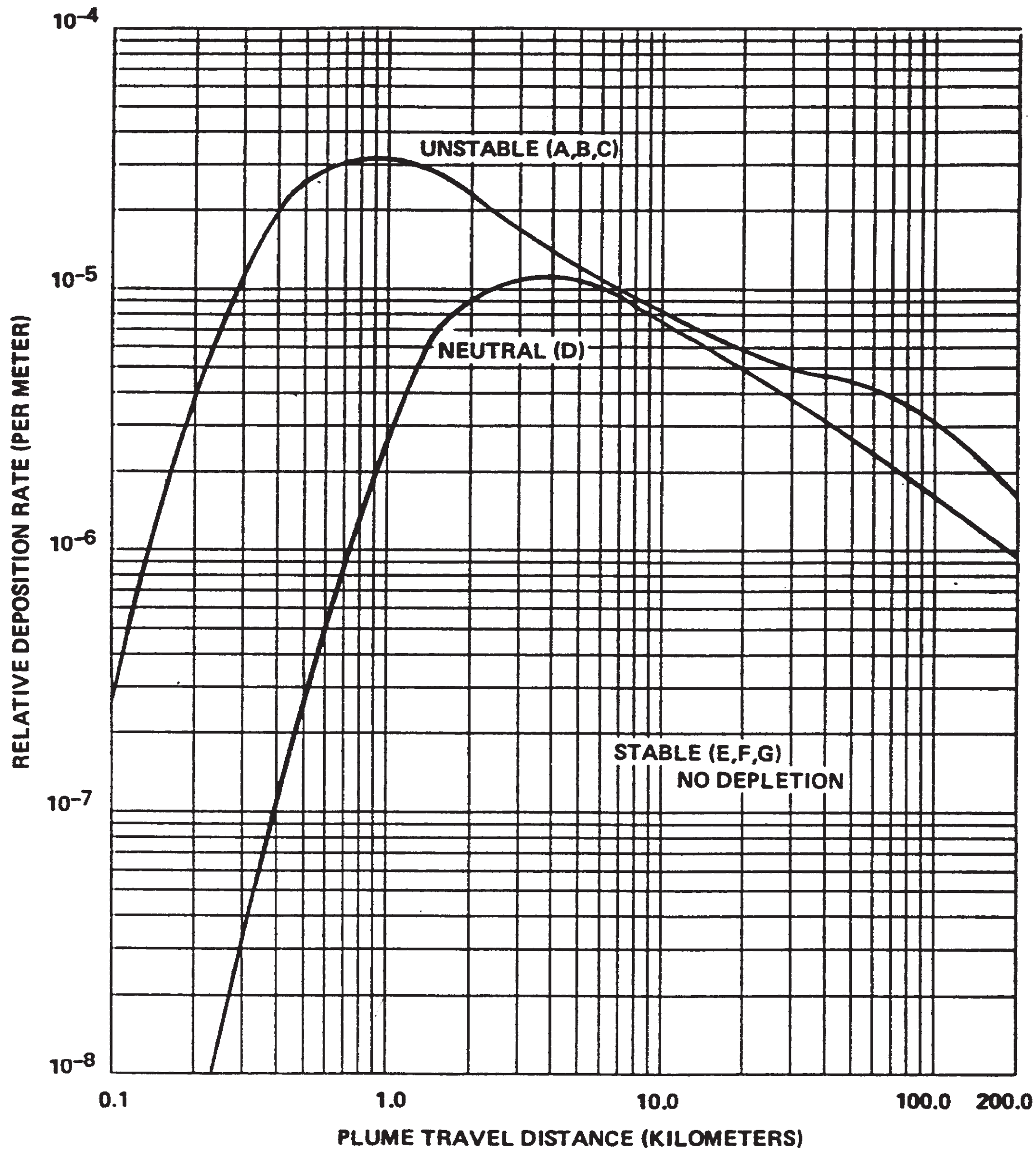
This graph is reproduced from Reference 5 (Figure 7).

Figure 8-8. Relative Deposition for 30-Meter Releases



This graph is reproduced from Reference 5 (Figure 8).

Figure 8-9. Relative Deposition for 60-Meter Releases



This graph is reproduced from Reference 5 (Figure 9).

Figure 8-10. Relative Deposition for 100-Meter (or Greater) Releases

CHAPTER 9
METHODS AND PARAMETERS FOR CALCULATION OF GASEOUS EFFLUENT PATHWAY DOSE FACTORS, R_{aipj}

9.1 INHALATION PATHWAY FACTOR

For the inhalation pathway, R_{aipj} in (mrem/y) per (μCi/m^3) is calculated as follows (Reference 1, Section 5.3.1.1):

$$R_{aipj} = K_1 \cdot (BR)_a \cdot (DFA)_{aij} \qquad \textbf{(9.1)}$$

where:

K_1 = the units conversion factor: 10^6 pCi/μCi.

$(BR)_a$ = the breathing rate of receptor age group a, in m^3/y, from Table 9-5.

$(DFA)_{aij}$ = the inhalation dose factor for receptor age group a, radionuclide i, and organ j, in mrem/pCi, from Table 9-7 through Table 9-10.

9.2 GROUND PLANE PATHWAY FACTOR

For the ground plane external exposure pathway, R_{aipj} in (m^2·mrem/y) per (μCi/s) is calculated as follows (Reference 1, Section 5.3.1.2):

$$R_{aipj} = K_1 \cdot K_2 \cdot (SHF) \cdot (DFG)_{ij} \cdot \left(\frac{1 - e^{-\lambda_i t}}{\lambda_i} \right) \qquad \textbf{(9.2)}$$

where:

K_1 = the units conversion factor: 10^6 pCi/μCi.

K_2 = the units conversion factor: 8760 h/y.

(SHF) = the shielding factor due to structure (dimensionless). The value used for (SHF) is 0.7, from (Reference 3, Table E–15).

$(DFG)_{ij}$ = the ground plane dose factor for radionuclide i and organ j, in (mrem/h) per (pCi/m^2), from Table 9-15. Dose factors are the same for all age groups, and those for the total body also apply to all organs other than skin.

λ_i = the radioactive decay constant for radionuclide i, in s^{-1}. Values of λ_i used in effluent calculations should be based on decay data from a recognized and current source, such as Reference 20.

t = the exposure time, in s. The value used for t is 4.73 x 10^8 s (= 15 y), from (Reference 1, Section 5.3.1.2).

9.3 GARDEN VEGETATION PATHWAY FACTOR

For radionuclides other than tritium in the garden vegetation consumption pathway, R_{aipj} in ($m^2 \cdot$mrem/y) per (μCi/s) is calculated as follows (Reference 1, Section 5.3.1.5):

$$R_{aipj} = K_1 \cdot \frac{r}{Y_v(\lambda_i + \lambda_w)} \cdot (DFL)_{aij} \cdot \left(U_{aL} f_L e^{-\lambda_i t_L} + U_{aS} f_g e^{-\lambda_i t_{hv}}\right) \qquad \textbf{(9.3)}$$

where:

K_1 = the units conversion factor: 10^6 pCi/μCi.

r = the fraction of deposited activity retained on the edible parts of garden vegetation (dimensionless). The value used for r is 1.0 for radioiodines and 0.2 for particulates, from (Reference 3, Table E–1).

Y_v = the areal density (agricultural productivity) of growing leafy garden vegetation, in kg/m^2, from Table 9-1.

λ_i = the radioactive decay constant for radionuclide i, in s^{-1}. Values of λ_i used in effluent calculations should be based on decay data from a recognized and current source, such as Reference 20.

λ_w = the rate constant for removal of activity on leaf and plant surfaces by weathering, in s^{-1}, from Table 9-1.

$(DFL)_{aij}$ = the ingestion dose factor for receptor age group a, radionuclide i, and organ j, in mrem/pCi, from Table 9-11 through Table 9-14.

U_{aL} = the consumption rate of fresh leafy garden vegetation by a receptor in age group a, in kg/y, from Table 9-5.

U_{aS} = the consumption rate of stored garden vegetation by a receptor in age group a, in kg/y, from Table 9-5.

f_L = the fraction of the annual intake of fresh leafy garden vegetation that is grown locally (dimensionless), from Table 9-1.

f_g = the fraction of the annual intake of stored garden vegetation that is grown locally (dimensionless), from Table 9-1.

t_L = the average time between harvest of fresh leafy garden vegetation and its consumption, in s, from Table 9-1.

t_{hv} = the average time between harvest of stored garden vegetation and its consumption, in s, from Table 9-1.

For tritium in the garden vegetation consumption pathway, R_{aipj} in (mrem/y) per (μCi/m^3) is calculated as follows (Reference 1, Section 5.3.1.5), based on the concentration in air rather than deposition onto the ground:

$$R_{aipj} = K_1 \cdot K_3 \cdot (DFL)_{aij} \cdot (U_{aL} f_L + U_{aS} f_g) \cdot 0.75 \cdot \left(\frac{0.5}{H}\right) \qquad \textbf{(9.4)}$$

where:

K_3 =	=	the units conversion factor: 10^3 g/kg.
H =	=	the absolute humidity of atmospheric air, in g/m^3, from Table 9-1.
0.75 =	=	the fraction of the mass of total garden vegetation that is water (dimensionless).
0.5 =	=	the ratio of the specific activity of tritium in garden vegetation water to that in atmospheric water (dimensionless).

and other parameters are as defined above.

Table 9-1. Miscellaneous Parameters for the Garden Vegetation Pathway

The following parameter values are for use in calculating R_{aipj} for the garden vegetation pathway only. The terms themselves are defined in section 9.3.

Parameter	Value	Reference
Y_v	2.0 kg/m^2	Ref. 3, Table E-15
λw	5.73 x 10^{-7} s^{-1} (14-day half-life)	Ref. 1, page 33
f_L	1.0	Ref. 1, page 36
f_g	0.76	Ref. 1, page 33
t_L	8.6 x 10^4 s (1 day)	Ref. 3, Table E-15
t_{hv}	5.18 x 10^6 s (60 days)	Ref. 3, Table E-15
H	8 g/m^3	Ref. 3

9.4 GRASS-COW-MILK PATHWAY FACTOR

For radionuclides other than tritium in the grass-cow-milk pathway, R_{aipj} in ($m^2 \cdot$mrem/y) per (μCi/s) is calculated as follows (Reference 1, Section 5.3.1.3):

$$R_{aipj} = K_1 \cdot \frac{r}{(\lambda_i + \lambda_w)} \cdot Q_F \cdot U_{ap} \cdot F_{mi} \cdot (DFL)_{aij} \cdot \left[\frac{f_p f_s}{Y_p} + \frac{(1 - f_p f_s)\, e^{-\lambda_i t_{hm}}}{Y_s} \right] \cdot e^{-\lambda_i t_f} \qquad \textbf{(9.5)}$$

where:

K_1	=	the units conversion factor: 10^6 pCi/μCi.
r	=	the fraction of deposited activity retained on the edible parts of vegetation (dimensionless). The value used for r is 1.0 for radioiodines and 0.2 for particulates, from (Reference 3, Table E–1).
λ_i	=	the radioactive decay constant for radionuclide i, in s^{-1}. Values of λ_i used in effluent calculations should be based on decay data from a recognized and current source, such as Reference 20.
λ_w	=	the rate constant for removal of activity on leaf and plant surfaces by weathering, in s^{-1}, from Table 9-2.
Q_F	=	the cow's consumption rate of feed, in kg/d, from Table 9-2.
U_{ap}		the consumption rate of cow milk by a receptor in age group a, in L/y, from Table 9-5.
F_{mi}	=	the stable element transfer coefficient applicable to radionuclide i, for cow's milk, in d/L, from Table 9-6.
$(DFL)_{aij}$	=	the ingestion dose factor for receptor age group a, radionuclide i, and organ j, in mrem/pCi, from Table 9-11 through Table 9-14.
f_p	=	the fraction of the year that the cow is on pasture (dimensionless), from Table 9-2.
f_s	=	the fraction of the cow's feed that is pasture grass while the cow is on pasture (dimensionless), from Table 9-2.
Y_p	=	the areal density (agricultural productivity) of growing pasture feed grass, in kg/m^2, from Table 9-2.
Y_s	=	the areal density (agricultural productivity) of growing stored feed, in kg/m^2, from Table 9-2.
t_{hm}	=	the transport time from harvest of stored feed to its consumption by the cow, in s, from Table 9-2.

t_f = the transport time from consumption of feed by the cow, to consumption of milk by the receptor, in s, from Table 9-2.

For tritium in the grass-cow-milk pathway, R_{aipj} in (mrem/y) per (μCi/m^3) is calculated as follows (Reference 1, Section 5.3.1.5), based on the concentration in air rather than deposition onto the ground:

$$R_{aipj} = K_1 \cdot K_3 \cdot Q_F \cdot U_{ap} \cdot F_{mi} \cdot (DFL)_{aij} \cdot 0.75 \cdot \left(\frac{0.5}{H} \right) \qquad \textbf{(9.6)}$$

where:

K_3 = the units conversion factor: 10^3 g/kg.

H = the absolute humidity of atmospheric air, in g/m^3, from Table 9-2.

0.75 = the fraction of the mass of total vegetation that is water (dimensionless).

0.5 = the ratio of the specific activity of tritium in vegetation water to that in atmospheric water (dimensionless).

and other parameters are as defined above.

Table 9-2. Miscellaneous Parameters for the Grass-Cow-Milk Pathway

The following parameter values are for use in calculating R_{aipj} for the grass-cow-milk pathway only. The terms themselves are defined in section 9.4.

Parameter	Value	Reference
λ_w	5.73×10^{-7} s^{-1} (14-day half-life)	Ref. 1, page 33
Q_F	50 kg/d	Ref. 3, Table E-3
f_p	1.0	Ref. 1, page 33
f_s	1.0	Ref. 1, page 33
Y_p	0.7 kg/m^2	Ref. 3, Table E-15
Y_s	2.0 kg/m^2	Ref. 3, Table E-15
t_{hm}	7.78×10^6 s (90 days)	Ref. 3, Table E-15
t_f	1.73×10^5 s (2 days)	Ref. 3, Table E-15
H	8 g/m^3	Ref. 3

9.5 GRASS-GOAT-MILK PATHWAY FACTOR

For radionuclides other than tritium in the grass-goat-milk pathway, R_{aipj} in ($m^2 \cdot$mrem/y) per (μCi/s) is calculated as follows (Reference 1, Section 5.3.1.3):

$$R_{aipj} = K_1 \cdot \frac{r}{(\lambda_i + \lambda_w)} \cdot Q_F \cdot U_{ap} \cdot F_{m\,i} \cdot (DFL)_{aij} \cdot \left[\frac{f_p f_s}{Y_p} + \frac{(1 - f_p f_s)\, e^{-\lambda_i t_{hm}}}{Y_s} \right] \cdot e^{-\lambda_i t_f} \qquad \textbf{(9.7)}$$

where:

K_1	=	the units conversion factor: 10^6 pCi/μCi.
r	=	the fraction of deposited activity retained on the edible parts of vegetation (dimensionless). The value used for r is 1.0 for radioiodines and 0.2 for particulates, from (Reference 3, Table E–1).
λ_i	=	the radioactive decay constant for radionuclide i, in s^{-1}. Values of λ_i used in effluent calculations should be based on decay data from a recognized and current source, such as Reference 20.
λ_w		the rate constant for removal of activity on leaf and plant surfaces by weathering, in s^{-1}, from Table 9-3.
Q_F	=	the goat's consumption rate of feed, in kg/d, from Table 9-3.
U_{ap}	=	the consumption rate of goat milk by a receptor in age group a, in L/y, from Table 9-5.
F_{mi}	=	the stable element transfer coefficient applicable to radionuclide i, for goat's milk, in d/L, from Table 9-6.
$(DFL)_{aij}$	=	the ingestion dose factor for receptor age group a, radionuclide i, and organ j, in mrem/pCi, from Table 9-11 through Table 9-14.
f_p	=	the fraction of the year that the goat is on pasture (dimensionless), from Table 9-3.
f_s	=	the fraction of the goat's feed that is pasture grass while the goat is on pasture (dimensionless), from Table 9-3.
Y_p	=	the areal density (agricultural productivity) of growing pasture feed grass, in kg/m^2, from Table 9-3.
Y_s	=	the areal density (agricultural productivity) of growing stored feed, in kg/m^2, from Table 9-3.
t_{hm}	=	the transport time from harvest of stored feed to its consumption by the goat, in s, from Table 9-3.

t_f = the transport time from consumption of feed by the goat, to consumption of milk by the receptor, in s, from Table 9-3.

For tritium in the grass-goat-milk pathway, R_{aipj} in (mrem/y) per (μCi/m^3) is calculated as follows (Reference 1, Section 5.3.1.5), based on the concentration in air rather than deposition onto the ground:

$$R_{aipj} = K_1 \cdot K_3 \cdot Q_F \cdot U_{ap} \cdot F_{m\,i} \cdot (DFL)_{aij} \cdot 0.75 \cdot \left(\frac{0.5}{H}\right) \qquad \textbf{(9.8)}$$

where:

K_3 = the units conversion factor: 10^3 g/kg.

H = the absolute humidity of atmospheric air, in g/m^3, from Table 9-3.

0.75 = the fraction of the mass of total vegetation that is water (dimensionless).

0.5 = the ratio of the specific activity of tritium in vegetation water to that in atmospheric water (dimensionless).

and other parameters are as defined above.

Table 9-3. Miscellaneous Parameters for the Grass-Goat-Milk Pathway

The following parameter values are for use in calculating R_{aipj} for the grass-goat-milk pathway only. The terms themselves are defined in section 9-5.

Parameter	Value	Reference
λ_w	5.73×10^{-7} s^{-1} (14-day half-life)	Ref. 1, page 33
Q_F	6 kg/d	Ref. 3, Table E-3
f_p	1.0	Ref. 1, page 33
f_s	1.0	Ref. 1, page 33
Y_p	0.7 kg/m^2	Ref. 3, Table E-15
Y_s	2.0 kg/m^2	Ref. 3, Table E-15
t_{hm}	7.78×10^6 s (90 days)	Ref. 3, Table E-15
t_f	1.73×10^5 s (2 days)	Ref. 3, Table E-15
H	8 g/m^3	Ref. 3

9.6 GRASS-COW-MEAT PATHWAY FACTOR

For radionuclides other than tritium in the grass-cow-meat pathway, R_{aipj} in ($m^2 \cdot$mrem/y) per (μCi/s) is calculated as follows (Reference 1, Section 5.3.1.4):

$$R_{aipj} = K_1 \cdot \frac{r}{(\lambda_i + \lambda_w)} \cdot Q_F \cdot U_{ap} \cdot F_{fi} \cdot (DFL)_{aij} \cdot \left[\frac{f_p f_s}{Y_p} + \frac{(1 - f_p f_s)\, e^{-\lambda_i t_{hm}}}{Y_s} \right] \cdot e^{-\lambda_i t_f} \qquad \textbf{(9.9)}$$

where:

K_1 = the units conversion factor: 10^6 pCi/μCi.

r = the fraction of deposited activity retained on the edible parts of vegetation (dimensionless). The value used for r is 1.0 for radioiodines and 0.2 for particulates, from (Reference 3, Table E–1).

λ_i = the radioactive decay constant for radionuclide i, in s^{-1}. Values of λ_i used in effluent calculations should be based on decay data from a recognized and current source, such as Reference 20.

λ_w = the rate constant for removal of activity on leaf and plant surfaces by weathering, in s^{-1}, from Table 9-4.

Q_F = the cow's consumption rate of feed, in kg/d, from Table 9-4.

U_{ap} = the consumption rate of meat by a receptor in age group a, in kg/y, from Table 9-5.

F_{fi} = the stable element transfer coefficient applicable to radionuclide i, for meat, in d/kg, from Table 9-6.

$(DFL)_{aij}$ = the ingestion dose factor for receptor age group a, radionuclide i, and organ j, in mrem/pCi, from Table 9-11 through Table 9-14.

f_p = the fraction of the year that the cow is on pasture (dimensionless), from Table 9-4.

f_s = the fraction of the cow's feed that is pasture grass while the cow is on pasture (dimensionless), from Table 9-4.

Y_p = the areal density (agricultural productivity) of growing pasture feed grass, in kg/m^2, from Table 9-4.

Y_s = the areal density (agricultural productivity) of growing stored feed, in kg/m^2, from Table 9-4.

t_{hm} = the transport time from harvest of stored feed to its consumption by the cow, in s, from Table 9-4.

t_f = the transport time from consumption of feed by the cow, to consumption of meat by the receptor, in s, from Table 9-4.

For tritium in the grass-cow-meat pathway, R_{aipj} in (mrem/y) per (μCi/m^3) is calculated as follows (Reference 1, Section 5.3.1.4), based on the concentration in air rather than deposition onto the ground:

$$R_{aipj} = K_1 \cdot K_3 \cdot Q_F \cdot U_{ap} \cdot F_{f\,i} \cdot (DFL)_{aij} \cdot 0.75 \cdot \left(\frac{0.5}{H}\right) \qquad \textbf{(9.10)}$$

where:

K_3 = the units conversion factor: 10^3 g/kg.

H = the absolute humidity of atmospheric air, in g/m^3, from Table 9-4.

0.75 = the fraction of the mass of total vegetation that is water (dimensionless).

0.5 = the ratio of the specific activity of tritium in vegetation water to that in atmospheric water (dimensionless).

and other parameters are as defined above.

Table 9-4. Miscellaneous Parameters for the Grass-Cow-Meat Pathway

The following parameter values are for use in calculating R_{aipj} for the grass-cow-meat pathway only. The terms themselves are defined in section 9-6.

Parameter	Value	Reference
λ_w	5.73×10^{-7} s^{-1} (14-day half-life)	Ref. 1, page 33
Q_F	50 kg/d	Ref. 3, Table E-3
f_p	1.0	Ref. 1, page 33
f_s	1.0	Ref. 1, page 33
Y_p	0.7 kg/m^2	Ref. 3, Table E-15
Y_s	2.0 kg/m^2	Ref. 3, Table E-15
t_{hm}	7.78×10^6 s (90 days)	Ref. 3, Table E-15
t_f	1.73×10^6 s (20 days)	Ref. 3, Table E-15
H	8 g/m^3	Ref. 3

Table 9-5. Individual Usage Factors

Usage Factor	Receptor Age Group			
	Infant	Child	Teenager	Adult
Milk Consumption Rate, U_{ap} (L/y)	330	330	400	310
Meat Consumption Rate, U_{ap} (kg/y)	0	41	65	110
Fresh Leafy Garden Vegetation Consumption Rate, U_{aL} (kg/y)	0	26	42	64
Stored Garden Vegetation Consumption Rate, U_{aS} (kg/y)	0	520	630	520
Breathing Rate, $(BR)_a$ (m^3/y)	1400	3700	8000	8000

All values are from Reference 3, Table E-5.

Table 9-6. Stable Element Transfer Data

Element	Cow Milk F_m (d/L)*	Goat Milk F_m (d/L)+	Meat F_f (d/kg)*
H	1.0 E-02	1.7 E-01	1.2 E-02
C	1.2 E-02	1.0 E-01	3.1 E-02
Na	4.0 E-02	4.0 E-02	3.0 E-02
P	2.5 E-02	2.5 E-01	4.6 E-02
Cr	2.2 E-03	2.2 E-03	2.4 E-03
Mn	2.5 E-04	2.5 E-04	8.0 E-04
Fe	1.2 E-03	1.3 E-04	4.0 E-02
Co	1.0 E-03	1.0 E-03	1.3 E-02
Ni	6.7 E-03	6.7 E-03	5.3 E-02
Cu	1.4 E-02	1.3 E-02	8.0 E-03
Zn	3.9 E-02	3.9 E-02	3.0 E-02
Br	5.0 E-02	5.0 E-02	2.6 E-02
Rb	3.0 E-02	3.0 E-02	3.1 E-02
Sr	8.0 E-04	1.4 E-02	6.0 E-04
Y	1.0 E-05	1.0 E-05	4.6 E-03
Zr	5.0 E-06	5.0 E-06	3.4 E-02
Nb	2.5 E-03	2.5 E-03	2.8 E-01
Mo	7.5 E-03	7.5 E-03	8.0 E-03
Tc	2.5 E-02	2.5 E-02	4.0 E-01
Ru	1.0 E-06	1.0 E-06	4.0 E-01
Rh	1.0 E-02	1.0 E-02	1.5 E-03
Ag	5.0 E-02	5.0 E-02	1.7 E-02
Sb	1.5 E-03	1.5 E-03	4.0 E-03
Te	1.0 E-03	1.0 E-03	7.7 E-02
I	6.0 E-03	6.0 E-02	2.9 E-03
Cs	1.2 E-02	3.0 E-01	4.0 E-03
Ba	4.0 E-04	4.0 E-04	3.2 E-03
La	5.0 E-06	5.0 E-06	2.0 E-04
Ce	1.0 E-04	1.0 E-04	1.2 E-03
Pr	5.0 E-06	5.0 E-06	4.7 E-03
Nd	5.0 E-06	5.0 E-06	3.3 E-03
W	5.0 E-04	5.0 E-04	1.3 E-03
Np	5.0 E-06	5.0 E-06	2.0 E-04

* - Values from Reference 3 (Table E-1) except as follows: Reference 2 (Table C-5) for Br and Sb.

\+ - Values from Reference 3, Table E-2 for H, C, P, Fe, Cu, Sr, I, and Cs in goat milk, and Table E-1 for all other elements in cow milk, except as follows: Reference 2 (Table C-5) for Br and Sb in cow milk.

Table 9-7. Inhalation Dose Factors for the Infant Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	4.62E-07	4.62E-07	4.62E-07	4.62E-07	4.62E-07	4.62E-07
C-14	1.89E-05	3.79E-06	3.79E-06	3.79E-06	3.79E-06	3.79E-06	3.79E-06
Na-24	7.54E-06	7.54E-06	7.54E-06	7.54E-06	7.54E-06	7.54E-06	7.54E-06
P-32	1.45E-03	8.03E-05	5.53E-05	No Data	No Data	No Data	1.15E-05
Cr-51	No Data	No Data	6.39E-08	4.11E-08	9.45E-09	9.17E-06	2.55E-07
Mn-54	No Data	1.81E-05	3.56E-06	No Data	3.56E-06	7.14E-04	5.04E-06
Mn-56	No Data	1.10E-09	1.58E-10	No Data	7.86E-10	8.95E-06	5.12E-05
Fe-55	1.41E-05	8.39E-06	2.38E-06	No Data	No Data	6.21E-05	7.82E-07
Fe-59	9.69E-06	1.68E-05	6.77E-06	No Data	No Data	7.25E-04	1.77E-05
Co-58	No Data	8.71E-07	1.30E-06	No Data	No Data	5.55E-04	7.95E-06
Co-60	No Data	5.73E-06	8.41E-06	No Data	No Data	3.22E-03	2.28E-05
Ni-63	2.42E-04	1.46E-05	8.29E-06	No Data	No Data	1.49E-04	1.73E-06
Ni-65	1.71E-09	2.03E-10	8.79E-11	No Data	No Data	5.80E-06	3.58E-05
Cu-64	No Data	1.34E-09	5.53E-10	No Data	2.84E-09	6.64E-06	1.07E-05
Zn-65	1.38E-05	4.47E-05	2.22E-05	No Data	2.32E-05	4.62E-04	3.67E-05
Zn-69	3.85E-11	6.91E-11	5.13E-12	No Data	2.87E-11	1.05E-06	9.44E-06
Br-83	No Data	No Data	2.72E-07	No Data	No Data	No Data	No Data
Br-84	No Data	No Data	2.86E-07	No Data	No Data	No Data	No Data
Br-85	No Data	No Data	1.46E-08	No Data	No Data	No Data	No Data
Rb-86	No Data	1.36E-04	6.30E-05	No Data	No Data	No Data	2.17E-06
Rb-88	No Data	3.98E-07	2.05E-07	No Data	No Data	No Data	2.42E-07
Rb-89	No Data	2.29E-07	1.47E-07	No Data	No Data	No Data	4.87E-08
Sr-89	2.84E-04	No Data	8.15E-06	No Data	No Data	1.45E-03	4.57E-05
Sr-90	2.92E-02	No Data	1.85E-03	No Data	No Data	8.03E-03	9.36E-05
Sr-91	6.83E-08	No Data	2.47E-09	No Data	No Data	3.76E-05	5.24E-05

All values are in (mrem/pCi inhaled). They are obtained from Reference 3 (Table E-10). Neither Reference 2 nor Reference 3 contains data for Rh–105, Sb–124, or Sb–125.

Table 9-7 (contd). Inhalation Dose Factors for the Infant Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Sr-92	7.50E-09	No Data	2.79E-10	No Data	No Data	1.70E-05	1.00E-04
Y-90	2.35E-06	No Data	6.30E-08	No Data	No Data	1.92E-04	7.43E-05
Y-91m	2.91E-10	No Data	9.90E-12	No Data	No Data	1.99E-06	1.68E-06
Y-91	4.20E-04	No Data	1.12E-05	No Data	No Data	1.75E-03	5.02E-05
Y-92	1.17E-08	No Data	3.29E-10	No Data	No Data	1.75E-05	9.04E-05
Y-93	1.07E-07	No Data	2.91E-09	No Data	No Data	5.46E-05	1.19E-04
Zr-95	8.24E-05	1.99E-05	1.45E-05	No Data	2.22E-05	1.25E-03	1.55E-05
Zr-97	1.07E-07	1.83E-08	8.36E-09	No Data	1.85E-08	7.88E-05	1.00E-04
Nb-95	1.12E-05	4.59E-06	2.70E-06	No Data	3.37E-06	3.42E-04	9.05E-06
Mo-99	No Data	1.18E-07	2.31E-08	No Data	1.89E-07	9.63E-05	3.48E-05
Tc-99m	9.98E-13	2.06E-12	2.66E-11	No Data	2.22E-11	5.79E-07	1.45E-06
Tc-101	4.65E-14	5.88E-14	5.80E-13	No Data	6.99E-13	4.17E-07	6.03E-07
Ru-103	1.44E-06	No Data	4.85E-07	No Data	3.03E-06	3.94E-04	1.15E-05
Ru-105	8.74E-10	No Data	2.93E-10	No Data	6.42E-10	1.12E-05	3.46E-05
Ru-106	6.20E-05	No Data	7.77E-06	No Data	7.61E-05	8.26E-03	1.17E-04
Rh-105	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Ag-110m	7.13E-06	5.16E-06	3.57E-06	No Data	7.80E-06	2.62E-03	2.36E-05
Sb-124	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Sb-125	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Te-125m	3.40E-06	1.42E-06	4.70E-07	1.16E-06	No Data	3.19E-04	9.22E-06
Te-127m	1.19E-05	4.93E-06	1.48E-06	3.48E-06	2.68E-05	9.37E-04	1.95E-05
Te-127	1.59E-09	6.81E-10	3.49E-10	1.32E-09	3.47E-09	7.39E-06	1.74E-05
Te-129m	1.01E-05	4.35E-06	1.59E-06	3.91E-06	2.27E-05	1.20E-03	4.93E-05
Te-129	5.63E-11	2.48E-11	1.34E-11	4.82E-11	1.25E-10	2.14E-06	1.88E-05
Te-131m	7.62E-08	3.93E-08	2.59E-08	6.38E-08	1.89E-07	1.42E-04	8.51E-05
Te-131	1.24E-11	5.87E-12	3.57E-12	1.13E-11	2.85E-11	1.47E-06	5.87E-06

Table 9-7 (contd). Inhalation Dose Factors for the Infant Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Te-132	2.66E-07	1.69E-07	1.26E-07	1.99E-07	7.39E-07	2.43E-04	3.15E-05
I-130	4.54E-06	9.91E-06	3.98E-06	1.14E-03	1.09E-05	No Data	1.42E-06
I-131	2.71E-05	3.17E-05	1.40E-05	1.06E-02	3.70E-05	No Data	7.56E-07
I-132	1.21E-06	2.53E-06	8.99E-07	1.21E-04	2.82E-06	No Data	1.36E-06
I-133	9.46E-06	1.37E-05	4.00E-06	2.54E-03	1.60E-05	No Data	1.54E-06
I-134	6.58E-07	1.34E-06	4.75E-07	3.18E-05	1.49E-06	No Data	9.21E-07
I-135	2.76E-06	5.43E-06	1.98E-06	4.97E-04	6.05E-06	No Data	1.31E-06
Cs-134	2.83E-04	5.02E-04	5.32E-05	No Data	1.36E-04	5.69E-05	9.53E-07
Cs-136	3.45E-05	9.61E-05	3.78E-05	No Data	4.03E-05	8.40E-06	1.02E-06
Cs-137	3.92E-04	4.37E-04	3.25E-05	No Data	1.23E-04	5.09E-05	9.53E-07
Cs-138	3.61E-07	5.58E-07	2.84E-07	No Data	2.93E-07	4.67E-08	6.26E-07
Ba-139	1.06E-09	7.03E-13	3.07E-11	No Data	4.23E-13	4.25E-06	3.64E-05
Ba-140	4.00E-05	4.00E-08	2.07E-06	No Data	9.59E-09	1.14E-03	2.74E-05
Ba-141	1.12E-10	7.70E-14	3.55E-12	No Data	4.64E-14	2.12E-06	3.39E-06
Ba-142	2.84E-11	2.36E-14	1.40E-12	No Data	1.36E-14	1.11E-06	4.95E-07
La-140	3.61E-07	1.43E-07	3.68E-08	No Data	No Data	1.20E-04	6.06E-05
La-142	7.36E-10	2.69E-10	6.46E-11	No Data	No Data	5.87E-06	4.25E-05
Ce-141	1.98E-05	1.19E-05	1.42E-06	No Data	3.75E-06	3.69E-04	1.54E-05
Ce-143	2.09E-07	1.38E-07	1.58E-08	No Data	4.03E-08	8.30E-05	3.55E-05
Ce-144	2.28E-03	8.65E-04	1.26E-04	No Data	3.84E-04	7.03E-03	1.06E-04
Pr-143	1.00E-05	3.74E-06	4.99E-07	No Data	1.41E-06	3.09E-04	2.66E-05
Pr-144	3.42E-11	1.32E-11	1.72E-12	No Data	4.80E-12	1.15E-06	3.06E-06
Nd-147	5.67E-06	5.81E-06	3.57E-07	No Data	2.25E-06	2.30E-04	2.23E-05
W-187	9.26E-09	6.44E-09	2.23E-09	No Data	No Data	2.83E-05	2.54E-05
Np-239	2.65E-07	2.37E-08	1.34E-08	No Data	4.73E-08	4.25E-05	1.78E-05

Table 9-8. Inhalation Dose Factors for the Child Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	3.04E-07	3.04E-07	3.04E-07	3.04E-07	3.04E-07	3.04E-07
C-14	9.70E-06	1.82E-06	1.82E-06	1.82E-06	1.82E-06	1.82E-06	1.82E-06
Na-24	4.35E-06	4.35E-06	4.35E-06	4.35E-06	4.35E-06	4.35E-06	4.35E-06
P-32	7.04E-04	3.09E-05	2.67E-05	No Data	No Data	No Data	1.14E-05
Cr-51	No Data	No Data	4.17E-08	2.31E-08	6.57E-09	4.59E-06	2.93E-07
Mn-54	No Data	1.16E-05	2.57E-06	No Data	2.71E-06	4.26E-04	6.19E-06
Mn-56	No Data	4.48E-10	8.43E-11	No Data	4.52E-10	3.55E-06	3.33E-05
Fe-55	1.28E-05	6.80E-06	2.10E-06	No Data	No Data	3.00E-05	7.75E-07
Fe-59	5.59E-06	9.04E-06	4.51E-06	No Data	No Data	3.43E-04	1.91E-05
Co-58	No Data	4.79E-07	8.55E-07	No Data	No Data	2.99E-04	9.29E-06
Co-60	No Data	3.55E-06	6.12E-06	No Data	No Data	1.91E-03	2.60E-05
Ni-63	2.22E-04	1.25E-05	7.56E-06	No Data	No Data	7.43E-05	1.71E-06
Ni-65	8.08E-10	7.99E-11	4.44E-11	No Data	No Data	2.21E-06	2.27E-05
Cu-64	No Data	5.39E-10	2.90E-10	No Data	1.63E-09	2.59E-06	9.92E-06
Zn-65	1.15E-05	3.06E-05	1.90E-05	No Data	1.93E-05	2.69E-04	4.41E-06
Zn-69	1.81E-11	2.61E-11	2.41E-12	No Data	1.58E-11	3.84E-07	2.75E-06
Br-83	No Data	No Data	1.28E-07	No Data	No Data	No Data	No Data
Br-84	No Data	No Data	1.48E-07	No Data	No Data	No Data	No Data
Br-85	No Data	No Data	6.84E-09	No Data	No Data	No Data	No Data
Rb-86	No Data	5.36E-05	3.09E-05	No Data	No Data	No Data	2.16E-06
Rb-88	No Data	1.52E-07	9.90E-08	No Data	No Data	No Data	4.66E-09
Rb-89	No Data	9.33E-08	7.83E-08	No Data	No Data	No Data	5.11E-10
Sr-89	1.62E-04	No Data	4.66E-06	No Data	No Data	5.83E-04	4.52E-05
Sr-90	2.73E-02	No Data	1.74E-03	No Data	No Data	3.99E-03	9.28E-05
Sr-91	3.28E-08	No Data	1.24E-09	No Data	No Data	1.44E-05	4.70E-05

All values are in (mrem/pCi inhaled). They are obtained from Reference 3 (Table E-9). Neither Reference 2 nor Reference 3 contains data for Rh–105, Sb–124, or Sb–125.

Table 9-8 (contd). Inhalation Dose Factors for the Child Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Sr-92	3.54E-09	No Data	1.42E-10	No Data	No Data	6.49E-06	6.55E-05
Y-90	1.11E-06	No Data	2.99E-08	No Data	No Data	7.07E-05	7.24E-05
Y-91m	1.37E-10	No Data	4.98E-12	No Data	No Data	7.60E-07	4.64E-07
Y-91	2.47E-04	No Data	6.59E-06	No Data	No Data	7.10E-04	4.97E-05
Y-92	5.50E-09	No Data	1.57E-10	No Data	No Data	6.46E-06	6.46E-05
Y-93	5.04E-08	No Data	1.38E-09	No Data	No Data	2.01E-05	1.05E-04
Zr-95	5.13E-05	1.13E-05	1.00E-05	No Data	1.61E-05	6.03E-04	1.65E-05
Zr-97	5.07E-08	7.34E-09	4.32E-09	No Data	1.05E-08	3.06E-05	9.49E-05
Nb-95	6.35E-06	2.48E-06	1.77E-06	No Data	2.33E-06	1.66E-04	1.00E-05
Mo-99	No Data	4.66E-08	1.15E-08	No Data	1.06E-07	3.66E-05	3.42E-05
Tc-99m	4.81E-13	9.41E-13	1.56E-11	No Data	1.37E-11	2.57E-07	1.30E-06
Tc-101	2.19E-14	2.30E-14	2.91E-13	No Data	3.92E-13	1.58E-07	4.41E-09
Ru-103	7.55E-07	No Data	2.90E-07	No Data	1.90E-06	1.79E-04	1.21E-05
Ru-105	4.13E-10	No Data	1.50E-10	No Data	3.63E-10	4.30E-06	2.69E-05
Ru-106	3.68E-05	No Data	4.57E-06	No Data	4.97E-05	3.87E-03	1.16E-04
Rh-105	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Ag-110m	4.56E-06	3.08E-06	2.47E-06	No Data	5.74E-06	1.48E-03	2.71E-05
Sb-124	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Sb-125	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Te-125m	1.82E-06	6.29E-07	2.47E-07	5.20E-07	No Data	1.29E-04	9.13E-06
Te-127m	6.72E-06	2.31E-06	8.16E-07	1.64E-06	1.72E-05	4.00E-04	1.93E-05
Te-127	7.49E-10	2.57E-10	1.65E-10	5.30E-10	1.91E-09	2.71E-06	1.52E-05
Te-129m	5.19E-06	1.85E-06	8.22E-07	1.71E-06	1.36E-05	4.76E-04	4.91E-05
Te-129	2.64E-11	9.45E-12	6.44E-12	1.93E-11	6.94E-11	7.93E-07	6.89E-06
Te-131m	3.63E-08	1.60E-08	1.37E-08	2.64E-08	1.08E-07	5.56E-05	8.32E-05
Te-131	5.87E-12	2.28E-12	1.78E-12	4.59E-12	1.59E-11	5.55E-07	3.60E-07

Table 9-8 (contd). Inhalation Dose Factors for the Child Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Te-132	1.30E-07	7.36E-08	7.12E-08	8.58E-08	4.79E-07	1.02E-04	3.72E-05
I-130	2.21E-06	4.43E-06	2.28E-06	4.99E-04	6.61E-06	No Data	1.38E-06
I-131	1.30E-05	1.30E-05	7.37E-06	4.39E-03	2.13E-05	No Data	7.68E-07
I-132	5.72E-07	1.10E-06	5.07E-07	5.23E-05	1.69E-06	No Data	8.65E-07
I-133	4.48E-06	5.49E-06	2.08E-06	1.04E-03	9.13E-06	No Data	1.48E-06
I-134	3.17E-07	5.84E-07	2.69E-07	1.37E-05	8.92E-07	No Data	2.58E-07
I-135	1.33E-06	2.36E-06	1.12E-06	2.14E-04	3.62E-06	No Data	1.20E-06
Cs-134	1.76E-04	2.74E-04	6.07E-05	No Data	8.93E-05	3.27E-05	1.04E-06
Cs-136	1.76E-05	4.62E-05	3.14E-05	No Data	2.58E-05	3.93E-06	1.13E-06
Cs-137	2.45E-04	2.23E-04	3.47E-05	No Data	7.63E-05	2.81E-05	9.78E-07
Cs-138	1.71E-07	2.27E-07	1.50E-07	No Data	1.68E-07	1.84E-08	7.29E-08
Ba-139	4.98E-10	2.66E-13	1.45E-11	No Data	2.33E-13	1.56E-06	1.56E-05
Ba-140	2.00E-05	1.75E-08	1.17E-06	No Data	5.71E-09	4.71E-04	2.75E-05
Ba-141	5.29E-11	2.95E-14	1.72E-12	No Data	2.56E-14	7.89E-07	7.44E-08
Ba-142	1.35E-11	9.73E-15	7.54E-13	No Data	7.87E-15	4.44E-07	7.41E-10
La-140	1.74E-07	6.08E-08	2.04E-08	No Data	No Data	4.94E-05	6.10E-05
La-142	3.50E-10	1.11E-10	3.49E-11	No Data	No Data	2.35E-06	2.05E-05
Ce-141	1.06E-05	5.28E-06	7.83E-07	No Data	2.31E-06	1.47E-04	1.53E-05
Ce-143	9.89E-08	5.37E-08	7.77E-09	No Data	2.26E-08	3.12E-05	3.44E-05
Ce-144	1.83E-03	5.72E-04	9.77E-05	No Data	3.17E-04	3.23E-03	1.05E-04
Pr-143	4.99E-06	1.50E-06	2.47E-07	No Data	8.11E-07	1.17E-04	2.63E-05
Pr-144	1.61E-11	4.99E-12	8.10E-13	No Data	2.64E-12	4.23E-07	5.32E-08
Nd-147	2.92E-06	2.36E-06	1.84E-07	No Data	1.30E-06	8.87E-05	2.22E-05
W-187	4.41E-09	2.61E-09	1.17E-09	No Data	No Data	1.11E-05	2.46E-05
Np-239	1.26E-07	9.04E-09	6.35E-09	No Data	2.63E-08	1.57E-05	1.73E-05

Table 9-9. Inhalation Dose Factors for the Teenager Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	1.59E-07	1.59E-07	1.59E-07	1.59E-07	1.59E-07	1.59E-07
C-14	3.25E-06	6.09E-07	6.09E-07	6.09E-07	6.09E-07	6.09E-07	6.09E-07
Na-24	1.72E-06	1.72E-06	1.72E-06	1.72E-06	1.72E-06	1.72E-06	1.72E-06
P-32	2.36E-04	1.37E-08	8.95E-06	No Data	No Data	No Data	1.16E-05
Cr-51	No Data	No Data	1.69E-08	9.37E-09	3.84E-09	2.62E-06	3.75E-07
Mn-54	No Data	6.39E-06	1.05E-06	No Data	1.59E-06	2.48E-04	8.35E-06
Mn-56	No Data	2.12E-10	3.15E-11	No Data	2.24E-10	1.90E-06	7.18E-06
Fe-55	4.18E-06	2.98E-06	6.93E-07	No Data	No Data	1.55E-05	7.99E-07
Fe-59	1.99E-06	4.62E-06	1.79E-06	No Data	No Data	1.91E-04	2.23E-05
Co-58	No Data	2.59E-07	3.47E-07	No Data	No Data	1.68E-04	1.19E-05
Co-60	No Data	1.89E-06	2.48E-06	No Data	No Data	1.09E-03	3.24E-05
Ni-63	7.25E-05	5.43E-06	2.47E-06	No Data	No Data	3.84E-05	1.77E-06
Ni-65	2.73E-10	3.66E-11	1.59E-11	No Data	No Data	1.17E-06	4.59E-06
Cu-64	No Data	2.54E-10	1.06E-10	No Data	8.01E-10	1.39E-06	7.68E-06
Zn-65	4.82E-06	1.67E-05	7.80E-06	No Data	1.08E-05	1.55E-04	5.83E-06
Zn-69	6.04E-12	1.15E-11	8.07E-13	No Data	7.53E-12	1.98E-07	3.56E-08
Br-83	No Data	No Data	4.30E-08	No Data	No Data	No Data	No Data
Br-84	No Data	No Data	5.41E-08	No Data	No Data	No Data	No Data
Br-85	No Data	No Data	2.29E-09	No Data	No Data	No Data	No Data
Rb-86	No Data	2.38E-05	1.05E-05	No Data	No Data	No Data	2.21E-06
Rb-88	No Data	6.82E-08	3.40E-08	No Data	No Data	No Data	3.65E-15
Rb-89	No Data	4.40E-08	2.91E-08	No Data	No Data	No Data	4.22E-17
Sr-89	5.43E-05	No Data	1.56E-06	No Data	No Data	3.02E-04	4.64E-05
Sr-90	1.35E-02	No Data	8.35E-04	No Data	No Data	2.06E-03	9.56E-05
Sr-91	1.10E-08	No Data	4.39E-10	No Data	No Data	7.59E-06	3.24E-05

All values are in (mrem/pCi inhaled). They are obtained from Reference 3 (Table E-8). Neither Reference 2 nor Reference 3 contains data for Rh–105, Sb–124, or Sb–125.

Table 9-9 (contd). Inhalation Dose Factors for the Teenager Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Sr-92	1.19E-09	No Data	5.08E-11	No Data	No Data	3.43E-06	1.49E-05
Y-90	3.73E-07	No Data	1.00E-08	No Data	No Data	3.66E-05	6.99E-05
Y-91m	4.63E-11	No Data	1.77E-12	No Data	No Data	4.00E-07	3.77E-09
Y-91	8.26E-05	No Data	2.21E-06	No Data	No Data	3.67E-04	5.11E-05
Y-92	1.84E-09	No Data	5.36E-11	No Data	No Data	3.35E-06	2.06E-05
Y-93	1.69E-08	No Data	4.65E-10	No Data	No Data	1.04E-05	7.24E-05
Zr-95	1.82E-05	5.73E-06	3.94E-06	No Data	8.42E-06	3.36E-04	1.86E-05
Zr-97	1.72E-08	3.40E-09	1.57E-09	No Data	5.15E-09	1.62E-05	7.88E-05
Nb-95	2.32E-06	1.29E-06	7.08E-07	No Data	1.25E-06	9.39E-05	1.21E-05
Mo-99	No Data	2.11E-08	4.03E-09	No Data	5.14E-08	1.92E-05	3.36E-05
Tc-99m	1.73E-13	4.83E-13	6.24E-12	No Data	7.20E-12	1.44E-07	7.66E-07
Tc-101	7.40E-15	1.05E-14	1.03E-13	No Data	1.90E-13	8.34E-08	1.09E-16
Ru-103	2.63E-07	No Data	1.12E-07	No Data	9.29E-07	9.79E-05	1.36E-05
Ru-105	1.40E-10	No Data	5.42E-11	No Data	1.76E-10	2.27E-06	1.13E-05
Ru-106	1.23E-05	No Data	1.55E-06	No Data	2.38E-05	2.01E-03	1.20E-04
Rh-105	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Ag-110m	1.73E-06	1.64E-06	9.99E-07	No Data	3.13E-06	8.44E-04	3.41E-05
Sb-124	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Sb-125	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Te-125m	6.10E-07	2.80E-07	8.34E-08	1.75E-07	No Data	6.70E-05	9.38E-06
Te-127m	2.25E-06	1.02E-06	2.73E-07	5.48E-07	8.17E-06	2.07E-04	1.99E-05
Te-127	2.51E-10	1.14E-10	5.52E-11	1.77E-10	9.10E-10	1.40E-06	1.01E-05
Te-129m	1.74E-06	8.23E-07	2.81E-07	5.72E-07	6.49E-06	2.47E-04	5.06E-05
Te-129	8.87E-12	4.22E-12	2.20E-12	6.48E-12	3.32E-11	4.12E-07	2.02E-07
Te-131m	1.23E-08	7.51E-09	5.03E-09	9.06E-09	5.49E-08	2.97E-05	7.76E-05
Te-131	1.97E-12	1.04E-12	6.30E-13	1.55E-12	7.72E-12	2.92E-07	1.89E-09

Table 9-9 (contd). Inhalation Dose Factors for the Teenager Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Te-132	4.50E-08	3.63E-08	2.74E-08	3.07E-08	2.44E-07	5.61E-05	5.79E-05
I-130	7.80E-07	2.24E-06	8.96E-07	1.86E-04	3.44E-06	No Data	1.14E-06
I-131	4.43E-06	6.14E-06	3.30E-06	1.83E-03	1.05E-05	No Data	8.11E-07
I-132	1.99E-07	5.47E-07	1.97E-07	1.89E-05	8.65E-07	No Data	1.59E-07
I-133	1.52E-06	2.56E-06	7.78E-07	3.65E-04	4.49E-06	No Data	1.29E-06
I-134	1.11E-07	2.90E-07	1.05E-07	4.94E-06	4.58E-07	No Data	2.55E-09
I-135	4.62E-07	1.18E-06	4.36E-07	7.76E-05	1.86E-06	No Data	8.69E-07
Cs-134	6.28E-05	1.41E-04	6.86E-05	No Data	4.69E-05	1.83E-05	1.22E-06
Cs-136	6.44E-06	2.42E-05	1.71E-05	No Data	1.38E-05	2.22E-06	1.36E-06
Cs-137	8.38E-05	1.06E-04	3.89E-05	No Data	3.80E-05	1.51E-05	1.06E-06
Cs-138	5.82E-08	1.07E-07	5.58E-08	No Data	8.28E-08	9.84E-09	3.38E-11
Ba-139	1.67E-10	1.18E-13	4.87E-12	No Data	1.11E-13	8.08E-07	8.06E-07
Ba-140	6.84E-06	8.38E-09	4.40E-07	No Data	2.85E-09	2.54E-04	2.86E-05
Ba-141	1.78E-11	1.32E-14	5.93E-13	No Data	1.23E-14	4.11E-07	9.33E-14
Ba-142	4.62E-12	4.63E-15	2.84E-13	No Data	3.92E-15	2.39E-07	5.99E-20
La-140	5.99E-08	2.95E-08	7.82E-09	No Data	No Data	2.68E-05	6.09E-05
La-142	1.20E-10	5.31E-11	1.32E-11	No Data	No Data	1.27E-06	1.50E-06
Ce-141	3.55E-06	2.37E-06	2.71E-07	No Data	1.11E-06	7.67E-05	1.58E-05
Ce-143	3.32E-08	2.42E-08	2.70E-09	No Data	1.08E-08	1.63E-05	3.19E-05
Ce-144	6.11E-04	2.53E-04	3.28E-05	No Data	1.51E-04	1.67E-03	1.08E-04
Pr-143	1.67E-06	6.64E-07	8.28E-08	No Data	3.86E-07	6.04E-05	2.67E-05
Pr-144	5.37E-12	2.20E-12	2.72E-13	No Data	1.26E-12	2.19E-07	2.94E-14
Nd-147	9.83E-07	1.07E-06	6.41E-08	No Data	6.28E-07	4.65E-05	2.28E-05
W-187	1.50E-09	1.22E-09	4.29E-10	No Data	No Data	5.92E-06	2.21E-05
Np-239	4.23E-08	3.99E-09	2.21E-09	No Data	1.25E-08	8.11E-06	1.65E-05

Table 9-10. Inhalation Dose Factors for the Adult Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	1.58E-07	1.58E-07	1.58E-07	1.58E-07	1.58E-07	1.58E-07
C-14	2.27E-06	4.26E-07	4.26E-07	4.26E-07	4.26E-07	4.26E-07	4.26E-07
Na-24	1.28E-06	1.28E-06	1.28E-06	1.28E-06	1.28E-06	1.28E-06	1.28E-06
P-32	1.65E-04	9.64E-06	6.26E-06	No Data	No Data	No Data	1.08E-05
Cr-51	No Data	No Data	1.25E-08	7.44E-09	2.85E-09	1.80E-06	4.15E-07
Mn-54	No Data	4.95E-06	7.87E-07	No Data	1.23E-06	1.75E-04	9.67E-06
Mn-56	No Data	1.55E-10	2.29E-11	No Data	1.63E-10	1.18E-06	2.53E-06
Fe-55	3.07E-06	2.12E-06	4.93E-07	No Data	No Data	9.01E-06	7.54E-07
Fe-59	1.47E-06	3.47E-06	1.32E-06	No Data	No Data	1.27E-04	2.35E-05
Co-58	No Data	1.98E-07	2.59E-07	No Data	No Data	1.16E-04	1.33E-05
Co-60	No Data	1.44E-06	1.85E-06	No Data	No Data	7.46E-04	3.56E-05
Ni-63	5.40E-05	3.93E-06	1.81E-06	No Data	No Data	2.23E-05	1.67E-06
Ni-65	1.92E-10	2.62E-11	1.14E-11	No Data	No Data	7.00E-07	1.54E-06
Cu-64	No Data	1.83E-10	7.69E-11	No Data	5.78E-10	8.48E-07	6.12E-06
Zn-65	4.05E-06	1.29E-05	5.82E-06	No Data	8.62E-06	1.08E-04	6.68E-06
Zn-69	4.23E-12	8.14E-12	5.65E-13	No Data	5.27E-12	1.15E-07	2.04E-09
Br-83	No Data	No Data	3.01E-08	No Data	No Data	No Data	2.90E-08
Br-84	No Data	No Data	3.91E-08	No Data	No Data	No Data	2.05E-13
Br-85	No Data	No Data	1.60E-09	No Data	No Data	No Data	No Data
Rb-86	No Data	1.69E-05	7.37E-06	No Data	No Data	No Data	2.08E-06
Rb-88	No Data	4.84E-08	2.41E-08	No Data	No Data	No Data	4.18E-19
Rb-89	No Data	3.20E-08	2.12E-08	No Data	No Data	No Data	1.16E-21
Sr-89	3.80E-05	No Data	1.09E-06	No Data	No Data	1.75E-04	4.37E-05
Sr-90	1.24E-02	No Data	7.62E-04	No Data	No Data	1.20E-03	9.02E-05
Sr-91	7.74E-09	No Data	3.13E-10	No Data	No Data	4.56E-06	2.39E-05

All values are in (mrem/pCi inhaled). They are obtained from Reference 3 (Table E-7), except as follows: Reference 2 (Table C–1) for Rh–105, Sb-124, and Sb-125.

Table 9-10 (contd). Inhalation Dose Factors for the Adult Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Sr-92	8.43E-10	No Data	3.64E-11	No Data	No Data	2.06E-06	5.38E-06
Y-90	2.61E-07	No Data	7.01E-09	No Data	No Data	2.12E-05	6.32E-05
Y-91m	3.26E-11	No Data	1.27E-12	No Data	No Data	2.40E-07	1.66E-10
Y-91	5.78E-05	No Data	1.55E-06	No Data	No Data	2.13E-04	4.81E-05
Y-92	1.29E-09	No Data	3.77E-11	No Data	No Data	1.96E-06	9.19E-06
Y-93	1.18E-08	No Data	3.26E-10	No Data	No Data	6.06E-06	5.27E-05
Zr-95	1.34E-05	4.30E-06	2.91E-06	No Data	6.77E-06	2.21E-04	1.88E-05
Zr-97	1.21E-08	2.45E-09	1.13E-09	No Data	3.71E-09	9.84E-06	6.54E-05
Nb-95	1.76E-06	9.77E-07	5.26E-07	No Data	9.67E-07	6.31E-05	1.30E-05
Mo-99	No Data	1.51E-08	2.87E-09	No Data	3.64E-08	1.14E-05	3.10E-05
Tc-99m	1.29E-13	3.64E-13	4.63E-12	No Data	5.52E-12	9.55E-08	5.20E-07
Tc-101	5.22E-15	7.52E-15	7.38E-14	No Data	1.35E-13	4.99E-08	1.36E-21
Ru-103	1.91E-07	No Data	8.23E-08	No Data	7.29E-07	6.31E-05	1.38E-05
Ru-105	9.88E-11	No Data	3.89E-11	No Data	1.27E-10	1.37E-06	6.02E-06
Ru-106	8.64E-06	No Data	1.09E-06	No Data	1.67E-05	1.17E-03	1.14E-04
Rh-105	9.24E-10	6.73E-10	4.43E-10	No Data	2.86E-09	2.41E-06	1.09E-05
Ag-110m	1.35E-06	1.25E-06	7.43E-07	No Data	2.46E-06	5.79E-04	3.78E-05
Sb-124	3.90E-06	7.36E-08	1.55E-06	9.44E-09	No Data	3.10E-04	5.08E-05
Sb-125	8.26E-06	8.91E-08	1.66E-06	7.34E-09	No Data	2.75E-04	1.26E-05
Te-125m	4.27E-07	1.98E-07	5.84E-08	1.31E-07	1.55E-06	3.92E-05	8.83E-06
Te-127m	1.58E-06	7.21E-07	1.96E-07	4.11E-07	5.72E-06	1.20E-04	1.87E-05
Te-127	1.75E-10	8.03E-11	3.87E-11	1.32E-10	6.37E-10	8.14E-07	7.17E-06
Te-129m	1.22E-06	5.84E-07	1.98E-07	4.30E-07	4.57E-06	1.45E-04	4.79E-05
Te-129	6.22E-12	2.99E-12	1.55E-12	4.87E-12	2.34E-11	2.42E-07	1.96E-08
Te-131m	8.74E-09	5.45E-09	3.63E-09	6.88E-09	3.86E-08	1.82E-05	6.95E-05
Te-131	1.39E-12	7.44E-13	4.49E-13	1.17E-12	5.46E-12	1.74E-07	2.30E-09

Table 9-10 (contd). Inhalation Dose Factors for the Adult Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Te-132	3.25E-08	2.69E-08	2.02E-08	2.37E-08	1.82E-07	3.60E-05	6.37E-05
I-130	5.72E-07	1.68E-06	6.60E-07	1.42E-04	2.61E-06	No Data	9.61E-07
I-131	3.15E-06	4.47E-06	2.56E-06	1.49E-03	7.66E-06	No Data	7.85E-07
I-132	1.45E-07	4.07E-07	1.45E-07	1.43E-05	6.48E-07	No Data	5.08E-08
I-133	1.08E-06	1.85E-06	5.65E-07	2.69E-04	3.23E-06	No Data	1.11E-06
I-134	8.05E-08	2.16E-07	7.69E-08	3.73E-06	3.44E-07	No Data	1.26E-10
I-135	3.35E-07	8.73E-07	3.21E-07	5.60E-05	1.39E-06	No Data	6.56E-07
Cs-134	4.66E-05	1.06E-04	9.10E-05	No Data	3.59E-05	1.22E-05	1.30E-06
Cs-136	4.88E-06	1.83E-05	1.38E-05	No Data	1.07E-05	1.50E-06	1.46E-06
Cs-137	5.98E-05	7.76E-05	5.35E-05	No Data	2.78E-05	9.40E-06	1.05E-06
Cs-138	4.14E-08	7.76E-08	4.05E-08	No Data	6.00E-08	6.07E-09	2.33E-13
Ba-139	1.17E-10	8.32E-14	3.42E-12	No Data	7.78E-14	4.70E-07	1.12E-07
Ba-140	4.88E-06	6.13E-09	3.21E-07	No Data	2.09E-09	1.59E-04	2.73E-05
Ba-141	1.25E-11	9.41E-15	4.20E-13	No Data	8.75E-15	2.42E-07	1.45E-17
Ba-142	3.29E-12	3.38E-15	2.07E-13	No Data	2.86E-15	1.49E-07	1.96E-26
La-140	4.30E-08	2.17E-08	5.73E-09	No Data	No Data	1.70E-05	5.73E-05
La-142	8.54E-11	3.88E-11	9.65E-12	No Data	No Data	7.91E-07	2.64E-07
Ce-141	2.49E-06	1.69E-06	1.91E-07	No Data	7.83E-07	4.52E-05	1.50E-05
Ce-143	2.33E-08	1.72E-08	1.91E-09	No Data	7.60E-09	9.97E-06	2.83E-05
Ce-144	4.29E-04	1.79E-04	2.30E-05	No Data	1.06E-04	9.72E-04	1.02E-04
Pr-143	1.17E-06	4.69E-07	5.80E-08	No Data	2.70E-07	3.51E-05	2.50E-05
Pr-144	3.76E-12	1.56E-12	1.91E-13	No Data	8.81E-13	1.27E-07	2.69E-18
Nd-147	6.59E-07	7.62E-07	4.56E-08	No Data	4.45E-07	2.76E-05	2.16E-05
W-187	1.06E-09	8.85E-10	3.10E-10	No Data	No Data	3.63E-06	1.94E-05
Np-239	2.87E-08	2.82E-09	1.55E-09	No Data	8.75E-09	4.70E-06	1.49E-05

Table 9-11. Ingestion Dose Factors for the Infant Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	3.08E-07	3.08E-07	3.08E-07	3.08E-07	3.08E-07	3.08E-07
C-14	2.37E-05	5.06E-06	5.06E-06	5.06E-06	5.06E-06	5.06E-06	5.06E-06
Na-24	1.01E-05	1.01E-05	1.01E-05	1.01E-05	1.01E-05	1.01E-05	1.01E-05
P-32	1.70E-03	1.00E-04	6.59E-05	No Data	No Data	No Data	2.30E-05
Cr-51	No Data	No Data	1.41E-08	9.20E-09	2.01E-09	1.79E-08	4.11E-07
Mn-54	No Data	1.99E-05	4.51E-06	No Data	4.41E-06	No Data	7.31E-06
Mn-56	No Data	8.18E-07	1.41E-07	No Data	7.03E-07	No Data	7.43E-05
Fe-55	1.39E-05	8.98E-06	2.40E-06	No Data	No Data	4.39E-06	1.14E-06
Fe-59	3.08E-05	5.38E-05	2.12E-05	No Data	No Data	1.59E-05	2.57E-05
Co-58	No Data	3.60E-06	8.98E-06	No Data	No Data	No Data	8.97E-06
Co-60	No Data	1.08E-05	2.55E-05	No Data	No Data	No Data	2.57E-05
Ni-63	6.34E-04	3.92E-05	2.20E-05	No Data	No Data	No Data	1.95E-06
Ni-65	4.70E-06	5.32E-07	2.42E-07	No Data	No Data	No Data	4.05E-05
Cu-64	No Data	6.09E-07	2.82E-07	No Data	1.03E-06	No Data	1.25E-05
Zn-65	1.84E-05	6.31E-05	2.91E-05	No Data	3.06E-05	No Data	5.33E-05
Zn-69	9.33E-08	1.68E-07	1.25E-08	No Data	6.98E-08	No Data	1.37E-05
Br-83	No Data	No Data	3.63E-07	No Data	No Data	No Data	No Data
Br-84	No Data	No Data	3.82E-07	No Data	No Data	No Data	No Data
Br-85	No Data	No Data	1.94E-08	No Data	No Data	No Data	No Data
Rb-86	No Data	1.70E-04	8.40E-05	No Data	No Data	No Data	4.35E-06
Rb-88	No Data	4.98E-07	2.73E-07	No Data	No Data	No Data	4.85E-07
Rb-89	No Data	2.86E-07	1.97E-07	No Data	No Data	No Data	9.74E-08
Sr-89	2.51E-03	No Data	7.20E-05	No Data	No Data	No Data	5.16E-05
Sr-90	1.85E-02	No Data	4.71E-03	No Data	No Data	No Data	2.31E-04
Sr-91	5.00E-05	No Data	1.81E-06	No Data	No Data	No Data	5.92E-05

All values are in (mrem/pCi ingested). They are obtained from Reference 3 (Table E-14). Neither Reference 2 nor Reference 3 contains data for Rh–105, Sb–124, or Sb–125.

Table 9-11 (contd). Ingestion Dose Factors for the Infant Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Sr-92	1.92E-05	No Data	7.13E-07	No Data	No Data	No Data	2.07E-04
Y-90	8.69E-08	No Data	2.33E-09	No Data	No Data	No Data	1.20E-04
Y-91m	8.10E-10	No Data	2.76E-11	No Data	No Data	No Data	2.70E-06
Y-91	1.13E-06	No Data	3.01E-08	No Data	No Data	No Data	8.10E-05
Y-92	7.65E-09	No Data	2.15E-10	No Data	No Data	No Data	1.46E-04
Y-93	2.43E-08	No Data	6.62E-10	No Data	No Data	No Data	1.92E-04
Zr-95	2.06E-07	5.02E-08	3.56E-08	No Data	5.41E-08	No Data	2.50E-05
Zr-97	1.48E-08	2.54E-09	1.16E-09	No Data	2.56E-09	No Data	1.62E-04
Nb-95	4.20E-08	1.73E-08	1.00E-08	No Data	1.24E-08	No Data	1.46E-05
Mo-99	No Data	3.40E-05	6.63E-06	No Data	5.08E-05	No Data	1.12E-05
Tc-99m	1.92E-09	3.96E-09	5.10E-08	No Data	4.26E-08	2.07E-09	1.15E-06
Tc-101	2.27E-09	2.86E-09	2.83E-08	No Data	3.40E-08	1.56E-09	4.86E-07
Ru-103	1.48E-06	No Data	4.95E-07	No Data	3.08E-06	No Data	1.80E-05
Ru-105	1.36E-07	No Data	4.58E-08	No Data	1.00E-06	No Data	5.41E-05
Ru-106	2.41E-05	No Data	3.01E-06	No Data	2.85E-05	No Data	1.83E-04
Rh-105	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Ag-110m	9.96E-07	7.27E-07	4.81E-07	No Data	1.04E-06	No Data	3.77E-05
Sb-124	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Sb-125	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Te-125m	2.33E-05	7.79E-06	3.15E-06	7.84E-06	No Data	No Data	1.11E-05
Te-127m	5.85E-05	1.94E-05	7.08E-06	1.69E-05	1.44E-04	No Data	2.36E-05
Te-127	1.00E-06	3.35E-07	2.15E-07	8.14E-07	2.44E-06	No Data	2.10E-05
Te-129m	1.00E-04	3.43E-05	1.54E-05	3.84E-05	2.50E-04	No Data	5.97E-05
Te-129	2.84E-07	9.79E-08	6.63E-08	2.38E-07	7.07E-07	No Data	2.27E-05
Te-131m	1.52E-05	6.12E-06	5.05E-06	1.24E-05	4.21E-05	No Data	1.03E-04
Te-131	1.76E-07	6.50E-08	4.94E-08	1.57E-07	4.50E-07	No Data	7.11E-06

Table 9-11 (contd). Ingestion Dose Factors for the Infant Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Te-132	2.08E-05	1.03E-05	9.61E-06	1.52E-05	6.44E-05	No Data	3.81E-05
I-130	6.00E-06	1.32E-05	5.30E-06	1.48E-03	1.45E-05	No Data	2.83E-06
I-131	3.59E-05	4.23E-05	1.86E-05	1.39E-02	4.94E-05	No Data	1.51E-06
I-132	1.66E-06	3.37E-06	1.20E-06	1.58E-04	3.76E-06	No Data	2.73E-06
I-133	1.25E-05	1.82E-05	5.33E-06	3.31E-03	2.14E-05	No Data	3.08E-06
I-134	8.69E-07	1.78E-06	6.33E-07	4.15E-05	1.99E-06	No Data	1.84E-06
I-135	3.64E-06	7.24E-06	2.64E-06	6.49E-04	8.07E-06	No Data	2.62E-06
Cs-134	3.77E-04	7.03E-04	7.10E-05	No Data	1.81E-04	7.42E-05	1.91E-06
Cs-136	4.59E-05	1.35E-04	5.04E-05	No Data	5.38E-05	1.10E-05	2.05E-06
Cs-137	5.22E-04	6.11E-04	4.33E-05	No Data	1.64E-04	6.64E-05	1.91E-06
Cs-138	4.81E-07	7.82E-07	3.79E-07	No Data	3.90E-07	6.09E-08	1.25E-06
Ba-139	8.81E-07	5.84E-10	2.55E-08	No Data	3.51E-10	3.54E-10	5.58E-05
Ba-140	1.71E-04	1.71E-07	8.81E-06	No Data	4.06E-08	1.05E-07	4.20E-05
Ba-141	4.25E-07	2.91E-10	1.34E-08	No Data	1.75E-10	1.77E-10	5.19E-06
Ba-142	1.84E-07	1.53E-10	9.06E-09	No Data	8.81E-11	9.26E-11	7.59E-07
La-140	2.11E-08	8.32E-09	2.14E-09	No Data	No Data	No Data	9.77E-05
La-142	1.10E-09	4.04E-10	9.67E-11	No Data	No Data	No Data	6.86E-05
Ce-141	7.87E-08	4.80E-08	5.65E-09	No Data	1.48E-08	No Data	2.48E-05
Ce-143	1.48E-08	9.82E-06	1.12E-09	No Data	2.86E-09	No Data	5.73E-05
Ce-144	2.98E-06	1.22E-06	1.67E-07	No Data	4.93E-07	No Data	1.71E-04
Pr-143	8.13E-08	3.04E-08	4.03E-09	No Data	1.13E-08	No Data	4.29E-05
Pr-144	2.74E-10	1.06E-10	1.38E-11	No Data	3.84E-11	No Data	4.93E-06
Nd-147	5.53E-08	5.68E-08	3.48E-09	No Data	2.19E-08	No Data	3.60E-05
W-187	9.03E-07	6.28E-07	2.17E-07	No Data	No Data	No Data	3.69E-05
Np-239	1.11E-08	9.93E-10	5.61E-10	No Data	1.98E-09	No Data	2.87E-05

Table 9-12. Ingestion Dose Factors for the Child Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	2.03E-07	2.03E-07	2.03E-07	2.03E-07	2.03E-07	2.03E-07
C-14	1.21E-05	2.42E-06	2.42E-06	2.42E-06	2.42E-06	2.42E-06	2.42E-06
Na-24	5.80E-06	5.80E-06	5.80E-06	5.80E-06	5.80E-06	5.80E-06	5.80E-06
P-32	8.25E-04	3.86E-05	3.18E-05	No Data	No Data	No Data	2.28E-05
Cr-51	No Data	No Data	8.90E-09	4.94E-09	1.35E-09	9.02E-09	4.72E-07
Mn-54	No Data	1.07E-05	2.85E-06	No Data	3.00E-06	No Data	8.98E-06
Mn-56	No Data	3.34E-07	7.54E-08	No Data	4.04E-07	No Data	4.84E-05
Fe-55	1.15E-05	6.10E-06	1.89E-06	No Data	No Data	3.45E-06	1.13E-06
Fe-59	1.65E-05	2.67E-05	1.33E-05	No Data	No Data	7.74E-06	2.78E-05
Co-58	No Data	1.80E-06	5.51E-06	No Data	No Data	No Data	1.05E-05
Co-60	No Data	5.29E-06	1.56E-05	No Data	No Data	No Data	2.93E-05
Ni-63	5.38E-04	2.88E-05	1.83E-05	No Data	No Data	No Data	1.94E-06
Ni-65	2.22E-06	2.09E-07	1.22E-07	No Data	No Data	No Data	2.56E-05
Cu-64	No Data	2.45E-07	1.48E-07	No Data	5.92E-07	No Data	1.15E-05
Zn-65	1.37E-05	3.65E-05	2.27E-05	No Data	2.30E-05	No Data	6.41E-06
Zn-69	4.38E-08	6.33E-08	5.85E-09	No Data	3.84E-08	No Data	3.99E-06
Br-83	No Data	No Data	1.71E-07	No Data	No Data	No Data	No Data
Br-84	No Data	No Data	1.98E-07	No Data	No Data	No Data	No Data
Br-85	No Data	No Data	9.12E-09	No Data	No Data	No Data	No Data
Rb-86	No Data	6.70E-05	4.12E-05	No Data	No Data	No Data	4.31E-06
Rb-88	No Data	1.90E-07	1.32E-07	No Data	No Data	No Data	9.32E-09
Rb-89	No Data	1.17E-07	1.04E-07	No Data	No Data	No Data	1.02E-09
Sr-89	1.32E-03	No Data	3.77E-05	No Data	No Data	No Data	5.11E-05
Sr-90	1.70E-02	No Data	4.31E-03	No Data	No Data	No Data	2.29E-04
Sr-91	2.40E-05	No Data	9.06E-07	No Data	No Data	No Data	5.30E-05

All values are in (mrem/pCi ingested). They are obtained from Reference 3 (Table E-13). Neither Reference 2 nor Reference 3 contains data for Rh–105, Sb–124, or Sb–125.

Table 9-12 (contd). Ingestion Dose Factors for the Child Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Sr-92	9.03E-06	No Data	3.62E-07	No Data	No Data	No Data	1.71E-04
Y-90	4.11E-08	No Data	1.10E-09	No Data	No Data	No Data	1.17E-04
Y-91m	3.82E-10	No Data	1.39E-11	No Data	No Data	No Data	7.48E-07
Y-91	6.02E-07	No Data	1.61E-08	No Data	No Data	No Data	8.02E-05
Y-92	3.60E-09	No Data	1.03E-10	No Data	No Data	No Data	1.04E-04
Y-93	1.14E-08	No Data	3.13E-10	No Data	No Data	No Data	1.70E-04
Zr-95	1.16E-07	2.55E-08	2.27E-08	No Data	3.65E-08	No Data	2.66E-05
Zr-97	6.99E-09	1.01E-09	5.96E-10	No Data	1.45E-09	No Data	1.53E-04
Nb-95	2.25E-08	8.76E-09	6.26E-09	No Data	8.23E-09	No Data	1.62E-05
Mo-99	No Data	1.33E-05	3.29E-06	No Data	2.84E-05	No Data	1.10E-05
Tc-99m	9.23E-10	1.81E-09	3.00E-08	No Data	2.63E-08	9.19E-10	1.03E-06
Tc-101	1.07E-09	1.12E-09	1.42E-08	No Data	1.91E-08	5.92E-10	3.56E-09
Ru-103	7.31E-07	No Data	2.81E-07	No Data	1.84E-06	No Data	1.89E-05
Ru-105	6.45E-08	No Data	2.34E-08	No Data	5.67E-07	No Data	4.21E-05
Ru-106	1.17E-05	No Data	1.46E-06	No Data	1.58E-05	No Data	1.82E-04
Rh-105	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Ag-110m	5.39E-07	3.64E-07	2.91E-07	No Data	6.78E-07	No Data	4.33E-05
Sb-124	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Sb-125	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Te-125m	1.14E-05	3.09E-06	1.52E-06	3.20E-06	No Data	No Data	1.10E-05
Te-127m	2.89E-05	7.78E-06	3.43E-06	6.91E-06	8.24E-05	No Data	2.34E-05
Te-127	4.71E-07	1.27E-07	1.01E-07	3.26E-07	1.34E-06	No Data	1.84E-05
Te-129m	4.87E-05	1.36E-05	7.56E-06	1.57E-05	1.43E-04	No Data	5.94E-05
Te-129	1.34E-07	3.74E-08	3.18E-08	9.56E-08	3.92E-07	No Data	8.34E-06
Te-131m	7.20E-06	2.49E-06	2.65E-06	5.12E-06	2.41E-05	No Data	1.01E-04
Te-131	8.30E-08	2.53E-08	2.47E-08	6.35E-08	2.51E-07	No Data	4.36E-07

Table 9-12 (contd). Ingestion Dose Factors for the Child Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Te-132	1.01E-05	4.47E-06	5.40E-06	6.51E-06	4.15E-05	No Data	4.50E-05
I-130	2.92E-06	5.90E-06	3.04E-06	6.50E-04	8.82E-06	No Data	2.76E-06
I-131	1.72E-05	1.73E-05	9.83E-06	5.72E-03	2.84E-05	No Data	1.54E-06
I-132	8.00E-07	1.47E-06	6.76E-07	6.82E-05	2.25E-06	No Data	1.73E-06
I-133	5.92E-06	7.32E-06	2.77E-06	1.36E-03	1.22E-05	No Data	2.95E-06
I-134	4.19E-07	7.78E-07	3.58E-07	1.79E-05	1.19E-06	No Data	5.16E-07
I-135	1.75E-06	3.15E-06	1.49E-06	2.79E-04	4.83E-06	No Data	2.40E-06
Cs-134	2.34E-04	3.84E-04	8.10E-05	No Data	1.19E-04	4.27E-05	2.07E-06
Cs-136	2.35E-05	6.46E-05	4.18E-05	No Data	3.44E-05	5.13E-06	2.27E-06
Cs-137	3.27E-04	3.13E-04	4.62E-05	No Data	1.02E-04	3.67E-05	1.96E-06
Cs-138	2.28E-07	3.17E-07	2.01E-07	No Data	2.23E-07	2.40E-08	1.46E-07
Ba-139	4.14E-07	2.21E-10	1.20E-08	No Data	1.93E-10	1.30E-10	2.39E-05
Ba-140	8.31E-05	7.28E-08	4.85E-06	No Data	2.37E-08	4.34E-08	4.21E-05
Ba-141	2.00E-07	1.12E-10	6.51E-09	No Data	9.69E-11	6.58E-10	1.14E-07
Ba-142	8.74E-08	6.29E-11	4.88E-09	No Data	5.09E-11	3.70E-11	1.14E-09
La-140	1.01E-08	3.53E-09	1.19E-09	No Data	No Data	No Data	9.84E-05
La-142	5.24E-10	1.67E-10	5.23E-11	No Data	No Data	No Data	3.31E-05
Ce-141	3.97E-08	1.98E-08	2.94E-09	No Data	8.68E-09	No Data	2.47E-05
Ce-143	6.99E-09	3.79E-06	5.49E-10	No Data	1.59E-09	No Data	5.55E-05
Ce-144	2.08E-06	6.52E-07	1.11E-07	No Data	3.61E-07	No Data	1.70E-04
Pr-143	3.93E-08	1.18E-08	1.95E-09	No Data	6.39E-09	No Data	4.24E-05
Pr-144	1.29E-10	3.99E-11	6.49E-12	No Data	2.11E-11	No Data	8.59E-08
Nd-147	2.79E-08	2.26E-08	1.75E-09	No Data	1.24E-08	No Data	3.58E-05
W-187	4.29E-07	2.54E-07	1.14E-07	No Data	No Data	No Data	3.57E-05
Np-239	5.25E-09	3.77E-10	2.65E-10	No Data	1.09E-09	No Data	2.79E-05

Table 9-13. Ingestion Dose Factors for the Teenager Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	1.06E-07	1.06E-07	1.06E-07	1.06E-07	1.06E-07	1.06E-07
C-14	4.06E-06	8.12E-07	8.12E-07	8.12E-07	8.12E-07	8.12E-07	8.12E-07
Na-24	2.30E-06	2.30E-06	2.30E-06	2.30E-06	2.30E-06	2.30E-06	2.30E-06
P-32	2.76E-04	1.71E-05	1.07E-05	No Data	No Data	No Data	2.32E-05
Cr-51	No Data	No Data	3.60E-09	2.00E-09	7.89E-10	5.14E-09	6.05E-07
Mn-54	No Data	5.90E-06	1.17E-06	No Data	1.76E-06	No Data	1.21E-05
Mn-56	No Data	1.58E-07	2.81E-08	No Data	2.00E-07	No Data	1.04E-05
Fe-55	3.78E-06	2.68E-06	6.25E-07	No Data	No Data	1.70E-06	1.16E-06
Fe-59	5.87E-06	1.37E-05	5.29E-06	No Data	No Data	4.32E-06	3.24E-05
Co-58	No Data	9.72E-07	2.24E-06	No Data	No Data	No Data	1.34E-05
Co-60	No Data	2.81E-06	6.33E-06	No Data	No Data	No Data	3.66E-05
Ni-63	1.77E-04	1.25E-05	6.00E-06	No Data	No Data	No Data	1.99E-06
Ni-65	7.49E-07	9.57E-08	4.36E-08	No Data	No Data	No Data	5.19E-06
Cu-64	No Data	1.15E-07	5.41E-08	No Data	2.91E-07	No Data	8.92E-06
Zn-65	5.76E-06	2.00E-05	9.33E-06	No Data	1.28E-05	No Data	8.47E-06
Zn-69	1.47E-08	2.80E-08	1.96E-09	No Data	1.83E-08	No Data	5.16E-08
Br-83	No Data	No Data	5.74E-08	No Data	No Data	No Data	No Data
Br-84	No Data	No Data	7.22E-08	No Data	No Data	No Data	No Data
Br-85	No Data	No Data	3.05E-09	No Data	No Data	No Data	No Data
Rb-86	No Data	2.98E-05	1.40E-05	No Data	No Data	No Data	4.41E-06
Rb-88	No Data	8.52E-08	4.54E-08	No Data	No Data	No Data	7.30E-15
Rb-89	No Data	5.50E-08	3.89E-08	No Data	No Data	No Data	8.43E-17
Sr-89	4.40E-04	No Data	1.26E-05	No Data	No Data	No Data	5.24E-05
Sr-90	8.30E-03	No Data	2.05E-03	No Data	No Data	No Data	2.33E-04
Sr-91	8.07E-06	No Data	3.21E-07	No Data	No Data	No Data	3.66E-05

All values are in (mrem/pCi ingested). They are obtained from Reference 3 (Table E-12). Neither Reference 2 nor Reference 3 contains data for Rh–105, Sb–124, or Sb–125.

Table 9-13 (contd). Ingestion Dose Factors for the Teenager Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Sr-92	3.05E-06	No Data	1.30E-07	No Data	No Data	No Data	7.77E-05
Y-90	1.37E-08	No Data	3.69E-10	No Data	No Data	No Data	1.13E-04
Y-91m	1.29E-10	No Data	4.93E-12	No Data	No Data	No Data	6.09E-09
Y-91	2.01E-07	No Data	5.39E-09	No Data	No Data	No Data	8.24E-05
Y-92	1.21E-09	No Data	3.50E-11	No Data	No Data	No Data	3.32E-05
Y-93	3.83E-09	No Data	1.05E-10	No Data	No Data	No Data	1.17E-04
Zr-95	4.12E-08	1.30E-08	8.94E-09	No Data	1.91E-08	No Data	3.00E-05
Zr-97	2.37E-09	4.69E-10	2.16E-10	No Data	7.11E-10	No Data	1.27E-04
Nb-95	8.22E-09	4.56E-09	2.51E-09	No Data	4.42E-09	No Data	1.95E-05
Mo-99	No Data	6.03E-06	1.15E-06	No Data	1.38E-05	No Data	1.08E-05
Tc-99m	3.32E-10	9.26E-10	1.20E-08	No Data	1.38E-08	5.14E-10	6.08E-07
Tc-101	3.60E-10	5.12E-10	5.03E-09	No Data	9.26E-09	3.12E-10	8.75E-17
Ru-103	2.55E-07	No Data	1.09E-07	No Data	8.99E-07	No Data	2.13E-05
Ru-105	2.18E-08	No Data	8.46E-09	No Data	2.75E-07	No Data	1.76E-05
Ru-106	3.92E-06	No Data	4.94E-07	No Data	7.56E-06	No Data	1.88E-04
Rh-105	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Ag-110m	2.05E-07	1.94E-07	1.18E-07	No Data	3.70E-07	No Data	5.45E-05
Sb-124	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Sb-125	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Te-125m	3.83E-06	1.38E-06	5.12E-07	1.07E-06	No Data	No Data	1.13E-05
Te-127m	9.67E-06	3.43E-06	1.15E-06	2.30E-06	3.92E-05	No Data	2.41E-05
Te-127	1.58E-07	5.60E-08	3.40E-08	1.09E-07	6.40E-07	No Data	1.22E-05
Te-129m	1.63E-05	6.05E-06	2.58E-06	5.26E-06	6.82E-05	No Data	6.12E-05
Te-129	4.48E-08	1.67E-08	1.09E-08	3.20E-08	1.88E-07	No Data	2.45E-07
Te-131m	2.44E-06	1.17E-06	9.76E-07	1.76E-06	1.22E-05	No Data	9.39E-05
Te-131	2.79E-08	1.15E-08	8.72E-09	2.15E-08	1.22E-07	No Data	2.29E-09

Table 9-13 (contd). Ingestion Dose Factors for the Teenager Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Te-132	3.49E-06	2.21E-06	2.08E-06	2.33E-06	2.12E-05	No Data	7.00E-05
I-130	1.03E-06	2.98E-06	1.19E-06	2.43E-04	4.59E-06	No Data	2.29E-06
I-131	5.85E-06	8.19E-06	4.40E-06	2.39E-03	1.41E-05	No Data	1.62E-06
I-132	2.79E-07	7.30E-07	2.62E-07	2.46E-05	1.15E-06	No Data	3.18E-07
I-133	2.01E-06	3.41E-06	1.04E-06	4.76E-04	5.98E-06	No Data	2.58E-06
I-134	1.46E-07	3.87E-07	1.39E-07	6.45E-06	6.10E-07	No Data	5.10E-09
I-135	6.10E-07	1.57E-06	5.82E-07	1.01E-04	2.48E-06	No Data	1.74E-06
Cs-134	8.37E-05	1.97E-04	9.14E-05	No Data	6.26E-05	2.39E-05	2.45E-06
Cs-136	8.59E-06	3.38E-05	2.27E-05	No Data	1.84E-05	2.90E-06	2.72E-06
Cs-137	1.12E-04	1.49E-04	5.19E-05	No Data	5.07E-05	1.97E-05	2.12E-06
Cs-138	7.76E-08	1.49E-07	7.45E-08	No Data	1.10E-07	1.28E-08	6.76E-11
Ba-139	1.39E-07	9.78E-11	4.05E-09	No Data	9.22E-11	6.74E-11	1.24E-06
Ba-140	2.84E-05	3.48E-08	1.83E-06	No Data	1.18E-08	2.34E-08	4.38E-05
Ba-141	6.71E-08	5.01E-11	2.24E-09	No Data	4.65E-11	3.43E-11	1.43E-13
Ba-142	2.99E-08	2.99E-11	1.84E-09	No Data	2.53E-11	1.99E-11	9.18E-20
La-140	3.48E-09	1.71E-09	4.55E-10	No Data	No Data	No Data	9.82E-05
La-142	1.79E-10	7.95E-11	1.98E-11	No Data	No Data	No Data	2.42E-06
Ce-141	1.33E-08	8.88E-09	1.02E-09	No Data	4.18E-09	No Data	2.54E-05
Ce-143	2.35E-09	1.71E-06	1.91E-10	No Data	7.67E-10	No Data	5.14E-05
Ce-144	6.96E-07	2.88E-07	3.74E-08	No Data	1.72E-07	No Data	1.75E-04
Pr-143	1.31E-08	5.23E-09	6.52E-10	No Data	3.04E-09	No Data	4.31E-05
Pr-144	4.30E-11	1.76E-11	2.18E-12	No Data	1.01E-11	No Data	4.74E-14
Nd-147	9.38E-09	1.02E-08	6.11E-10	No Data	5.99E-09	No Data	3.68E-05
W-187	1.46E-07	1.19E-07	4.17E-08	No Data	No Data	No Data	3.22E-05
Np-239	1.76E-09	1.66E-10	9.22E-11	No Data	5.21E-10	No Data	2.67E-05

Table 9-14. Ingestion Dose Factors for the Adult Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	1.05E-07	1.05E-07	1.05E-07	1.05E-07	1.05E-07	1.05E-07
C-14	2.84E-06	5.68E-07	5.68E-07	5.68E-07	5.68E-07	5.68E-07	5.68E-07
Na-24	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06
P-32	1.93E-04	1.20E-05	7.46E-06	No Data	No Data	No Data	2.17E-05
Cr-51	No Data	No Data	2.66E-09	1.59E-09	5.86E-10	3.53E-09	6.69E-07
Mn-54	No Data	4.57E-06	8.72E-07	No Data	1.36E-06	No Data	1.40E-05
Mn-56	No Data	1.15E-07	2.04E-08	No Data	1.46E-07	No Data	3.67E-06
Fe-55	2.75E-06	1.90E-06	4.43E-07	No Data	No Data	1.06E-06	1.09E-06
Fe-59	4.34E-06	1.02E-05	3.91E-06	No Data	No Data	2.85E-06	3.40E-05
Co-58	No Data	7.45E-07	1.67E-06	No Data	No Data	No Data	1.51E-05
Co-60	No Data	2.14E-06	4.72E-06	No Data	No Data	No Data	4.02E-05
Ni-63	1.30E-04	9.01E-06	4.36E-06	No Data	No Data	No Data	1.88E-06
Ni-65	5.28E-07	6.86E-08	3.13E-08	No Data	No Data	No Data	1.74E-06
Cu-64	No Data	8.33E-08	3.91E-08	No Data	2.10E-07	No Data	7.10E-06
Zn-65	4.84E-06	1.54E-05	6.96E-06	No Data	1.03E-05	No Data	9.70E-06
Zn-69	1.03E-08	1.97E-08	1.37E-09	No Data	1.28E-08	No Data	2.96E-09
Br-83	No Data	No Data	4.02E-08	No Data	No Data	No Data	5.79E-08
Br-84	No Data	No Data	5.21E-08	No Data	No Data	No Data	4.09E-13
Br-85	No Data	No Data	2.14E-09	No Data	No Data	No Data	No Data
Rb-86	No Data	2.11E-05	9.83E-06	No Data	No Data	No Data	4.16E-06
Rb-88	No Data	6.05E-08	3.21E-08	No Data	No Data	No Data	8.36E-19
Rb-89	No Data	4.01E-08	2.82E-08	No Data	No Data	No Data	2.33E-21
Sr-89	3.08E-04	No Data	8.84E-06	No Data	No Data	No Data	4.94E-05
Sr-90	7.58E-03	No Data	1.86E-03	No Data	No Data	No Data	2.19E-04
Sr-91	5.67E-06	No Data	2.29E-07	No Data	No Data	No Data	2.70E-05

All values are in (mrem/pCi ingested). They are obtained from Reference 3 (Table E–11), except as follows: Reference 2 (Table A–3) for Rh–105, Sb–124, and Sb–125.

Table 9-14 (contd). Ingestion Dose Factors for the Adult Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Sr-92	2.15E-06	No Data	9.30E-08	No Data	No Data	No Data	4.26E-05
Y-90	9.62E-09	No Data	2.58E-10	No Data	No Data	No Data	1.02E-04
Y-91m	9.09E-11	No Data	3.52E-12	No Data	No Data	No Data	2.67E-10
Y-91	1.41E-07	No Data	3.77E-09	No Data	No Data	No Data	7.76E-05
Y-92	8.45E-10	No Data	2.47E-11	No Data	No Data	No Data	1.48E-05
Y-93	2.68E-09	No Data	7.40E-11	No Data	No Data	No Data	8.50E-05
Zr-95	3.04E-08	9.75E-09	6.60E-09	No Data	1.53E-08	No Data	3.09E-05
Zr-97	1.68E-09	3.39E-10	1.55E-10	No Data	5.12E-10	No Data	1.05E-04
Nb-95	6.22E-09	3.46E-09	1.86E-09	No Data	3.42E-09	No Data	2.10E-05
Mo-99	No Data	4.31E-06	8.20E-07	No Data	9.76E-06	No Data	9.99E-06
Tc-99m	2.47E-10	6.98E-10	8.89E-09	No Data	1.06E-08	3.42E-10	4.13E-07
Tc-101	2.54E-10	3.66E-10	3.59E-09	No Data	6.59E-09	1.87E-10	1.10E-21
Ru-103	1.85E-07	No Data	7.97E-08	No Data	7.06E-07	No Data	2.16E-05
Ru-105	1.54E-08	No Data	6.08E-09	No Data	1.99E-07	No Data	9.42E-06
Ru-106	2.75E-06	No Data	3.48E-07	No Data	5.31E-06	No Data	1.78E-04
Rh-105	1.22E-07	8.86E-08	5.83E-08	No Data	3.76E-07	No Data	1.41E-05
Ag-110m	1.60E-07	1.48E-07	8.79E-08	No Data	2.91E-07	No Data	6.04E-05
Sb-124	2.81E-06	5.30E-08	1.11E-06	6.79E-09	No Data	2.18E-06	7.95E-05
Sb-125	2.23E-06	2.40E-08	4.48E-07	1.98E-09	No Data	2.33E-04	1.97E-05
Te-125m	2.68E-06	9.71E-07	3.59E-07	8.06E-07	1.09E-05	No Data	1.07E-05
Te-127m	6.77E-06	2.42E-06	8.25E-07	1.73E-06	2.75E-05	No Data	2.27E-05
Te-127	1.10E-07	3.95E-08	2.38E-08	8.15E-08	4.48E-07	No Data	8.68E-06
Te-129m	1.15E-05	4.29E-06	1.82E-06	3.95E-06	4.80E-05	No Data	5.79E-05
Te-129	3.14E-08	1.18E-08	7.65E-09	2.41E-08	1.32E-07	No Data	2.37E-08
Te-131m	1.73E-06	8.46E-07	7.05E-07	1.34E-06	8.57E-06	No Data	8.40E-05
Te-131	1.97E-08	8.23E-09	6.22E-09	1.62E-08	8.63E-08	No Data	2.79E-09

Table 9-14 (contd). Ingestion Dose Factors for the Adult Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Te-132	2.52E-06	1.63E-06	1.53E-06	1.80E-06	1.57E-05	No Data	7.71E-05
I-130	7.56E-07	2.23E-06	8.80E-07	1.89E-04	3.48E-06	No Data	1.92E-06
I-131	4.16E-06	5.95E-06	3.41E-06	1.95E-03	1.02E-05	No Data	1.57E-06
I-132	2.03E-07	5.43E-07	1.90E-07	1.90E-05	8.65E-07	No Data	1.02E-07
I-133	1.42E-06	2.47E-06	7.53E-07	3.63E-04	4.31E-06	No Data	2.22E-06
I-134	1.06E-07	2.88E-07	1.03E-07	4.99E-06	4.58E-07	No Data	2.51E-10
I-135	4.43E-07	1.16E-06	4.28E-07	7.65E-05	1.86E-06	No Data	1.31E-06
Cs-134	6.22E-05	1.48E-04	1.21E-04	No Data	4.79E-05	1.59E-05	2.59E-06
Cs-136	6.51E-06	2.57E-05	1.85E-05	No Data	1.43E-05	1.96E-06	2.92E-06
Cs-137	7.97E-05	1.09E-04	7.14E-05	No Data	3.70E-05	1.23E-05	2.11E-06
Cs-138	5.52E-08	1.09E-07	5.40E-08	No Data	8.01E-08	7.91E-09	4.65E-13
Ba-139	9.70E-08	6.91E-11	2.84E-09	No Data	6.46E-11	3.92E-11	1.72E-07
Ba-140	2.03E-05	2.55E-08	1.33E-06	No Data	8.67E-09	1.46E-08	4.18E-05
Ba-141	4.71E-08	3.56E-11	1.59E-09	No Data	3.31E-11	2.02E-11	2.22E-17
Ba-142	2.13E-08	2.19E-11	1.34E-09	No Data	1.85E-11	1.24E-11	3.00E-26
La-140	2.50E-09	1.26E-09	3.33E-10	No Data	No Data	No Data	9.25E-05
La-142	1.28E-10	5.82E-11	1.45E-11	No Data	No Data	No Data	4.25E-07
Ce-141	9.36E-09	6.33E-09	7.18E-10	No Data	2.94E-09	No Data	2.42E-05
Ce-143	1.65E-09	1.22E-06	1.35E-10	No Data	5.37E-10	No Data	4.56E-05
Ce-144	4.88E-07	2.04E-07	2.62E-08	No Data	1.21E-07	No Data	1.65E-04
Pr-143	9.20E-09	3.69E-09	4.56E-10	No Data	2.13E-09	No Data	4.03E-05
Pr-144	3.01E-11	1.25E-11	1.53E-12	No Data	7.05E-12	No Data	4.33E-18
Nd-147	6.29E-09	7.27E-09	4.35E-10	No Data	4.25E-09	No Data	3.49E-05
W-187	1.03E-07	8.61E-08	3.01E-08	No Data	No Data	No Data	2.82E-05
Np-239	1.19E-09	1.17E-10	6.45E-11	No Data	3.65E-10	No Data	2.40E-05

Table 9-15. External Dose Factors for Standing on Contaminated Ground

Nuclide	T. Body	Skin
H-3	0.00	0.00
C-14	0.00	0.00
Na-24	2.50E-08	2.90E-08
P-32	0.00	0.00
Cr-51	2.20E-10	2.60E-10
Mn-54	5.80E-09	6.80E-09
Mn-56	1.10E-08	1.30E-08
Fe-55	0.00	0.00
Fe-59	8.00E-09	9.40E-09
Co-58	7.00E-09	8.20E-09
Co-60	1.70E-08	2.00E-08
Ni-63	0.00	0.00
Ni-65	3.70E-09	4.30E-09
Cu-64	1.50E-09	1.70E-09
Zn-65	4.00E-09	4.60E-09
Zn-69	0.00	0.00
Br-83	6.40E-11	9.30E-11
Br-84	1.20E-08	1.40E-08
Br-85	0.00	0.00
Rb-86	6.30E-10	7.20E-10
Rb-88	3.50E-09	4.00E-09
Rb-89	1.50E-08	1.80E-08
Sr-89	5.60E-13	6.50E-13
Sr-90	0.00	0.00

Nuclide	T. Body	Skin
Sr-91	7.10E-09	8.30E-09
Sr-92	9.00E-09	1.00E-08
Y-90	2.20E-12	2.60E-12
Y-91m	3.80E-09	4.40E-09
Y-91	2.40E-11	2.70E-11
Y-92	1.60E-09	1.90E-09
Y-93	5.70E-10	7.80E-10
Zr-95	5.00E-09	5.80E-09
Zr-97	5.50E-09	6.40E-09
Nb-95	5.10E-09	6.00E-09
Mo-99	1.90E-09	2.20E-09
Tc-99m	9.60E-10	1.10E-09
Tc-101	2.70E-09	3.00E-09
Ru-103	3.60E-09	4.20E-09
Ru-105	4.50E-09	5.10E-09
Ru-106	1.50E-09	1.80E-09
Rh-105	6.60E-10	7.70E-10
Ag-110m	1.80E-08	2.10E-08
Sb-124	1.30E-08	1.50E-08
Sb-125	3.10E-09	3.50E-09
Te-125m	3.50E-11	4.80E-11
Te-127m	1.10E-12	1.30E-12
Te-127	1.00E-11	1.10E-11
Te-129m	7.70E-10	9.00E-10

All values are in (mrem/h) per (pCi/m^2). They are obtained from Reference 3 (Table E-6), except as follows: Reference 2 (Table A–7) for Rh-105, Sb-124, and Sb-125.

Table 9-15 (contd). External Dose Factors for Standing on Contaminated Ground

Nuclide	T.Body	Skin
Te-129	7.10E-10	8.40E-10
Te-131m	8.40E-09	9.90E-09
Te-131	2.20E-09	2.60E-06
Te-132	1.70E-09	2.00E-09
I-130	1.40E-08	1.70E-08
I-131	2.80E-09	3.40E-09
I-132	1.70E-08	2.00E-08
I-133	3.70E-09	4.50E-09
I-134	1.60E-08	1.90E-08
I-135	1.20E-08	1.40E-08
Cs-134	1.20E-08	1.40E-08
Cs-136	1.50E-08	1.70E-08
Cs-137	4.20E-09	4.90E-09
Cs-138	2.10E-08	2.40E-08
Ba-139	2.40E-09	2.70E-09
Ba-140	2.10E-09	2.40E-09
Ba-141	4.30E-09	4.90E-09
Ba-142	7.90E-09	9.00E-09
La-140	1.50E-08	1.70E-08
La-142	1.50E-08	1.80E-08
Ce-141	5.50E-10	6.20E-10
Ce-143	2.20E-09	2.50E-09
Ce-144	3.20E-10	3.70E-10
Pr-143	0.00	0.00
Pr-144	2.00E-10	2.30E-10
Nd-147	1.00E-09	1.20E-09
W-187	3.10E-09	3.60E-09
Np-239	9.50E-10	1.10E-09

CHAPTER 10
DEFINITIONS OF EFFLUENT CONTROL TERMS

The terms defined in this chapter are used in the presentation of the above chapters. These terms are shown in all capital letters to indicate that they are specifically defined.

10.1 TERMS SPECIFIC TO THE ODCM

The following terms are used in the ODCM, but are not found in the Technical Specifications:

ACTION(S)

An ACTION shall be that part of a control that prescribes remedial measures required under designated conditions.

BATCH RELEASE

A BATCH RELEASE is the discharge of wastes of a discrete volume. Prior to sampling for analyses, each liquid batch shall be isolated and then thoroughly mixed by a method described in the ODCM to assure representative sampling.

COMPOSITE SAMPLE

A COMPOSITE SAMPLE is one which contains material from multiple waste releases, in which the quantity of sample is proportional to the quantity of waste discharged, and in which the method of sampling employed results in a specimen that is representative of the wastes released. Prior to analyses, all liquid samples that are to be aliquotted for a COMPOSITE SAMPLE shall be mixed thoroughly, in order for the COMPOSITE SAMPLE to be representative of the effluent release.

When assessing the consequences of a waste release at the pre-release or post-release stage, the most recent available COMPOSITE SAMPLE results for the applicable release pathway may be used.

CONTINUOUS RELEASE

A CONTINUOUS RELEASE is the discharge of wastes of a non-discrete volume, e.g., from a volume within a system that has an input flow during the continuous release. To be representative of the quantities and concentrations of radioactive materials in CONTINUOUS RELEASES of liquid effluents, samples shall be collected in proportion to the rate of flow of the effluent stream or to the quantity of liquid waste discharged.

FREQUENCY NOTATION

The FREQUENCY NOTATION specified for the performance of surveillance requirements shall correspond to the intervals defined below, with a maximum allowable extension not to exceed 25% of the surveillance interval.

NOTATION	FREQUENCY
S (Once per shift)	At least once per 12 hours.
D (Daily)	At least once per 24 hours.
W (Weekly)	At least once per 7 days.
M (Monthly)	At least once per 31 days.
SM (Semi-Monthly)	At least twice per calendar month*

Q (Quarterly)	At least once per 92 days.
SA (Semi–annually)	At least once per 184 days.
R (Refueling)	At least once per 18 months.
S/U (Startup)	Prior to each reactor startup.
NA	Not applicable.
P (Prior)	Completed prior to each release.

*Semi-monthly sampling means one sample on two different weeks of every calendar month. No other grace period applies.

GASEOUS WASTE PROCESSING SYSTEM

A GASEOUS WASTE PROCESSING SYSTEM shall be any system designed and installed to reduce radioactive gaseous effluents by collecting Reactor Coolant System offgases from the Reactor Coolant System and providing for delay or holdup for the purpose of reducing the total radioactivity prior to release to the environment.

LIQUID RADWASTE TREATMENT SYSTEM

A LIQUID RADWASTE TREATMENT SYSTEM is any system designed and installed to reduce radioactive materials in liquid effluents by systematic collection, retention, and processing through filtration, evaporation, separation and/or ion exchange treatment. This system consists of at least one collection tank, one evaporator or demineralizer system, one post-treatment tank and associated components providing for treatment flow and functional control.

MAJOR CHANGES TO RADIOACTIVE WASTE TREATMENT SYSTEMS

For the purposes of the ODCM, MAJOR CHANGES TO RADIOACTIVE WASTE TREATMENT SYSTEMS include the following changes to such systems:

(1) Major changes in process equipment, components, structures, or effluent monitoring instrumentation as described in the Final Safety Analysis Report (FSAR) or as evaluated in the Nuclear Regulatory Commission staff's Safety Evaluation Report (SER) (e.g., deletion of evaporators and installation of demineralizers);

(2) Changes in the design of radwaste treatment systems that could significantly increase quantities of effluents released from those previously considered in the FSAR and SER;

(3) Changes in system design which may invalidate the accident analysis as described in the SER (e.g., changes in tank capacity that would alter the curies released); or

(4) Changes in system design that could potentially result in a significant increase in occupational exposure of operating personnel (e.g., use of temporary equipment without adequate shielding provisions).

MEMBER(S) OF THE PUBLIC[1]

A MEMBER OF THE PUBLIC means any individual except when that individual is receiving an *occupational dose*[2]. This category may include persons who use portions of the site for recreational, occupational, or other purposes not associated with the plant.

MINIMUM DETECTABLE CONCENTRATION

The MINIMUM DETECTABLE CONCENTRATION (MDC) is defined, for purposes of the controls in this ODCM, as the smallest concentration of radioactive material in a sample that will yield a net count above system background and that will be detected with 95-percent probability, with only 5-percent probability of falsely concluding that a blank observation represents a "real" signal.

For a particular measurement system, which may include radiochemical separation, the MDC for a given radionuclide is determined as follows (Reference 18):

where:

MDC = the *a priori* MINIMUM DETECTABLE CONCENTRATION (μCi per unit mass or volume).

$$MDC = \frac{\dfrac{2.71}{t_s} + 3.29\sqrt{R_b\left(\dfrac{1}{t_s} + \dfrac{1}{t_b}\right)}}{E \cdot V \cdot 2.22 \times 10^6 \cdot Y \cdot e^{-\lambda \Delta t}}$$

R_b = the background counting rate, or the counting rate of a blank sample, as appropriate (counts per minute).
t_s = the length of the sample counting period (minutes).
t_b = the length of the background counting period (minutes).
E = the counting efficiency (counts per disintegration)
V = the sample size (units of mass or volume).
2.22×10^6 = the number of disintegrations per minute per μCi.
Y = the fractional radiochemical yield, when applicable.
λ = the radioactive decay constant for the given radionuclide (h^{-1}). Values of λ used in effluent calculations should be based on decay data from a recognized and current source, such as Reference 20.
Δt = for effluent samples, the elapsed time between the midpoint of sample collection and the time of counting (h); for environmental samples, the elapsed time between the end of sample collection and the time of counting (h).

1 The italicized terms in this definition, which are not otherwise used in this ODCM, shall have the definitions assigned to them by 10 CFR 20.1003.

2 Except as delineated in other parts of 10 CFR chapter I.

Typical values of E, V, Y, and Δt should be used in the calculation. It should be recognized that the MDC is defined as an *a priori* (before the fact) limit representing the capability of a measurement system, and not as an *a posteriori* (after the fact) limit for a particular measurement.

PRINCIPAL GAMMA EMITTERS

The PRINCIPAL GAMMA EMITTERS for which the MINIMUM DETECTABLE CONCENTRATION (MDC) limit applies include exclusively the following radionuclides:

- For liquid radioactive effluents: Mn–54, Fe–59, Co–58, Co–60, Zn–65, Mo–99, Cs-134, Cs–137, and Ce–141. Ce–144 shall also be measured, but with an MDC of 5 x 10^{-6} μCi/mL.

- For gaseous radioactive effluents: In noble gas releases, Kr–87, Kr–88, Xe–133, Xe–133m, Xe–135, Xe–138; and in particulate releases, Mn–54, Fe–59, Co–58, Co-60, Zn–65, Mo–99, Cs–134, Cs–137, Ce–141, and Ce–144.

- For environmental media: The gamma emitters specifically listed in Table 4-3.

These lists do not mean that only these nuclides are to be considered. Other gamma peaks that are identifiable, together with those of the above nuclides, shall also be analyzed and reported in the Radioactive Effluent Release Report, the Annual Radiological Environmental Operating Report, or other applicable report(s).

SITE BOUNDARY

For the purpose of effluent controls defined in the ODCM, the SITE BOUNDARY shall be as shown in Figure 4-1.

SOURCE CHECK

A SOURCE CHECK shall be the qualitative assessment of channel response when the channel sensor is exposed to a source of increased radioactivity.

UNRESTRICTED AREA

The UNRESTRICTED AREA shall be any area access to which is neither limited nor controlled by the licensee, or any area within the SITE BOUNDARY used for residential quarters or for industrial, commercial, institutional, and/or recreational purposes.

VENTILATION EXHAUST TREATMENT SYSTEM

The VENTILATION EXHAUST TREATMENT SYSTEM is any system designed and installed to reduce gaseous radioiodine or radioactive material in particulate form in effluents, by passing ventilation or vent exhaust gases through charcoal adsorbers and/or HEPA filters, for the purpose of removing iodines or particulates from the gaseous exhaust stream prior to the release to the environment. (Such a system is not considered to have any effect on any noble gas effluents). Engineered Safety Feature (ESF) atmospheric cleanup systems are not considered to be VENTILATION EXHAUST TREATMENT SYSTEM components.

10.2 TERMS DEFINED IN THE TECHNICAL SPECIFICATIONS

The following terms are defined in the Technical Specifications, Section 1.0. Because they are used throughout the Limits of Operation sections of the ODCM, they are presented here for convenience. In the event of discrepancies between the definitions below and those in the Technical Specifications, the Technical Specification definitions shall take precedence.

CHANNEL CALIBRATION

A CHANNEL CALIBRATION shall be the adjustment, as necessary, of the channel, such that it responds within the required range and accuracy to known values of input. The CHANNEL CALIBRATION shall encompass the entire channel including the required sensor, alarm, interlock, and/or trip functions and may be performed by any series of sequential, overlapping, or total channel steps, so that the entire channel is calibrated.

CHANNEL CHECK

A CHANNEL CHECK shall be the qualitative assessment of channel behavior during operation by observation. This determination shall include, where possible, comparison of the channel indication and/or status with other indications and/or status derived from independent instrument channels measuring the same parameter.

CHANNEL FUNCTIONAL TEST (CFT)

A CHANNEL FUNCTIONAL TEST shall be the injection of a simulated signal into the channel as close to the sensor as practicable to verify FUNCTIONALITY of required alarm, interlock, and/or trip functions. The CHANNEL FUNCTIONAL TEST shall include adjustments, as necessary, of the required alarm, interlock, and/or trip setpoints, so that the setpoints are within the required range and accuracy.

DOSE EQUIVALENT I–131

DOSE EQUIVALENT I–131 shall be that concentration of I–131 (μCi/g) which alone would produce the same thyroid dose as the quantity and isotopic mixture of I–131, I–132, I–133, I–134, and I–135 actually present. The thyroid dose conversion factors used for this calculation shall be those listed in EPA Federal Guidance Report No. 11, “Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion,” EPA-520/1-88-020, September 1988.

MODE (or OPERATIONAL MODE)

An OPERATIONAL MODE shall correspond to any one inclusive combination of core reactivity condition, power level, average reactor coolant temperature, and reactor vessel head closure bolt tensioning specified in Section 1.0 of the Technical Specifications with fuel in the reactor vessel.

FUNCTIONAL (or FUNCTIONALITY)

FUNCTIONALITY exists when a system, subsystem, train, component or device is capable of performing its specified function(s), and when all necessary attendant instrumentation, controls, electrical power, cooling or seal water, lubrication or other auxiliary equipment that are required for the system, subsystem, train, component or device to perform its function(s) are also capable of performing their related support function(s).

RATED THERMAL POWER

RATED THERMAL POWER shall be a total reactor core heat transfer rate to the reactor coolant of 3565 MWt.

THERMAL POWER

THERMAL POWER shall be the total reactor core heat transfer rate to the reactor coolant.

Edwin I. Hatch Nuclear Plant – Units 1&2
Joseph M. Farley Nuclear Plant – Units 1&2
Vogtle Electric Generating Plant – Units 1&2
Vogtle Electric Generating Plant – Unit 3
Annual Non-Radiological Environmental Operating Reports and Annual Radioactive Effluent Release Reports for 2022

Enclosure 9

Vogtle Electric Generating Plant – Units 1&2
Offsite Dose Calculation Manual – Version 36

OFFSITE DOSE CALCULATION MANUAL

FOR

SOUTHERN NUCLEAR OPERATING COMPANY

VOGTLE ELECTRIC GENERATING PLANT

Version 36

OCTOBER 2022

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF FIGURES

REFERENCES

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CHAPTER 1

INTRODUCTION

The Offsite Dose Calculation Manual is a supporting document of the Technical Specifications. As such, it describes the methodology and parameters to be used in the calculation of offsite doses due to radioactive liquid and gaseous effluents, and in the calculation of liquid and gaseous effluent monitoring instrumentation alarm setpoints. In addition, it contains the following:

- The controls required by the Technical Specifications, governing the radioactive effluent and radiological environmental monitoring programs.

- Schematics of liquid and gaseous radwaste effluent treatment systems, which include designation of release points to UNRESTRICTED AREAS.

- A list and maps indicating the specific sample locations for the Radiological Environmental Monitoring Program.

- Specifications and descriptions of the information that must be included in the Annual Radiological Environmental Operating Report and the Radioactive Effluent Release Report required by the Technical Specifications.

The ODCM will be maintained at the plant for use as a reference guide and training document of accepted methodologies and calculations. Changes in the calculational methods or parameters will be incorporated into the ODCM in order to ensure that it represents current methodology in all applicable areas. Any computer software used to perform the calculations described will be maintained current with the ODCM.

Equations and methods used in the ODCM are based on those presented in NUREG–0133 (Reference 1), in Regulatory Guide 1.109 (References 2 and 3), in Regulatory Guide 1.111 (References 4 and 5), and in Regulatory Guide 1.113 (Reference 6).

CHAPTER 2

LIQUID EFFLUENTS

2.1 LIMITS OF OPERATION

The following Liquid Effluent Controls implement requirements established by Technical Specifications Section 5.0. Terms printed in all capital letters are defined in Chapter 10.

2.1.1 Liquid Effluent Monitoring Instrumentation Control

In accordance with Technical Specification 5.5.4.a, the radioactive liquid effluent monitoring instrumentation channels shown in Table 2-1 shall be FUNCTIONAL with their alarm/trip setpoints set to ensure that the limits specified in Section 2.1.2 are not exceeded. The alarm/trip setpoints of these channels shall be determined in accordance with Section 2.3.

2.1.1.1 Applicability

This limit applies at all times.

2.1.1.2 Actions

With a radioactive liquid effluent monitoring instrumentation channel alarm/trip setpoint less conservative than required by the above control, immediately suspend the release of radioactive liquid effluents monitored by the affected channel, declare the channel NON-FUNCTIONAL, or change the setpoint to a conservative value.

With less than the minimum number of radioactive liquid effluent monitoring instrumentation channels FUNCTIONAL, take the ACTION shown in Table 2-1. Restore the NON-FUNCTIONAL instrumentation to FUNCTIONAL status within 30 days, or if unsuccessful, explain in the next Radioactive Effluent Release Report, per Technical Specification 5.6.3, why this NON-FUNCTIONALITY was not corrected in a timely manner.

This control does not affect shutdown requirements or MODE changes.

2.1.1.3 Surveillance Requirements

Each radioactive liquid effluent monitoring instrumentation channel shall be demonstrated FUNCTIONAL by performance of the CHANNEL CHECK, SOURCE CHECK, CHANNEL CALIBRATION, and CHANNEL FUNCTIONALITY TEST operations at the frequencies shown in Table 2-2. Specific instrument numbers are provided in parentheses for information only. The numbers apply to each unit. These numbers will help to identify associated channels or loops and are not intended to limit the requirements to the specific instruments associated with the number.

2.1.1.4 Basis

The radioactive liquid effluent instrumentation is provided to monitor and control, as applicable, the releases of radioactive materials in liquid effluents during actual or potential releases of liquid effluents. The Alarm/Trip Setpoints for these instruments shall be calculated and adjusted in accordance with the methodology and parameters in Section 2.3 to ensure that the alarm/trip will occur prior to exceeding the limits of Section 2.1.2. The FUNCTIONALITY and use of this instrumentation is consistent with the requirements of General Design Criteria 60, 63, and 64 of Appendix A to 10 CFR Part 50.

Table 2-1. Radioactive Liquid Effluent Monitoring Instrumentation

Instrument	FUNCTIONALITY Requirements[a]	
	Minimum Channels FUNCTIONAL	ACTION
1. Radwaste Monitors Providing Alarm and Automatic Termination of Release		
a. Liquid Radwaste Effluent Line (RE–0018)	1	37
b. Steam Generator Blowdown Effluent Line (RE-0021)	1	38
c. Turbine Building Effluent Line (RE–0848)	1	38
2. Radwaste Monitors Providing Alarm, but Not Automatic Termination of Release		
NSCW Effluent Line (RE-0020 A)	1	39
NSCW Effluent Line (RE-0020 B)	1	39
3. Flowrate Measurement Devices		
a. Liquid Radwaste Effluent Line (FT–0018), (FT-1084A/B), or (FT-1085A/B)	1	40
b. Steam Generator Blowdown Effluent Line (FT-0021)	1	40
c. Flow to Blowdown Sump (AFQI-7620, FI7620A)	1	40

a. All requirements in this table apply to each unit.

Table 2-1 (contd). Notation for Table 2-1 — ACTION Statements

ACTION 37 — With the number of channels FUNCTIONAL less than required by the Minimum Channels FUNCTIONAL requirement, effluent releases may continue provided that prior to initiating a release:

a. The local radiation monitor reading (if functional) is recorded at least once per 12 hours during the release or at least two independent samples are analyzed in accordance with Section 2.1.2.3, and

b. At least two technically qualified members of the Facility Staff independently verify the discharge line valving and the release rate calculations.

Otherwise, suspend release of radioactive effluents via this pathway.

ACTION 38 — With the number of channels FUNCTIONAL less than required by the Minimum Channels FUNCTIONAL requirement, effluent releases via this pathway may continue provided the local radiation monitor reading (if functional) is recorded at least once per 12 hours or grab samples are analyzed for gross radioactivity at a MINIMUM DETECTABLE CONCENTRATION no higher than 1×10^{-7} μCi/mL using gross beta/gamma counting or 5×10^{-7} μCi/mL for the principal gamma emitters using gamma-ray spectroscopy.

a. At least once per 12 hours when the specific activity of the secondary coolant is greater than 0.01 μCi/gram DOSE EQUIVALENT I–131.

b. At least once per 24 hours when the specific activity of the secondary coolant is less than or equal to 0.01 μCi/gram DOSE EQUIVALENT I–131.

ACTION 39 — With the number of channels FUNCTIONAL less than required by the Minimum Channels FUNCTIONAL requirement, effluent releases via this pathway may continue provided that, at least once per 12 hours, the local radiation monitor reading (if functional) is recorded or grab samples are collected and analyzed for radioactivity at a MINIMUM DETECTABLE CONCENTRATION no higher than 1×10^{-7} μCi/mL using gross beta/gamma counting or 5×10^{-7} μCi/mL for the principal gamma emitters using gamma-ray spectroscopy.

ACTION 40 — With the number of channels FUNCTIONAL less than required by the Minimum Channels FUNCTIONAL requirement, effluent releases via this pathway may continue provided the flowrate is estimated at least once per 4 hours during actual releases. Pump curves generated in place may be used to estimate flow.

Table 2-2. Radioactive Liquid Effluent Monitoring Instrumentation Surveillance Requirements

Instrument	Surveillance Requirements[d]			
	CHANNEL CHECK	SOURCE CHECK	CHANNEL CALIBRA-TION	CHANNEL FUNCTIONAL TEST
1. Radwaste Monitors Providing Alarm and Automatic Termination of Release				
a. Liquid Radwaste Effluent Line (RE-0018)	P	P	R[b]	R[a(1)]
b. Steam Generator Blowdown Effluent Line (RE-0021)	M	SA	R[b]	R[a(1)]
c. Turbine Building Effluent Line (RE-0848)	M	SA	R[b]	R[a(1)]
2. Radwaste Monitors Providing Alarm, but Not Automatic Termination of Release				
NSCW Effluent Line (RE-0020 A&B)	M	SA	R[b]	R[a(2)]
3. Flowrate Measurement Devices				
a. Liquid Radwaste Effluent Line (FT-0018)	P[c]	NA	R	NA
b. Liquid Radwaste Effluent Line (FT-1084A/B), or (FT-1085A/B)	M[c]	NA	R	NA
b. Steam Generator Blowdown Effluent Line (FT-0021)	M[c]	NA	R	NA
d. Flow to Blowdown Sump (AFQI-7620, FI7620A)	M[c]	NA	R	Q

Table 2-2 (contd). Notation for Table 2-2

a. In addition to the basic functions of a CHANNEL FUNCTIONAL TEST (Section 10.2):

(1) The CHANNEL FUNCTIONAL TEST shall also demonstrate that automatic isolation of this pathway and control room annunciation occurs (for item a. below only); and control room CRT indication occurs (if any of the following conditions exist):

(a) Instrument indicates measured levels above the alarm/trip setpoint;

(b) Instrument indicates an “Equipment Trouble” alarm;

(c) Instrument indicates a “Low” alarm; or

(d) Instrument indicates channel “Deactivated”.

(2) The CHANNEL FUNCTIONAL TEST shall also demonstrate that control room annunciation occurs (for item a. below only); and that control room CRT indication occurs (if any of the following conditions exist):

(a) Instrument indicates measured levels above the alarm/trip setpoint;

(b) Instrument indicates an “Equipment Trouble” alarm;

(c) Instrument indicates a “Low” alarm; or

(d) Instrument indicates channel “Deactivated”.

b. The initial CHANNEL CALIBRATION shall be performed using one or more of the reference standards certified by the National Institute of Standards and Technology or using standards that have been obtained from suppliers that participate in measurements assurance activities with NIST. These standards shall permit calibrating the system over its intended range of energy and measurement range. For subsequent CHANNEL CALIBRATION, sources that have been related to the initial calibration shall be used.

c. CHANNEL CHECK shall consist of verifying indication of flow during periods of release. CHANNEL CHECK shall be made at least once per 24 hours on days on which continuous, periodic, or batch releases are made.

d. All requirements in this table apply to each unit.

2.1.2 Liquid Effluent Concentration Control

In accordance with Technical Specifications 5.5.4.b and 5.5.4.c, the concentration of radioactive material released in liquid effluents to UNRESTRICTED AREAS shall be limited at all times to ten times the concentrations specified in 10 CFR 20, Appendix B, Table 2, Column 2 for radionuclides other than dissolved or entrained noble gases. For dissolved or entrained noble gases, the concentration shall be limited to 1×10^{-4} μCi/mL total activity.

2.1.2.1 Applicability

This limit applies at all times.

2.1.2.2 Actions

With the concentration of radioactive material released in liquid effluents to UNRESTRICTED AREAS exceeding the limits stated in Section 2.1.2, immediately restore the concentration to within the stated limits.

This control does not affect shutdown requirements or MODE changes.

2.1.2.3 Surveillance Requirements

The radioactivity content of each batch of radioactive liquid waste shall be determined by sampling and analysis in accordance with Table 2-3. The results of radioactive analyses shall be used with the calculational methods in Section 2.3 to assure that the concentration at the point of release is maintained within the limits of Section 2.1.2.

2.1.2.4 Basis

This control is provided to ensure that the concentration of radioactive materials released in liquid waste effluents to UNRESTRICTED AREAS will be less than ten times the concentration levels specified in 10 CFR 20, Appendix B, Table 2, Column 2. This limitation provides additional assurance that the levels of radioactive materials in bodies of water in UNRESTRICTED AREAS will result in exposures within (1) the Section II.A design objectives of Appendix I, 10 CFR 50, to a MEMBER OF THE PUBLIC, and (2) the limits of 10 CFR 20.1301 to the population. The concentration limit for dissolved or entrained noble gases is based upon the assumption that Xe–135 is the controlling radioisotope and its MPC in air (submersion) was converted to an equivalent concentration in water using the methods described in International Commission on Radiological Protection (ICRP) Publication 2 (1959). The resulting concentration of 2×10^{-4} was then multiplied by the ratio of the effluent concentration limit for Xe-135, stated in Appendix B, Table 2, Column 1 of 10 CFR 20 (paragraphs 20.1001 to 20.2401), to the MPC for Xe-135, stated in Appendix B, Table II, Column 1 of 10 CFR 20 (paragraphs 20.1 to 20.601), to obtain the limiting concentration of 1×10^{-4} μCi/mL.

Table 2-3. Radioactive Liquid Waste Sampling and Analysis Program

Liquid Release Type	Sampling and Analysis Requirements[a,b]			
	Sampling FREQUENCY	Minimum Analysis FREQUENCY	Type of Activity Analysis	MINIMUM DETECTABLE CONCENTRATION (MDC) (μCi/mL)
A. BATCH RELEASES				
1. Waste Monitor Tank 2. Drainage of System	P Each BATCH	P Each BATCH	PRINCIPAL GAMMA EMITTERS I-131	5 E-7 1 E-6
	P One BATCH/M	M	Dissolved and Entrained Gases (Gamma Emitters)	1 E-5
	P Each BATCH	M COMPOSITE	H-3 Gross Alpha	1 E-5 1 E-7
	P Each BATCH	Q COMPOSITE	Sr-89, Sr-90 Fe-55	5 E-8 1 E-6
B. CONTINUOUS RELEASES				
Waste Water Retention Basin[c]	Continuous	W COMPOSITE	PRINCIPAL GAMMA EMITTERS I-131	5 E-7 1 E-6
	M Grab Sample	M	Dissolved and Entrained Gases (Gamma Emitters)	1 E-5
	Continuous	M COMPOSITE	H-3 Gross Alpha	1 E-5 1 E-7
	Continuous	Q COMPOSITE	Sr-89, Sr-90 Fe-55	5 E-8 1 E-6

Table 2-3 (contd). Notation for Table 2-3

a. All requirements in this table apply to each unit.

b. Terms printed in all capital letters are defined in Chapter 10.

c. The WWRB will not be considered a release point until there is a confirmed primary to secondary leak. Once a primary to secondary leak has been confirmed, this composite shall be analyzed as specified until the leak is repaired. This surveillance will continue until three consecutive weekly composite samples have shown no activity above the MDC.

2.1.3 Liquid Effluent Dose Control

In accordance with Technical Specifications 5.5.4.d and 5.5.4.e, the dose or dose commitment to a MEMBER OF THE PUBLIC from radioactive materials in liquid effluents released, from each unit, to UNRESTRICTED AREAS shall be limited:

a. During any calendar quarter to less than or equal to 1.5 mrem to the total body and to less than or equal to 5 mrem to any organ, and

b. During any calendar year to less than or equal to 3 mrem to the total body and to less than or equal to 10 mrem to any organ.

2.1.3.1 Applicability

These limits apply at all times.

2.1.3.2 Actions

With the calculated dose from the release of radioactive materials in liquid effluents exceeding any of the limits of Section 2.1.3., prepare and submit to the Nuclear Regulatory Commission within 30 days a special report which identifies the cause(s) for exceeding the limit(s); defines the corrective actions to be taken to reduce the releases; and defines the proposed corrective actions to be taken to assure that subsequent releases will be in compliance with the limits of Section 2.1.3.

This control does not affect shutdown requirements or MODE changes.

2.1.3.3 Surveillance Requirements

At least once per 31 days, cumulative dose contributions from liquid effluents for the current calendar quarter and the current calendar year shall be determined, for each unit, in accordance with Section 2.4.

2.1.3.4 Basis

This control is provided to implement the requirements of Sections II.A, III.A and IV.A of Appendix I, 10 CFR Part 50. The limits stated in Section 2.1.3 implement the guides set forth in Section II.A of Appendix I. The ACTIONS stated in Section 2.1.3.2 provide the required operating flexibility and at the same time implement the guides set forth in Section IV.A of Appendix I to assure that the releases of radioactive material in liquid effluents will be kept "as low as is reasonably achievable." Also, for fresh water sites with drinking water supplies that can be potentially affected by plant operations, there is reasonable assurance that the operation of the facility will not result in radionuclide concentrations in the finished drinking water that are in excess of the requirements of 40 CFR Part 141. The dose calculations in Section 2.4 implement the requirements in Section III.A of Appendix I, which state that conformance with the guides of Appendix I be shown by calculational procedures based on models and data, such that the actual exposure of a MEMBER OF THE PUBLIC through appropriate pathways is unlikely to be substantially underestimated. The equations specified in Section 2.4 for calculating the doses due to the actual release rates of radioactive materials in liquid effluents are consistent with the methodology provided in Regulatory Guide 1.109 (Reference 3) and Regulatory Guide 1.113 (Reference 6).

This control applies to the release of liquid effluents from each unit at the site. The liquid effluents from shared LIQUID RADWASTE TREATMENT SYSTEMs are to be proportioned between the units.

2.1.4 Liquid Radwaste Treatment System Control

In accordance with Technical Specification 5.5.4.f, the LIQUID RADWASTE TREATMENT SYSTEM shall be FUNCTIONAL. The appropriate portions of the system shall be used to reduce radioactivity in liquid wastes prior to their discharge when the projected doses due to the liquid effluent, from each unit, to UNRESTRICTED AREAS would exceed 0.06 mrem to the total body or 0.2 mrem to any organ of a MEMBER OF THE PUBLIC in 31 days.

2.1.4.1 Applicability

This limit applies at all times.

2.1.4.2 Actions

With radioactive liquid waste being discharged without treatment and in excess of the above limits and any portion of the LIQUID RADWASTE TREATMENT SYSTEM not in operation, prepare and submit to the Nuclear Regulatory Commission within 30 days a special report which includes the following information:

a. Explanation of why liquid radwaste was being discharged without treatment, identification of any NON-FUNCTIONAL equipment or subsystems and the reason for the NON-FUNCTIONALITY,

b. Action(s) taken to restore the NON-FUNCTIONAL equipment to FUNCTIONAL status, and

c. Summary description of action(s) taken to prevent a recurrence.

This control does not affect shutdown requirements or MODE changes.

2.1.4.3 Surveillance Requirements

Doses due to liquid releases to UNRESTRICTED AREAS shall be projected at least once per 31 days, in accordance with Section 2.5, during periods in which the LIQUID RADWASTE TREATMENT SYSTEMs are not being fully utilized.

The LIQUID RADWASTE TREATMENT SYSTEM shall be demonstrated FUNCTIONAL by meeting the controls of Sections 2.1.2 and 2.1.3.

2.1.4.4 Basis

The FUNCTIONALITY of the LIQUID RADWASTE TREATMENT SYSTEM ensures that this system will be available for use whenever liquid effluents require treatment prior to release to the UNRESTRICTED AREAS. The requirement that the appropriate portions of this system be used when specified provides assurance that the releases of radioactive materials in liquid effluents will be kept "as low as is reasonably achievable." This control implements the requirements of 10 CFR Part 50.36a, General Design Criterion 60 of Appendix A to 10 CFR Part 50, and the design objective given in Section II.D of Appendix I to 10 CFR Part 50. The specified limits governing the use of appropriate portions of the LIQUID RADWASTE TREATMENT SYSTEM were specified as a suitable fraction of the dose design objectives set forth in Section II.A of Appendix I, 10 CFR Part 50, for liquid effluents.

This control applies to the release of radioactive materials in liquid effluents from each unit at the site. For units with shared radwaste systems, the liquid effluents from the shared system are to be proportioned among the units sharing that system.

2.1.5 Major Changes to Liquid Radioactive Waste Treatment Systems

Licensee initiated MAJOR CHANGES TO LIQUID RADIOACTIVE WASTE TREATMENT SYSTEMS:

a. Shall be reported to the Nuclear Regulatory Commission in the Radioactive Effluent Release Report for the period in which the change was implemented. The discussion of each change shall contain the information described in Section 7.2.2.7.

b. Shall become effective upon review by the Plant Review Board and approval by the Plant Manager.

2.2 LIQUID RADWASTE TREATMENT SYSTEM

The Vogtle Electric Generating Plant is located on the west bank of the Savannah River approximately 151 river miles from the Atlantic Ocean. There are two pressurized water reactors on the site. Each unit is served by a separate LIQUID RADWASTE TREATMENT SYSTEM; however, certain components are shared between the two systems. Schematics of the LIQUID RADWASTE TREATMENT SYSTEMs are presented in Figure 2-1 and Figure 2-2. Liquid discharge pathways are shown in Figure 2-3.

All liquid radwastes treated by the LIQUID RADWASTE TREATMENT SYSTEM are collected in 5,000-gallon or 20,000-gallon waste monitor tanks. Releases from the waste monitor tanks are to the discharge line from the blowdown sump, and from there to the Savannah River. The blowdown sump also receives input from the waste water retention basins, turbine plant cooling water blowdown, and nuclear service cooling water blowdown. Additional dilution water is available from the cooling tower makeup water bypass line.

Although no significant quantities of radioactivity are expected in the nuclear service cooling water, the steam generator blowdown processing system, or the turbine building drain system, these effluent pathways are monitored as a precautionary measure. The monitors serving the latter two pathways provide for automatic termination of releases from these systems in the event that radio-activity is detected above predetermined levels. These two systems discharge to the waste water retention basin. Sampling and analysis of releases via all three of these pathways must be sufficient to ensure that the liquid effluent dose limits specified in the controls of Section 2.1.3 are not exceeded.

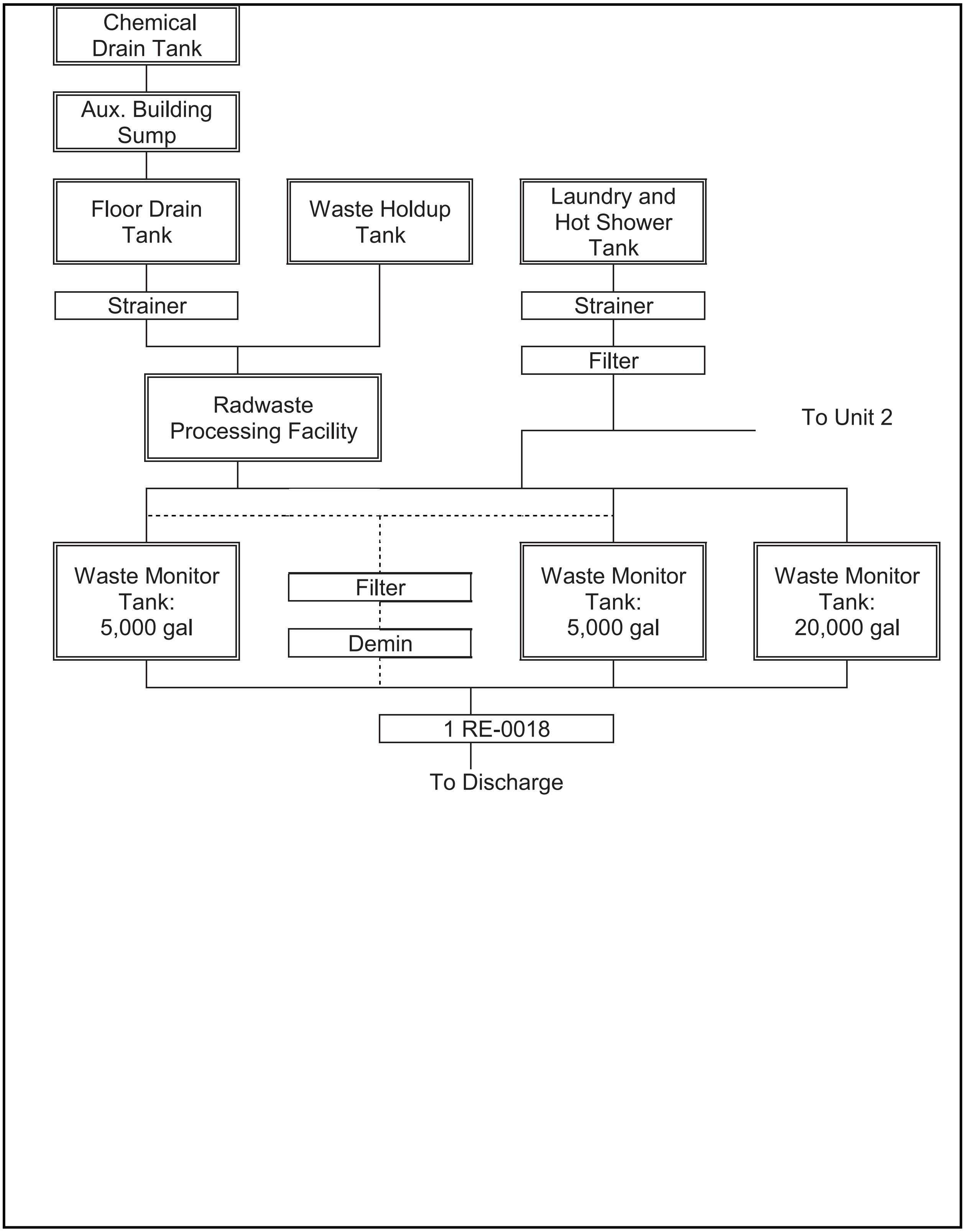


Figure 2-1. Unit 1 Liquid Radwaste Treatment System

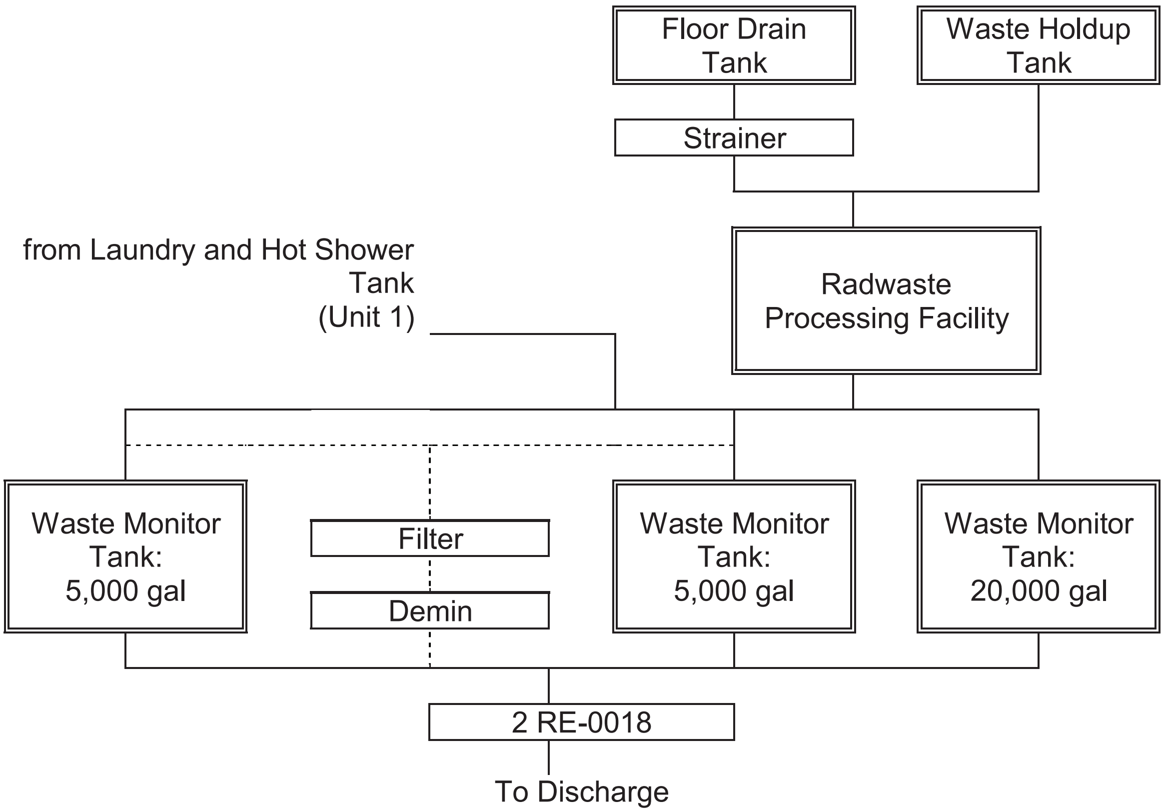


Figure 2-2. Unit 2 Liquid Radwaste Treatment System

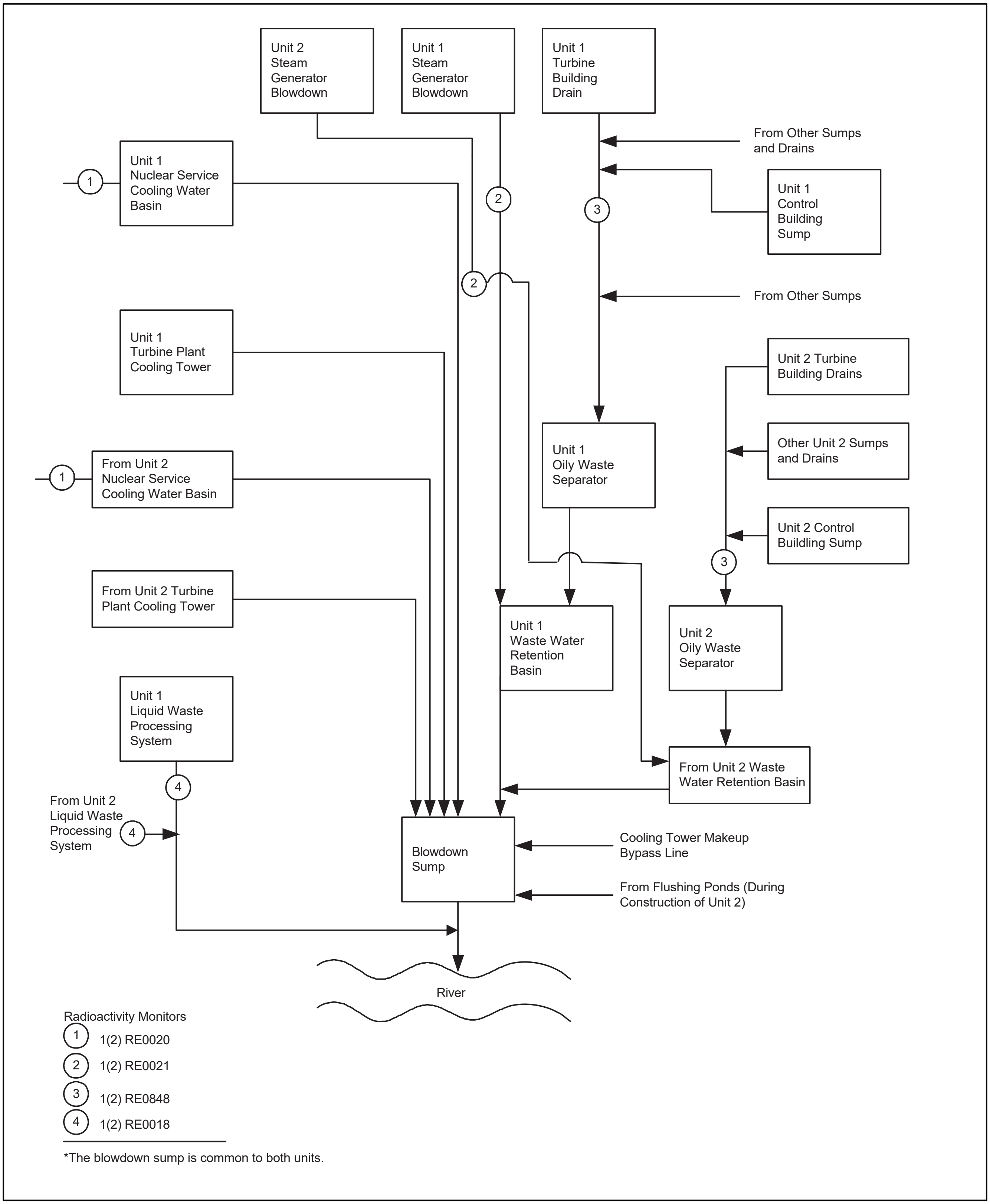


Figure 2-3. Liquid Radwaste Discharge Pathways

2.3 LIQUID EFFLUENT MONITOR SETPOINTS

2.3.1 General Provisions Regarding Setpoints

Liquid monitor setpoints calculated in accordance with the methodology presented in this section will be regarded as upper bounds for the actual high alarm setpoints. That is, a lower value for the high alarm setpoint may be established or retained on the monitor, if desired. Intermediate level setpoints should be established at an appropriate level to give sufficient warning prior to reaching the high alarm setpoint. If no release is planned for a particular pathway, or if there is no detectable activity in the planned release, the monitor setpoint should be established as close to background as practical to prevent spurious alarms, and yet alarm should an inadvertent release occur.

Two basic setpoint methodologies are presented below. For radwaste system discharge monitors, setpoints are determined to assure that the limits of Section 2.1.2 are not exceeded. For monitors on streams that are not expected to contain significant radioactivity, the purpose of the monitor setpoints is to cause an alarm on low levels of radioactivity, and to terminate the release where this is possible. Section 2.1.1 establishes the requirements for liquid effluent monitoring instrumentation. Table 2-4 lists the monitors for which each of the setpoint methodologies is applicable.

Table 2-4. Applicability of Liquid Monitor Setpoint Methodologies

Liquid Radwaste Discharge Monitors

Setpoint Method: Section 2.3.2

Release Type: BATCH

Unit 1 or Unit 2 Liquid Waste Treatment System Effluent
Monitor: 1RE-0018 / 2RE-0018

Normally Low-Radioactivity Streams with Termination or Diversion upon Alarm

Setpoint Method: Section 2.3.3

Release Type: CONTINUOUS

Unit 1 or Unit 2 Steam Generator Blowdown Effluent
Monitor: 1RE-0021 / 2RE-0021

Unit 1 or Unit 2 Turbine Building Drain Effluent
Monitor: 1RE-0848 / 2RE-0848

Normally Low-Radioactivity Streams with Alarm Only

Setpoint Method: Section 2.3.3

Release Type: CONTINUOUS

Unit 1 or Unit 2 Nuclear Service Cooling Water System Effluent
Monitors (2 per unit): 1RE-0020 A and B
2RE-0020 A and B

2.3.2 Setpoints for Radwaste System Discharge Monitors

2.3.2.1 Overview of Method

LIQUID RADWASTE TREATMENT SYSTEM effluent line radioactivity monitors are intended to provide alarm and automatic termination of release prior to exceeding the limits specified in Section 2.1.2 at the point of release of the diluted effluent into the UNRESTRICTED AREA. Therefore, their alarm/trip setpoints are established to ensure compliance with the following equation (equation adapted from Addendum to Reference 1):

$$\frac{c \cdot f}{F + f} \leq TF \cdot C_{ECL} \qquad \textbf{(2.1)}$$

where:

C_{ECL} = the Effluent Concentration Limit corresponding to the mix of radionuclides in the effluent being considered for discharge, in μCi/mL.

c = the setpoint, in μCi/mL, of the radioactivity monitor measuring the concentration of radioactivity in the effluent line prior to dilution and subsequent release. The setpoint represents a concentration which, if exceeded, could result in concentrations exceeding the limits of Section 2.1.2 in the UNRESTRICTED AREA.

f = the effluent flowrate at the location of the radioactivity monitor, in gpm.

F = the dilution stream flowrate which can be assured prior to the release point to the UNRESTRICTED AREA, in gpm. A predetermined dilution flowrate must be assured for use in the calculation of the radioactivity monitor setpoint.

TF = the tolerance factor selected to allow flexibility in the establishment of a practical monitor setpoint which could accommodate effluent releases at concentrations higher than the ECL values stated in 10 CFR 20, Appendix B, Table 2, Column 2; the tolerance factor must not exceed a value of 10.

While equation (2.1) shows the relationships of the critical parameters that determine the setpoint, it cannot be applied practically to a mixture of radionuclides with different Effluent Concentration Limits (ECLs). For a mixture of radionuclides, equation (2.1) is satisfied in a practicable manner based on the calculated ECL fraction of the radionuclide mixture and the dilution stream flowrate that can be assured for the duration of the release (F_d), by calculating the maximum permissible effluent flowrate (f_m) and the radioactivity monitor setpoint (c).

The setpoint method presented below is applicable to the release of only one tank of liquid radwaste per reactor unit at a given time. Liquid releases must be controlled administratively to ensure that this condition is met; otherwise, the setpoint method may not ensure that the limits of Section 2.1.2 are not exceeded.

2.3.2.2 Setpoint Calculation Steps

Step 1: Determine the radionuclide concentrations in the liquid waste being considered for release in accordance with the sampling and analysis requirements of Section 2.1.2.

All liquid radwastes treated by the LIQUID RADWASTE TREATMENT SYSTEM are collected in waste monitor tanks for sampling and analysis. The 5,000-gallon waste monitor tanks are recirculated for a minimum of 30 minutes, and the 20,000-gallon waste monitor tanks are recirculated for a minimum of 45 minutes. This mixing assures that a representative sample can be taken from the tank.

The total concentration of the liquid waste is determined by the results of all required analyses on the collected sample, as follows:

$$\sum_i C_i = C_a + \sum_s C_s + C_f + C_t + \sum_g C_g \qquad \textbf{(2.2)}$$

where:

C_a = the gross concentration of alpha emitters in the liquid waste, not less than that measured in the most recent applicable composite sample.

C_s = the concentration of strontium radioisotope s (Sr–89 or Sr–90) in the liquid waste, not less than that measured in the most recent applicable composite sample.

C_f = the concentration of Fe–55 in the liquid waste, not less than that measured in the most recent applicable composite sample.

C_t = the concentration of H–3 in the liquid waste, not less than that measured in the most recent applicable composite sample.

C_g = the concentration of gamma emitter g in the liquid waste as measured by gamma ray spectroscopy performed on the sample for the release under consideration.

The C_g term will be included in the analysis of each waste sample; terms for gross concentrations of alpha emitters, Sr-89, Sr-90, Fe-55, and tritium will be included in accordance with the sampling and analysis program required for the waste stream (see Section 2.1.2). For each analysis, only radionuclides identified and detected above background for the given measurement should be included in the calculation. When using the alternate setpoint methodology of step 5.b, the historical maximum values of C_a, C_s, C_f, and C_t shall be used.

Step 2: Determine the required dilution factor for the mix of radionuclides detected in the waste.

Measured radionuclide concentrations are used to calculate ECL fractions. The ECL fractions are used along with a safety factor to calculate the required dilution factor; this is the minimum ratio of dilution flowrate to waste flowrate that must be maintained throughout the release to ensure that the limits of Section 2.1.2 are not exceeded at the point of discharge into the UNRESTRICTED AREA. The required dilution factor, RDF, is calculated as the sum of the dilution factors required for gamma emitters (RDF_{γ}) and for non-gamma-emitters ($RDF_{n\gamma}$):

$$RDF = \left[\sum_i \frac{C_i}{ECL_i} \right] \div \left[(SF)(TF) \right]$$

$$= RDF_\gamma + RDF_{n\gamma} \tag{2.3}$$

$$RDF_\gamma = \frac{\left[\sum_g \frac{C_g}{ECL_g} \right]}{(SF)(TF)} \tag{2.4}$$

where:

$$RDF_{n\gamma} = \frac{\left[\frac{C_a}{ECL_a} + \sum_s \frac{C_s}{ECL_s} + \frac{C_f}{ECL_f} + \frac{C_t}{ECL_t} \right]}{(SF)(TF)} \tag{2.5}$$

C_i	=	the measured concentration of radionuclide i as defined in step 1, in μCi/mL. The C_a, C_s, C_f, and C_t terms will be included in the calculation as appropriate.
ECL_i	=	the Effluent Concentration Limit for radionuclide i from 10 CFR Part 20, Appendix B, Table 2, Column 2 (except for noble gases as discussed below). In the absence of information regarding the solubility classification of a given radionuclide in the waste stream, the solubility class with the lowest ECL shall be assumed. For dissolved or entrained noble gases, the concentration shall be limited to $1\text{x}10^{-4}$ μCi/mL. For gross alpha, the ECL shall be $2\text{x}10^{-9}$ μCi/mL; if specific alpha-emitting radionuclides are measured, the ECL for the specific radionuclide(s) should be used.
SF	=	the safety factor selected to compensate for statistical fluctuations and errors of measurement. The value for the safety factor must be between 0 and 1. A value of 0.5 is reasonable for liquid releases; a more precise value may be developed if desired.
TF	=	the tolerance factor (as defined in Section 2.3.2.1).

Step 3: Determine the release-specific assured dilution stream flowrate.

Determine the dilution stream flowrate that can be assured during the release period, designated F_d; this value is the setpoint for the dilution stream flowrate measurement device.

If simultaneous radioactive releases are planned from the same or different reactor units, the dilution stream must be allocated among all the simultaneous releases. There will only be one such release per unit at a given time, unless there is detectable radioactivity in one of the normally low-radioactivity streams (see Section 2.3.3). Allocation of the dilution stream to multiple release paths is accomplished as follows:

$$F_{dp} = F_d \left(AF_p \right) \tag{2.6}$$

where:

F_{dp} = the dilution flowrate allocated to release pathway p, in gpm.

AF_p = the dilution allocation factor for release pathway p. AF_p may be assigned any value between 0 and 1 for each active release pathway, under the condition that the sum of the AF_p for all active release pathways for the entire plant site does not exceed 1.

F_d = the assured minimum dilution flow for the unit, in gpm.

In the normal case in which the only release pathways with detectable radioactivity are the LIQUID RADWASTE TREATMENT SYSTEMs of each unit, AF_p for each unit may be assigned the value of 0.5 to permit releases from either unit to be made without regard to any releases from the other unit; if only one unit's LIQUID RADWASTE TREATMENT SYSTEM is releasing at a given time, its AF_p may be increased proportionately. If more precise allocation factor values are desired, they may be determined based on the relative radiological impact of each active release pathway; this may be approximated by multiplying the RDF of each effluent stream by its respective planned release flowrate, and comparing these values. If only one simultaneous release is being made, its AF_p may be assigned the value of 1, making F_{dp} equal to F_d.

For the case where RDF ≤ 1, the planned release meets the limits of Section 2.1.2 without dilution, and *could* be released with any desired effluent flowrate and dilution flowrate. However, in order to maintain individual doses due to liquid effluent releases as low as is reasonably achievable, no releases with detectable radioactivity *should* be made if the assured dilution flowrate, F_d, is less than 12,000 gpm.

Step 4: Determine the maximum allowable waste discharge flowrate.

For the case where RDF > 1, the maximum permissible effluent discharge flowrate for this release pathway, f_{mp} (in gpm), is calculated as follows:

$$f_{mp} = \frac{F_{dp}}{(RDF - 1)} \tag{2.7}$$

For the case RDF ≤ 1, equation (2.7) is not valid. However, as discussed above, when RDF ≤ 1, the release may be made at full discharge pump capacity; the radioactivity monitor setpoint must still be calculated in accordance with Step 5 below.

NOTE 1: Discharge flowrates are actually limited by the discharge pump capacity. When the calculated maximum permissible release flowrate exceeds the pump capacity, the release may be made at full capacity. Discharge flowrates less than the pump capacity must be achieved by throttling if this is available; if throttling is not available, the release may not be made as planned.

NOTE 2: If, at the time of the planned release, there is detectable radioactivity due to plant operations in the dilution stream, the diluting capacity of the dilution stream is diminished. (In addition, sampling and analysis of the other radioactive effluents affecting the dilution stream must be sufficient to ensure that the liquid effluent dose limits specified in the controls of Section 2.1.3 are not exceeded.) Under these conditions, equation (2.7) must be modified to account for the radioactivity present in the dilution stream prior to the introduction of the planned release:

$$f_{mp} = \frac{F_{dp}}{(RDF - 1)}\left(1 - \sum_r\left[\frac{f_r}{F_d}\sum_i\left(\frac{C_{ir}}{ECL_i}\right)\right]\right) \quad \textbf{(2.8)}$$

where:

C_{ir} = the measured concentration of radionuclide i in release pathway r that is contributing to radioactivity in the dilution stream.

f_r = the effluent discharge flowrate of release pathway r.

If the entire dilution stream contains detectable activity due to plant operations, whether or not its source is identified, $f_r = F_d$, and C_{ir} is the concentration in the total dilution system. This note does not apply: a) if the RDF of the planned release is ≤ 1; or b) if the release contributing radioactivity to the dilution stream has been accounted for by the assignment of an allocation factor.

Step 5: Determine the maximum radioactivity monitor setpoint concentration.

Based on the values determined in previous steps, the radioactivity monitor setpoint for the planned release is calculated to ensure that the limits of Section 2.1.2 will not be exceeded. Because the radioactivity monitor responds primarily to gamma radiation, the monitor setpoint c_p for release pathway p (in μCi/mL) is based on the concentration of gamma emitters in the waste stream, as follows:

$$c_p = A_p \sum_g c_g \quad \textbf{(2.9)}$$

where:

A_p = an adjustment factor which will allow the setpoint to be established in a practical manner to prevent spurious alarms while allowing a margin between measured concentrations and the limits of Section 2.1.2.

Step 5.a. If the concentration of gamma emitters in the effluent to be released is sufficient that the high alarm setpoint can be established at a level that will prevent spurious alarms, A_p should be calculated as follows:

$$A_p = \frac{1}{RDF} \times ADF$$

$$= \frac{1}{RDF} \times \frac{(F_{dp} + f_{ap})}{f_{ap}} \quad \textbf{(2.10)}$$

where:

ADF = the assured dilution factor.

f_{ap} = the anticipated actual discharge flowrate for the planned release (in gpm), a value less than f_{mp}. The release must then be controlled so that the actual effluent discharge flowrate does not exceed f_{ap} at any time.

Step 5.b. Alternatively, A_p may be calculated as follows:

$$A_p = \frac{ADF - RDF_{n\gamma}}{RDF_\gamma} \quad \textbf{(2.11)}$$

Step 5.c. Evaluate the computed value of A_p as follows:

If $A_p \geq 1$, calculate the monitor setpoint, c_p. However, if c_p is within about 10 percent of C_g, it may be impractical to use this value of c_p. This situation indicates that measured concentrations are approaching values which would cause limits of Section 2.1.2 to be exceeded. Therefore, steps should be taken to reduce potential concentrations at the point of discharge; these steps may include decreasing the planned effluent discharge flowrate, increasing the dilution stream flowrate, postponing simultaneous releases, and/or decreasing the effluent concentrations by further processing the liquid planned for release. Alternatively, allocation factors for the active liquid release pathways may be reassigned. When one or more of these actions has been taken, repeat Steps 1–5 to calculate a new radioactivity monitor setpoint.

If $A_p < 1$, the release may not be made as planned. Consider the alternatives discussed in the paragraph above, and calculate a new setpoint based on the results of the actions taken.

2.3.2.3 Use of the Calculated Setpoint

The setpoint calculated above is in the units µCi/mL. The monitor actually measures a count rate, subtracts a predetermined background count rate, and multiplies by a calibration factor to convert from count rate to µCi/mL.

Initial calibration of the monitors by the manufacturer and Georgia Power Company utilized NIST-traceable liquid solutions with gamma ray emissions over the range 0.08 to 1.33 MeV, in the exact geometry of each production monitor. The calibration factor is a function of the radionuclide mix in the liquid to be released, and will be calculated for the monitor based on the results of the pre-release sample results from the laboratory gamma-ray spectrometer system. The mix-dependent calibration factor will be used as the gain factor in the PERMS monitor, or used to modify the calculated base monitor setpoint so that the default calibration factor in the PERMS monitor can be left unchanged.

Notwithstanding the initial calibration, monitor calibration data for conversion between count rate and concentration *may* include operational data obtained from determining the monitor response to stream concentrations measured by liquid sample analysis. In all cases, monitor background must be controlled so that the monitor is capable of responding to concentrations in the range of the setpoint value.

2.3.3 Setpoints for Monitors on Normally Low-Radioactivity Streams

Radioactivity in these streams (listed in Table 2-4 above) is expected to be at very low levels, generally below detection limits. Accordingly, the purpose of these monitors is to alarm upon the occurrence of significant radioactivity in these streams, and to terminate or divert the release where this is possible.

2.3.3.1 Normal Conditions

When radioactivity in one of these streams is at its normal low level, its radioactivity monitor setpoint should be established as close to background as practical to prevent spurious alarms, and yet alarm should an inadvertent release occur.

2.3.3.2 Conditions Requiring an Elevated Setpoint

Under the following conditions, radionuclide concentrations must be determined and an elevated radioactivity monitor setpoint determined for these pathways:

- For streams that can be diverted or isolated, a new monitor setpoint must be established when it is desired to discharge the stream directly to the dilution water even though the radioactivity in the stream exceeds the level which would normally be diverted or isolated.

- For streams that cannot be diverted or isolated, a new monitor setpoint must be established whenever: the radioactivity in the stream becomes detectable above the background levels of the applicable laboratory analyses; or the associated radioactivity monitor detects activity in the stream at levels above the established alarm setpoint.

When an elevated monitor setpoint is required for any of these effluent streams, it should be determined in the same manner as described in Section 2.3.2. However, special consideration must be given to Step 3. An allocation factor must be assigned to the normally low-radioactivity release pathway under consideration, and allocation factors for other release pathways discharging simultaneously must be adjusted downward (if necessary) to ensure that the sum of the allocation factors does not exceed 1. Sampling and analysis of the normally low-radioactivity streams must be sufficient to ensure that the liquid effluent dose limits specified in the controls of Section 2.1.3 are not exceeded.

2.4 LIQUID EFFLUENT DOSE CALCULATIONS

The following sub-sections present the methods required for liquid effluent dose calculations, in deepening levels of detail. Applicable site-specific pathways and parameter values for the calculation of D_τ, $A_{i\tau}$, and CF_{iv} are summarized in Table 2-5.

2.4.1 Calculation of Dose

The dose limits for a MEMBER OF THE PUBLIC specified in Section 2.1.3 are on a per-unit basis. Therefore, the doses calculated in accordance with this section must be determined and recorded on a per-unit basis, including apportionment of releases shared between the two units.

For the purpose of implementing Section 2.1.3, the dose to the maximum exposed individual due to radionuclides identified in liquid effluents released from each unit to UNRESTRICTED AREAS will be calculated as follows (equation from Reference 1, page 15):

$$D_\tau = \sum_i A_{i\tau} \left[\sum_{l=1}^{m} \left(\Delta t_l C_{il} F_l \right) \right] \qquad \textbf{(2.12)}$$

where:

D_τ = the cumulative dose commitment to the total body or to any organ τ, in mrem, due to radioactivity in liquid effluents released during the total of the m time periods Δt_l.

$A_{i\tau}$ = the site-related adult ingestion dose commitment factor, for the total body or for any organ τ, due to identified radionuclide i, in (mrem·mL)/(h·μCi). Methods for the calculation of $A_{i\tau}$ are presented below in Section 2.4.2. The values of $A_{i\tau}$ to be used in dose calculations for releases from the plant site are listed in Table 2-8.

Δt_l = the length of time period l, over which C_{il} and F_l are averaged for liquid releases, in h.

C_{il} = the average concentration of radionuclide i in undiluted liquid effluent during time period l, in μCi/mL. Only radionuclides identified and detected above background in their respective samples should be included in the calculation.

F_l = the near-field average dilution factor in the receiving water of the UNRESTRICTED AREA:

$$F_l = \frac{f_t}{F_t \times Z} \qquad \textbf{(2.13)}$$

where:

f_t = the average undiluted liquid waste flowrate actually observed during the period of radioactivity release, in gpm.

F_t = the average dilution stream flowrate actually observed during the period of radioactivity release, in gpm. If simultaneous releases from both units occur, the dilution stream flowrate F_t must be allocated between them. In such cases, F_l is unit-specific.

Z = the applicable dilution factor for the receiving water body, in the near field of the discharge structure, during the period of radioactivity release, from Table 2-5.

NOTE: In equation (2.13), the product (F_t x Z) is limited to 1000 cfs (= 448,000 gpm) or less. (Reference 1, Section 4.3.)

2.4.2 <u>Calculation of $A_{i\tau}$</u>

The site-related adult ingestion dose commitment factor, $A_{i\tau}$, is calculated as follows (equation adapted from Reference 1, page 16, by addition of the irrigated garden vegetation pathway):

$$A_{i\tau} = 1.14 \times 10^5 \left(\frac{U_w}{D_w} e^{-\lambda_i t_w} + U_f BF_i \, e^{-\lambda_i t_f} + U_v CF_{iv} \right) DF_{i\tau} \qquad \textbf{(2.14)}$$

where:

1.14×10^5 = a units conversion factor, determined by:

10^6 pCi/μCi x 10^3 mL/L ÷ 8760 h/y.

U_w = the adult drinking water consumption rate applicable to the plant site (L/y).

D_w = the dilution factor from the near field of the discharge structure for the plant site to the potable water intake location.

λ_i = the decay constant for radionuclide i (h^{-1}). Values of λ_i used in effluent calculations should be based on decay data from a recognized and current source, such as Reference 20.

t_w = the transit time from release to receptor for potable water consumption (h).

U_f = the adult rate of fish consumption applicable to the plant site (kg/y).

BF_i = the bioaccumulation factor for radionuclide i applicable to freshwater fish in the receiving water body for the plant site, in (pCi/kg)/(pCi/L) = (L/kg). For specific values applicable to the plant site, see Table 2-6.

t_f = the transit time from release to receptor for fish consumption (h).

U_v = the adult consumption rate for irrigated garden vegetation applicable to the plant site (kg/y).

CF_{iv} = the concentration factor for radionuclide i in irrigated garden vegetation, as applicable to the vicinity of the plant site, in (pCi/kg)/(pCi/L). Methods for calculation of CF_{iv} are presented below in Section 2.4.3.

$DF_{i\tau}$ = the dose conversion factor for radionuclide i for adults, in organ τ (mrem/pCi). For specific values, see Table 2-7.

2.4.3 Calculation of Cf_{iv}

The concentration factor for radionuclide i in irrigated garden vegetation, CF_{iv} in (L/kg), is calculated as follows:

- For radionuclides other than tritium (equation adapted from Reference 3, equations A–8 and A–9):

$$CF_{iv} = M \cdot I \left[\frac{r\left(1 - e^{-\lambda_{Ei} t_e}\right)}{Y_v \lambda_{Ei}} + \frac{f_I B_{iv}\left(1 - e^{-\lambda_i t_b}\right)}{P\lambda_i} \right] e^{-\lambda_i t_h} \qquad \textbf{(2.15)}$$

- For tritium (equation adapted from Reference 3, equations A–9 and A–10):

$$CF_{iv} = M \cdot L_v \qquad \textbf{(2.16)}$$

where:

M = the additional river dilution factor from the near field of the discharge structure for the plant site to the point of irrigation water usage.

I = the average irrigation rate during the growing season (L)/($m^2 \cdot h$).

r = the fraction of irrigation-deposited activity retained on the edible portions of leafy garden vegetation.

Y_v = the areal density (agricultural productivity) of leafy garden vegetation (kg/m^2)

f_I = the fraction of the year that garden vegetation is irrigated.

B_{iv} = the crop to soil concentration factor applicable to radionuclide i (pCi/kg garden vegetation)/(pCi/kg soil).

P = the effective surface density of soil (kg/m^2).

λ_i = the decay constant for radionuclide i (h^{-1}). Values of λ_i used in effluent calculations should be based on decay data from a recognized and current source, such as Reference 20.

λ_w = the rate constant for removal of activity from plant leaves by weathering (h^{-1}).

λ_{Ei} = the effective removal rate for activity deposited on crop leaves (h^{-1}) calculated as: $\lambda_{Ei} = \lambda_i + \lambda_w$.

t_e = the period of leafy garden vegetation exposure during the growing season (h).

t_b = the period of long-term buildup of activity in soil (h).

t_h = the time between harvest of garden vegetation and human consumption (h).

L_v = the water content of leafy garden vegetation edible parts (L/kg).

Table 2-5. Parameters for Calculation of Doses Due to Liquid Effluent Releases

Dose Calculation Receptor Locations:

Fish: Vicinity of plant discharge

Drinking Water: 112 miles downstream, at Beaufort, SC (Reference 12)

Irrigated Garden Vegetation: None (Reference 12)

Numerical Parameters:

Parameter	Value	Reference
Z	10, for May through December 20, for January through April	Ref. 11
U_w	730 L/y	Ref 3
D_w	8	Ref. 7
t_w	48 h	Ref. 3, Sec. A.2; Ref. 8
U_f	21 kg/y	Ref. 3, Table E-5
t_f	24 h	Ref. 3, Sec. A.2
U_v	0 kg/y *	Ref. 12
M	1.0 +	
I	No value **	
r	0.25	Ref. 3, Table E-15.
Y_v	2.0 kg/m^2	Ref. 3, Table E-15
f_l	1.0 +	
P	240 kg/m^2	Ref. 3, Table E-15
λ_w	0.0021 h^{-1} (i.e., half-life of 14 d)	Ref. 3, Table E-15
t_e	1440 h (= 60 d)	Ref. 3, Table E-15
t_b	1.31 x 10^5 h (= 15 y)	Ref. 3, Table E-15
t_h	24 h	Ref. 3, Table E-15
L_v	0.92 L/kg	Based on Ref. 21, Table 5.16 (for lettuce, cabbage, etc.)

* - Because there is no irrigated garden vegetation pathway downstream of the plant site, the consumption of irrigated garden vegetation is set to zero, and the other pathway parameters are defaults.

\+ - There is no established default value for this parameter. The most conservative physically realistic value is 1.0.

Table 2-6. Element Transfer Factors

Element	Freshwater Fish BF_i^*
H	9.0 E-01
C	4.6 E+03
Na	1.0 E+02
P	3.0 E+03
Cr	2.0 E+02
Mn	4.0 E+02
Fe	1.0 E+02
Co	5.0 E+01
Ni	1.0 E+02
Cu	5.0 E+01
Zn	2.0 E+03
Br	4.2 E+02
Rb	2.0 E+03
Sr	3.0 E+01
Y	2.5 E+01
Zr	3.3 E+00
Nb	5.5 E+02
Mo	1.0 E+01
Tc	1.5 E+01
Ru	1.0 E+01
Rh	1.0 E+01
Ag	2.3 E+00
Sb	2.0 E+02
Te	4.0 E+02
I	1.5 E+01
Cs	2.0 E+03
Ba	4.0 E+00
La	2.5 E+01
Ce	1.0 E+00
Pr	2.5 E+01
Nd	2.5 E+01
W	1.2 E+03
Np	1.0 E+01

* - Bioaccumulation Factors for freshwater fish, in (pCi/kg)/(pCi/L). They are obtained from Reference 3 (Table A-1), except as follows: Reference 9 for P; Reference 2 (Table A-8) for Ag; and Reference 10 for Nb and Sb.

Table 2-7. Adult Ingestion Dose Factors

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	1.05E-07	1.05E-07	1.05E-07	1.05E-07	1.05E-07	1.05E-07
C-14	2.84E-06	5.68E-07	5.68E-07	5.68E-07	5.68E-07	5.68E-07	5.68E-07
Na-24	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06
P-32	1.93E-04	1.20E-05	7.46E-06	No Data	No Data	No Data	2.17E-05
Cr-51	No Data	No Data	2.66E-09	1.59E-09	5.86E-10	3.53E-09	6.69E-07
Mn-54	No Data	4.57E-06	8.72E-07	No Data	1.36E-06	No Data	1.40E-05
Mn-56	No Data	1.15E-07	2.04E-08	No Data	1.46E-07	No Data	3.67E-06
Fe-55	2.75E-06	1.90E-06	4.43E-07	No Data	No Data	1.06E-06	1.09E-06
Fe-59	4.34E-06	1.02E-05	3.91E-06	No Data	No Data	2.85E-06	3.40E-05
Co-58	No Data	7.45E-07	1.67E-06	No Data	No Data	No Data	1.51E-05
Co-60	No Data	2.14E-06	4.72E-06	No Data	No Data	No Data	4.02E-05
Ni-63	1.30E-04	9.01E-06	4.36E-06	No Data	No Data	No Data	1.88E-06
Ni-65	5.28E-07	6.86E-08	3.13E-08	No Data	No Data	No Data	1.74E-06
Cu-64	No Data	8.33E-08	3.91E-08	No Data	2.10E-07	No Data	7.10E-06
Zn-65	4.84E-06	1.54E-05	6.96E-06	No Data	1.03E-05	No Data	9.70E-06
Zn-69	1.03E-08	1.97E-08	1.37E-09	No Data	1.28E-08	No Data	2.96E-09
Br-83	No Data	No Data	4.02E-08	No Data	No Data	No Data	5.79E-08
Br-84	No Data	No Data	5.21E-08	No Data	No Data	No Data	4.09E-13
Br-85	No Data	No Data	2.14E-09	No Data	No Data	No Data	No Data
Rb-86	No Data	2.11E-05	9.83E-06	No Data	No Data	No Data	4.16E-06
Rb-88	No Data	6.05E-08	3.21E-08	No Data	No Data	No Data	8.36E-19
Rb-89	No Data	4.01E-08	2.82E-08	No Data	No Data	No Data	2.33E-21
Sr-89	3.08E-04	No Data	8.84E-06	No Data	No Data	No Data	4.94E-05
Sr-90	7.58E-03	No Data	1.86E-03	No Data	No Data	No Data	2.19E-04
Sr-91	5.67E-06	No Data	2.29E-07	No Data	No Data	No Data	2.70E-05

All values are in (mrem/pCi ingested). They are obtained from Reference 3 (Table E-11), except as follows: Reference 2 (Table A–3) for Rh-105, Sb-124, and Sb-125.

Table 2-7 (contd). Adult Ingestion Dose Factors

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Sr-92	2.15E-06	No Data	9.30E-08	No Data	No Data	No Data	4.26E-05
Y-90	9.62E-09	No Data	2.58E-10	No Data	No Data	No Data	1.02E-04
Y-91m	9.09E-11	No Data	3.52E-12	No Data	No Data	No Data	2.67E-10
Y-91	1.41E-07	No Data	3.77E-09	No Data	No Data	No Data	7.76E-05
Y-92	8.45E-10	No Data	2.47E-11	No Data	No Data	No Data	1.48E-05
Y-93	2.68E-09	No Data	7.40E-11	No Data	No Data	No Data	8.50E-05
Zr-95	3.04E-08	9.75E-09	6.60E-09	No Data	1.53E-08	No Data	3.09E-05
Zr-97	1.68E-09	3.39E-10	1.55E-10	No Data	5.12E-10	No Data	1.05E-04
Nb-95	6.22E-09	3.46E-09	1.86E-09	No Data	3.42E-09	No Data	2.10E-05
Mo-99	No Data	4.31E-06	8.20E-07	No Data	9.76E-06	No Data	9.99E-06
Tc-99m	2.47E-10	6.98E-10	8.89E-09	No Data	1.06E-08	3.42E-10	4.13E-07
Tc-101	2.54E-10	3.66E-10	3.59E-09	No Data	6.59E-09	1.87E-10	1.10E-21
Ru-103	1.85E-07	No Data	7.97E-08	No Data	7.06E-07	No Data	2.16E-05
Ru-105	1.54E-08	No Data	6.08E-09	No Data	1.99E-07	No Data	9.42E-06
Ru-106	2.75E-06	No Data	3.48E-07	No Data	5.31E-06	No Data	1.78E-04
Rh-105	1.22E-07	8.86E-08	5.83E-08	No Data	3.76E-07	No Data	1.41E-05
Ag-110m	1.60E-07	1.48E-07	8.79E-08	No Data	2.91E-07	No Data	6.04E-05
Sb-124	2.81E-06	5.30E-08	1.11E-06	6.79E-09	No Data	2.18E-06	7.95E-05
Sb-125	2.23E-06	2.40E-08	4.48E-07	1.98E-09	No Data	2.33E-04	1.97E-05
Te-125m	2.68E-06	9.71E-07	3.59E-07	8.06E-07	1.09E-05	No Data	1.07E-05
Te-127m	6.77E-06	2.42E-06	8.25E-07	1.73E-06	2.75E-05	No Data	2.27E-05
Te-127	1.10E-07	3.95E-08	2.38E-08	8.15E-08	4.48E-07	No Data	8.68E-06
Te-129m	1.15E-05	4.29E-06	1.82E-06	3.95E-06	4.80E-05	No Data	5.79E-05
Te-129	3.14E-08	1.18E-08	7.65E-09	2.41E-08	1.32E-07	No Data	2.37E-08
Te-131m	1.73E-06	8.46E-07	7.05E-07	1.34E-06	8.57E-06	No Data	8.40E-05
Te-131	1.97E-08	8.23E-09	6.22E-09	1.62E-08	8.63E-08	No Data	2.79E-09

Table 2-7 (contd). Adult Ingestion Dose Factors

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Te-132	2.52E-06	1.63E-06	1.53E-06	1.80E-06	1.57E-05	No Data	7.71E-05
I-130	7.56E-07	2.23E-06	8.80E-07	1.89E-04	3.48E-06	No Data	1.92E-06
I-131	4.16E-06	5.95E-06	3.41E-06	1.95E-03	1.02E-05	No Data	1.57E-06
I-132	2.03E-07	5.43E-07	1.90E-07	1.90E-05	8.65E-07	No Data	1.02E-07
I-133	1.42E-06	2.47E-06	7.53E-07	3.63E-04	4.31E-06	No Data	2.22E-06
I-134	1.06E-07	2.88E-07	1.03E-07	4.99E-06	4.58E-07	No Data	2.51E-10
I-135	4.43E-07	1.16E-06	4.28E-07	7.65E-05	1.86E-06	No Data	1.31E-06
Cs-134	6.22E-05	1.48E-04	1.21E-04	No Data	4.79E-05	1.59E-05	2.59E-06
Cs-136	6.51E-06	2.57E-05	1.85E-05	No Data	1.43E-05	1.96E-06	2.92E-06
Cs-137	7.97E-05	1.09E-04	7.14E-05	No Data	3.70E-05	1.23E-05	2.11E-06
Cs-138	5.52E-08	1.09E-07	5.40E-08	No Data	8.01E-08	7.91E-09	4.65E-13
Ba-139	9.70E-08	6.91E-11	2.84E-09	No Data	6.46E-11	3.92E-11	1.72E-07
Ba-140	2.03E-05	2.55E-08	1.33E-06	No Data	8.67E-09	1.46E-08	4.18E-05
Ba-141	4.71E-08	3.56E-11	1.59E-09	No Data	3.31E-11	2.02E-11	2.22E-17
Ba-142	2.13E-08	2.19E-11	1.34E-09	No Data	1.85E-11	1.24E-11	3.00E-26
La-140	2.50E-09	1.26E-09	3.33E-10	No Data	No Data	No Data	9.25E-05
La-142	1.28E-10	5.82E-11	1.45E-11	No Data	No Data	No Data	4.25E-07
Ce-141	9.36E-09	6.33E-09	7.18E-10	No Data	2.94E-09	No Data	2.42E-05
Ce-143	1.65E-09	1.22E-06	1.35E-10	No Data	5.37E-10	No Data	4.56E-05
Ce-144	4.88E-07	2.04E-07	2.62E-08	No Data	1.21E-07	No Data	1.65E-04
Pr-143	9.20E-09	3.69E-09	4.56E-10	No Data	2.13E-09	No Data	4.03E-05
Pr-144	3.01E-11	1.25E-11	1.53E-12	No Data	7.05E-12	No Data	4.33E-18
Nd-147	6.29E-09	7.27E-09	4.35E-10	No Data	4.25E-09	No Data	3.49E-05
W-187	1.03E-07	8.61E-08	3.01E-08	No Data	No Data	No Data	2.82E-05
Np-239	1.19E-09	1.17E-10	6.45E-11	No Data	3.65E-10	No Data	2.40E-05

Table 2-8. Site-Related Ingestion Dose Factors, $A_{i\tau}$

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00	1.32E+00	1.32E+00	1.32E+00	1.32E+00	1.32E+00	1.32E+00
C-14	3.13E+04	6.26E+03	6.26E+03	6.26E+03	6.26E+03	6.26E+03	6.26E+03
Na-24	1.36E+02	1.36E+02	1.36E+02	1.36E+02	1.36E+02	1.36E+02	1.36E+02
P-32	1.32E+06	8.22E+04	5.11E+04	0.00	0.00	0.00	1.49E+05
Cr-51	0.00	0.00	1.27E+00	7.58E-01	2.79E-01	1.68E+00	3.19E+02
Mn-54	0.00	4.41E+03	8.42E+02	0.00	1.31E+03	0.00	1.35E+04
Mn-56	0.00	1.74E-01	3.08E-02	0.00	2.21E-01	0.00	5.55E+00
Fe-55	6.86E+02	4.74E+02	1.11E+02	0.00	0.00	2.65E+02	2.72E+02
Fe-59	1.07E+03	2.51E+03	9.61E+02	0.00	0.00	7.01E+02	8.36E+03
Co-58	0.00	9.59E+01	2.15E+02	0.00	0.00	0.00	1.94E+03
Co-60	0.00	2.78E+02	6.14E+02	0.00	0.00	0.00	5.23E+03
Ni-63	3.25E+04	2.25E+03	1.09E+03	0.00	0.00	0.00	4.70E+02
Ni-65	1.72E-01	2.23E-02	1.02E-02	0.00	0.00	0.00	5.66E-01
Cu-64	0.00	2.75E+00	1.29E+00	0.00	6.94E+00	0.00	2.35E+02
Zn-65	2.32E+04	7.37E+04	3.33E+04	0.00	4.93E+04	0.00	4.64E+04
Zn-69	7.88E-07	1.51E-06	1.05E-07	0.00	9.79E-07	0.00	2.26E-07
Br-83	0.00	0.00	3.83E-02	0.00	0.00	0.00	5.52E-02
Br-84	0.00	0.00	1.22E-12	0.00	0.00	0.00	9.61E-18
Br-85	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rb-86	0.00	9.75E+04	4.54E+04	0.00	0.00	0.00	1.92E+04
Rb-88	0.00	1.29E-22	6.82E-23	0.00	0.00	0.00	1.78E-33
Rb-89	0.00	1.61E-26	1.14E-26	0.00	0.00	0.00	0.00
Sr-89	2.49E+04	0.00	7.16E+02	0.00	0.00	0.00	4.00E+03
Sr-90	6.23E+05	0.00	1.53E+05	0.00	0.00	0.00	1.80E+04
Sr-91	7.25E+01	0.00	2.93E+00	0.00	0.00	0.00	3.45E+02
Sr-92	3.33E-01	0.00	1.44E-02	0.00	0.00	0.00	6.60E+00
Y-90	5.04E-01	0.00	1.35E-02	0.00	0.00	0.00	5.34E+03
Y-91m	1.04E-11	0.00	4.01E-13	0.00	0.00	0.00	3.04E-11
Y-91	9.77E+00	0.00	2.61E-01	0.00	0.00	0.00	5.38E+03
Y-92	4.61E-04	0.00	1.35E-05	0.00	0.00	0.00	8.07E+00
Y-93	3.19E-02	0.00	8.82E-04	0.00	0.00	0.00	1.01E+03
Zr-95	5.47E-01	1.75E-01	1.19E-01	0.00	2.75E-01	0.00	5.56E+02
Zr-97	7.40E-03	1.49E-03	6.83E-04	0.00	2.26E-03	0.00	4.62E+02
Nb-95	8.09E+00	4.50E+00	2.42E+00	0.00	4.45E+00	0.00	2.73E+04
Mo-99	0.00	1.07E+02	2.04E+01	0.00	2.43E+02	0.00	2.49E+02
Tc-99m	5.70E-04	1.61E-03	2.05E-02	0.00	2.44E-02	7.89E-04	9.53E-01

All values are in (mrem·mL)/(h·μCi). They are calculated using equation (2.14), and data from Table 2-5, Table 2-6, and Table 2-7. When "No Data" is shown for a radionuclide-organ combination in Table 2-7, $A_{i\tau}$ factors in this table are presented as zero.

Table 2-8 (contd). Site-Related Ingestion Dose Factors, $A_{i\tau}$

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Tc-101	2.71E-33	3.91E-33	3.83E-32	0.00	7.03E-32	2.00E-33	0.00
Ru-103	6.21E+00	0.00	2.68E+00	0.00	2.37E+01	0.00	7.25E+02
Ru-105	8.79E-03	0.00	3.47E-03	0.00	1.14E-01	0.00	5.38E+00
Ru-106	9.42E+01	0.00	1.19E+01	0.00	1.82E+02	0.00	6.10E+03
Rh-105	2.32E+00	1.69E+00	1.11E+00	0.00	7.15E+00	0.00	2.68E+02
Ag-110m	2.53E+00	2.34E+00	1.39E+00	0.00	4.61E+00	0.00	9.56E+02
Sb-124	1.36E+03	2.56E+01	5.37E+02	3.28E+00	0.00	1.05E+03	3.84E+04
Sb-125	1.09E+03	1.17E+01	2.19E+02	9.68E-01	0.00	1.14E+05	9.63E+03
Te-125m	2.56E+03	9.29E+02	3.43E+02	7.71E+02	1.04E+04	0.00	1.02E+04
Te-127m	6.51E+03	2.33E+03	7.93E+02	1.66E+03	2.64E+04	0.00	2.18E+04
Te-127	1.78E+01	6.40E+00	3.85E+00	1.32E+01	7.25E+01	0.00	1.41E+03
Te-129m	1.09E+04	4.07E+03	1.73E+03	3.74E+03	4.55E+04	0.00	5.49E+04
Te-129	1.78E-05	6.68E-06	4.33E-06	1.36E-05	7.47E-05	0.00	1.34E-05
Te-131m	9.57E+02	4.68E+02	3.90E+02	7.42E+02	4.74E+03	0.00	4.65E+04
Te-131	8.64E-17	3.61E-17	2.73E-17	7.10E-17	3.78E-16	0.00	1.22E-17
Te-132	1.97E+03	1.27E+03	1.19E+03	1.41E+03	1.23E+04	0.00	6.02E+04
I-130	7.60E+00	2.24E+01	8.85E+00	1.90E+03	3.50E+01	0.00	1.93E+01
I-131	1.73E+02	2.48E+02	1.42E+02	8.13E+04	4.25E+02	0.00	6.55E+01
I-132	5.27E-03	1.41E-02	4.93E-03	4.93E-01	2.24E-02	0.00	2.65E-03
I-133	2.59E+01	4.51E+01	1.37E+01	6.62E+03	7.86E+01	0.00	4.05E+01
I-134	2.18E-08	5.94E-08	2.12E-08	1.03E-06	9.44E-08	0.00	5.17E-11
I-135	1.31E+00	3.44E+00	1.27E+00	2.27E+02	5.52E+00	0.00	3.89E+00
Cs-134	2.98E+05	7.10E+05	5.80E+05	0.00	2.30E+05	7.62E+04	1.24E+04
Cs-136	2.96E+04	1.17E+05	8.42E+04	0.00	6.51E+04	8.92E+03	1.33E+04
Cs-137	3.82E+05	5.23E+05	3.43E+05	0.00	1.78E+05	5.90E+04	1.01E+04
Cs-138	9.12E-12	1.80E-11	8.92E-12	0.00	1.32E-11	1.31E-12	7.68E-17
Ba-139	5.64E-06	4.02E-09	1.65E-07	0.00	3.76E-09	2.28E-09	1.00E-05
Ba-140	3.74E+02	4.69E-01	2.45E+01	0.00	1.60E-01	2.69E-01	7.69E+02
Ba-141	8.47E-25	6.40E-28	2.86E-26	0.00	5.95E-28	3.63E-28	3.99E-34
Ba-142	0.00	0.00	0.00	0.00	0.00	0.00	0.00
La-140	1.10E-01	5.56E-02	1.47E-02	0.00	0.00	0.00	4.08E+03
La-142	2.19E-07	9.96E-08	2.48E-08	0.00	0.00	0.00	7.27E-04
Ce-141	1.15E-01	7.79E-02	8.84E-03	0.00	3.62E-02	0.00	2.98E+02
Ce-143	8.65E-03	6.39E+00	7.08E-04	0.00	2.81E-03	0.00	2.39E+02
Ce-144	6.22E+00	2.60E+00	3.34E-01	0.00	1.54E+00	0.00	2.10E+03
Pr-143	6.10E-01	2.44E-01	3.02E-02	0.00	1.41E-01	0.00	2.67E+03
Pr-144	1.48E-28	6.14E-29	7.51E-30	0.00	3.46E-29	0.00	2.13E-35
Nd-147	4.11E-01	4.75E-01	2.84E-02	0.00	2.78E-01	0.00	2.28E+03
W-187	1.47E+02	1.23E+02	4.31E+01	0.00	0.00	0.00	4.04E+04
Np-239	2.81E-02	2.76E-03	1.52E-03	0.00	8.62E-03	0.00	5.67E+02

2.5 LIQUID EFFLUENT DOSE PROJECTIONS

2.5.1 Thirty-One Day Dose Projections

In order to meet the requirements for operation of the LIQUID RADWASTE TREATMENT SYSTEM (see Section 2.1.4), dose projections must be made at least once each 31 days; this applies during periods in which a discharge to UNRESTRICTED AREAS of liquid effluents containing radioactive materials occurs or is expected.

Projected 31-day doses to individuals due to liquid effluents may be determined as follows:

$$D_{\tau p} = \left(\frac{D_{\tau c}}{t} \right) \times 31 + D_{\tau a} \qquad \textbf{(2.17)}$$

where:

$D_{\tau p}$ = the projected dose to the total body or organ τ, for the next 31 days of liquid releases.

$D_{\tau c}$ = the cumulative dose to the total body or organ τ, for liquid releases that have occurred in the elapsed portion of the current quarter, plus the release under consideration.

t = the number of whole or partial days elapsed into the current quarter, including the time to the end of the release under consideration (even if the release continues into the next quarter).

$D_{\tau a}$ = the anticipated dose contribution to the total body or any organ τ, due to any planned activities during the next 31-day period, if those activities will result in liquid releases that are in addition to routine liquid effluents. If only routine liquid effluents are anticipated, $D_{\tau a}$ may be set to zero.

2.5.2 Dose Projections for Specific Releases

Dose projections may be performed for a particular release by performing a prerelease dose calculation assuming that the planned release will proceed as anticipated. For individual dose projections due to liquid releases, follow the methodology of Section 2.4, using sample analysis results for the source to be released, and parameter values expected to exist during the release period.

2.6 DEFINITIONS OF LIQUID EFFLUENT TERMS

The following symbolic terms are used in the presentation of liquid effluent calculations in the subsections above.

Term	Definition	Section of Initial Use
A_p =	the adjustment factor used in calculating the effluent monitor setpoint for liquid release pathway p: the ratio of the assured dilution to the required dilution [unitless].	2.3.2.2
ADF =	the assured dilution factor for a planned release [unitless].	2.3.2.2
AF_p =	the dilution allocation factor for liquid release pathway p [unitless].	2.3.2.2
$A_{i\tau}$ =	the site-related adult ingestion dose commitment factor, for the total body or for any organ τ, due to identified radionuclide i [(mrem · mL)/(h · μCi)]. The values of $A_{i\tau}$ are listed in Table 2-8.	2.4.1
B_{iv} =	the crop to soil concentration factor applicable to radionuclide i, [(pCi/kg garden vegetation)/(pCi/kg soil)].	2.4.3
BF_i =	the bioaccumulation factor for radionuclide i for freshwater fish [(pCi/kg)/(pCi/L)]. Values are listed in Table 2-6.	2.4.2
c =	the setpoint of the radioactivity monitor measuring the concentration of radioactivity in the effluent line, prior to dilution and subsequent release [μCi/mL].	2.3.2.1
c_p =	the calculated effluent radioactivity monitor setpoint for liquid release pathway p [μCi/mL].	2.3.2.2
C_a =	the gross concentration of alpha emitters in the liquid waste as measured in the applicable composite sample [μCi/mL].	2.3.2.2
C_{ECL} =	the Effluent Concentration Limit stated in 10 CFR 20, Appendix B, Table 2, Column 2 [μCi/mL].	2.3.2.1
C_f =	the concentration of Fe–55 in the liquid waste as measured in the applicable composite sample [μCi/mL].	2.3.2.2

Term	Definition	Section of Initial Use
C_g =	the concentration of gamma emitter g in the liquid waste as measured by gamma ray spectroscopy performed on the applicable prerelease waste sample [μCi/mL].	2.3.2.2
C_i =	the measured concentration of radionuclide i in a sample of liquid effluent [μCi/mL].	2.3.2.2
C_{il} =	the average concentration of radionuclide i in undiluted liquid effluent during time period l [μCi/mL].	2.4.1
C_{ir} =	the measured concentration of radionuclide i in release pathway r that is contributing to radioactivity in the dilution stream [μCi/mL].	2.3.2.2
C_s =	the concentration of strontium radioisotope s (Sr–89 or Sr-90) in the liquid waste as measured in the applicable composite sample [μCi/mL].	2.3.2.2
C_t =	the concentration of H–3 in the liquid waste as measured in the applicable composite sample [μCi/mL].	2.3.2.2
CF_{iv} =	the concentration factor for radionuclide i in irrigated garden vegetation [(pCi/kg)/(pCi/L)].	2.4.2
D_w =	the dilution factor from the near field of the discharge structure to the potable water intake location [unitless].	2.4.2
D_τ =	the cumulative dose commitment to the total body or to any organ τ, due to radioactivity in liquid effluents released during a given time period [mrem].	2.4.1
$D_{\tau a}$ =	the anticipated dose contribution to the total body or any organ τ, due to any planned activities during the next 31-day period [mrem].	2.5.1
$D_{\tau c}$ =	the cumulative dose to the total body or organ τ, for liquid releases that have occurred in the elapsed portion of the current quarter, plus the release under consideration [mrem].	2.5.1
$D_{\tau p}$ =	the projected dose to the total body or organ τ, for the next 31 days of liquid releases [mrem].	2.5.1

Term	Definition	Section of Initial Use
$DF_{i\tau}$ =	the dose conversion factor for radionuclide i for adults, in organ τ [mrem/pCi]. Values are listed in Table 2-7.	2.4.2
ECL_i =	the liquid Effluent Concentration Limit for radionuclide i from 10 CFR Part 20, Appendix B, Table 2, Column 2 [μCi/mL].	2.3.2.2
f =	the effluent flowrate at the location of the radioactivity monitor [gpm].	2.3.2.1
f_{ap} =	the anticipated actual discharge flowrate for a planned release from liquid release pathway p [gpm].	2.3.2.2
f_l =	the fraction of the year that garden vegetation is irrigated [unitless].	2.4.3
f_{mp} =	the maximum permissible effluent discharge flowrate for release pathway p [gpm].	2.3.2.2
f_r =	the effluent discharge flowrate of release pathway r [gpm].	2.3.2.2
f_t =	the average undiluted liquid waste flowrate actually observed during the period of a liquid release [gpm].	2.4.1
F =	the dilution stream flowrate which can be assured prior to the release point to the UNRESTRICTED AREA [gpm].	2.3.2.1
F_d =	the entire assured dilution flowrate for the plant site during the release period [gpm].	2.3.2.2
F_{dp} =	the dilution flowrate allocated to release pathway p [gpm].	2.3.2.2
F_l =	the near-field average dilution factor in the receiving water of the UNRESTRICTED AREA [unitless].	2.4.1
F_t =	the average dilution stream flowrate actually observed during the period of a liquid release [gpm].	2.4.1
I =	the average irrigation rate during the growing season [$L/(m^2 \cdot h)$].	2.4.3
L_v =	the water content of leafy garden vegetation edible parts [L/kg].	2.4.3

Term	Definition	Section of Initial Use
M =	the additional river dilution factor from the near field of the discharge structure for the plant site to the point of irrigation water usage [unitless].	2.4.3
P =	the effective surface density of soil [kg/m^2].	2.4.3
r =	the fraction of irrigation-deposited activity retained on the edible portions of leafy garden vegetation.	2.4.3
RDF =	the required dilution factor: the minimum ratio by which liquid effluent must be diluted before reaching the UNRESTRICTED AREA, in order to ensure that the limits of Section 2.1.2 are not exceeded [unitless].	2.3.2.2
RDF_γ =	the RDF for a liquid release due only to its concentration of gamma-emitting radionuclides [unitless].	2.3.2.2
$RDF_{n\gamma}$ =	the RDF for a liquid release due only to its concentration of non-gamma-emitting radionuclides [unitless].	2.3.2.2
SF =	the safety factor selected to compensate for statistical fluctuations and errors of measurement [unitless].	2.3.2.2
t =	the number of whole or partial days elapsed into the current quarter, including the time to the end of the release under consideration.	2.5.1
t_b =	the period of long-term buildup of activity in soil [h].	2.4.3
t_e =	the period of leafy garden vegetation exposure during the growing season [h].	2.4.3
t_f =	the transit time from release to receptor for fish consumption [h].	2.4.2
t_h =	the time between harvest of garden vegetation and human consumption [h].	2.4.3
t_w =	the transit time from release to receptor for potable water consumption [h].	2.4.2

Term	Definition	Section of Initial Use
TF =	the tolerance factor selected to allow flexibility in the establishment of a practical monitor setpoint which could accommodate effluent releases at concentrations higher than the ECL values stated in 10 CFR 20, Appendix B, Table 2, Column 2 [unitless]; the tolerance factor must not exceed a value of 10.	2.3.2.1
U_f =	the adult rate of fish consumption [kg/y].	2.4.2
U_v =	the adult consumption rate for irrigated garden vegetation [kg/y].	2.4.2
U_w =	the adult drinking water consumption rate applicable to the plant site [L/y].	2.4.2
Y_v =	the areal density (agricultural productivity) of leafy garden vegetation [kg/m^2].	2.4.3
Z =	the applicable dilution factor for the receiving water body, in the near field of the discharge structure, during the period of radioactivity release [unitless].	2.4.1
Δt_1 =	the length of time period 1, over which C_{i1} and F_1 are averaged for liquid releases [h].	2.4.1
λ_{Ei} =	the effective removal rate for activity deposited on crop leaves [h^{-1}].	2.4.3
λ_i =	the decay constant for radionuclide i [h^{-1}].	2.4.2
λ_w =	the rate constant for removal of activity from plant leaves by weathering [h^{-1}].	2.4.3

CHAPTER 3
GASEOUS EFFLUENTS

3.1 LIMITS OF OPERATION

The following Limits of Operation implement requirements established by Technical Specifications Section 5.0. Terms printed in all capital letters are defined in Chapter 10.

3.1.1 Gaseous Effluent Monitoring Instrumentation Control

In accordance with Technical Specification 5.5.4.a, the radioactive gaseous effluent monitoring instrumentation channels shown in Table 3-1 shall be FUNCTIONAL with their alarm/trip setpoints set to ensure that the limits of Section 3.1.2.a are not exceeded. The alarm/trip setpoints of these channels shall be determined in accordance with Section 3.3.

3.1.1.1 Applicability

These limits apply as shown in Table 3-1.

3.1.1.2 Actions

With a radioactive gaseous effluent monitoring instrumentation channel alarm/trip setpoint less conservative than required by the above control, immediately suspend the release of radioactive gaseous effluents monitored by the affected channel, declare the channel NON-FUNCTIONAL, or restore the setpoint to a value that will ensure that the limits of Section 3.1.2.a are met.

With less than the minimum number of radioactive gaseous effluent monitoring instrumentation channels FUNCTIONAL, take the ACTION shown in Table 3-1. Restore the NON-FUNCTIONAL instrumentation to FUNCTIONAL status within 30 days, or if unsuccessful, explain in the next Radioactive Effluent Release Report, per Technical Specification 5.6.3, why this NON-FUNCTIONALITY was not corrected in a timely manner.

This control does not affect shutdown requirements or MODE changes.

3.1.1.3 Surveillance Requirements

Each radioactive gaseous effluent monitoring instrumentation channel shall be demonstrated FUNCTIONAL by performance of the CHANNEL CHECK, SOURCE CHECK, CHANNEL CALIBRATION and CHANNEL FUNCTIONAL TEST operations at the frequencies shown in Table 3-2.

3.1.1.4 Basis

The radioactive gaseous effluent instrumentation is provided to monitor and control, as applicable, the releases of radioactive materials in gaseous effluents during actual or potential releases of gaseous effluents. The Alarm/Trip Setpoints for these instruments shall be calculated and adjusted in accordance with the methodology and parameters in Section 3.3 to ensure that the alarm/trip will occur prior to exceeding the limits of Section 3.1.2.a. The FUNCTIONALITY and use of this instrumentation is consistent with the requirements of General Design Criteria 60, 63, and 64 of Appendix A to 10 CFR Part 50.

Table 3-1. Radioactive Gaseous Effluent Monitoring Instrumentation

Instrument	FUNCTIONALITY Requirements		
	Minimum Channels FUNCTIONAL	Applicability	ACTION
1. GASEOUS RADWASTE TREATMENT SYSTEM (Common)			
a. Noble Gas Activity Monitor, with Alarm and Automatic Termination of Release (ARE-0014)	1	During releases[a]	45
b. Effluent System Flowrate Measuring Device (AFT-0014)	1	During releases[a]	46
2. Turbine Building Vent (Each Unit)			
a. Noble Gas Activity Monitor (RE-12839C)	1	During releases[a]	47
b. Iodine and Particulate Samplers (RE-12839A & B)	1	During releases[a]	51
c. Flowrate Monitor (FT-12839 or FIS-12862)[b]	1	During releases[a]	46
d. Sampler Flowrate Monitor (1FIT-13211, 2FIT-13211)	1	During releases[a]	46
3. Plant Vent (Each Unit)			
a. Noble Gas Activity Monitor (RE-12442C or RE-12444C)	1	At all times	47,48
b. Iodine Sampler/Monitor (RE-12442B or RE-12444B)	1	At all times	51
c. Particulate Sampler/Monitor (RE-12442A or RE-12444A)	1	At all times	51
d. Flowrate Monitor (FT-12442 or 12835)	1	At all times	46
e. Sampler Flowrate Monitor (FI-12442 or FI-12444N)	1	At all times	46
4. Radwaste Processing Facility Vent (Common)			
a. Particulate Monitor (ARE-16980)	1	During releases[a]	51

a. "During releases" means "During radioactive releases via this pathway."

b. During emergency filtration.

Table 3-1 (contd). Notation for Table 3-1 — ACTION Statements

ACTION 45 — With the number of channels FUNCTIONAL less than required by the Minimum Channels FUNCTIONAL requirement, the contents of the tank(s) may be released to the environment for up to 14 days provided that prior to initiating the release:

a. The local radiation monitor reading (if functional) is recorded at least once per 12 hours or at least two independent samples of the tank's contents are analyzed, and

b. At least two technically qualified members of the Facility Staff independently verify the discharge line valving, and verify the release rate calculations.

Otherwise, suspend release of radioactive effluents via this pathway.

ACTION 46 — With the number of channels FUNCTIONAL less than required by the Minimum Channels FUNCTIONAL requirement, effluent releases via this pathway may continue provided the flowrate is estimated at least once per 4 hours.

ACTION 47 — With the number of channels FUNCTIONAL less than required by the Minimum Channels FUNCTIONAL requirement, effluent releases via this pathway may continue provided the local radiation monitor reading (if functional) is recorded at least once per 12 hours or grab samples are taken at least once per 12 hours and these samples are analyzed for radioactivity within 24 hours. With the plant vent radiation monitor iodine and particulate channels NON-FUNCTIONAL during the loss of sample line heat tracing, the noble gas channel of RE-12442 and RE-12444 would still be considered valid.

ACTION 48 — With the number of channels FUNCTIONAL less than required by the Minimum Channels FUNCTIONAL requirement, record the local radiation monitor reading (if functional) for RE-2565C at least once per 12 hours or immediately suspend containment purging of radioactive effluents via this pathway.

ACTION 49 — (Not Used)

ACTION 50 — (Not Used)

ACTION 51 — With the number of channels FUNCTIONAL less than required by the Minimum Channels FUNCTIONAL requirement, effluent releases via the affected pathway may continue provided one of the following options is available (1) the local radiation monitor reading (if functional) is recorded at least once per 12 hours (2) samples are continuously collected with the installed skid or (3) samples are continuously collected with auxiliary sampling equipment. RE-12444A and B may be verified functional by recording local radiation monitor skid flow once per 12 hours. With the plant vent radiation monitor particulate and iodine channels NON-FUNCTIONAL during the loss of sample line heat tracing, estimate radioactive releases for up to 48 hours while continuing to monitor noble gas activity from RE-12442 and RE-12444.

Table 3-2. Radioactive Gaseous Effluent Monitoring Instrumentation Surveillance Requirements

Instrument	Surveillance Requirements				
	CHANNEL CHECK	SOURCE CHECK	CHANNEL CALIBRATION	CHANNEL FUNCTIONAL TEST	MODES[c]
1. GASEOUS RADWASTE TREATMENT SYSTEM (Common)					
a. Noble Gas Activity Monitor, with Alarm and Automatic Termination of Release (ARE-0014)	P	P	R[b]	R[a(1)]	During Release
b. Effluent System Flowrate Measuring Device (AFT-0014)	P	NA	R	NA	During Release
2. Turbine Building Vent (Each Unit)					
a. Noble Gas Activity Monitor (RE-12839C)	M	SA	R[b]	R[a(2)]	During Release
b. Iodine and Particulate Samplers (RE-12839A&B)	M[d]	NA	NA	NA	During Release
c. Flowrate Monitor (FT-12839 or FIS-12862)	M	NA	R	NA	During Release
d. Sampler Flowrate Monitor (1FIT-13211, 2FIT-13211)	M	NA	R	Q	During Release
3. Plant Vent (Each Unit)					
a. Noble Gas Activity Monitor (RE-12442C or RE-12444C)	M	SA	R[b]	R[a(2)]	All
b. Particulate and Iodine Monitors (RE-12442A&B)	M[d]	NA	R	R[a(2)]	All
c. Particulate and Iodine Samplers (RE–12444A&B)	M[d]	NA	NA	NA	All
d. Flowrate Monitor (FT-12442 or 12835)	M	NA	R	NA	All
e. Sampler Flowrate Monitor (FI-12442 or FI–12444N)	M	NA	R	Q	All
4. Radwaste Processing Facility Vent (Common)					
a. Particulate Monitor (ARE-16980)	M[d]	SA	R[e]	N/A	During Release

Table 3-2 (contd). Notation for Table 3-2

a. In addition to the basic functions of a CHANNEL FUNCTIONAL TEST (Section 10.2):

   (1) The CHANNEL FUNCTIONAL TEST shall also demonstrate that automatic isolation of this pathway and control room annunciation occurs (for item a. below only); and control room CRT indication occurs (if any of the following conditions exist):

      (a) Instrument indicates measured levels above the alarm/trip setpoint;

      (b) Instrument indicates an “Equipment Trouble” alarm;

      (c) Instrument indicates a “Low” alarm; or

      (d) Instrument indicates channel “Deactivated.”

   (2) The CHANNEL FUNCTIONAL TEST shall also demonstrate that control room annunciation occurs (for item a. below only); and that control room CRT indication occurs (if any of the following conditions exist):

      (a) Instrument indicates measured levels above the alarm/trip setpoint;

      (b) Instrument indicates an “Equipment Trouble” alarm;

      (c) Instrument indicates a “Low” alarm; or

      (d) Instrument indicates channel “Deactivated.” ("Loss of counts" for ARE-16980 only)

b. The initial CHANNEL CALIBRATION shall be performed using one or more of the reference standards certified by the National Institute of Standards and Technology, or using standards that have been obtained from suppliers that participate in measurement assurance activities with NIST. These standards shall permit calibrating the system over its intended range of energy and measurement range. For any subsequent CHANNEL CALIBRATION, sources that have been related to the initial calibration shall be used.

c. MODES in which surveillance is required. “All” means “At all times.” “During release” means “During radioactive release via this pathway.”

d. The channel check shall consist of visually verifying that the collection device (i.e., particulate filter or charcoal cartridge, etc.) is in place for sampling.

e. The CHANNEL CALIBRATION verifies proper operation of the CHANNEL FUNCTIONAL TEST requirements described in Notation a(2) above.

3.1.2 Gaseous Effluent Dose Rate Control

In accordance with Technical Specifications 5.5.4.c and 5.5.4.g, the licensee shall conduct operations so that the dose rates due to radioactive materials released in gaseous effluents from the site to areas at and beyond the SITE BOUNDARY are limited as follows:

a. For noble gases: Less than or equal to a dose rate of 500 mrem/y to the total body and less than or equal to a dose rate of 3000 mrem/y to the skin, and

b. For Iodine-131, Iodine-133, tritium, and for all radionuclides in particulate form with half-lives greater than 8 days: Less than or equal to a dose rate of 1500 mrem/y to any organ.

3.1.2.1 Applicability

This limit applies at all times.

3.1.2.2 Actions

With a dose rate due to radioactive material released in gaseous effluents exceeding the limit stated in Section 3.1.2, immediately decrease the release rate to within the stated limit.

These limits do not affect shutdown requirements or MODE changes.

3.1.2.3 Surveillance Requirements

The dose rates due to radioactive materials in areas at or beyond the SITE BOUNDARY due to releases of gaseous effluents shall be determined to be within the above limits, in accordance with the methods and procedures in Section 3.4.1, by obtaining representative samples and performing analyses in accordance with the sampling and analysis program specified in Table 3-3.

3.1.2.4 Basis

This control is provided to ensure that gaseous effluent dose rates will be maintained within the limits that historically have provided reasonable assurance that radioactive material discharged in gaseous effluents will not result in a dose to a MEMBER OF THE PUBLIC in an UNRESTRICTED AREA, either within or outside the SITE BOUNDARY, exceeding the limits specified in Appendix I of 10 CFR Part 50, while allowing operational flexibility for effluent releases. For MEMBERS OF THE PUBLIC who may at times be within the SITE BOUNDARY, the occupancy of the MEMBER OF THE PUBLIC will be sufficiently low to compensate for any increase in the atmospheric diffusion factor above that for the SITE BOUNDARY.

The dose rate limit for Iodine-131, Iodine-133, tritium, and radionuclides in particulate form with half-lives greater than 8 days specifically applies to dose rates to a child via the inhalation pathway.

This control applies to the release of gaseous effluents from all reactors at the site.

Table 3-3. Radioactive Gaseous Waste Sampling and Analysis Program

Gaseous Release Type	Sampling and Analysis Requirements[a]			
	Sampling FREQUENCY	Minimum Analysis FREQUENCY	Type of Activity Analysis	MINIMUM DETECTABLE CONCENTRATION (MDC) (μCi/mL)
Waste Gas Decay Tank (Common)	P Each Tank Grab Sample	P Each Tank	Noble Gas PRINCIPAL GAMMA EMITTERS	1 E-4
Containment Purge 24" or 14" (Each Unit)	P[c] Each Purge Grab Sample	P[c] Each Purge	Noble Gas PRINCIPAL GAMMA EMITTERS	1 E-4
		M	H-3 (Oxide)	1 E-6
Plant Vent (Each Unit)	M[c,d,f] Grab Sample	M[c]	Noble Gas PRINCIPAL GAMMA EMITTERS	1 E-4
			H-3 (Oxide)	1 E-6
Condenser Air Ejector & Steam Packing Exhaust (Each Unit)[b]	M Grab Sample	M	Noble Gas PRINCIPAL GAMMA EMITTERS	1 E-4
			H-3 (Oxide)	1 E-6
Plant Vent, Condenser Air Ejector & Steam Packing Exhaust (Each Unit)[b]	CONTINUOUS[g]	W[e] Charcoal or Silver Zeolite Sample	I-131	1 E-12
	CONTINUOUS[g]	W[e] Particulate Sample	Particulate PRINCIPAL GAMMA EMITTERS	1 E-11
	CONTINUOUS[g]	M COMPOSITE Particulate Sample	Gross Alpha	1 E-11
	CONTINUOUS[g]	Q COMPOSITE Particulate Sample	Sr-89, Sr-90	1 E-11
Radwaste Processing Facility Vent (Common)	CONTINUOUS[g]	W[h] Particulate Sample	Particulate PRINCIPAL GAMMA EMITTERS	1 E-11

Table 3-3 (contd). Notation for Table 3-3

a. Terms printed in all capital letters are defined in Chapter 10.

b. The turbine building vent is the release point for the condenser air ejector and steam packing exhaust. All sampling and analyses may be omitted for this vent, provided the absence of a primary to secondary leak has been demonstrated, that is, if the gamma activity in the secondary water does not exceed background by more than 20%.

c. Sampling and analysis shall also be performed following shutdown, startup, or a THERMAL POWER change exceeding 15% of the RATED THERMAL POWER within a one-hour period. This requirement does not apply if (1) analysis shows that the DOSE EQUIVALENT I–131 concentration in the primary coolant has not increased more than a factor of 3; and (2) the noble gas monitor shows that effluent activity has not increased more than a factor of 3.

d. Tritium grab samples shall be taken at least once per 24 hours when the refueling cavity is flooded.

e. Samples shall be changed at least once per 7 days and analyses shall be completed within 48 hours after changing (or after removal from sampler). Sampling shall also be performed at least once per 24 hours for at least 7 days following each shutdown, startup, or THERMAL POWER change exceeding 15% of RATED THERMAL POWER in one hour, and analyses shall be completed within 48 hours of changing. When samples collected for 24 hours are analyzed, the corresponding MDC may be increased by a factor of 10. This requirement does not apply if (1) analysis shows that the DOSE EQUIVALENT I–131 concentration in the primary coolant has not increased more than a factor of 3; and (2) the noble gas monitor shows that effluent activity has not increased more than a factor of 3.

f. Tritium grab samples shall be taken at least once per 7 days from the Unit 1 plant vent, whenever spent fuel is in the spent fuel pool (Unit 1 plant vent only).

g. The ratio of the sample flowrate to the sampled stream flowrate shall be known for the time period covered by each dose or dose rate calculation made in accordance with controls specified in Sections 3.1.2, 3.1.3, and 3.1.4.

h. Samples shall be changed at least once per 7 days and analyses shall be completed within 48 hours after changing (or removal of sampler).

3.1.3 Gaseous Effluent Air Dose Control

In accordance with Technical Specifications 5.5.4.e and 5.5.4.h, the air dose due to noble gases released in gaseous effluents, from each reactor unit, to areas at and beyond the SITE BOUNDARY shall be limited to the following:

a. During any calendar quarter: Less than or equal to 5 mrad for gamma radiation and less than or equal to 10 mrad for beta radiation, and

b. During any calendar year: Less than or equal to 10 mrad for gamma radiation and less than or equal to 20 mrad for beta radiation.

3.1.3.1 Applicability

This limit applies at all times.

3.1.3.2 Actions

With the calculated air dose from radioactive noble gases in gaseous effluents exceeding any of the above limits, prepare and submit to the Nuclear Regulatory Commission within 30 days a special report which identifies the cause(s) for exceeding the limit(s); defines the corrective actions that have been taken to reduce the releases; and defines the proposed corrective actions to be taken to assure that subsequent releases of radioactive noble gases in gaseous effluents will be in compliance with the limits of Section 3.1.3.

This control does not affect shutdown requirements or MODE changes.

3.1.3.3 Surveillance Requirements

Cumulative air dose contributions from noble gas radionuclides released in gaseous effluents from each unit to areas at and beyond the SITE BOUNDARY, for the current calendar quarter and current calendar year, shall be determined in accordance with Section 3.4.2 at least once per 31 days.

3.1.3.4 Basis

This control is provided to implement the requirements of Sections II.B, III.A and IV.A of Appendix I, 10 CFR Part 50. Section 3.1.3 implements the guides set forth in Section II.B of Appendix I. The ACTION statements in Section 3.1.3.2 provide the required operating flexibility and at the same time implement the guides set forth in Section IV.A of Appendix I, assuring that the releases of radioactive material in gaseous effluents to UNRESTRICTED AREAS will be kept “as low as is reasonably achievable.” The Surveillance requirements in Section 3.1.3.3 implement the requirements in Section III.A of Appendix I, which require that conformance with the guides of Appendix I be shown by calculational procedures based on models and data such that the actual exposure of a MEMBER OF THE PUBLIC through appropriate pathways is unlikely to be substantially underestimated. The dose calculations established in Section 3.4.2 for calculating the doses due to the actual releases of noble gases in gaseous effluents are consistent with the methodology provided in Regulatory Guide 1.109 (Reference 3), and Regulatory Guide 1.111 (Reference 5). The equations in Section 3.4.2 provided for determining the air doses at the SITE BOUNDARY are based upon the historical annual average atmospheric conditions.

3.1.4 Control on Gaseous Effluent Dose to a Member of the Public

In accordance with Technical Specifications 5.5.4.e and 5.5.4.i, the dose to a MEMBER OF THE PUBLIC from I–131, I–133, tritium, and all radionuclides in particulate form with half-lives greater than 8 days in gaseous effluents released, from each reactor unit, to areas at and beyond the SITE BOUNDARY shall be limited to the following:

a. During any calendar quarter: Less than or equal to 7.5 mrem to any organ, and

b. During any calendar year: Less than or equal to 15 mrem to any organ.

3.1.4.1 Applicability

This limit applies at all times.

3.1.4.2 Actions

With the calculated dose from the release of I-131, I-133, tritium, or radionuclides in particulate form with half-lives greater than 8 days, in gaseous effluents exceeding any of the above limits, prepare and submit to the Nuclear Regulatory Commission within 30 days a special report which identifies the cause(s) for exceeding the limit; defines the corrective actions that have been taken to reduce the releases of radioiodines and radionuclides in particulate form with half-lives greater than 8 days in gaseous effluents; and defines proposed corrective actions to assure that subsequent releases will be in compliance with the limits stated in Section 3.1.4.

This control does not affect shutdown requirements or MODE changes.

3.1.4.3 Surveillance Requirements

Cumulative organ dose contributions to a MEMBER OF THE PUBLIC from I–131, I–133, tritium, and radionuclides in particulate form with half-lives greater than 8 days released in gaseous effluents from each unit to areas at and beyond the SITE BOUNDARY, for the current calendar quarter and current calendar year, shall be determined in accordance with Section 3.4.3 at least once per 31 days.

3.1.4.4 Basis

This control is provided to implement the requirements of Section II.C, III.A and IV.A of Appendix I, 10 CFR Part 50. The limits stated in Section 3.1.4 are the guides set forth in Section II.C of Appendix I. The ACTION statements in Section 3.1.4.2 provide the required operating flexibility and at the same time implement the guides set forth in Section IV.A of Appendix I to assure that the releases of radioactive materials in gaseous effluents to UNRESTRICTED AREAS will be kept "as low as is reasonably achievable." The calculational methods specified in the Surveillance Requirements of Section 3.1.4.3 implement the requirements in Section III.A of Appendix I that conformance with the guides of Appendix I be shown by calculational procedures based on models and data, such that the actual exposure of a MEMBER OF THE PUBLIC through appropriate pathways is unlikely to be substantially underestimated. The calculational methods in Section 3.4.3 for calculating the doses due to the actual releases of the subject materials are consistent with the methodology provided in Regulatory Guide 1.109 (Reference 3), and Regulatory Guide 1.111 (Reference 5). These equations provide for determining the actual doses based upon the historical annual average atmospheric conditions. The release specifications for radioiodines, radioactive materials in particulate form and radionuclides other than noble gases are dependent on the existing radionuclide pathways to man, in the areas at and beyond the SITE BOUNDARY. The pathways which were examined in the development of these calculations were: 1) individual inhalation of airborne radionuclides, 2) deposition of radionuclides onto green leafy garden vegetation with subsequent consumption by man, 3) deposition onto grassy areas where milk animals and meat producing animals graze with consumption of the milk and meat by man, and 4) deposition on the ground with subsequent exposure of man.

3.1.5 Gaseous Radwaste Treatment System Control

In accordance with Technical Specification 5.5.4.f, the GASEOUS WASTE PROCESSING SYSTEM and the VENTILATION EXHAUST TREATMENT SYSTEM shall be FUNCTIONAL. The appropriate portions of the GASEOUS WASTE PROCESSING SYSTEM and the VENTILATION EXHAUST TREATMENT SYSTEM shall be used to reduce radioactive materials in gaseous wastes prior to their discharge when the projected doses in 31 days due to gaseous effluent releases, from each reactor unit, to areas at and beyond the SITE BOUNDARY would exceed 0.2 mrad to air from gamma radiation, 0.4 mrad to air from beta radiation, or 0.3 mrem to any organ of a MEMBER OF THE PUBLIC.

3.1.5.1 Applicability

These limits apply at all times.

3.1.5.2 Actions

With gaseous waste being discharged without treatment and in excess of the limits in Section 3.1.5, prepare and submit to the Nuclear Regulatory Commission within 30 days a special report which includes the following information:

a. Identification of any NON-FUNCTIONAL equipment or subsystem and the reason for NON-FUNCTIONALITY,

b. Action(s) taken to restore the NON-FUNCTIONAL equipment to FUNCTIONAL status, and

c. Summary description of action(s) taken to prevent a recurrence.

This control does not affect shutdown requirements or MODE changes.

3.1.5.3 Surveillance Requirements

Doses due to gaseous releases from each unit to areas at and beyond the SITE BOUNDARY shall be projected at least once per 31 days, in accordance with Section 3.5.1, when the GASEOUS WASTE PROCESSING SYSTEM or the VENTILATION EXHAUST TREATMENT SYSTEM is not being fully utilized.

The GASEOUS WASTE PROCESSING SYSTEM and the VENTILATION EXHAUST TREATMENT SYSTEM shall be demonstrated FUNCTIONAL:

by meeting the controls of Sections 3.1.2, and either 3.1.3 (for the GASEOUS WASTE PROCESSING SYSTEM) or 3.1.4 (for the VENTILATION EXHAUST TREATMENT SYSTEM).

3.1.5.4 Basis

The FUNCTIONALITY of the GASEOUS WASTE PROCESSING SYSTEM ensures that the system will be available for use whenever gaseous effluents require treatment prior to release to the environment. The requirement that the appropriate portions of this system be used, when specified, provides reasonable assurance that the releases of radioactive materials in gaseous effluents will be kept "as low as is reasonably achievable." This control implements the requirements of 10 CFR Part 50.36a, General Design Criterion 60 of Appendix A to 10 CFR Part 50, and the design objectives given in Section II.D of Appendix I to 10 CFR Part 50. The specified limits governing the use of appropriate portions of the system were specified as a suitable fraction of the dose design objectives set forth in Section II.B and II.C of Appendix I, 10 CFR Part 50, for gaseous effluents.

This control applies to the release of radioactive materials in gaseous effluents from each unit at the site. For units with shared radwaste treatment systems, the gaseous effluents from the shared system are proportioned among the units sharing that system.

3.1.6 Major Changes to Gaseous Radioactive Waste Treatment Systems

Licensee initiated MAJOR CHANGES TO GASEOUS RADIOACTIVE WASTE TREATMENT SYSTEMS:

a. Shall be reported to the Nuclear Regulatory Commission in the Radioactive Effluents Release Report for the period in which the change was implemented. The discussion of each change shall contain the information described in Section 7.2.2.7.

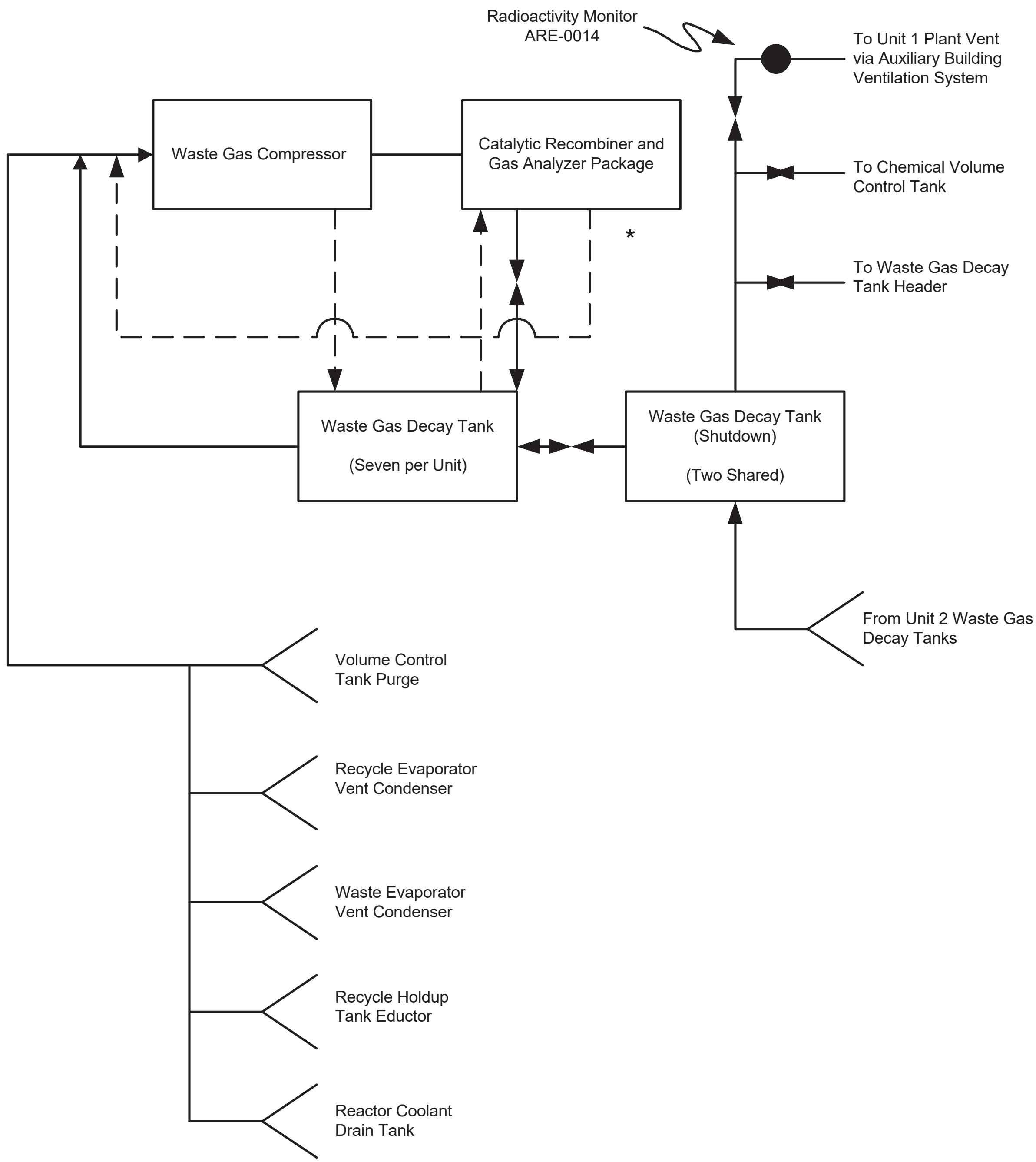
b. Shall become effective upon review by the Plant Review Board and approval by the Plant Manager.

3.2 GASEOUS WASTE PROCESSING SYSTEM

At Plant Vogtle, there are five potential points where radioactivity may be released to the atmosphere in gaseous discharges. These five *potential* release pathways are the Unit 1 and Unit 2 Plant Vents; the Unit 1 and Unit 2 Turbine Building Vents; and the Radwaste Processing Facility Vent. However, the Turbine Building Vents are not normal release pathways unless a primary-to-secondary leak exists. The Radwaste Processing Facility Vent is not a normal release pathway unless a spill occurs. The figures on the following pages give schematic diagrams of the Gaseous Waste Treatment System and the Ventilation Exhaust Treatment Systems (Reference 11).

The Unit 1 Plant Vent release pathway includes two release sources that are common to the two units: ventilation air from the Fuel Handling Building, and discharges from the GASEOUS WASTE PROCESSING SYSTEM. Otherwise, discharges from the two reactor units are separated. Reactor Containment Building ventilation releases are through the respective plant vents. The Turbine Building Vent serves as the discharge point for both the condenser air ejector and the steam packing exhauster system. The Radwaste Processing Facility Vent includes sources from the Radwaste Processing Facility Process area.

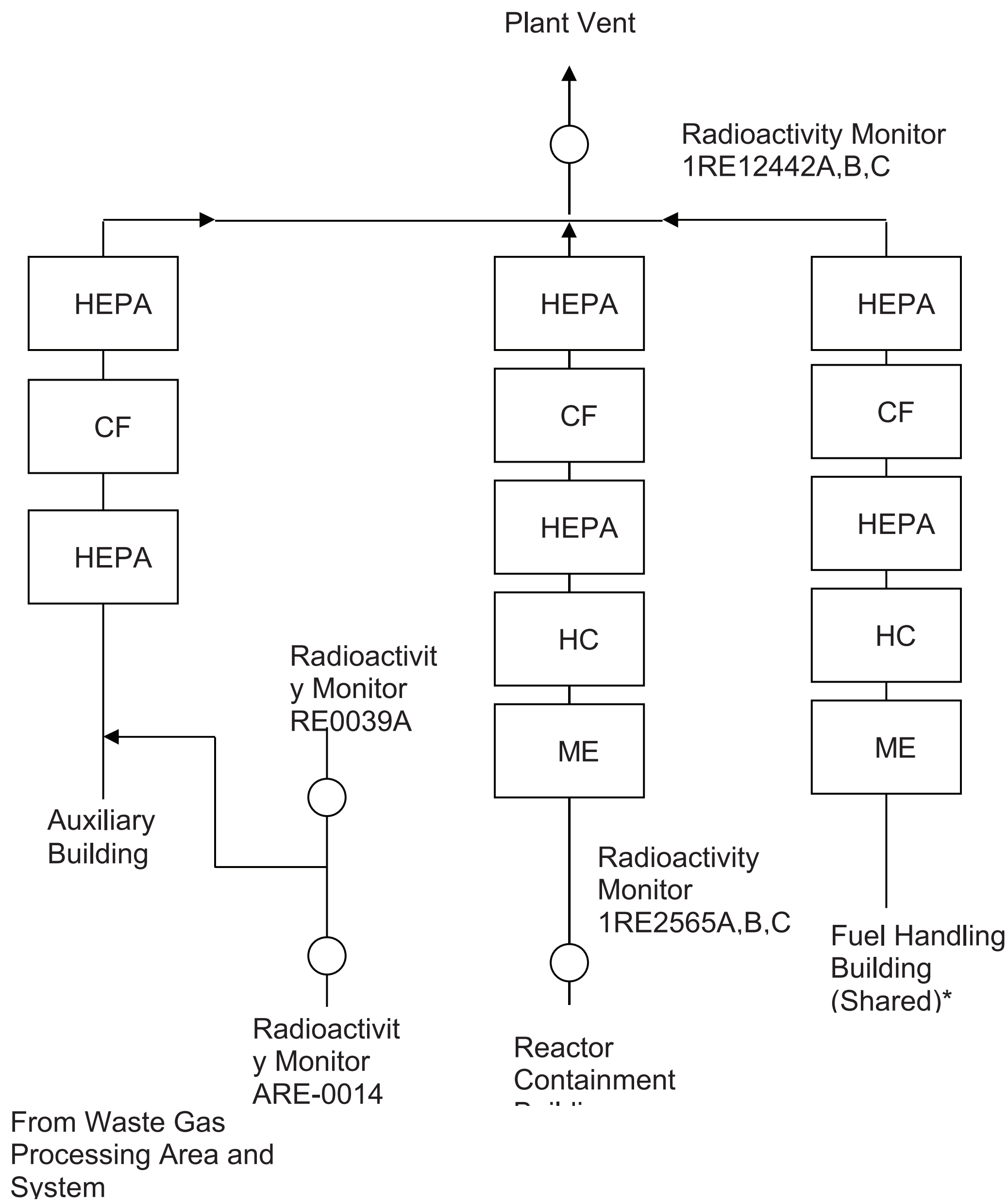
Releases from the two Turbine Building Vents and the Radwaste Processing Facility Vent are considered to be ground-level releases, whereas releases from the two Plant Vents are considered mixed-mode releases. Chapter 8 discusses the calculation of atmospheric dispersion parameters using the ground-level and mixed-mode (i.e., split-wake) models. All five potential release pathways are considered to be continuous (as opposed to batch) in nature.



*Dotted line operational between 20 and 100 psig

NOTE: This is typical of both units. However, Unit 2 GWPS releases via Unit 1 plant vent.

Figure 3-1. Schematic Diagram of the Gaseous Radwaste Treatment System



HEPA - High-Efficiency Particulate Air Filter
CF - Activated Charcoal Filter
HC - Heating Coil
ME - Moisture Eliminator

* Prior to treatment by the Fuel Handling Building Ventilation Exhaust Treatment System, Exhaust from Unit 1 Spent Fuel Pool Area is monitored by ARE2532B and ARE2533B; exhaust from Unit 2 Spent Fuel Pool Area is monitored by ARE2532A and ARE2533A.

Figure 3-2. Schematic Diagram of the Unit 1 Plant Vent Release Pathway

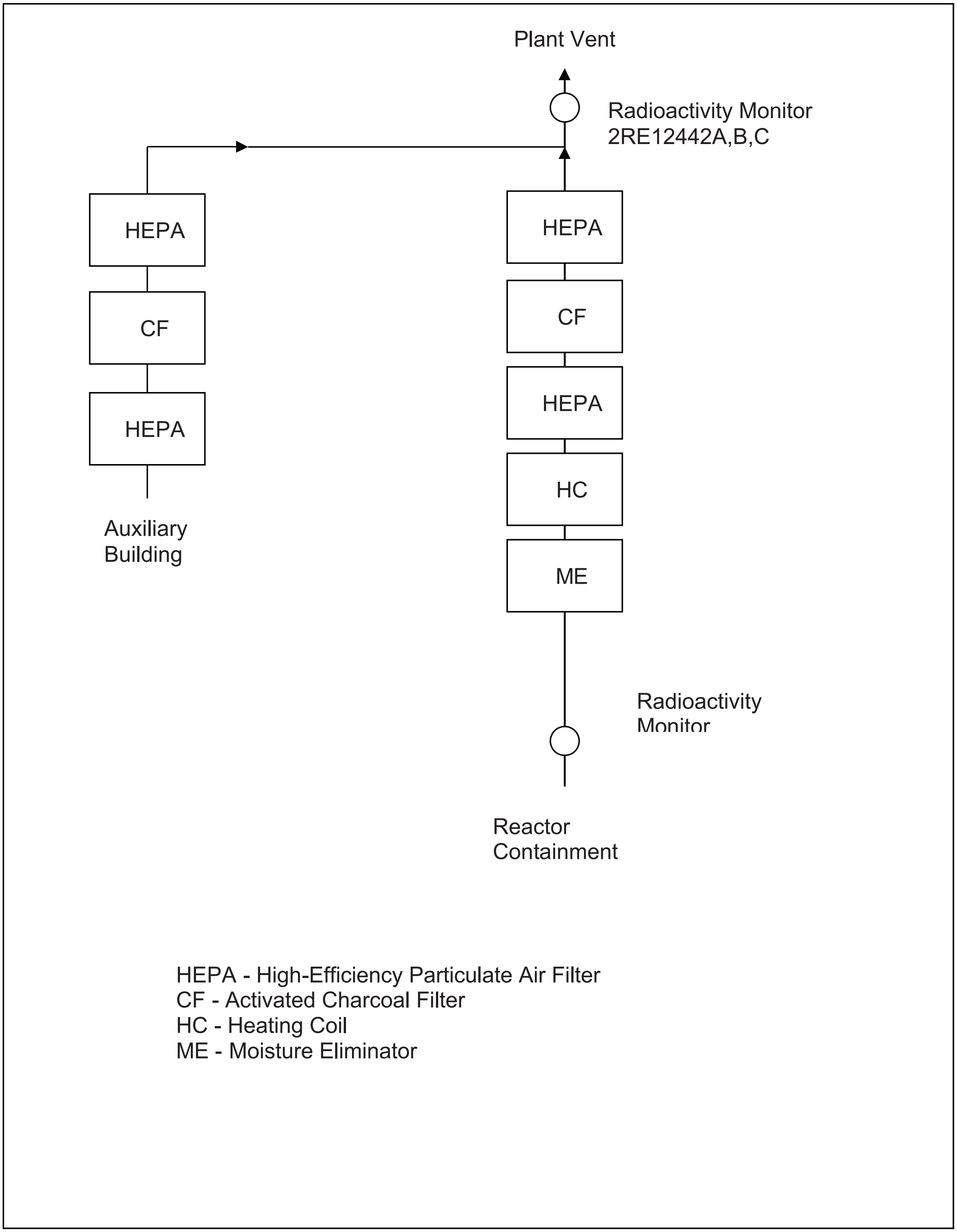
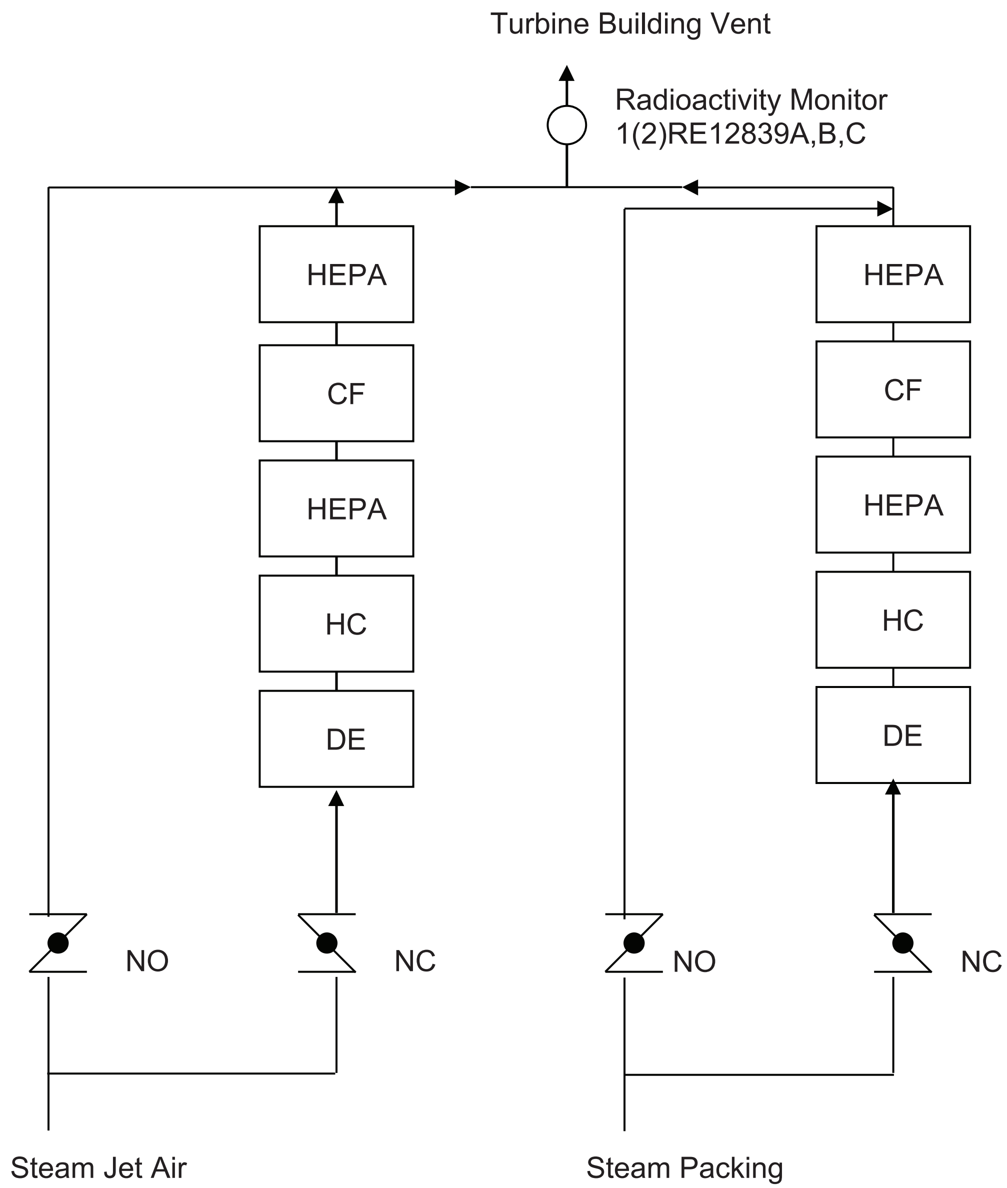


Figure 3-3. Schematic Diagram of the Unit 2 Plant Vent Release Pathway



HEPA - High-Efficiency Particulate Air Filter
CF - Activated Charcoal Filter
HC - Heating Coil
DE - Demister
NO - Normally Open
NC - Normally Closed

NOTE: This is typical of both units.

Figure 3-4. Schematic Diagram of the Turbine Building Vent Release Pathway (Typical of Both Units)

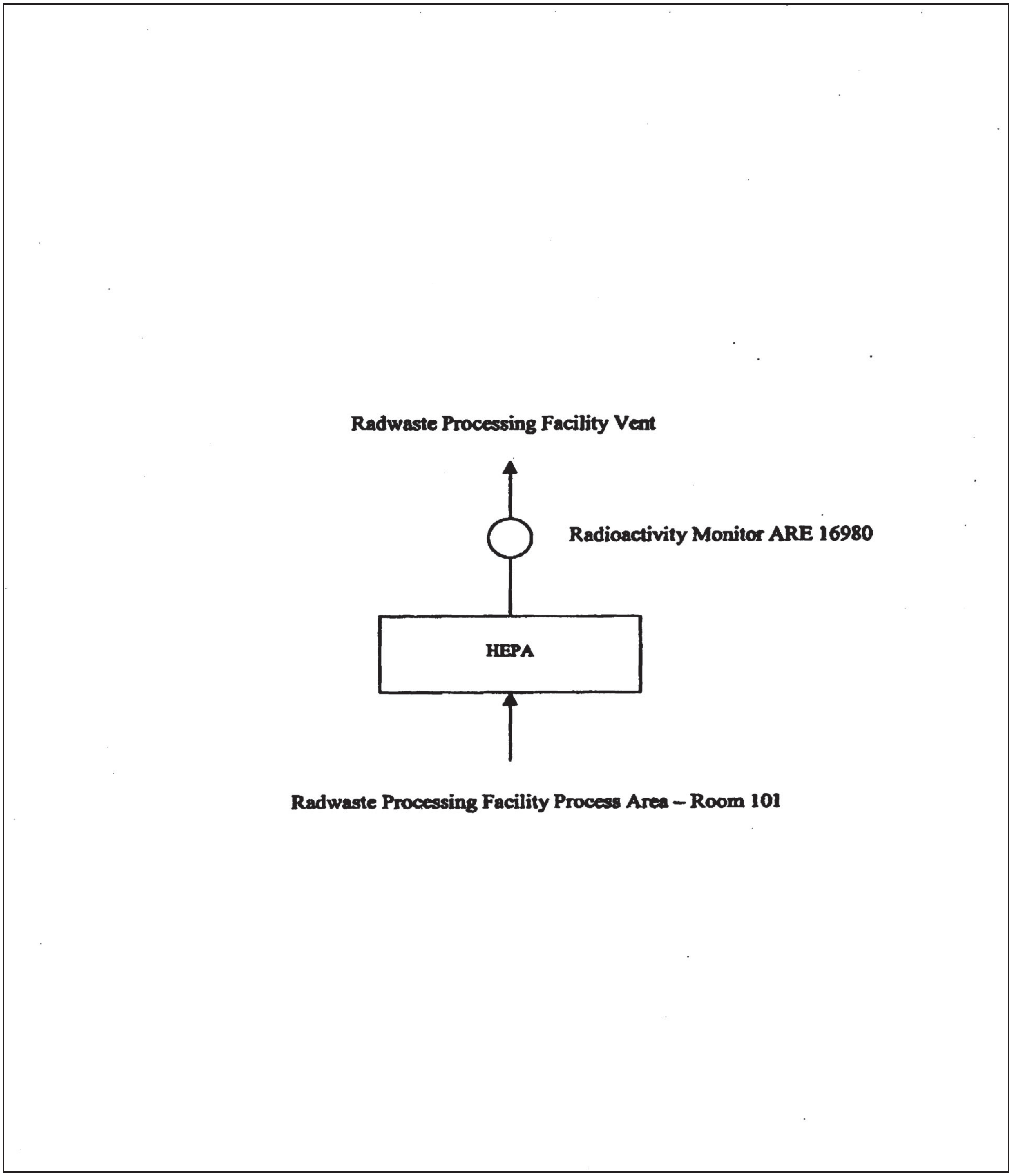


Figure 3-5. Schematic Diagram of the Radwaste Processing Facility Ventilation Release Pathway

3.3 GASEOUS EFFLUENT MONITOR SETPOINTS

3.3.1 General Provisions Regarding Noble Gas Monitor Setpoints

Noble gas radioactivity monitor setpoints calculated in accordance with the methodology presented in this section are intended to ensure that the limits of Section 3.1.2.a are not exceeded. They will be regarded as upper bounds for the actual high alarm setpoints. That is, a lower high alarm setpoint may be established or retained on the monitor, if desired. Intermediate level setpoints should be established at an appropriate level to give sufficient warning prior to reaching the high alarm setpoint.

If no release is planned for a given pathway, or if there is no detectable activity in the gaseous stream being evaluated for release, the setpoint should be calculated in accordance with the methods presented below, based on an assumed concentration of Kr-88 that leads to a practical setpoint. A practical setpoint in this context is one which prevents spurious alarms, and yet produces an alarm should a significant inadvertent release occur.

Section 3.1.1 establishes the requirements for gaseous effluent monitoring instrumentation, and Section 3.2 describes the VENTILATION EXHAUST TREATMENT SYSTEM and the GASEOUS WASTE PROCESSING SYSTEM. From those Sections, it can be seen that certain monitors are located on final release pathways, that is, streams that are being monitored immediately before being discharged from the plant; the setpoint methodology for these monitors is presented in Section 3.3.2. Other monitors are located on source streams, that is, streams that merge with other streams prior to passing a final monitor and being discharged; the setpoint methodology for these monitors is presented in Section 3.3.3. Table 3-4 identifies which of these setpoint methodologies applies to each monitor. Some additional monitors with special setpoint requirements are discussed in Section 3.3.5.

As established in Section 3.1.1, gaseous effluent monitor setpoints are *required* only for the noble gas monitors on certain potential release streams: the two Plant Vents, the two Turbine Building Vents, and the GASEOUS WASTE PROCESSING SYSTEM discharge. However, because of the potential significance of releases from other sources, Section 3.3 discusses setpoint methodologies for certain additional monitors, as well.

Table 3-4. Applicability of Gaseous Monitor Setpoint Methodologies

Final Release Pathways with no Monitored Source Streams

Setpoint Method: Section 3.3.2
Release Elevation: Ground-level

Unit 1 or Unit 2 Turbine Building Vent

Monitor: 1RE-12839C/2RE-12839C
Maximum Flowrate: 900 cfm (4.25 E+05 mL/s)

Final Release Pathways with One or More Monitored Source Streams

Release Elevation: Mixed-Mode

Unit 1 Plant Vent

Monitors: 1RE-12442C, 1RE-12444C
Maximum Flowrate: 187,000 cfm (8.83 E+07 mL/s)
Setpoint Method: Section 3.3.2
Release Type: CONTINUOUS

Source Stream: Unit 1 Reactor Containment Purge

Monitor: 1RE-2565C
Maximum Flowrate: release-dependent
Setpoint Method: Section 3.3.3
Release Type: BATCH

Source Stream: Gaseous Waste Treatment System

Monitor: ARE-0014
Maximum Flowrate: release-dependent
Setpoint Method: Section 3.3.3
Release Type: BATCH

Unit 2 Plant Vent

Monitors: 2RE-12442C, 2RE-12444C
Maximum Flowrate: 112,500 cfm (5.31 E+07 mL/s)
Setpoint Method: Section 3.3.2
Release Type: CONTINUOUS

Source Stream: Unit 2 Reactor Containment Purge

Monitor: 2RE-2565C
Maximum Flowrate: release-dependent
Setpoint Method: Section 3.3.3
Release Type: BATCH

$(\overline{X/Q})_{vb}$ Values for Use in Setpoint Calculations

Ground-Level Releases: 2.55×10^{-6} s/m^3 [NE Sector]

Mixed-Mode Releases: 4.62×10^{-7} s/m^3 [NE Sector]

Maximum flowrate values are from Reference 11, Table 11.5.2-1 and Table 11.5.5-1.

3.3.2 Setpoint for the Final Noble Gas Monitor on Each Release Pathway

3.3.2.1 Overview of Method

Gaseous effluent radioactivity monitors are intended to alarm prior to exceeding the limits of Section 3.1.2.a. Therefore, their alarm setpoints are established to ensure compliance with the following equation:

$$c = \text{the lesser of} \begin{cases} AG \cdot SF \cdot X \cdot R_t \\ AG \cdot SF \cdot X \cdot R_k \end{cases} \qquad \textbf{(3.1)}$$

where:

c = the setpoint, in µCi/mL, of the radioactivity monitor measuring the concentration of radioactivity in the effluent line prior to release. The setpoint represents a concentration which, if exceeded, could result in dose rates exceeding the limits of Section 3.1.2.a at or beyond the SITE BOUNDARY.

AG = an administrative allocation factor applied to divide the release limit among all the gaseous release pathways at the site.

SF = the safety factor selected to compensate for statistical fluctuations and errors of measurement.

X = the noble gas concentration for the release under consideration.

R_t = the ratio of the dose rate limit for the total body, 500 mrem/y, to the dose rate to the total body for the conditions of the release under consideration.

R_k = the ratio of the dose rate limit for the skin, 3000 mrem/y, to the dose rate to the skin for the conditions of the release under consideration.

Equation (3.1) shows the relationships of the critical parameters that determine the setpoint. However, in order to apply the methodology presented in the equation to a mixture of noble gas radionuclides, radionuclide-specific concentrations and dose factors must be taken into account under conditions of maximum flowrate for the release point and annual average meteorology.

The basic setpoint method presented below is applicable to the radioactivity monitor nearest the point of release for the release pathway. For monitors measuring the radioactivity in source streams that merge with other streams prior to subsequent monitoring and release, the modifications presented in Section 3.3.3 must be applied.

3.3.2.2 Setpoint Calculation Steps

Step 1: Determine the concentration, X_{iv}, of each noble gas radionuclide i in the gaseous stream v being considered for release, in accordance with the sampling and analysis requirements of Section 3.1.2. Then sum these concentrations to determine the total noble gas concentration, $\sum_i X_{iv}$.

Step 2: Determine R_t, the ratio of the dose rate limit for the total body, 500 mrem/y, to the total body dose rate due to noble gases detected in the release under consideration, as follows:

$$R_t = \frac{500}{\overline{(X/Q)}_{vb} \sum_i \left[K_i \cdot Q_{iv}\right]} \qquad \textbf{(3.2)}$$

where:

500 = the dose rate limit for the total body, 500 mrem/y.

$\overline{(X/Q)}_{vb}$ = the highest annual average relative concentration at the SITE BOUNDARY for the discharge point of release pathway v. Table 3-4 includes an indication of what release elevation is applicable to each release pathway; release elevation determines the appropriate value of $\overline{(X/Q)}_{vb}$.

K_i = the total-body dose factor due to gamma emissions from noble gas radionuclide i, in (mrem/y)/(μCi/m^3), from Table 3-5.

Q_{iv} = the release rate of noble gas radionuclide i from the release pathway under consideration, in μCi/s, calculated as the product of X_{iv} and f_{av}, where:

X_{iv} = the concentration of noble gas radionuclide i for the particular release, in μCi/mL.

f_{av} = the maximum anticipated flowrate for release pathway v during the period of the release under consideration, in mL/s.

Step 3: Determine R_k, the ratio of the dose rate limit for the skin, 3000 mrem/y, to the skin dose rate due to noble gases detected in the release under consideration, as follows:

$$R_k = \frac{3000}{\overline{(X/Q)}_{vb} \sum_i \left[\left(L_i + 1.1 M_i\right) \cdot Q_{iv}\right]} \qquad \textbf{(3.3)}$$

where:

3000 = the dose rate limit for the skin, 3000 mrem/y.

L_i = the skin dose factor due to beta emissions from noble gas radionuclide i, in (mrem/y)/(μCi/m3), from Table 3-5.

M_i = the air dose factor due to gamma emissions from noble gas radionuclide i, in (mrad/y)/(μCi/m3), from Table 3-5.

1.1 = the factor to convert air dose in mrad to skin dose in mrem.

All other terms were defined previously.

Step 4: Determine the maximum noble gas radioactivity monitor setpoint concentration.

Based on the values determined in previous steps, the radioactivity monitor setpoint for the planned release is calculated to ensure that the limits of Section 3.1.2.a will not be exceeded. Because the radioactivity monitor responds primarily to radiation from noble gas radionuclides, the monitor setpoint c_{nv} (in μCi/mL) is based on the concentration of all noble gases in the waste stream, as follows:

where:

c_{nv} = the calculated setpoint, in μCi/mL, for the noble gas monitor serving gaseous release pathway v.

$$c_{nv} = the \quad lesser \quad of \begin{cases} AG_v \cdot SF \cdot \sum_i X_{iv} \cdot R_t \\ AG_v \cdot SF \cdot \sum_i X_{iv} \cdot R_k \end{cases} \qquad \textbf{(3.4)}$$

AG_v = the administrative allocation factor for gaseous release pathway v, applied to divide the release limit among all the gaseous release pathways at the site. The allocation factor may be assigned any value between 0 and 1, under the condition that the sum of the allocation factors for all simultaneously-active final release pathways at the entire plant site does not exceed 1. Alternative methods for determination of AG_v are presented in Section 3.3.4.

SF = the safety factor selected to compensate for statistical fluctuations and errors of measurement. The value for the safety factor must be between 0 and 1. A value of 0.5 is reasonable for gaseous releases; a more precise value may be developed if desired.

X_{iv} = the measured concentration of noble gas radionuclide i in gaseous stream v, as defined in Step 1, in μCi/mL.

The values of R_t and R_k to be used in the calculation are those which were determined in Steps 2 and 3 above.

Step 5: Determine whether the release is permissible, as follows:

If $c_{nv} \geq \sum_i X_{iv}$, the release is permissible. However, if c_{nv} is within about 10 percent of $\sum_i X_{iv}$, it may be impractical to use this value of c_{nv}. This situation indicates that measured concentrations are approaching values which would cause the limits of Section 3.1.2.a to be exceeded. Therefore, steps should be taken to reduce contributing source terms of gaseous radioactive material, or to adjust the allocation of the limits among the active release points. The setpoint calculations (steps 1–4) must then be repeated with parameters that reflect the modified conditions.

If $c_{nv} < \sum_i X_{iv}$, the release may not be made as planned. Consider the alternatives discussed in the paragraph above, and calculate a new setpoint based on the results of the actions taken.

3.3.2.3 Use of the Calculated Setpoint

The setpoint calculated above is in the units μCi/mL. The monitor actually measures a count rate, subtracts a predetermined background count rate, and multiplies by a calibration factor to convert from count rate to μCi/mL.

Initial calibration by the manufacturer and Georgia Power Company of the gaseous effluent monitors specified in Section 3.1.1 utilized at least one NIST-traceable gaseous radionuclide source in the exact geometry of each production monitor. The point and gaseous sources used covered the beta particle end point energy range from 0.293 MeV to at least 1.488 MeV. The calibration factor is a function of the radionuclide mix in the gas to be released, and normally will be calculated for the monitor based on the results of the sample results from the laboratory gamma-ray spectrometer system. The mix-dependent calibration factor will be used as the gain factor in the PERMS monitor, or used to modify the calculated base monitor setpoint so that the default calibration factor in the PERMS monitor can be left unchanged.

Notwithstanding the initial calibration, monitor calibration data for conversion between count rate and concentration *may* include operational data obtained from determining the monitor response to stream concentrations measured by sample analysis.

In all cases, monitor background must be controlled so that the monitor is capable of responding to concentrations in the range of the setpoint value. Contributions to the monitor background may include any or all of the following factors: ambient background radiation, plant-related radiation levels at the monitor location (which may change between shutdown and power conditions), and internal background due to contamination of the monitor's sample chamber.

3.3.3 <u>Setpoints for Noble Gas Monitors on Effluent Source Streams</u>

Table 3-4 lists certain gaseous release pathways as being source streams. As may be seen in the figures of Section 3.2, these are streams that merge with other streams, prior to passing a final radioactivity monitor and being released. Unlike the final monitors, the source stream monitors measure radioactivity in effluent streams for which flow can be terminated; therefore, the source stream monitors have control logic to terminate the source stream release at the alarm setpoint.

3.3.3.1 Setpoint of the Monitor on the Source Stream

<u>Step 1</u>: Determine the concentration X_{is} of each noble gas radionuclide i in source stream s (in μCi/mL) according to the results of its required sample analyses [see Section 3.1.2].

<u>Step 2</u>: Determine r_t, the ratio of the dose rate limit for the total body, 500 mrem/y, to the total body dose rate due to noble gases detected in the source stream under consideration. Use the X_{is} values and the maximum anticipated source stream flowrate f_{as} in equation (3.2) to determine the total body dose rate for the source stream, substituting r_t for R_t.

The SITE BOUNDARY relative dispersion value used in Steps 2 and 3 for the source stream is the same as the $\overline{(X/Q)}_{vb}$ that applies to the respective merged stream. This is because the $\overline{(X/Q)}$ value is determined by the meteorology of the plant site and the physical attributes of the release point, and is unaffected by whether or not a given source stream is operating.

Step 3: Determine r_k, the ratio of the dose rate limit for the skin, 3000 mrem/y, to the skin dose rate due to noble gases detected in the source stream under consideration. Use the X_{is} values and the maximum anticipated source stream flow rate f_{as} in equation (3.3) to determine the skin dose rate for the source stream, substituting r_k for R_k.

Step 4: Determine the maximum noble gas radioactivity monitor setpoint concentration, as follows:

$$c_{ns} = the \quad lesser \quad of \begin{cases} AG_s \cdot SF \cdot \sum_i X_{is} \cdot r_t \\ \\ AG_s \cdot SF \cdot \sum_i X_{is} \cdot r_k \end{cases} \qquad \textbf{(3.5)}$$

where:

c_{ns} = the calculated setpoint (in μCi/mL) for the noble gas monitor serving gaseous source stream s.

AG_s = the administrative allocation factor applied to gaseous source stream s. For a given final release point v, the sum of all the AG_s values for source streams contributing to the final release point must not exceed the release point's allocation factor Ag_v.

X_{is} = the measured concentration of noble gas radionuclide i in gaseous source stream s, as defined in Step 1, in μCi/mL.

The values of r_t and r_k to be used in the calculation are those which were determined in Steps 2 and 3 above. The safety factor, SF, was defined previously.

Step 5: Determine whether the release is permissible, as follows:

If $c_{ns} \geq \sum_i X_{is}$, the release is permissible. However, if c_{ns} is within about 10 percent of $\sum_i X_{is}$, it may be impractical to use this value of c_{ns}. This situation indicates that measured concentrations are approaching values which would cause the limits of Section 3.1.2.a to be exceeded. Therefore, steps should be taken to reduce contributing source terms of gaseous radioactive material, or to adjust the allocation of the limits among the active release points. The setpoint calculations (steps 1–4) must then be repeated with parameters that reflect the modified conditions.

If $c_{ns} < \sum_i X_{is}$, the release may not be made as planned. Consider the alternatives discussed in the paragraph above, and calculate a new setpoint based on the results of the actions taken.

3.3.3.2 Effect on the Setpoint of the Monitor on the Merged Stream

Before beginning a release from a monitored source stream, a setpoint must be determined for the source stream monitor as presented in Section 3.3.3.1. In addition, whether or not the source stream has its own effluent monitor, the previously-determined maximum allowable setpoint for the downstream final monitor on the merged stream must be redetermined. This is accomplished by repeating the steps of Section 3.3.2, with the following modifications.

Modification 1: The new maximum anticipated flowrate of the merged stream is the sum of the old merged stream maximum flowrate, and the maximum flowrate of the source stream being considered for release.

$$(f_{av})_{new} = (f_{av})_{old} + f_{as} \qquad \textbf{(3.6)}$$

Modification 2: The new concentration of noble gas radionuclide i in the merged stream includes both the contribution of the merged stream *without* the source stream, *and* the source stream being considered for release.

$$(X_{iv})_{new} = \frac{(f_{av})_{old} \cdot (X_{iv})_{old} + f_{as} \cdot X_{is}}{(f_{av})_{new}} \qquad \textbf{(3.7)}$$

3.3.4 Determination of Allocation Factors, AG

When simultaneous gaseous releases are conducted, an administrative allocation factor must be applied to divide the release limit among the active gaseous release pathways. This is to assure that the dose rate limit for areas at and beyond the SITE BOUNDARY (see Section 3.1.2) will not be exceeded by simultaneous releases. The allocation factor for any pathway may be assigned any value between 0 and 1, under the following two conditions:

1. The sum of the allocation factors for all simultaneously-active *final* release paths at the plant site may not exceed 1.

2. The sum of the allocation factors for all simultaneously-active *source streams* merging into a given final release pathway may not exceed the allocation factor of that final release pathway.

Any of the following three methods may be used to assign the allocation factors to the active gaseous release pathways:

1. For ease of implementation, AG_v may be equal for all release pathways:

   $$AG_v = \frac{1}{N} \qquad \textbf{(3.8)}$$

   where:

   N = the number of simultaneously active gaseous release pathways.

2. AG_v for a given release pathway may be selected based on an *estimate* of the portion of the total SITE BOUNDARY dose rate (from all simultaneous releases) that is contributed

by the release pathway. During periods when a given building or release pathway is not subject to gaseous radioactive releases, it may be assigned an allocation factor of zero.

3. AG_v for a given release pathway may be selected based on a *calculation* of the portion of the total SITE BOUNDARY dose rate that is contributed by the release pathway, as follows:

$$AG_v = \frac{\left(\overline{X/Q}\right)_{vb} \sum_i \left(K_i Q_{iv}\right)}{\sum_{r=1}^{N}\left[\left(\overline{X/Q}\right)_{rb} \sum_i \left(K_i Q_{ir}\right)\right]} \qquad \textbf{(3.9)}$$

where:

$\overline{(X/Q)}_{vb}$ = the annual average SITE BOUNDARY relative concentration applicable to the gaseous release pathway v for which the allocation factor is being determined, in s/m^3.

K_i = the total-body dose factor due to gamma emissions from noble gas radionuclide i, in (mrem/y)/(μCi/m^3), from Table 3-5.

Q_{iv} = the release rate of noble gas radionuclide i from release pathway v, in μCi/s, calculated as the product of X_{iv} and f_{av}, where:

X_{iv} = the concentration of noble gas radionuclide i applicable to the gaseous release pathway v for which the allocation factor is being determined, in μCi/mL.

f_{av} = the discharge flowrate applicable to gaseous release pathway v for which the allocation factor is being determined, in mL/s.

$\overline{(X/Q)}_{rb}$ = the annual average SITE BOUNDARY relative concentration applicable to active gaseous release pathway r, in s/m^3.

Q_{ir} = the release rate of noble gas radionuclide i applicable to active release pathway r, in μCi/s, calculated as the product of X_{ir} and f_{ar}, where:

X_{ir} = the concentration of noble gas radionuclide i applicable to active gaseous release pathway r, in μCi/mL.

f_{ar} = the discharge flowrate applicable to active gaseous release pathway r, in mL/s.

N = the number of simultaneously active gaseous release pathways (including pathway v that is of interest).

NOTE: Although equations (3.8) and (3.9) are written to illustrate the assignment of the allocation factors for final release pathways, they may also be used to assign allocation factors to the source streams that merge into a given final release pathway.

3.3.5 Setpoints for Noble Gas Monitors with Special Requirements

At present, VEGP has no noble gas monitors for which setpoint methodologies are to be presented in the ODCM, and that require methods other than those in Section 3.3.2 or Section 3.3.3.

3.3.6 Setpoints for Particulate and Iodine Monitors

In accordance with Section 5.1.1 of NRC NUREG-0133 (Reference 1), the effluent controls of Section 3.1.1 do not require that the ODCM establish setpoint calculation methods for particulate and iodine monitors. Therefore, the following is provided for information only: Initial setpoints for the particulate channels of effluent monitors RE–12442 and RE–2565 were determined as described in Reference 13.

3.4 GASEOUS EFFLUENT COMPLIANCE CALCULATIONS

3.4.1 Dose Rates at and Beyond the Site Boundary

Because the dose rate limits for areas at and beyond the SITE specified in Section 3.1.2 are *site* limits applicable at any instant in time, the summations extend over all simultaneously active gaseous final release pathways at the *plant site*. Table 3-4 identifies the gaseous final release pathways at the plant site, and indicates the $\overline{(X/Q)}_{vb}$ value for each.

3.4.1.1 Dose Rates Due to Noble Gases

For the purpose of implementing the controls of Section 3.1.2.a, the dose rates due to noble gas radionuclides in areas at or beyond the SITE BOUNDARY, due to releases of gaseous effluents, shall be calculated as follows:

For total body dose rates:

$$DR_t = \sum_v \left\{ \overline{(X/Q)}_{vb} \sum_i \left[K_i Q_{iv} \right] \right\} \tag{3.10}$$

For skin dose rates:

$$DR_k = \sum_v \left\{ \overline{(X/Q)}_{vb} \sum_i \left[(L_i + 1.1 M_i) Q_{iv} \right] \right\} \tag{3.11}$$

where:

DR_t = the total body dose rate at the time of the release, in mrem/y.

DR_k = the skin dose rate at the time of the release, in mrem/y.

Q_{iv} = the release rate of noble gas radionuclide i, in μCi/s, equal to the product of f_{tv} and X_{iv}, where:

f_{tv} = the actual average flowrate for release pathway v during the period of the release, in mL/s.

All other terms were defined previously.

3.4.1.2 Dose Rates Due to Iodine-131, Iodine-133, Tritium, and Radionuclides in Particulate Form with Half-Lives Greater than 8 Days

For the purpose of implementing the controls of Section 3.1.2.b, the dose rates due to Iodine-131, Iodine-133, tritium, and all radionuclides in particulate form with half-lives greater than 8 days, in areas at or beyond the SITE BOUNDARY, due to releases of gaseous effluents, shall be calculated as follows:

$$DR_o = \sum_v \left\{ \overline{(X/Q)}_{vb} \sum_i \left[P_{io} \, Q'_{iv} \right] \right\} \tag{3.12}$$

where:

DR_o = the dose rate to organ o at the time of the release, in mrem/y.

P_{io} = the site-specific dose factor for radionuclide i and organ o, in (mrem/y)/(μCi/m^3). Since the dose rate limits specified in Section 3.1.2.b apply only to the child age group exposed to the inhalation pathway, the values of P_{io} may be obtained from Table 3-9, "R_{aipj} for Inhalation Pathway, Child Age Group."

Q'_{iv} = the release rate of radionuclide i from gaseous release pathway v, in μCi/s. For the purpose of implementing the controls of Section 3.1.2.b, only I–131, I–133, tritium, and all radionuclides in particulate form with half-lives greater than 8 days should be included in this calculation.

All other terms were defined previously.

3.4.2 Noble Gas Air Dose at or Beyond Site Boundary

For the purpose of implementing the controls of Section 3.1.3, air doses in areas at or beyond the SITE BOUNDARY due to releases of noble gases from each unit shall be calculated as follows (adapted from Reference 1, page 28, by including only long-term releases):

$$D_\beta = 3.17 \times 10^{-8} \sum_v \left\{ \left(\overline{X/Q}\right)_{vb} \sum_i \left[N_i \cdot \tilde{Q}_{iv} \right] \right\} \quad \textbf{(3.13)}$$

$$D_\gamma = 3.17 \times 10^{-8} \sum_v \left\{ \left(\overline{X/Q}\right)_{vb} \sum_i \left[M_i \cdot \tilde{Q}_{iv} \right] \right\} \quad \textbf{(3.14)}$$

where:

3.17×10^{-8} = a units conversion factor: 1 y/(3.15×10^7 s).

D_β = the air dose due to beta emissions from noble gas radionuclides, in mrad.

D_γ = the air dose due to gamma emissions from noble gas radionuclides, in mrad.

N_i = the air dose factor due to beta emissions from noble gas radionuclide i (mrad/y)/(μCi/m^3), from Table 3-5.

M_i = the air dose factor due to gamma emissions from noble gas radionuclide i (mrad/y)/(μCi/m^3), from Table 3-5.

$\tilde{Q}_{iv}$ = the cumulative release of noble gas radionuclide i from release pathway v (μCi), during the period of interest.

and all other terms are as defined above.

Because the air dose limit is on a per-reactor-unit basis, the summations extend over all gaseous final release pathways for a given *unit*. For a release pathway discharging materials originating in both reactor units, the activity discharged from the release point may be apportioned to the two units in any reasonable manner, provided that all activity released via the particular shared release pathway is apportioned to one or the other unit.

The gaseous final release pathways at the plant site, and the $\overline{(X/Q)}_{vb}$ for each, are identified in Table 3-4.

Table 3-5. Dose Factors for Exposure to a Semi-Infinite Cloud of Noble Gases

Nuclide	γ - Body (K) (mrem/y) per ($\mu Ci/m^3$)	β - Skin (L) (mrem/y) per ($\mu Ci/m^3$)	γ - Air (M) (mrad/y) per ($\mu Ci/m^3$)	β - Air (N) (mrad/y) per ($\mu Ci/m^3$)
Kr-83m	7.56 E-02	0.00 E+00	1.93 E+01	2.88 E+02
Kr-85m	1.17 E+03	1.46 E+03	1.23 E+03	1.97 E+03
Kr-85	1.61 E+01	1.34 E+03	1.72 E+01	1.95 E+03
Kr-87	5.92 E+03	9.73 E+03	6.17 E+03	1.03 E+04
Kr-88	1.47 E+04	2.37 E+03	1.52 E+04	2.93 E+03
Kr-89	1.66 E+04	1.01 E+04	1.73 E+04	1.06 E+04
Kr-90	1.56 E+04	7.29 E+03	1.63 E+04	7.83 E+03
Xe-131m	9.15 E+01	4.76 E+02	1.56 E+02	1.11 E+03
Xe-133m	2.51 E+02	9.94 E+02	3.27 E+02	1.48 E+03
Xe-133	2.94 E+02	3.06 E+02	3.53 E+02	1.05 E+03
Xe-135m	3.12 E+03	7.11 E+02	3.36 E+03	7.39 E+02
Xe-135	1.81 E+03	1.86 E+03	1.92 E+03	2.46 E+03
Xe-137	1.42 E+03	1.22 E+04	1.51 E+03	1.27 E+04
Xe-138	8.83 E+03	4.13 E+03	9.21 E+03	4.75 E+03
Ar-41	8.84 E+03	2.69 E+03	9.30 E+03	3.28 E+03

All values in this table were obtained from Reference 3 (Table B-1), with units converted.

Table 3-6. Dose Factors for Exposure to Direct Radiation from Noble Gases in an Elevated Finite Plume

The contents of this table are not applicable to VEGP.

3.4.3 Dose to a Member of the Public at or Beyond Site Boundary

The dose received by an individual due to gaseous releases from each reactor unit, to areas at or beyond the SITE BOUNDARY, depends on the individual's location, age group, and exposure pathways. The MEMBER OF THE PUBLIC expected to receive the highest dose in the plant vicinity is referred to as the controlling receptor. The dosimetrically-significant attributes of the currently-defined controlling receptor are presented in Table 3-7.

Doses to a MEMBER OF THE PUBLIC due to gaseous releases of I–131, I–133, tritium, and all radionuclides in particulate form from each unit shall be calculated as follows (equation adapted from Reference 1, page 29, by considering only long-term releases):

$$D_{ja} = 3.17 \times 10^{-8} \sum_{p} \left\{ \sum_{i} R_{aipj} \sum_{v} \left[W_{vip} \cdot \tilde{Q}'_{iv} \right] \right\} \quad \textbf{(3.15)}$$

where:

D_{ja} = the dose to organ j of an individual in age group a, due to gaseous releases of I–131, I–133, tritium, and all radionuclides in particulate form with half-lives greater than 8 days, in mrem.

3.17×10^{-8} = a units conversion factor: 1 y/(3.15×10^{7} s).

R_{aipj} = the site-specific dose factor for age group a, radionuclide i, exposure pathway p, and organ j. For the purpose of implementing the controls of Section 3.1.4, the exposure pathways applicable to calculating the dose to the currently-defined controlling receptor are included in Table 3-7; values of R_{aipj} for each exposure pathway and radionuclide applicable to calculations of dose to the controlling receptor are included in Tables 3-8 through 3-12.

A detailed discussion of the methods and parameters used for calculating R_{aipj} for the plant site is presented in Chapter 9. That information may be used for recalculating the R_{aipj} values if the underlying parameters change, or for calculating R_{aipj} values for special radionuclides and age groups when performing the assessments discussed in Section 3.4.4 below.

W_{vip} = the annual average relative dispersion or deposition at the location of the controlling receptor, for release pathway v, as appropriate to exposure pathway p and radionuclide i.

For all tritium pathways, and for the inhalation of any radionuclide: W_{vip} is $\overline{(X/Q)}_{vp}$, the annual average relative dispersion factor for release pathway v, at the location of the controlling receptor (s/m^3). For the ground-plane exposure pathway, and for all ingestion-related pathways for radionuclides other than tritium: W_{vip} is $\overline{(D/Q)}_{vp}$, the annual average relative deposition factor for release pathway v, at the location of the controlling receptor (m^{-2}). Values of $\overline{(X/Q)}_{vp}$ and $\overline{(D/Q)}_{vp}$ for use in calculating the dose to the currently-defined controlling receptor are included in Table 3-7.

$\tilde{Q}'_{iv}$ = the cumulative release of radionuclide i from release pathway v, during the period of interest (μCi). For the purpose of implementing the controls of Section 3.1.4, only I–131, I–133, tritium, and all radionuclides in particulate form with half-lives greater than 8 days should be included in this calculation. In any dose assessment using the methods of this subsection, only radionuclides detectable above background in their respective samples should be included in the calculation.

Because the member of the public dose limit is on a per-unit basis, the summations extend over all gaseous final release pathways for a given *unit*. For a release pathway discharging materials originating in both reactor units, the activity discharged from the release point may be apportioned between the two units in any reasonable manner, provided that all activity released from the plant site is apportioned to one or the other unit.

The gaseous final release pathways at the plant site, and the release elevation for each, are identified in Table 3-4.

Table 3-7. Attributes of the Controlling Receptor

The locations of members of the public in the vicinity of the plant site, and the exposure pathways associated with those locations, are determined in the Annual Land Use Census. Dispersion and deposition values were calculated based on site meteorological data collected for the period January 1, 1985 through December 31, 1987.

Based on an analysis of this information, the current controlling receptor for the plant site is described as follows.

Sector: WSW

Distance: 1.2 miles

Age Group: Child

Exposure Pathways: Inhalation, ground plane, cow meat, and garden vegetation

Dispersion Factors $\overline{(X/Q)}_{vb}$:

Ground-Level release points: 6.20 E-7 s/m^3
Mixed-Mode release points: 1.27 E-7 s/m^3

Deposition Factors $\overline{(D/Q)}_{vb}$:

Ground-Level release points: 2.80 E-9 m^{-2}
Mixed-Mode release points: 9.90 E-10 m^{-2}

3.4.4 Dose Calculations to Support Other Requirements

Case 1: A radiological impact assessment may be required to support evaluation of a reportable event.

Dose calculations may be performed using the equations in Section 3.4.3, with the substitution of the dispersion and deposition parameters [(X/Q) and (D/Q)] for the period covered by the report, and using the appropriate pathway dose factors (R_{aipj}) for the receptor of interest. Methods for calculating (X/Q) and (D/Q) from meteorological data are presented in Chapter 8.

Values of R_{aipj} other than those presented in Tables 3-8 through 3-12 may need to be calculated. Methods and parameters for calculating values of R_{aipj} are presented in Chapter 9. When calculating R_{aipj} for evaluation of an event, pathway and usage factors specific to the receptor involved in the event may be used in place of the values in Chapter 9, if the specific values are known.

Case 2: A dose calculation is required to evaluate the results of the Land Use Census, under the provisions of Section 4.1.2.

In the event that the Land Use Census reveals that exposure pathways have changed at previously-identified locations, or if new locations are identified, it may be necessary to calculate doses at two or more locations to determine which should be designated as the controlling receptor. Such dose calculations may be performed using the equations in Section 3.4.3, with the substitution of the annual average dispersion and deposition values [$\overline{(X/Q)}$ and $\overline{(D/Q)}$] for the locations of interest, and using the appropriate pathway dose factors (R_{aipj}) for the receptors of interest.

Methods for calculating (X/Q) and (D/Q) from meteorological data are presented in Chapter 8. The values of R_{aipj} other than those presented in Tables 3-8 through 3-12 may need to be calculated. Methods and parameters for calculating values of R_{aipj} are presented in Chapter 9.

Case 3: Under Section 5.2, a dose calculation may be required to support the determination of a component of the total dose to a receptor other than that currently defined as the controlling receptor.

Dose calculations would be performed using the equations in Section 3.4.3, with the dispersion and deposition parameters and appropriate values of (R_{aipj}) for the receptor of interest.

Appropriate values of the dispersion and deposition parameters, if not found in Table 3-7, would need to be calculated. Methods for calculating (X/Q) and (D/Q) from meterological data are presented in Chapter 8.

Appropriate values of R_{aipj}, if not found in Tables 3-8 through 3-12, would need to be calculated. Methods and parameters for calculating values of R_{aipj} are presented in Chapter 9.

Table 3-8. R_{aipj} for Ground Plane Pathway, All Age Groups

Nuclide	T. Body	Skin
H-3	0.00	0.00
C-14	0.00	0.00
P-32	0.00	0.00
Cr-51	4.66E+06	5.51E+06
Mn-54	1.39E+09	1.63E+09
Fe-55	0.00	0.00
Fe-59	2.73E+08	3.21E+08
Co-58	3.79E+08	4.44E+08
Co-60	2.15E+10	2.53E+10
Ni-63	0.00	0.00
Zn-65	7.47E+08	8.59E+08
Rb-86	8.99E+06	1.03E+07
Sr-89	2.16E+04	2.51E+04
Sr-90	0.00	0.00
Y-91	1.07E+06	1.21E+06
Zr-95	2.45E+08	2.84E+08
Nb-95	1.37E+08	1.61E+08
Ru-103	1.08E+08	1.26E+08
Ru-106	4.22E+08	5.07E+08
Ag-110m	3.44E+09	4.01E+09
Sb-124	5.98E+08	6.90E+08
Sb-125	2.34E+09	2.64E+09
Te-125m	1.55E+06	2.13E+06
Te-127m	9.16E+04	1.08E+05
Te-129m	1.98E+07	2.31E+07
I-131	1.72E+07	2.09E+07
I-133	2.45E+06	2.98E+06
Cs-134	6.86E+09	8.00E+09
Cs-136	1.51E+08	1.71E+08
Cs-137	1.03E+10	1.20E+10
Ba-140	2.05E+07	2.35E+07
Ce-141	1.37E+07	1.54E+07
Ce-144	6.95E+07	8.04E+07
Pr-143	0.00	0.00
Nd-147	8.39E+06	1.01E+07

1. Units are $m^2 \cdot (mrem/yr)/(\mu Ci/s)$.
2. The values in the Total Body column also apply to the Bone, Liver, Thyroid, Kidney, Lung, and GI-LLI organs.
3. This table also supports the calculations of section 6.2.

Table 3-9. R_{aipj} for Inhalation Pathway, Child Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00	1.12E+03	1.12E+03	1.12E+03	1.12E+03	1.12E+03	1.12E+03
C-14	3.59E+04	6.73E+03	6.73E+03	6.73E+03	6.73E+03	6.73E+03	6.73E+03
P-32	2.60E+06	1.14E+05	9.88E+04	0.00	0.00	0.00	4.22E+04
Cr-51	0.00	0.00	1.54E+02	8.55E+01	2.43E+01	1.70E+04	1.08E+03
Mn-54	0.00	4.29E+04	9.51E+03	0.00	1.00E+04	1.58E+06	2.29E+04
Fe-55	4.74E+04	2.52E+04	7.77E+03	0.00	0.00	1.11E+05	2.87E+03
Fe-59	2.07E+04	3.34E+04	1.67E+04	0.00	0.00	1.27E+06	7.07E+04
Co-58	0.00	1.77E+03	3.16E+03	0.00	0.00	1.11E+06	3.44E+04
Co-60	0.00	1.31E+04	2.26E+04	0.00	0.00	7.07E+06	9.62E+04
Ni-63	8.21E+05	4.63E+04	2.80E+04	0.00	0.00	2.75E+05	6.33E+03
Zn-65	4.26E+04	1.13E+05	7.03E+04	0.00	7.14E+04	9.95E+05	1.63E+04
Rb-86	0.00	1.98E+05	1.14E+05	0.00	0.00	0.00	7.99E+03
Sr-89	5.99E+05	0.00	1.72E+04	0.00	0.00	2.16E+06	1.67E+05
Sr-90	1.01E+08	0.00	6.44E+06	0.00	0.00	1.48E+07	3.43E+05
Y-91	9.14E+05	0.00	2.44E+04	0.00	0.00	2.63E+06	1.84E+05
Zr-95	1.90E+05	4.18E+04	3.70E+04	0.00	5.96E+04	2.23E+06	6.11E+04
Nb-95	2.35E+04	9.18E+03	6.55E+03	0.00	8.62E+03	6.14E+05	3.70E+04
Ru-103	2.79E+03	0.00	1.07E+03	0.00	7.03E+03	6.62E+05	4.48E+04
Ru-106	1.36E+05	0.00	1.69E+04	0.00	1.84E+05	1.43E+07	4.29E+05
Ag-110m	1.69E+04	1.14E+04	9.14E+03	0.00	2.12E+04	5.48E+06	1.00E+05
Sb-124	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sb-125	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Te-125m	6.73E+03	2.33E+03	9.14E+02	1.92E+03	0.00	4.77E+05	3.38E+04
Te-127m	2.49E+04	8.55E+03	3.02E+03	6.07E+03	6.36E+04	1.48E+06	7.14E+04
Te-129m	1.92E+04	6.85E+03	3.04E+03	6.33E+03	5.03E+04	1.76E+06	1.82E+05
I-131	4.81E+04	4.81E+04	2.73E+04	1.62E+07	7.88E+04	0.00	2.84E+03
I-133	1.66E+04	2.03E+04	7.70E+03	3.85E+06	3.38E+04	0.00	5.48E+03
Cs-134	6.51E+05	1.01E+06	2.25E+05	0.00	3.30E+05	1.21E+05	3.85E+03
Cs-136	6.51E+04	1.71E+05	1.16E+05	0.00	9.55E+04	1.45E+04	4.18E+03
Cs-137	9.07E+05	8.25E+05	1.28E+05	0.00	2.82E+05	1.04E+05	3.62E+03
Ba-140	7.40E+04	6.48E+01	4.33E+03	0.00	2.11E+01	1.74E+06	1.02E+05
Ce-141	3.92E+04	1.95E+04	2.90E+03	0.00	8.55E+03	5.44E+05	5.66E+04
Ce-144	6.77E+06	2.12E+06	3.61E+05	0.00	1.17E+06	1.20E+07	3.89E+05
Pr-143	1.85E+04	5.55E+03	9.14E+02	0.00	3.00E+03	4.33E+05	9.73E+04
Nd-147	1.08E+04	8.73E+03	6.81E+02	0.00	4.81E+03	3.28E+05	8.21E+04

1. Units are (mrem/yr)/(μCi/m^3) for all radionuclides.
2. This table also supports the calculations of section 6.2.

Table 3-10. R_{aipj} for Inhalation Pathway, Adult Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00	1.26E+03	1.26E+03	1.26E+03	1.26E+03	1.26E+03	1.26E+03
C-14	1.82E+04	3.41E+03	3.41E+03	3.41E+03	3.41E+03	3.41E+03	3.41E+03
P-32	1.32E+06	7.71E+04	5.01E+04	0.00	0.00	0.00	8.64E+04
Cr-51	0.00	0.00	1.00E+02	5.95E+01	2.28E+01	1.44E+04	3.32E+03
Mn-54	0.00	3.96E+04	6.30E+03	0.00	9.84E+03	1.40E+06	7.74E+04
Fe-55	2.46E+04	1.70E+04	3.94E+03	0.00	0.00	7.21E+04	6.03E+03
Fe-59	1.18E+04	2.78E+04	1.06E+04	0.00	0.00	1.02E+06	1.88E+05
Co-58	0.00	1.58E+03	2.07E+03	0.00	0.00	9.28E+05	1.06E+05
Co-60	0.00	1.15E+04	1.48E+04	0.00	0.00	5.97E+06	2.85E+05
Ni-63	4.32E+05	3.14E+04	1.45E+04	0.00	0.00	1.78E+05	1.34E+04
Zn-65	3.24E+04	1.03E+05	4.66E+04	0.00	6.90E+04	8.64E+05	5.34E+04
Rb-86	0.00	1.35E+05	5.90E+04	0.00	0.00	0.00	1.66E+04
Sr-89	3.04E+05	0.00	8.72E+03	0.00	0.00	1.40E+06	3.50E+05
Sr-90	9.92E+07	0.00	6.10E+06	0.00	0.00	9.60E+06	7.22E+05
Y-91	4.62E+05	0.00	1.24E+04	0.00	0.00	1.70E+06	3.85E+05
Zr-95	1.07E+05	3.44E+04	2.33E+04	0.00	5.42E+04	1.77E+06	1.50E+05
Nb-95	1.41E+04	7.82E+03	4.21E+03	0.00	7.74E+03	5.05E+05	1.04E+05
Ru-103	1.53E+03	0.00	6.58E+02	0.00	5.83E+03	5.05E+05	1.10E+05
Ru-106	6.91E+04	0.00	8.72E+03	0.00	1.34E+05	9.36E+06	9.12E+05
Ag-110m	1.08E+04	1.00E+04	5.94E+03	0.00	1.97E+04	4.63E+06	3.02E+05
Sb-124	3.12E+04	5.89E+02	1.24E+04	7.55E+01	0.00	2.48E+06	4.06E+05
Sb-125	6.61E+04	7.13E+02	1.33E+04	5.87E+01	0.00	2.20E+06	1.01E+05
Te-125m	3.42E+03	1.58E+03	4.67E+02	1.05E+03	1.24E+04	3.14E+05	7.06E+04
Te-127m	1.26E+04	5.77E+03	1.57E+03	3.29E+03	4.58E+04	9.60E+05	1.50E+05
Te-129m	9.76E+03	4.67E+03	1.58E+03	3.44E+03	3.66E+04	1.16E+06	3.83E+05
I-131	2.52E+04	3.58E+04	2.05E+04	1.19E+07	6.13E+04	0.00	6.28E+03
I-133	8.64E+03	1.48E+04	4.52E+03	2.15E+06	2.58E+04	0.00	8.88E+03
Cs-134	3.73E+05	8.48E+05	7.28E+05	0.00	2.87E+05	9.76E+04	1.04E+04
Cs-136	3.90E+04	1.46E+05	1.10E+05	0.00	8.56E+04	1.20E+04	1.17E+04
Cs-137	4.78E+05	6.21E+05	4.28E+05	0.00	2.22E+05	7.52E+04	8.40E+03
Ba-140	3.90E+04	4.90E+01	2.57E+03	0.00	1.67E+01	1.27E+06	2.18E+05
Ce-141	1.99E+04	1.35E+04	1.53E+03	0.00	6.26E+03	3.62E+05	1.20E+05
Ce-144	3.43E+06	1.43E+06	1.84E+05	0.00	8.48E+05	7.78E+06	8.16E+05
Pr-143	9.36E+03	3.75E+03	4.64E+02	0.00	2.16E+03	2.81E+05	2.00E+05
Nd-147	5.27E+03	6.10E+03	3.65E+02	0.00	3.56E+03	2.21E+05	1.73E+05

1. Units are (mrem/yr)/(μCi/m^3) for all radionuclides.
2. This table is included to support the calculations of section 6.2.

Table 3-11. R_{aipj} for Cow Meat Pathway, Child Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00	2.34E+02	2.34E+02	2.34E+02	2.34E+02	2.34E+02	2.34E+02
C-14	5.29E+05	1.06E+05	1.06E+05	1.06E+05	1.06E+05	1.06E+05	1.06E+05
P-32	7.41E+09	3.47E+08	2.86E+08	0.00	0.00	0.00	2.05E+08
Cr-51	0.00	0.00	8.79E+03	4.88E+03	1.33E+03	8.91E+03	4.66E+05
Mn-54	0.00	8.01E+06	2.13E+06	0.00	2.25E+06	0.00	6.72E+06
Fe-55	4.57E+08	2.42E+08	7.51E+07	0.00	0.00	1.37E+08	4.49E+07
Fe-59	3.76E+08	6.09E+08	3.03E+08	0.00	0.00	1.77E+08	6.34E+08
Co-58	0.00	1.64E+07	5.02E+07	0.00	0.00	0.00	9.58E+07
Co-60	0.00	6.93E+07	2.04E+08	0.00	0.00	0.00	3.84E+08
Ni-63	2.91E+10	1.56E+09	9.91E+08	0.00	0.00	0.00	1.05E+08
Zn-65	3.75E+08	1.00E+09	6.22E+08	0.00	6.30E+08	0.00	1.76E+08
Rb-86	0.00	5.77E+08	3.55E+08	0.00	0.00	0.00	3.71E+07
Sr-89	4.82E+08	0.00	1.38E+07	0.00	0.00	0.00	1.87E+07
Sr-90	1.04E+10	0.00	2.64E+09	0.00	0.00	0.00	1.40E+08
Y-91	1.80E+06	0.00	4.82E+04	0.00	0.00	0.00	2.40E+08
Zr-95	2.66E+06	5.85E+05	5.21E+05	0.00	8.38E+05	0.00	6.11E+08
Nb-95	3.10E+06	1.21E+06	8.62E+05	0.00	1.13E+06	0.00	2.23E+09
Ru-103	1.55E+08	0.00	5.96E+07	0.00	3.90E+08	0.00	4.01E+09
Ru-106	4.44E+09	0.00	5.54E+08	0.00	5.99E+09	0.00	6.90E+10
Ag-110m	8.39E+06	5.67E+06	4.53E+06	0.00	1.06E+07	0.00	6.74E+08
Sb-124	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sb-125	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Te-125m	5.69E+08	1.54E+08	7.59E+07	1.60E+08	0.00	0.00	5.49E+08
Te-127m	1.77E+09	4.78E+08	2.11E+08	4.24E+08	5.06E+09	0.00	1.44E+09
Te-129m	1.79E+09	5.00E+08	2.78E+08	5.77E+08	5.26E+09	0.00	2.18E+09
I-131	1.65E+07	1.66E+07	9.46E+06	5.50E+09	2.73E+07	0.00	1.48E+06
I-133	5.67E-01	7.02E-01	2.66E-01	1.30E+02	1.17E+00	0.00	2.83E-01
Cs-134	9.22E+08	1.51E+09	3.19E+08	0.00	4.69E+08	1.68E+08	8.16E+06
Cs-136	1.62E+07	4.46E+07	2.88E+07	0.00	2.37E+07	3.54E+06	1.57E+06
Cs-137	1.33E+09	1.28E+09	1.88E+08	0.00	4.16E+08	1.50E+08	7.99E+06
Ba-140	4.38E+07	3.84E+04	2.56E+06	0.00	1.25E+04	2.29E+04	2.22E+07
Ce-141	2.22E+04	1.11E+04	1.64E+03	0.00	4.86E+03	0.00	1.38E+07
Ce-144	2.32E+06	7.26E+05	1.24E+05	0.00	4.02E+05	0.00	1.89E+08
Pr-143	3.34E+04	1.00E+04	1.66E+03	0.00	5.43E+03	0.00	3.60E+07
Nd-147	1.17E+04	9.47E+03	7.33E+02	0.00	5.19E+03	0.00	1.50E+07

Units are (mrem/yr)/(μCi/m^3) for tritium, and m^2·(mrem/yr)/(μCi/s) for all other radionuclides.

Table 3-12. R_{aipj} for Garden Vegetation Pathway, Child Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00	4.01E+03	4.01E+03	4.01E+03	4.01E+03	4.01E+03	4.01E+03
C-14	8.89E+08	1.78E+08	1.78E+08	1.78E+08	1.78E+08	1.78E+08	1.78E+08
P-32	3.37E+09	1.58E+08	1.30E+08	0.00	0.00	0.00	9.31E+07
Cr-51	0.00	0.00	1.17E+05	6.50E+04	1.78E+04	1.19E+05	6.21E+06
Mn-54	0.00	6.65E+08	1.77E+08	0.00	1.86E+08	0.00	5.58E+08
Fe-55	8.01E+08	4.25E+08	1.32E+08	0.00	0.00	2.40E+08	7.87E+07
Fe-59	3.98E+08	6.43E+08	3.20E+08	0.00	0.00	1.86E+08	6.70E+08
Co-58	0.00	6.44E+07	1.97E+08	0.00	0.00	0.00	3.76E+08
Co-60	0.00	3.78E+08	1.12E+09	0.00	0.00	0.00	2.10E+09
Ni-63	3.95E+10	2.11E+09	1.34E+09	0.00	0.00	0.00	1.42E+08
Zn-65	8.13E+08	2.16E+09	1.35E+09	0.00	1.36E+09	0.00	3.80E+08
Rb-86	0.00	4.52E+08	2.78E+08	0.00	0.00	0.00	2.91E+07
Sr-89	3.60E+10	0.00	1.03E+09	0.00	0.00	0.00	1.39E+09
Sr-90	1.24E+12	0.00	3.15E+11	0.00	0.00	0.00	1.67E+10
Y-91	1.86E+07	0.00	4.99E+05	0.00	0.00	0.00	2.48E+09
Zr-95	3.86E+06	8.48E+05	7.55E+05	0.00	1.21E+06	0.00	8.85E+08
Nb-95	4.10E+05	1.60E+05	1.14E+05	0.00	1.50E+05	0.00	2.96E+08
Ru-103	1.53E+07	0.00	5.90E+06	0.00	3.86E+07	0.00	3.97E+08
Ru-106	7.45E+08	0.00	9.30E+07	0.00	1.01E+09	0.00	1.16E+10
Ag-110m	3.21E+07	2.17E+07	1.73E+07	0.00	4.04E+07	0.00	2.58E+09
Sb-124	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sb-125	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Te-125m	3.51E+08	9.50E+07	4.67E+07	9.84E+07	0.00	0.00	3.38E+08
Te-127m	1.32E+09	3.56E+08	1.57E+08	3.16E+08	3.77E+09	0.00	1.07E+09
Te-129m	8.41E+08	2.35E+08	1.31E+08	2.71E+08	2.47E+09	0.00	1.03E+09
I-131	1.43E+08	1.44E+08	8.17E+07	4.75E+10	2.36E+08	0.00	1.28E+07
I-133	3.53E+06	4.37E+06	1.65E+06	8.11E+08	7.28E+06	0.00	1.76E+06
Cs-134	1.60E+10	2.63E+10	5.55E+09	0.00	8.15E+09	2.93E+09	1.42E+08
Cs-136	8.24E+07	2.27E+08	1.47E+08	0.00	1.21E+08	1.80E+07	7.96E+06
Cs-137	2.39E+10	2.29E+10	3.38E+09	0.00	7.46E+09	2.68E+09	1.43E+08
Ba-140	2.77E+08	2.42E+05	1.61E+07	0.00	7.89E+04	1.45E+05	1.40E+08
Ce-141	6.56E+05	3.27E+05	4.86E+04	0.00	1.43E+05	0.00	4.08E+08
Ce-144	1.27E+08	3.98E+07	6.78E+06	0.00	2.21E+07	0.00	1.04E+10
Pr-143	1.46E+05	4.37E+04	7.23E+03	0.00	2.37E+04	0.00	1.57E+08
Nd-147	7.15E+04	5.79E+04	4.48E+03	0.00	3.18E+04	0.00	9.17E+07

Units are (mrem/yr)/(μCi/m^3) for tritium, and $m^2\cdot$(mrem/yr)/(μCi/s) for all other radionuclides.

3.5 GASEOUS EFFLUENT DOSE PROJECTIONS

3.5.1 Thirty-One Day Dose Projections

In order to meet the requirements of the limit for operation of the gaseous radwaste treatment system (see Section 3.1.5), dose projections must be made at least once each 31 days; this applies during periods in which a discharge to areas at or beyond the SITE BOUNDARY of gaseous effluents containing radioactive materials occurs or is expected.

Projected 31–day air doses and doses to individuals due to gaseous effluents may be determined as follows:

For air doses:

$$D_{\beta\rho} = \left(\frac{D_{\beta c}}{t}\right) \times 31 + D_{\beta a}$$

$$D_{\gamma\rho} = \left(\frac{D_{\gamma c}}{t}\right) \times 31 + D_{\gamma a} \qquad \textbf{(3.16)}$$

For individual doses:

$$D_{op} = \left(\frac{D_{oc}}{t}\right) \times 31 + D_{oa} \qquad \textbf{(3.17)}$$

where:

$D_{\beta p}$ = the projected air dose due to beta emissions from noble gases, for the next 31 days of gaseous releases.

$D_{\beta c}$ = the cumulative air dose due to beta emissions from noble gas releases that have occurred in the elapsed portion of the current quarter, plus the release under consideration.

$D_{\beta a}$ = the anticipated air dose due to beta emissions from noble gas releases, contributed by any planned activities during the next 31–day period, if those activities will result in gaseous releases that are in addition to routine gaseous effluents. If only routine gaseous effluents are anticipated, $D_{\beta a}$ may be set to zero.

$D_{\gamma p}$ = the projected air dose due to gamma emissions from noble gases for the next 31 days of gaseous releases.

$D_{\gamma c}$ = the cumulative air dose due to gamma emissions from noble gas releases that have occurred in the elapsed portion of the current quarter, plus the release under consideration.

$D_{\gamma a}$ = the anticipated air dose due to gamma emissions from noble gas releases, contributed by any planned activities during the next 31–day period, if those activities will result in gaseous releases that are in addition to routine gaseous effluents. If only routine gaseous effluents are anticipated, $D_{\gamma a}$ may be set to zero.

D_{op} = the projected dose to the total body or organ o, due to releases of I–131, I-133, tritium, and particulates for the next 31 days of gaseous releases.

D_{oc} = the cumulative dose to the total body or organ o, due to releases of I–131, I-133, tritium, and particulates that have occurred in the elapsed portion of the current quarter, plus the release under consideration.

D_{oa} = the anticipated dose to the total body or organ o, due to releases of I–131, I-133, tritium, and particulates, contributed by any planned activities during the next 31–day period, if those activities will result in gaseous releases that are in addition to routine gaseous effluents. If only routine gaseous effluents are anticipated, D_{oa} may be set to zero.

t = the number of whole or partial days elapsed into the current quarter, including the time to the end of the release under consideration (even if the release continues into the next quarter).

3.5.2 Dose Projections for Specific Releases

Dose projections may be performed for a particular release by performing a pre-release dose calculation assuming that the planned release will proceed as anticipated. For air dose and individual dose projections due to gaseous effluent releases, follow the methodology of Section 3.4, using sample analysis results for the gaseous stream to be released, and parameter values expected to exist during the release period.

3.6 DEFINITIONS OF GASEOUS EFFLUENT TERMS

Term	Definition	Section of Initial Use
AG =	the administrative allocation factor for gaseous streams, applied to divide the gaseous release limit among all the release pathways [unitless].	3.3.2.1
AG_s =	the administrative allocation factor for gaseous source stream s, applied to divide the gaseous release limit among all the release pathways [unitless].	3.3.3
AG_v =	the administrative allocation factor for gaseous release pathway v, applied to divide the gaseous release limit among all the release pathways [unitless].	3.3.2.2
c =	the setpoint of the radioactivity monitor measuring the concentration of radioactivity in the effluent line prior to release [μCi/mL].	3.3.2.1
c_{ns} =	the calculated noble gas effluent monitor setpoint for gaseous source stream s [μCi/mL].	3.3.3
c_{nv} =	the calculated noble gas effluent monitor setpoint for release pathway v [μCi/mL].	3.3.2.2
D_{ja} =	the dose to organ j of an individual in age group a, due to gaseous releases of I–131, I–133, tritium, and radionuclides in particulate form with half-lives greater than 8 days [mrem].	3.4.3
D_{oa} =	the anticipated dose to organ o due to releases of non-noble-gas radionuclides, contributed by any planned activities during the next 31–day period [mrem].	3.5.1
D_{oc} =	the cumulative dose to organ o due to releases of non-noble-gas radionuclides that have occurred in the elapsed portion of the current quarter, plus the release under consideration [mrem].	3.5.1
D_{op} =	the projected dose to organ o due to the next 31 days of gaseous releases of non-noble-gas radionuclides [mrem].	3.5.1
D_β =	the air dose due to beta emissions from noble gas radionuclides [mrad].	3.4.2
$D_{\beta a}$ =	the anticipated air dose due to beta emissions from noble gas releases, contributed by any planned activities during the next 31–day period [mrad].	3.5.1

Term	Definition	Section of Initial Use
$D_{\beta c}$ =	the cumulative air dose due to beta emissions from noble gas releases that have occurred in the elapsed portion of the current quarter, plus the release under consideration [mrad].	3.5.1
$D_{\beta p}$ =	the projected air dose due to beta emissions from noble gases, for the next 31 days of gaseous releases [mrad].	3.5.1
D_{γ} =	the air dose due to gamma emissions from noble gas radionuclides [mrad].	3.4.2
$D_{\gamma a}$ =	the anticipated air dose due to gamma emissions from noble gas releases, contributed by any planned activities during the next 31–day period [mrad].	3.5.1
$D_{\gamma c}$ =	the cumulative air dose due to gamma emissions from noble gas releases that have occurred in the elapsed portion of the current quarter, plus the release under consideration [mrad].	3.5.1
$D\gamma_{p}$ =	the projected air dose due to gamma emissions from noble gases, for the next 31 days of gaseous releases [mrad].	3.5.1
$(\overline{D/Q})_{vp}$ =	the annual average relative deposition factor for release pathway v, at the location of the controlling receptor, from Table 3-7 [m^{-2}].	3.4.3
DR_k =	the skin dose rate at the time of the release [mrem/y].	3.4.1.1
DR_o =	the dose rate to organ o at the time of the release [mrem/y].	3.4.1.2
DR_t =	the total body dose rate at the time of the release [mrem/y].	3.4.1.1
f_{av} =	the maximum anticipated actual discharge flowrate for release pathway v during the period of the planned release [mL/s].	3.3.2.2
f_{as} =	the maximum anticipated actual discharge flowrate for gaseous source stream s during the period of the planned release [mL/s].	3.3.3
K_i =	the total body dose factor due to gamma emissions from noble gas radionuclide i, from Table 3-5 [(mrem/y)/(μCi/m^3)].	3.3.2.2
L_i =	the skin dose factor due to beta emissions from noble gas radionuclide i, from Table 3-5 [(mrem/y)/(μCi/m^3)].	3.3.2.2
M_i =	the air dose factor due to gamma emissions from noble gas radionuclide i, from Table 3-5 [(mrad/y)/(μCi/m^3)].	3.4.2

Term	Definition	Section of Initial Use
N =	the number of simultaneously active gaseous release pathways [unitless].	3.3.4
N_i =	the air dose factor due to beta emissions from noble gas radionuclide i, from Table 3-5 [(mrad/y)/(μCi/m^3)].	3.4.2
P_{io} =	the site-specific dose factor for radionuclide i (I–131, I–133, tritium, and radionuclides in particulate form with half-lives greater than 8 days) and organ o. The values of P_{io} are equal to the site-specific R_{aipj} values presented in Table 3-9 [(mrem/y)/(μCi/m^3)].	3.4.1.2
Q_{iv} =	the release rate of noble gas radionuclide i from release pathway v during the period of interest [μCi/s].	3.3.2.2
Q'_{iv}=	the release rate of radionuclide i (I–131, I–133, tritium, and radionuclides in particulate form with half-lives greater than 8 days) from gaseous release pathway v during the period of interest [μCi/s].	3.4.1.2
$\tilde{Q}_{iv}$ =	the cumulative release of noble gas radionuclide i from release pathway v during the period of interest [μCi].	3.4.2
$\tilde{Q}'_{iv}$=	the cumulative release of non-noble-gas radionuclide i from release pathway v, during the period of interest [μCi].	3.4.3
R_{aipj} =	the site-specific dose factor for age group a, radionuclide i, exposure pathway p, and organ j. Values and units of R_{aipj} for each exposure pathway, age group, and radionuclide that may arise in calculations for implementing Section 3.1.4 are listed in Table 3-8 through Table 3-9.	3.4.3
R_k =	the ratio of the skin dose rate limit for noble gases, to the skin dose rate due to noble gases in the release under consideration [unitless].	3.3.2.1
R_t =	the ratio of the total body dose rate limit for noble gases, to the total body dose rate due to noble gases in the release under consideration [unitless].	3.3.2.1
r_k =	the ratio of the skin dose rate limit for noble gases, to the skin dose rate due to noble gases in the source stream under consideration [unitless].	3.3.3.1
r_t =	the ratio of the total body dose rate limit for noble gases, to the total body dose rate due to noble gases in the source stream under consideration [unitless].	3.3.3.1

Term	Definition	Section of Initial Use
SF =	the safety factor used in gaseous setpoint calculations to compensate for statistical fluctuations and errors of measurement [unitless].	3.3.2.2
t =	the number of whole or partial days elapsed in the current quarter, including the period of the release under consideration.	3.5.1
W_{vip} =	the annual average relative dispersion [$\overline{(X/Q)}_{vp}$] or deposition [$\overline{(D/Q)}_{vp}$] at the location of the controlling receptor, for release pathway v, as appropriate to exposure pathway p and radionuclide i.	3.4.3
X =	the noble gas concentration for the release under consideration [μCi/mL].	3.3.2.1
X_{ir} =	the concentration of radionuclide i applicable to active gaseous release pathway r [μCi/mL].	3.3.4
X_{is} =	the measured concentration of radionuclide i in gaseous source stream s [μCi/mL].	3.3.3
X_{iv} =	the measured concentration of radionuclide i in gaseous stream v [μCi/mL].	3.3.2.2
(X/Q) =	the highest relative concentration at any point at or beyond the SITE BOUNDARY [s/m^3].	3.3.2.1
$\overline{(X/Q)}_{rb}$ =	the annual average SITE BOUNDARY relative concentration applicable to active gaseous release pathway r [s/m^3].	3.3.4
$\overline{(X/Q)}_{vb}$ =	the highest annual average relative concentration at the SITE BOUNDARY for the discharge point of release pathway v, from Table 3-4 [s/m^3].	3.3.2.2
$\overline{(X/Q)}_{vp}$ =	annual average relative dispersion factor for release pathway v, at the location of the controlling receptor, from Table 3-7 [s/m^3].	3.4.3

CHAPTER 4
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

4.1 LIMITS OF OPERATION

The following limits are the same for both units at the site. Thus, a single program including monitoring, land use survey, and quality assurance serves both units.

4.1.1 Radiological Environmental Monitoring

The Radiological Environmental Monitoring Program (REMP) shall be conducted as specified in Table 4-1.

4.1.1.1 Applicability

This control applies at all times.

4.1.1.2 Actions

4.1.1.2.1 With the REMP not being conducted as specified in Table 4-1, submit to the Nuclear Regulatory Commission (NRC), in the Annual Radiological Environmental Operating Report, a description of the reasons for not conducting the program as required and the plans for preventing a recurrence. Deviations from the required sampling schedule are permitted if specimens are unobtainable due to hazardous conditions, unavailability, inclement weather, equipment malfunction, or other just reasons. If deviations are due to equipment malfunction, efforts shall be made to complete corrective action prior to the end of the next sampling period.

4.1.1.2.2 With the confirmed[1] measured level of radioactivity as a result of plant effluents in an environmental sampling medium specified in Table 4-1 exceeding the reporting levels of Table 4-2 when averaged over any calendar quarter, submit within 30 days a special report to the NRC. The special report shall identify the cause(s) for exceeding the limit(s) and define the corrective action(s) to be taken to reduce radioactive effluents so that the potential annual dose to a MEMBER OF THE PUBLIC is less than the calendar year limits of Sections 2.1.3, 3.1.3, and 3.1.4. The methodology and parameters used to estimate the potential annual dose to a MEMBER OF THE PUBLIC shall be indicated in the special report.

When more than one of the radionuclides in Table 4-2 are detected in the sampling medium, this report shall be submitted if:

$$\frac{concentration\ (1)}{reporting\ level\ (1)} + \frac{concentration\ (2)}{reporting\ level\ (2)} + \cdots \geq 1.0$$

1 Defined as confirmed by reanalysis of the original sample, or analysis of a duplicate or new sample, as appropriate. The results of the confirmatory analysis shall be completed at the earliest time consistent with the analysis.

When radionuclides other than those in Table 4-2 are detected and are the result of plant effluents, this special report shall be submitted if the potential annual dose to a MEMBER OF THE PUBLIC is equal to or greater than the calendar year limits stated in Sections 2.1.3, 3.1.3, and 3.1.4. This special report is not required if the measured level of radioactivity was not the result of plant effluents; however, in such an event, the condition shall be described in the Annual Radiological Environmental Operating Report. The levels of naturally-occurring radionuclides which are not included in the plant's effluent releases need not be reported.

4.1.1.2.3 If adequate samples of milk, or during the growing season, grass or leafy vegetation, can no longer be obtained from one or more of the sample locations required by Table 4-1, or if the availability is frequently or persistently wanting, efforts shall be made: to identify specific locations for obtaining suitable replacement samples; and to add any replacement locations to the REMP given in the ODCM within 30 days. The specific locations from which samples became unavailable may be deleted from the REMP. Pursuant to Technical Specification 5.5.1, documentation shall be submitted in the next Radioactive Effluent Release Report for the change(s) in the ODCM, including revised figure(s) and table(s) reflecting the changes to the location(s), with supporting information identifying the cause of the unavailability of samples and justifying the selection of any new location(s).

4.1.1.2.4 This control does not affect shutdown requirements or MODE changes.

4.1.1.3 Surveillance Requirements

The REMP samples shall be collected pursuant to Table 4-1 from the locations described in Section 4.2, and shall be analyzed pursuant to the requirements of Table 4-1 and Table 4-3. Required detection capabilities for thermoluminescent dosimeters used for environmental measurements shall be in accordance with the recommendations of Regulatory Guide 4.13. Program changes may be initiated based on operational experience.

Analyses shall be performed in such a manner that the stated MINIMUM DETECTABLE CONCENTRATIONs (MDCs) will be achieved under routine conditions. Occasionally background fluctuations, unavoidable small sample sizes, the presence of interfering radionuclides, or other uncontrollable circumstances may render these MDCs unachievable. In such cases, the contributing factors will be identified and described in the Annual Radiological Environmental Operating Report.

4.1.1.4 Basis

The REMP required by this control provides representative measurements of radiation and of radioactive materials in those exposure pathways, and for those radionuclides, which lead to the highest potential radiation exposures of MEMBERS OF THE PUBLIC resulting from the plant operation. The REMP implements Section IV.B.2, Appendix I, 10 CFR 50, and thereby supplements the radiological effluent monitoring program by measuring concentrations of radioactive materials and levels of radiation, which may then be compared with those expected on the basis of the effluent measurements and modeling of the environmental exposure pathways.

The detection capabilities required by Table 4-3 are within state-of-the-art for routine environmental measurements in industrial laboratories.

Table 4-1. Radiological Environmental Monitoring Program

Exposure Pathway and/or Sample	Number of Representative Samples and Sample Locations(1)	Sampling and Collection Frequency	Type and Frequency of Analysis
	1. DIRECT RADIATION		
Direct Radiation(2)	Thirty-six or more routine monitoring stations, either with two or more dosimeters, or with one instrument for measuring and recording dose rate continuously, placed as follows: An inner ring of stations, one in each meteorological sector in the general area of the site boundary. An outer ring of stations, one in each meteorological sector at approximately 5 miles from the site. The balance of the stations to be placed in special interest areas such as population centers, nearby residences, schools, and in one or more areas to serve as control stations.	Quarterly.	Gamma dose quarterly.
	2. AIRBORNE		
Radioiodine and Particulates	Samples from 5 or more locations as follows: Three or more samples from close to the three site boundary locations, in different sectors. One sample from the vicinity of a community having the highest calculated annual average ground-level D/Q. One sample from a control location, as, for example, a population center 10 to 20 miles distant and in the least prevalent wind direction.	Continuous sampler operation with sample collection weekly, or more frequently if required by dust loading.	<u>Radioiodine Canister</u>: I-131 analysis weekly. <u>Particulate Sampler</u>: Gross beta radioactivity analysis following filter change, and gamma isotopic analysis of composite (by location) quarterly.(3)(4)

Table 4-1. Radiological Environmental Monitoring Program

Exposure Pathway and/or Sample	Number of Representative Samples and Sample Locations(1)	Sampling and Collection Frequency	Type and Frequency of Analysis
3. WATERBORNE			
Surface(5)	One sample upstream. One sample downstream.	Composite sample over 1-month period.(6)	Gamma isotopic analysis monthly; composite for tritium analysis quarterly.(4)
Drinking	Two samples at each of the one to three nearest water treatment plants that could be affected by discharges from the facility. Two samples at a control location.	Composite sample of river water near intake at each water treatment plant over 2-week period when I-131 analysis is performed, monthly composite otherwise; and grab sample of finished water at each water treatment plant every 2 weeks or monthly, as appropriate.(6)	I-131 analysis on each sample when the dose calculated for the consumption of the water is greater than 1 mrem per year. Composite for gross beta and gamma isotopic analyses monthly. Composite for tritium analysis quarterly.(4)(7)
Sediment from Shoreline	One sample from downstream area with existing or potential recreational value. One sample from upstream area not influenced by plant discharge.	Semiannually.	Gamma isotopic analysis semi-annually.(4)
Groundwater	On-site groundwater monitoring is not required at Vogtle per NUREG 1301. Groundwater monitoring is performed under NMP-EN-002.	See NMP-EN-002.	See NMP-EN-002.

Table 4-1. Radiological Environmental Monitoring Program

Exposure Pathway and/or Sample	Number of Representative Samples and Sample Locations(1)	Sampling and Collection Frequency	Type and Frequency of Analysis
	4. INGESTION		
Milk	Samples from milking animals in three locations within 3 miles distance having the highest dose potential; if there are none, then one sample from milking animals in each of three areas between 3 and 5 miles distance where doses are calculated to be greater than 1 mrem per year.(7) One sample from milking animals at a control location about 10 miles distant or beyond, and preferably in a wind direction of low prevalence.	Semimonthly.	Gamma isotopic analysis semi-monthly.(4)(8)
Fish	At least one sample of any commercially and recreationally important species in vicinity of plant discharge area. At least one sample of any species in areas not influenced by plant discharge.	Semiannually.	Gamma isotopic analyses on edible portions.(4)
	At least one sample of any anadromous species in vicinity of plant discharge.	During spring spawning season.	Gamma isotopic analyses on edible portion.(4)
Grass or Leafy Vegetation	One sample from two onsite locations near the site boundary in different sectors.	Monthly during growing season.	Gamma isotopic.(4)(8)
	One sample from a control location about 15 miles distant.	Monthly during growing season.	Gamma isotopic.(4)(8)

Table 4-1. Radiological Environmental Monitoring Program

TABLE NOTATIONS

(1) For each sample location in this table, specific parameters of distance and direction sector from a point midway between the center of the two reactors, and additional description where pertinent, are provided in Table 4-4, and in Figure 4-1 through Figure 4-4 of this ODCM.

(2) One or more instruments, such as a pressurized ion chamber, for measuring and recording dose rate continuously, may be used in place of or in addition to integrating dosimeters. For the purpose of this table, a thermoluminescent dosimeter (TLD) is considered to be one phosphor; two or more phosphors in a packet are considered as two or more dosimeters. Film badges shall not be used as dosimeters for measuring direct radiation.

(3) Airborne particulate sample filters shall be analyzed for gross beta radioactivity 24 hours or more after sampling to allow for radon and thoron daughter decay. If gross beta activity in air particulate samples is greater than 10 times the yearly mean of control samples, gamma isotopic analysis shall be performed on the individual samples.

(4) Gamma isotopic analysis means the identification and quantification of gamma-emitting radionuclides that may be attributable to the effluents from the facility.

(5) The upstream sample shall be taken at a distance beyond significant influence of the discharge. The downstream sample shall be taken in an area beyond but near the mixing zone.

(6) Composite sample aliquots shall be collected at time intervals that are very short (e.g., hourly) relative to the compositing period (e.g., monthly) in order to assure obtaining a representative sample.

(7) The dose shall be calculated for the maximum organ and age group, using the methodology and parameters in the ODCM.

(8) If gamma isotopic analysis is not sensitive enough to meet the required MDC for I-131, a separate analysis for I-131 will be performed.

Table 4-2. Reporting Levels for Radioactivity Concentrations in Environmental Samples

Analysis	Water (pCi/L)	Airborne Particulate or Gases (pCi/m^3)	Fish (pCi/kg, wet)	Milk (pCi/L)	Grass or Leafy Vegetation (pCi/kg, wet)
H-3	2 E+4[a]				
Mn-54	1 E+3		3 E+4		
Fe-59	4 E+2		1 E+4		
Co-58	1 E+3		3 E+4		
Co-60	3 E+2		1 E+4		
Zn-65	3 E+2		2 E+4		
Zr-95	4 E+2				
Nb-95	7 E+2				
I-131	2 E+0[b]	9 E-1		3 E+0	1 E+2
Cs-134	3 E+1	1 E+1	1 E+3	6 E+1	1 E+3
Cs-137	5 E+1	2 E+1	2 E+3	7 E+1	2 E+3
Ba-140	2 E+2			3 E+2	
La-140	1 E+2			4 E+2	

a. This is the 40 CFR 141 value for drinking water samples. If no drinking water pathway exists, a value of 3 E+04 pCi/L may be used.

b. If no drinking water pathway exists, a value of 20 pCi/L may be used.

Table 4-3. Values for the Minimum Detectable Concentration (MDC)

Analysis	Minimum Detectable Concentration (MDC)[a]					
	Water (pCi/L)	Airborne Particulate or Gases (pCi/m^3)	Fish (pCi/kg, wet)	Milk (pCi/L)	Grass or Leafy Vegetation (pCi/kg, wet)	Sediment (pCi/kg, dry)
Gross Beta	4 E+0	1 E-2				
H-3	2 E+3[b]					
Mn-54	1.5 E+1		1.3 E+2			
Fe-59	3 E+1		2.6 E+2			
Co-58, Co-60	1.5 E+1		1.3 E+2			
Zn-65	3 E+1		2.6 E+2			
Zr-95	3 E+1					
Nb-95	1.5 E+1					
I-131	1 E+0[c]	7 E-2		1 E+0	6 E+1	
Cs-134	1.5 E+1	5 E-2	1.3 E+2	1.5 E+1	6 E+1	1.5 E+2
Cs-137	1.8 E+1	6 E-2	1.5 E+2	1.8 E+1	8 E+1	1.8 E+2
Ba-140	6 E+1			6 E+1		
La-140	1.5 E+1			1.5 E+1		

a. See the definition of MINIMUM DETECTABLE CONCENTRATION in Section 10.1. Other peaks which are measurable and identifiable as plant effluents, together with the radionuclides in this table, shall be analyzed and reported in accordance with Section 7.1.

b. If no drinking water pathway exists, a value of 3 E+3 pCi/L may be used.

c. If no drinking water pathway exists, a value of 1.5 E+1 pCi/L may be used.

4.1.2 Land Use Census

A land use census shall be conducted and shall identify the following within a distance of 5 miles in each of the 16 meteorological sectors: the location of the nearest milk animal,[1] the nearest permanent residence, and the nearest garden of greater than 500 square feet producing broad leafy vegetation. Land within the Savannah River Site is excluded from this census.

4.1.2.1 Applicability

This control applies at all times.

4.1.2.2 Actions

4.1.2.2.1 With a land use census identifying a location(s) which yields a calculated dose or dose commitment greater than values currently being calculated in accordance with Section 3.4.3, identify the new location(s) in the next Radioactive Effluent Release Report.

4.1.2.2.2 With a land use census identifying a location(s) which yields a calculated dose or dose commitment (via the same exposure pathway) 20 percent greater than at a location from which samples are currently being obtained in accordance with Section 4.1.1, add the new location(s) to the REMP within 30 days if samples are available. The sampling location, excluding control station location(s), having the lowest calculated dose or dose commitment (via the same exposure pathway) may be deleted from the REMP if new sampling locations are added. Pursuant to Technical Specification 5.5.1 submit in the next Radioactive Effluent Release Report any change(s) in the ODCM, including the revised figure(s) and table(s) reflecting any new location(s) and information supporting the change(s).

4.1.2.2.3 This control does not affect shutdown requirements or MODE changes.

4.1.2.3 Surveillance Requirements

The land use census shall be conducted annually, using that information which will provide good results, such as a door-to-door census, a visual census from automobile or aircraft, consultation with local agriculture authorities, or some combination of these methods, as feasible. Results of the land use census shall be included in the Annual Radiological Environmental Operating Report.

4.1.2.4 Basis

This control is provided to ensure that changes in the use of UNRESTRICTED AREAS are identified and that modifications to the REMP are made if required by the results of this census. This census satisfies the requirements of Section IV.B.3 of Appendix I to 10 CFR Part 50. Restricting the census to gardens of greater than 500 ft^2 provides assurance that significant exposure pathways via leafy vegetables will be identified and monitored since a garden of this size is the minimum required to produce the quantity (26 kg/y) of leafy vegetables assumed in Regulatory Guide 1.109 for consumption by a child. To determine this minimum garden size, the following assumptions were made: (1) 20 percent of the garden was used for growing broad leaf vegetation (i.e., similar to lettuce and cabbage) and (2) a vegetation yield of 2 kg/m^2 was obtained.

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[1] Defined as a cow or goat that is producing milk for human consumption.

4.1.3 Interlaboratory Comparison Program

Analyses shall be performed on radioactive materials supplied as part of an Interlaboratory Comparison Program which satisfies the requirements of Regulatory Guide 4.15, Revision 1, February, 1979.

4.1.3.1 Applicability

This control applies at all times.

4.1.3.2 Actions

With analyses not being performed as required by Section 4.1.3, report the corrective actions taken to prevent a recurrence in the Annual Radiological Environmental Operating Report.

This control does not affect shutdown requirements or MODE changes.

4.1.3.3 Surveillance Requirements

A summary of the results obtained as part of the required Interlaboratory Comparison Program shall be included in the Annual Radiological Environmental Operating Report.

4.1.3.4 Basis

The requirement for participation in an approved Interlaboratory Comparison Program is provided to ensure that independent checks on the precision and accuracy of the measurements of radioactive material in environmental sample matrices are performed as part of the quality assurance program for environmental monitoring, in order to demonstrate that the results are reasonably valid for the purposes of Section IV.B.2, Appendix I, 10 CFR 50.

4.2 RADIOLOGICAL ENVIRONMENTAL MONITORING LOCATIONS

Table 4-4 and Figure 4-1 through Figure 4-4 specify the locations at which the measurements and samples are taken for the REMP required by Section 4.1.1.

Table 4-4. Radiological Environmental Monitoring Locations

Location Number	Descriptive Location	Direction	Distance (miles)	Sample Type(1)
1	River Bank	N	1.1	D
2	River Bank	NNE	0.8	D
3*	Discharge Area	NE	0.6	A
3*	River Bank	NE	0.7	D
4	River Bank	ENE	0.8	D
5	River Bank	E	1.0	D
6	Plant Wilson	ESE	1.1	D
7	Simulator Building	SE	1.7	D,V,A
8	River Road	SSE	1.1	D
9	River Road	S	1.1	D
10*	Met Tower	SSW	0.9	A
10*	River Road	SSW	1.1	D
11	River Road	SW	1.2	D
12	River Road	WSW	1.2	D,A
13	River Road	W	1.3	D
14	River Road	WNW	1.8	D
15	Hancock Landing Road	NW	1.5	D,V
16	Hancock Landing Road	NNW	1.4	D,A
17	Savannah River Site, River Road	N	5.4	D
18	Savannah River Site, D Area	NNE	5.0	D
19	Savannah River Site, Road A.13	NE	4.6	D
20	Savannah River Site, Road A.13.1	ENE	4.8	D
21	Savannah River Site, Road A.17	E	5.3	D
22	River Bank Downstream of Buxton Landing	ESE	5.2	D
23	River Road	SE	4.6	D
24	Chance Road	SSE	4.9	D
25	Chance Road near Highway 23	S	5.2	D
26	Highway 23 and Ebenezer Church Rd.	SSW	4.6	D

*Two locations in the same sector and shown as a single sample station in Figure 4-1

Table 4-4 (contd). Radiological Environmental Monitoring Locations

Location Number	Descriptive Location	Direction	Distance (miles)	Sample Type(1)
27	Highway 23, opposite Boll Weevil Road	SW	4.7	D
28	Thomas Road	WSW	5.0	D
29	Claxton-Lively Road	W	5.1	D
30	Nathaniel Howard Road	WNW	5.0	D
31	River Road at Allen's Chapel Fork	NW	5.0	D
32	River Bank	NNW	4.7	D
35	Girard	SSE	6.6	D,A
36	GPC Waynesboro Operating Headquarters	WSW	13.9	D,A
37	Substation; Waynesboro, GA	WSW	16.7	D,V
43	Employees Recreation Area	SW	2.2	D
47	Oak Grove Church	SE	10.4	D
48	McBean Cemetery	NW	10.2	D
51	SGA School; Sardis, GA	S	11.0	D
52	Oglethorp Substation; Alexander, GA	SW	10.7	D
80	Augusta Water Treatment Plant	NNW	29.0	W(2)
81	Savannah River	N	2.5	F(3),S(4)
82	Savannah River (RM 151.2)	NNE	0.8	R
83	Savannah River (RM 150.4)	ENE	0.8	R,S(4)
84	Savannah River (RM 149.5)	ESE	1.6	R
85	Savannah River	ESE	4.3	F(3)
87	Beaufort - Jasper Water Treatment Plant; Beaufort, SC	SE	76.0	W(5) SEE NOTE 5
88	Cherokee Hill Water Treatment Plant; Port Wentworth, GA	SSE	72.0	W(6)
89	Purrysburg Water Treatment Plant; Purrysburg, SC	SSE	76.0	W(7)
101	Girard Dairy	S	5.5	M
102	Seven Oaks Dairy/Harmony Grove Dairy	w	7.5/23.6	M
110	Vogtle 1 & 2 River Intake	NE	0.6	V
111	Wilson Transmission Line ROW	E	0.7	V

Table 4-4 (cont.) Radiological Environmental Monitoring Locations

TABLE NOTATIONS

(1) Sample Types:

A - Airborne Radioactivity
D - Direct Radiation
F - Fish
M - Milk
R - River Water
S - River Shoreline Sediment
W - Drinking Water (at water treatment plant)
V - Vegetation

(2) The intake for the Augusta Water Treatment Plant is located on the Augusta Canal. The entrance to this canal is at river mile (RM) 207 on the Savannah River. The canal effectively parallels the river. The intake to the pumping station is about 4 miles down the canal and only 0.1 mile from the river (across land).

(3) About a 5-mile stretch of the river is generally needed to obtain adequate fish samples. Samples are normally gathered between RM 153 and 158 for upriver collections and between RMs 144 and 149.4 for downriver collections.

(4) Sediment is collected at locations with existing or potential recreational value. High water shifting of the river bottom or other reasons could cause a suitable location for sediment collection to become unavailable or unsuitable. Thus, a stretch of river between RM 148.5 and 150.5 is designated for downriver sediment collections, while a stretch between RM 153 and 154 is designated for upriver collections. In practice, collections are normally made at RM 150.2 for downriver collections and at RM 153.3 for upriver collections.

(5) DELETED THIS SAMPLE LOCATION IN 2014 (REF 34). Two additional indicator stations are available. Historical: The intake for the Beaufort-Jasper Water Treatment Plant is located at the end of a canal which begins at RM 39.3 on the Savannah River. This intake is about 16 miles by line of sight down the canal from its beginning on the Savannah River.

(6) The intake for the Cherokee Hill Water Treatment Plant is located on Abercorn Creek, which is about one and a quarter creek miles from its mouth on the Savannah River at RM 29.

(7) The intake for the Purrysburg Water Treatment Plant is located on the same canal as the Beaufort–Jasper Water Treatment Plant. The Purrysburg intake is nearer to the Savannah River at the beginning of the canal.

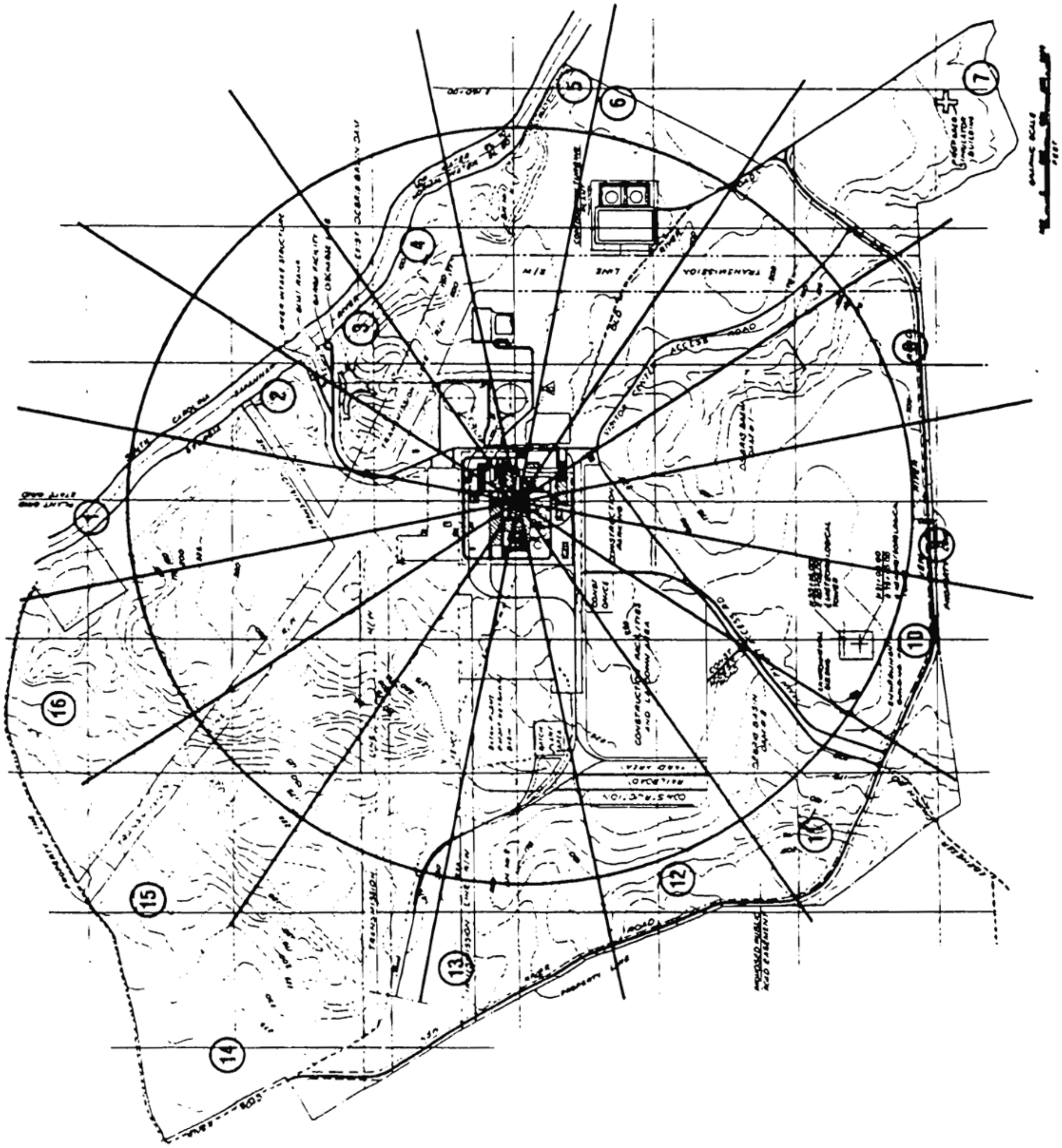

Figure 4-1. Terrestrial Stations Near Site Boundary

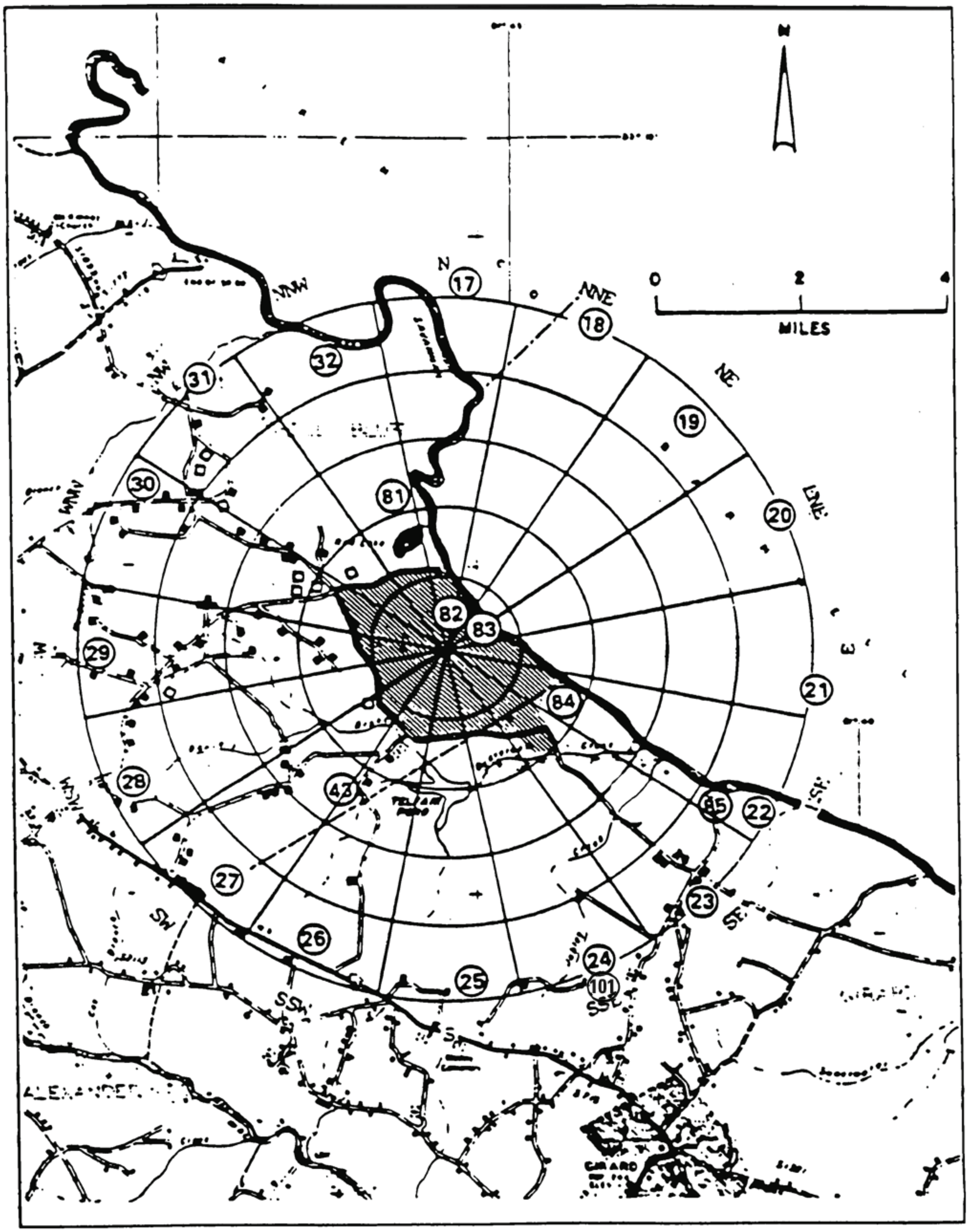

Figure 4-2. Terrestrial Stations and Aquatic Stations, 0-5 Miles

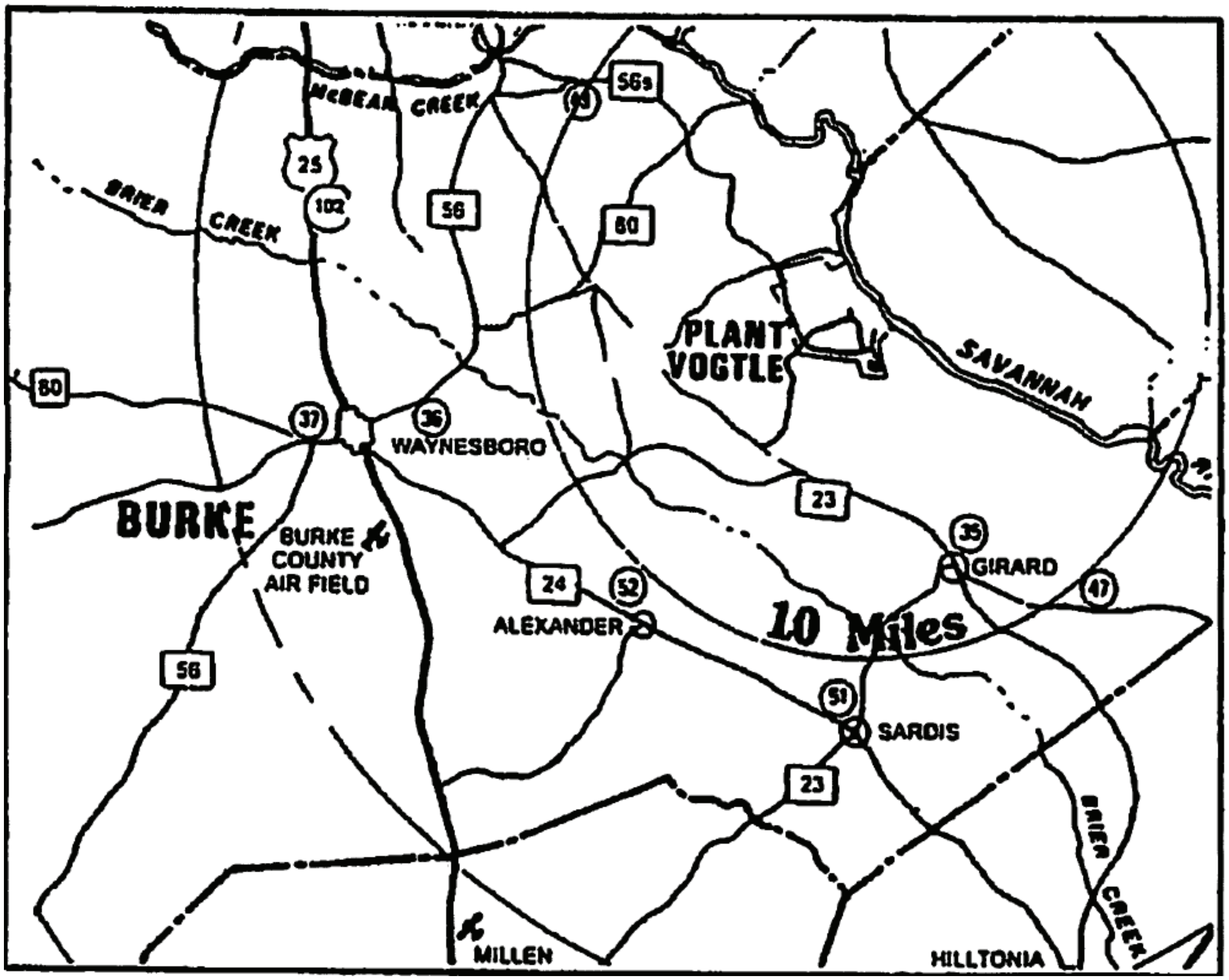

Figure 4-3. Terrestrial Stations Beyond 5 Miles

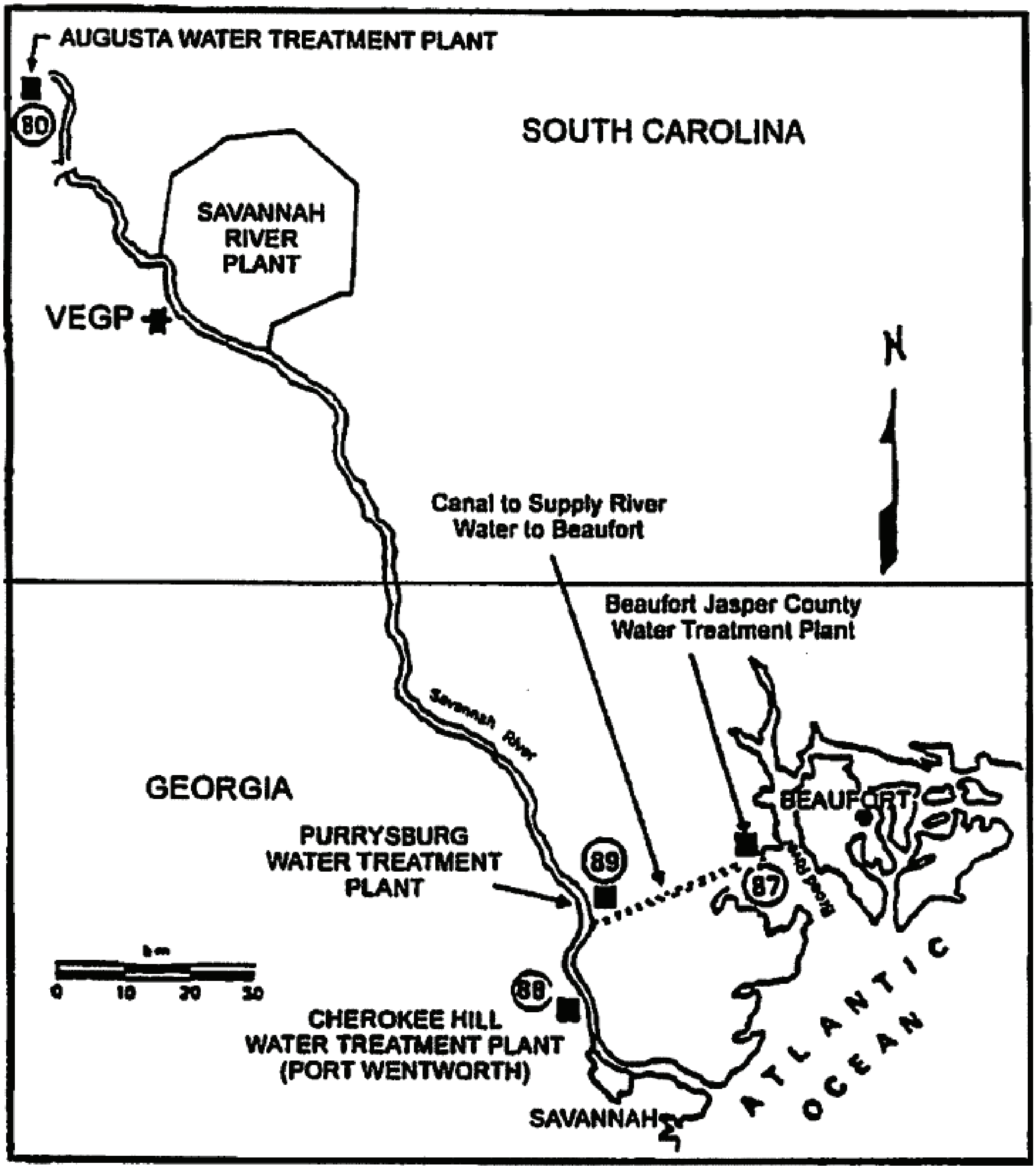

Figure 4-4. Drinking Water Stations

CHAPTER 5
TOTAL DOSE DETERMINATIONS

5.1 LIMIT OF OPERATION

In accordance with Technical Specification 5.5.4.j, the dose or dose commitment to any MEMBER OF THE PUBLIC over a calendar year, due to releases of radioactivity and to radiation from uranium fuel cycle sources, shall be limited to less than or equal to 25 mrem to the total body or any organ, except the thyroid, which shall be limited to less than or equal to 75 mrem.

5.1.1 Applicability

This limit applies at all times.

5.1.2 Actions

With the calculated doses from the release of radioactive materials in liquid or gaseous effluents exceeding twice the limits of Section 2.1.3, 3.1.3, or 3.1.4, calculations shall be made according to Section 5.2 methods to determine whether the limits of Section 5.1 have been exceeded. If these limits have been exceeded, prepare and submit a special report to the Nuclear Regulatory Commission within 30 days, which defines the corrective actions to be taken to reduce subsequent releases to prevent recurrence of exceeding the limits of Section 5.1 and includes the schedule for achieving conformance with the limits of Section 5.1. This special report, as defined in 10 CFR 20.2203, shall also include an analysis which estimates the radiation exposure (dose) to a MEMBER OF THE PUBLIC from uranium fuel cycle sources (including all effluent pathways and direct radiation) for the calendar year that includes the release(s) covered by this report. This special report shall also describe the levels of radiation and concentrations of radioactive material involved, and the cause of the exposure levels or concentrations. If the estimated dose(s) exceeds the limits of Section 5.1, and if the release condition resulting in violation of the provisions of 40 CFR 190 has not already been corrected, the special report shall include a request for variance in accordance with the provisions of 40 CFR 190 and including the specified information of 40 CFR 190.11(b). Submittal of the report is considered a timely request, and a variance is granted until staff action on the request is complete.

This control does not affect shutdown requirements or MODE changes.

5.1.3 Surveillance Requirements

Cumulative dose contributions from liquid and gaseous effluents and from direct radiation shall be determined in accordance with Section 5.2. This requirement is applicable only under the conditions set forth above in Section 5.1.2.

5.1.4 Basis

This control is provided to meet the dose limitations and reporting requirements of 40 CFR 190. The control requires the preparation and submittal of a special report whenever the calculated doses from plant radioactive effluents exceed the limits of Section 5.1. For sites containing up to 4 reactors, it is highly unlikely that the resultant dose to a MEMBER OF THE PUBLIC will exceed the dose limits of 40 CFR 190 if the individual reactors remain within twice the dose design objectives of Appendix I and if direct radiation doses from the units, such as direct exposure from outside storage tanks, are kept small. The special report will describe a course of action which should result in the limitation of dose to a MEMBER OF THE PUBLIC for a calendar year to within the 40 CFR 190 limits. For the purposes of the special report, it may be assumed that the dose commitment to the MEMBER OF THE PUBLIC from other uranium fuel cycle sources is negligible with the exception that dose contributions from other uranium fuel cycle facilities at the same site or within a radius of 5 miles must be considered. If the dose to any MEMBER OF THE PUBLIC is estimated to exceed the requirements of 40 CFR 190, the special report with a request for variance (provided the release conditions resulting in violation of 40 CFR 190 have not already been corrected), in accordance with the provisions of 40 CFR 190.11 and 10 CFR 20.2203(a)(4), is considered to be a timely request and fulfills the requirements of 40 CFR 190 until NRC staff action is completed. The variance only relates to the limits of 40 CFR 190, and does not apply in any way to the requirements for dose limitation as addressed in other sections of this ODCM. An individual is not considered a MEMBER OF THE PUBLIC during any period in which he/she is engaged in carrying out any operation which is part of the nuclear fuel cycle.

5.2 DEMONSTRATION OF COMPLIANCE

There are no other uranium fuel cycle facilities within 5 miles of the plant site. Therefore, for the purpose of demonstrating compliance with the limits of Section 5.1, the total dose to a MEMBER OF THE PUBLIC in the vicinity of the plant site due to uranium fuel cycle sources shall be determined as follows:

$$D_{Tk} = D_L + D_G + D_D + D_N \qquad \textbf{(5.1)}$$

where:

D_{Tk} = the total dose or dose commitment to the total body or organ k, in mrem.

D_L = the dose to the same organ due to radioactivity discharged from the plant site in liquid effluents, calculated in accordance with Section 2.4.1, in mrem.

D_G = the dose to the same organ due to non-noble-gas radionuclides discharged from the plant site in gaseous effluents, calculated for the controlling receptor in accordance with Section 3.4.3, in mrem.

D_D = the direct radiation dose to the whole body of an individual at the controlling receptor location, due to radioactive materials retained within the plant site, in mrem. Values of direct radiation dose may be determined by measurement, calculation, or a combination of the two.

D_N = the external whole body dose to an individual at the controlling receptor location, due to gamma ray emissions from noble gas radionuclides discharged from the plant site in gaseous effluents, in mrem. D_N is calculated as follows (equation adapted from Reference 1, page 22, by recasting in cumulative dose form):

$$D_N = 3.17 \times 10^{-8} \sum_v \left\{ \left(\overline{X/Q}\right)_{vp} \sum_i \left[K_i \cdot \tilde{Q}_{iv} \right] \right\} \qquad \textbf{(5.2)}$$

where:

3.17×10^{-8} = a units conversion factor: 1 y/(3.15×10^7 s).

$\tilde{Q}_{iv}$ = the cumulative release of noble gas radionuclide i from release pathway v (μCi), during the period of interest.

K_i = the total-body dose factor due to gamma emissions from noble gas radionuclide i (mrem/y)/(μCi/m^3), from Table 3-5.

$\left(\overline{X/Q}\right)_{vp}$ = annual average relative dispersion factor for release pathway v, at the location of the controlling receptor, from Table 3-7 [s/m^3].

As defined above, D_L and D_G are for different age groups, while D_D and D_N are not age group specific. When a more precise determination of D_{Tk} is desired, values of D_L and D_G may be calculated for all four age groups, and those values used in equation (5.1) to determine age group specific values of D_{Tk}; the largest value of D_{Tk} for any age group may then be compared to the limits of Section 5.1.

CHAPTER 6
POTENTIAL DOSES TO MEMBERS OF THE PUBLIC DUE TO THEIR ACTIVITIES INSIDE THE SITE BOUNDARY

6.1 REQUIREMENT FOR CALCULATION

To support the reporting requirements of Section 7.2.2.3, an assessment of the radiation doses from radioactive liquid and gaseous effluents to MEMBERS OF THE PUBLIC due to their activities inside the SITE BOUNDARY shall be performed as specified in Section 6.2, at least once per calendar year.

6.2 CALCULATIONAL METHOD

For the purpose of performing the calculations required in Section 6.1, the dose to a member of the public inside the SITE BOUNDARY shall be determined at the locations, and for the receptor age groups, defined in Table 6-1. The dose to such a receptor at any one of the defined locations shall be determined as follows:

$$D_{Ik} = \left[D_A + D_S + D_P\right] \cdot F_o \qquad \textbf{(6.1)}$$

where:

D_{Ik} = the total dose to the total body or organ k, in mrem.

D_A = the dose to the same organ due to <u>inhalation</u> of non-noble-gas radionuclides discharged from the plant site in gaseous effluents, calculated in accordance with Section 3.4.3, in mrem. The $\overline{(X/Q)}$ value to be used is given for each receptor location in Table 6-1; depleted $\overline{(X/Q)}$ values may be used in calculations for non-noble-gas radionuclides.

D_S = the dose to the same organ due to <u>ground plane deposition</u> of non-noble-gas radionuclides discharged from the plant site in gaseous effluents, calculated in accordance with Section 3.4.3, in mrem. The $\overline{(D/Q)}$ value to be used is given for each receptor location in Table 6-1.

D_P = the external whole body dose due to gamma ray emissions from noble gas radionuclides discharged from the plant site in gaseous effluents, calculated using equation (5.2), in mrem. The $\overline{(X/Q)}$ values that are to be used are given for each receptor location in Table 6-1.

F_o = the occupancy factor for the given location, which is the fraction of the year that one individual MEMBER OF THE PUBLIC is assumed to be present at the receptor location [unitless]. Values of F_o for each receptor location are included in Table 6-1.

Table 6-1. Attributes of Member of the Public Receptor Locations Inside the Site Boundary

Location: Visitors Center, SE at 447 meters

Age Group: Child

Occupancy Factor: 4.57×10^{-4} (based on 4 hours per year)

Dispersion and Deposition Parameters:

Parameter	Ground-Level	Mixed-Mode
Undepleted $(\overline{X/Q})$, s/m^3	5.93 E-6	7.12 E-7
Depleted $(\overline{X/Q})$, s/m^3	5.58 E-6	6.74 E-7
$(\overline{D/Q})$, m^{-2}	2.28 E-8	5.77 E-9

CHAPTER 7
REPORTS

7.1 ANNUAL RADIOLOGICAL ENVIRONMENTAL OPERATING REPORT

7.1.1 Requirement for Report

In accordance with Technical Specification 5.6.2, the Annual Radiological Environmental Operating Report covering the REMP activities during the previous calendar year shall be submitted before May 15 of each year. (A single report fulfills the requirements for both units.) The material provided shall be consistent with the objectives outlined in section 4.1 and section 7.1.2 of the ODCM, and in Sections IV.B.2, IV.B.3, and IV.C of Appendix I to 10 CFR Part 50.

7.1.2 Report Contents

The materials specified in the following subsections shall be included in each Annual Radiological Environmental Operating Report:

7.1.2.1 Data

The report shall include summarized and tabulated results of all REMP samples required by Table 4-1 taken during the report period, in a format similar to that contained in Table 3 of the Radiological Assessment Branch Technical Position (Reference 19); the results for any additional samples shall also be reported. In the event that some results are not available for inclusion with the report, the report shall be submitted noting and explaining the reasons for the missing results; the missing data shall be submitted as soon as possible in a supplementary report. The results for naturally-occurring radionuclides not included in plant effluents need not be reported.

7.1.2.2 Evaluations

Interpretations and analyses of trends of the results shall be included in the report, including the following: (as appropriate) comparisons with preoperational studies, operational controls, and previous environmental reports; and an assessment of any observed impacts of the plant operation on the environment. If the measured level of radioactivity in an environmental sampling medium exceeding the reporting levels of Table 4-2 is not the result of plant effluents, the condition shall be described as required by Section 4.1.1.2.2.

7.1.2.3 Programmatic Information

Also to be included in each report are the following: a summary description of the REMP; a map(s) of all sampling locations keyed to a table giving distances and directions from a point midway between the centers of the two reactors; the results of land use censuses required by Section 4.1.2; and the results of licensee participation in the Interlaboratory Comparison Program required by Section 4.1.3.

7.1.2.4 Descriptions of Program Deviations

Discussions of deviations from the established program must be included in each report, as follows:

7.1.2.4.1 If the REMP is not conducted as required in Table 4-1, a description of the reasons for not conducting the program as required, and the plans for preventing a recurrence, must be included in the report.

7.1.2.4.2 If the MDCs required by Table 4-3 are not achieved, the contributing factors must be identified and described in the report.

7.1.2.4.3 If Interlaboratory Comparison Program analyses are not performed as required by Section 4.1.3, the corrective actions taken to prevent a recurrence must be included in the report.

7.2 RADIOACTIVE EFFLUENT RELEASE REPORT

7.2.1 Requirement for Report

In accordance with Technical Specification 5.6.3, the Radioactive Effluent Release Report covering the operation of the units during the previous calendar year of operation shall be submitted in accordance with 10 CFR Part 50.36a. (A single submittal may be made for Units 1 and 2. However, the submittal shall specify the releases of radioactive material in liquid and gaseous effluents from each unit and solid radioactive waste from the site.) The report shall include a summary of the quantities of radioactive liquid and gaseous effluents and solid waste released from the units. The material provided shall be consistent with the objectives outlined throughout this ODCM and the Process Control Program (PCP) and in conformance with 10 CFR Part 50.36a and Section IV.B.1 of Appendix I to 10 CFR Part 50.

7.2.2 Report Contents

The materials specified in the following subsections shall be included in each Radioactive Effluent Release Report:

7.2.2.1 Quantities of Radioactive Materials Released

The report shall include a summary of the quantities of radioactive liquid and gaseous effluents and solid waste released from the units as outlined in NRC Regulatory Guide 1.21, “Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants,” Revision 1, June 1974, with liquid and gaseous effluent data summarized on a quarterly basis and solid radioactive waste data summarized on a semiannual basis following the format of Appendix B thereof. Unplanned releases of radioactive materials in gaseous and liquid effluents from the site to UNRESTRICTED AREAS shall be included in the report, tabulated either by quarter or by event. For gamma emitters released in liquid and gaseous effluents, in addition to the principal gamma emitters for which MDCs are specifically established in Table 2-3 and Table 3-3, other peaks which are measurable and identifiable also shall be identified and reported.

7.2.2.2 Meteorological Data

The report shall include an annual summary of hourly meteorological data collected over the previous year. This annual summary may be either in the form of an hour-by-hour listing of wind speed, wind direction, and atmospheric stability, and precipitation (if measured) on digital media; or in the form of joint frequency distributions of wind speed, wind direction, and atmospheric stability. In lieu of submission with the Radioactive Effluent Release Report, the licensee has the option of retaining this summary of required meteorological data on site in a file that shall be provided to the NRC upon request.

7.2.2.3 Dose Assessments

The report shall include an assessment of the radiation doses due to the radioactive liquid and gaseous effluents released from each unit during the previous calendar year. Historical annual average meteorology or the meteorological conditions concurrent with the time of release of radioactive materials in gaseous effluents (as determined by sampling frequency and measurement) shall be used for determining the gaseous pathway doses. This assessment of radiation doses shall be performed in accordance with Sections 2.1.3, 2.4, 3.1.3, 3.1.4, 3.4.2, 3.4.3, 5.1, and 5.2.

If a determination is required by Section 5.1.2, the report shall also include an assessment of radiation doses to the likely most exposed MEMBER OF THE PUBLIC from reactor releases and other nearby uranium fuel cycle sources (including doses from primary effluent pathways and direct radiation) for the previous calendar year to show conformance with 40 CFR 190, Environmental Radiation Protection Standards for Nuclear Power Operation; this dose assessment must be performed in accordance with Chapter 5. The report shall also include an assessment of the radiation doses from radioactive liquid and gaseous effluents to MEMBERS OF THE PUBLIC due to their activities inside the SITE BOUNDARY during the report period; this assessment must be performed in accordance with Chapter 6. All assumptions used in making these assessments (i.e., specific activity, exposure time, and location) shall be included in the report.

7.2.2.4 Solid Radwaste Data

For each type of solid waste shipped offsite during the report period, the following information shall be included:

a. Waste volume,
b. Total curie quantity (specify whether determined by measurement of estimate),
c. Principal radionuclides (specify whether determined by measurement or estimate),
d. Type of waste (e.g., spent resin, compacted dry waste, evaporator bottoms),
e. Type of container (e.g., LSA, Type A, Type B, Large Quantity),
f. Solidification agent (e.g., cement, urea formaldehyde)
and
g. Class of solid wastes (as defined by 10 CFR Part 61.)

7.2.2.5 Licensee Initiated Document Changes

Licensee initiated changes shall be submitted to the Nuclear Regulatory Commission as a part of or concurrent with the Radioactive Effluent Release Report for the period in which any changes were made. Such changes to the ODCM shall be submitted pursuant to Technical Specification 5.5.1. This requirement includes:

7.2.2.5.1 Any changes to the sampling locations in the radiological environmental monitoring program, including any changes made pursuant to Section 4.1.1.2.3. Documentation of changes made pursuant to Section 4.1.1.2.3 shall include supporting information identifying the cause of the unavailability of samples.

7.2.2.5.2 Any changes to dose calculation locations or pathways, including any changes made pursuant to Section 4.1.2.2.2.

7.2.2.6 Descriptions of Program Deviations

Discussions of deviations from the established program shall be included in each report, as follows:

7.2.2.6.1 The report shall include deviations from the liquid and gaseous effluent monitoring instrumentation FUNCTIONALITY requirements included in Sections 2.1.1 and 3.1.1, respectively. The report shall include an explanation as to why the NON-FUNCTIONALITY of the liquid or gaseous effluent monitoring instrumentation was not corrected within the specified time requirement.

7.2.2.6.2 The report shall include a description of the events leading to liquid holdup tanks or gas storage tanks exceeding the limits of Technical Specification 5.5.12.

7.2.2.7 Major Changes to Radioactive Waste Treatment Systems

As required by Sections 2.1.5 and 3.1.6, licensee initiated MAJOR CHANGES TO RADIOACTIVE WASTE TREATMENT SYSTEMS (liquid and gaseous) shall be reported to the Nuclear Regulatory Commission in the Radioactive Effluent Release Report covering the period in which the change was reviewed and accepted for implementation.[1] The discussion of each change shall contain:

a. A summary of the evaluation that led to the determination that the change could be made in accordance with 10 CFR 50.59;

b. Sufficient detailed information to totally support the reason for the change without benefit of additional supplemental information;

c. A detailed description of the equipment, components, and processes involved and the interfaces with other plant systems;

d. An evaluation of the change which shows the predicted releases of radioactive materials in liquid and gaseous effluents that differ from those previously predicted in the license applications and amendments thereto;

e. An evaluation of the change which shows the expected maximum exposures to individuals in the UNRESTRICTED AREA and to the general population that differ from those previously estimated in the license applications and amendments thereto;

f. A comparison of the predicted releases of radioactive materials, in liquid and gaseous effluents, to the actual releases for the period prior to when the changes are to be made;

g. An estimate of the exposure to plant operating personnel as a result of the change; and

h. Documentation of the fact that the change was reviewed and found acceptable by the PRB.

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[1] In lieu of inclusion in the Radioactive Effluents Release Report, this same information may be submitted as part of the annual FSAR update.

7.3 MONTHLY OPERATING REPORT

This ODCM establishes no requirements pertaining to the Monthly Operating Report.

7.4 SPECIAL REPORTS

Special reports shall be submitted to the Nuclear Regulatory Commission as required by Sections 2.1.3.2, 2.1.4.2, 3.1.3.2, 3.1.4.2, 3.1.5.2, 4.1.1.2.2, and 5.1.2.

CHAPTER 8
METEOROLOGICAL MODELS

The models presented in this chapter are those which were used to compute the specific values of meteorology-related parameters that are referenced throughout this ODCM. These models should also be used whenever it is necessary to calculate values of these parameters for new locations of interest.

Note: Although Plant Vogtle has no pure elevated releases, the sections on elevated-mode calculations (8.1.2 and 8.2.2) are included for convenience in calculating mixed-mode values, and to preserve section number compatibility with the ODCMs of the other Southern Company nuclear power plants.

8.1 ATMOSPHERIC DISPERSION

Atmospheric dispersion may be calculated using the appropriate form of the sector-averaged Gaussian model. Gaseous release elevations may be considered to be either at ground-level, elevated, or mixed-mode. Facility release elevations for each gaseous release point are as indicated in Table 3-4.

8.1.1 Ground-Level Releases

Relative concentration calculations for ground-level releases, or for the ground-level portion of mixed-mode releases, shall be made as follows:

$$\left(X/Q\right)_G = \frac{2.032\,\delta\,K_r}{N\ r}\sum_{jk}\left[\frac{n_{jk}}{u_j\,\Sigma_{zk}}\right] \quad \textbf{(8.1)}$$

where:

$(X/Q)_G$ = the ground-level sector-averaged relative concentration for a given wind direction (sector) and distance (s/m^3).

2.032 = $(2/\pi)^{1/2}$ divided by the width in radians of a 22.5° sector, which is 0.3927 radians.

δ = the plume depletion factor for all radionuclides other than noble gases at a distance r shown in Figure 8-3. For noble gases, the depletion factor is unity. If an undepleted relative concentration is desired, the depletion factor is unity. Only depletion by deposition is considered since depletion by radioactive decay would be of little significance at the distances considered.

K_r = the terrain recirculation factor corresponding to a distance r, taken from Appendix A of Reference 15.

n_{jk} = the number of hours that wind of wind speed class j is directed into the given sector during the time atmospheric stability category k existed.

N = the total hours of valid meteorological data recorded throughout the period of interest for all sectors, wind speed classes, and stability categories.

u_j = the wind speed (mid-point of wind speed class j) at ground level (m/s).

r = the distance from release point to location of interest (m).

Σ_{zk} = the vertical standard deviation of the plume concentration distribution considering the initial dispersion within the building wake, calculated as follows:

$$\Sigma_{zk} = the \quad lesser \quad of \begin{cases} \left(\sigma_{zk}^2 + \dfrac{b^2}{2\pi}\right)^{1/2} \\ OR \\ \sqrt{3}(\sigma_{zk}) \end{cases} \tag{8.2}$$

σ_{zk} = the vertical standard deviation of the plume concentration distribution (m) for a given distance and stability category k as shown in Figure 8-1. The stability category is determined by the vertical temperature gradient $\Delta T/\Delta z$ (°C/100 m).

π = 3.1416

b = the maximum height of adjacent plant structure (55 m).

8.1.2 Elevated Releases

Relative dispersion calculations for elevated releases, or for the elevated portion of mixed-mode releases, shall be made as follows:

$$(X/Q)_E = \frac{2.032K_r}{N\ r} \sum_{jk} \left[\frac{\delta_k n_{jk} exp\left(\dfrac{-h^2}{2\sigma_{zk}^2}\right)}{u_j \sigma_{zk}} \right] \tag{8.3}$$

where:

$(X/Q)_E$ = the elevated release sector-averaged relative concentration for a given wind direction (sector) and distance (s/m^3).

δ_k = the plume depletion factor for all radionuclides other than noble gases at a distance r for elevated releases, as shown in Figure 8-4, Figure 8-5, and Figure 8-6. For an elevated release, this factor is stability dependent. For noble gases, the depletion factor is unity. If an undepleted relative concentration is desired, the depletion factor is unity. Only depletion by deposition is considered since depletion by radioactive decay would be of little significance at the distances considered.

n_{jk} = the number of hours that wind of wind speed class j is directed into the given sector during the time atmospheric stability category k existed.

u_j = the wind speed (mid-point of wind speed class j) at the effective release height h (m/s).

h = the effective height of the release (m), which is calculated as follows:

$$h = h_v + h_{pr} - h_t - c_v \tag{8.4}$$

h_v = the height of the release point (m).

h_t = the maximum terrain height between the release point and the point of interest (m), from Table 8-1.

h_{pr} = the additional height due to plume rise (m) which is calculated as follows and limited by $h_{pr(max)}$:

$$h_{pr} = 1.44\, d \left(\frac{W_o}{u} \right)^{2/3} \cdot \left(\frac{x}{d} \right)^{1/3} \tag{8.5}$$

$$h_{pr}(max) = the \quad lesser \quad of: \begin{cases} 3\left(\frac{W_o}{u} \right) \cdot d \\ OR \\ 1.5\left(\frac{F_m}{u} \right)^{1/3} \cdot s^{-1/6} \end{cases} \tag{8.6}$$

d = the inside diameter of the vent (m).

c_v = the correction for low vent exit velocity (m), which is calculated as follows:

$$c_v = \begin{cases} 3\left(1.5 - \frac{W_o}{u} \right) \cdot d & for\ \frac{W_o}{u} < 1.5 \\ OR & \\ 0 & for\ \frac{W_o}{u} \geq 1.5 \end{cases} \tag{8.7}$$

F_m = the momentum flux parameter (m^4/s^2), which is calculated as follows:

$$F_m = \left(W_o \cdot \frac{d}{2} \right)^2 \tag{8.8}$$

S = the stability parameter:

= $8.75 \times 10^{-4}\ s^{-2}$ for $-0.5 < \Delta T \leq 1.5$
= $1.75 \times 10^{-3}\ s^{-2}$ for $1.5 < \Delta T \leq 4.0$

= $2.45 \times 10^{-3}\ s^{-2}$ for $\Delta T > 4.0$

All other symbols are as previously defined in Section 8.1.1.

8.1.3 Mixed-Mode Releases

Relative dispersion calculations for mixed-mode releases shall be made as follows:

$$(X/Q)_M = (1 - E) \cdot (X/Q)_E + E \cdot (X/Q)_G \qquad \textbf{(8.9)}$$

where:

$(X/Q)_M$ = the mixed-mode release sector-averaged relative concentration for a given wind direction (sector) and distance (s/m^3).

E = the fraction of hours during which releases are considered as ground-level releases, calculated as follows:

$$E = \begin{cases} 1.0 & \text{for } \frac{W_o}{u_j} \le 1.0 \\ 2.58 - 1.58 \cdot \left(\frac{W_o}{u_j}\right) & \text{for } 1.0 < \frac{W_o}{u_j} \le 1.5 \\ 0.3 - 0.06 \cdot \left(\frac{W_o}{u_j}\right) & \text{for } 1.5 < \frac{W_o}{u_j} \le 5.0 \\ 0 & \text{for } \frac{W_o}{u_j} > 5.0 \end{cases} \qquad \textbf{(8.10)}$$

All other symbols are as previously defined.

8.2 RELATIVE DEPOSITION

Plume depletion may be calculated using the appropriate form of the sector-averaged Gaussian model. Gaseous release elevations may be considered to be either at ground-level, elevated, or mixed-mode. Facility release elevations for each gaseous release points are as indicated in Table 3-4.

8.2.1 Ground-Level Releases

Relative deposition calculations for ground-level releases, or for the ground-level portion of mixed-mode releases, shall be made as follows:

$$(D/Q)_G = \frac{2.55 D_g \ K_r}{N \ r} \sum_k n_k \qquad \textbf{(8.11)}$$

where:

$(D/Q)_G$ = the ground-level sector-averaged relative deposition for a given wind direction (sector) and distance (m^{-2}).

2.55 = the inverse of the number of radians in a 22.5° sector [= $(2\pi/16)^{-1}$].

D_g = the deposition rate at distance r, taken from Figure 8-7 for ground-level releases (m^{-1}).

n_k = the number of hours in which the wind is directed into the sector of interest, and during which stability category k exists.

All other symbols are as defined previously in Section 8.1.

8.2.2 Elevated Releases

Relative deposition calculations for elevated releases, or for the elevated portion of mixed-mode releases, shall be made as follows:

$$(D/Q)_E = \frac{2.55 K_r}{N \ r} \sum_k (n_k \ D_{ek}) \qquad \textbf{(8.12)}$$

where:

$(D/Q)_E$ = the elevated-plume sector-averaged relative deposition for a given wind direction (sector) and distance (m^{-2}).

D_{ek} = the elevated plume deposition rate at distance r, taken from Figure 8-8, Figure 8-9, or Figure 8-10, as appropriate to the plume effective release height h defined in Section 8.1.2, for stability class k (m^{-1}).

All other symbols are as defined previously.

8.2.3 Mixed-Mode Releases

Relative deposition calculations for mixed-mode releases shall be made as follows:

$$(D/Q)_M = (1 - E) \cdot (D/Q)_E + E \cdot (D/Q)_G \quad \textbf{(8.13)}$$

where:

$(D/Q)_M$ = the mixed-mode release sector-averaged relative deposition for a given wind direction (sector) and distance (m^{-2}).

E = the fraction of hours during which releases are considered as ground-level releases, defined in Section 8.1.3.

All other symbols are as previously defined.

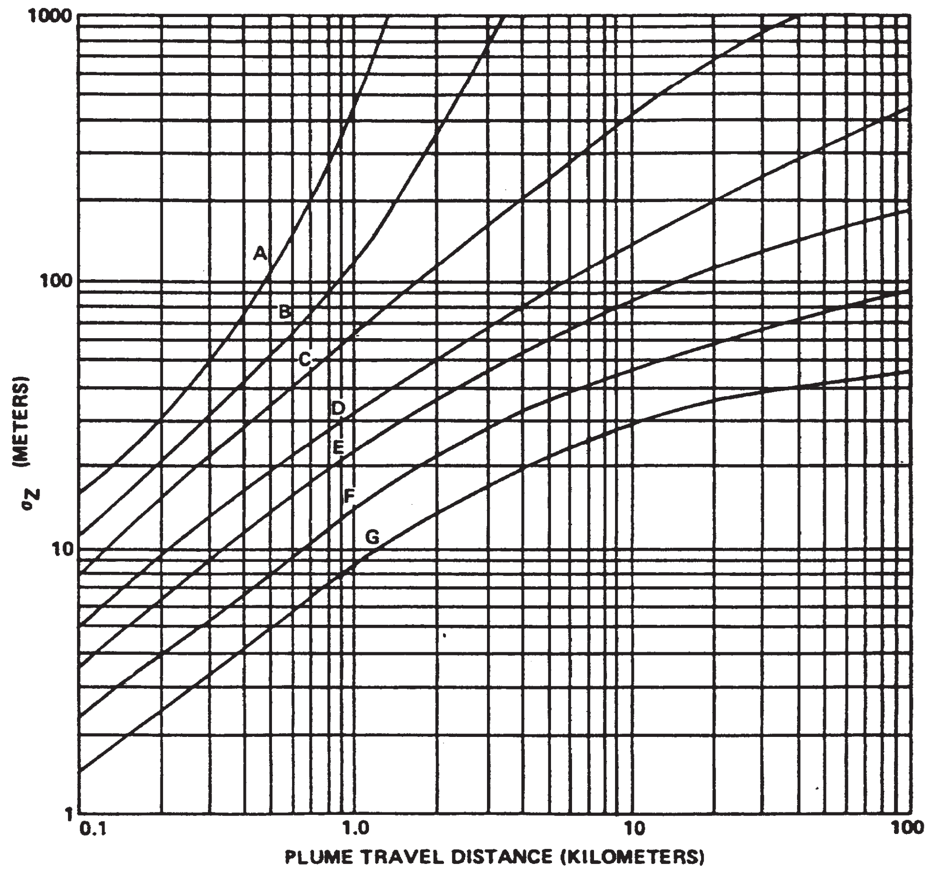
8.3 ELEVATED PLUME DOSE FACTORS

These factors are not required in effluent dose calculations for VEGP.

Table 8-1. Terrain Elevation Above Plant Site Grade

Dist. (m)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	8.7	5.7	1.4	5.8	5.7	3.5
1,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	16.7	13.4	3.3	10.4	11.8	6.8
1,500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	21.7	18.6	7.3	12.2	14.3	7.3
2,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	21.7	18.6	7.3	12.2	14.3	7.3
2,500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	21.7	18.6	7.3	12.2	14.3	7.3
3,000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	23.7	18.6	7.3	12.2	14.3	7.3
3,500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	24.4	18.6	7.3	12.2	16.9	7.3
4,000	0.0	0.0	0.0	0.0	0.0	0.0	4.5	0.0	0.0	4.7	24.4	18.6	7.3	12.2	16.9	7.3
5,000	0.0	0.0	0.0	0.0	0.0	0.0	11.1	0.0	0.0	4.7	24.7	18.6	7.3	12.2	16.9	7.3
6,000	0.0	0.0	0.0	0.0	0.0	0.0	11.1	0.0	0.0	4.7	26.8	18.6	7.3	12.2	16.9	7.3
7,000	0.0	0.0	0.0	7.8	0.0	0.0	11.1	0.0	3.6	4.7	26.8	18.6	7.3	12.2	16.9	7.3
8,000	0.0	0.0	21.1	13.9	0.0	0.0	11.8	0.0	14.6	4.7	26.8	18.6	7.3	12.2	16.9	7.3
9,000	0.0	0.0	24.4	14.6	0.0	0.0	12.7	7.1	14.6	5.1	26.8	18.6	7.3	12.2	16.9	7.3
10,000	0.0	10.2	24.4	20.2	0.0	0.0	17.1	17.0	14.6	6.8	26.8	18.6	7.3	12.2	16.9	7.3
12,000	0.0	15.9	26.8	20.2	0.0	0.0	17.1	19.5	14.6	6.8	34.1	28.9	13.4	12.2	16.9	7.3
14,000	0.0	15.9	26.8	20.2	0.0	0.0	17.1	19.5	14.6	6.8	34.1	28.9	13.4	16.5	19.7	7.3
16,000	0.0	15.9	26.8	21.7	13.2	0.0	17.1	19.5	14.6	6.8	34.1	28.9	13.4	16.5	25.7	7.3

Data in this table are obtained from Reference 11.



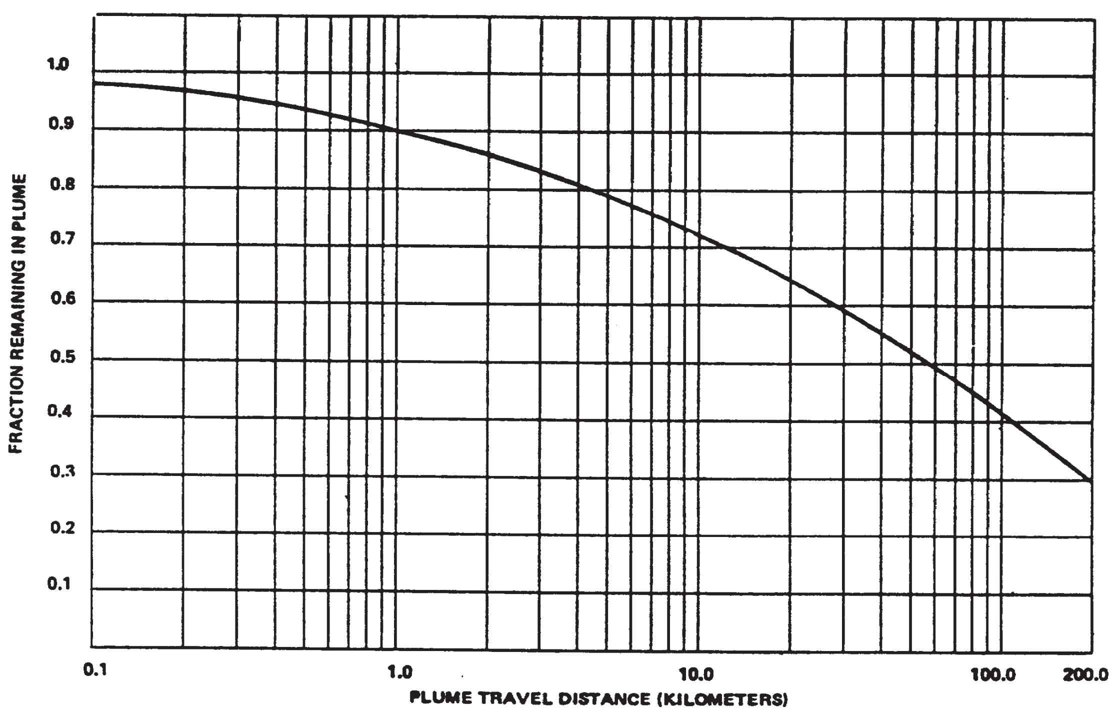
Category	Range of Vertical Temperature Gradient (°C/100 m)	Range of Vertical Temperature Gradient (°F/100 ft)
A	$\Delta T/\Delta Z < -1.9$	$\Delta T/\Delta Z < -1.0$
B	$-1.9 \leq \Delta T/\Delta Z < -1.7$	$-1.0 \leq \Delta T/\Delta Z < -0.9$
C	$-1.7 \leq \Delta T/\Delta Z < -1.5$	$-0.9 \leq \Delta T/\Delta Z < -0.8$
D	$-1.5 \leq \Delta T/\Delta Z < -0.5$	$-0.8 \leq \Delta T/\Delta Z < -0.3$
E	$-0.5 \leq \Delta T/\Delta Z < 1.5$	$-0.3 \leq \Delta T/\Delta Z < 0.8$
F	$1.5 \leq \Delta T/\Delta Z < 4.0$	$0.8 \leq \Delta T/\Delta Z < 2.2$
G	$4.0 \leq \Delta T/\Delta Z$	$2.2 \leq \Delta T/\Delta Z$

This graph is reproduced from Reference 5 (Figure 1).

Figure 8-1. Vertical Standard Deviation of Material in a Plume (σ_Z)

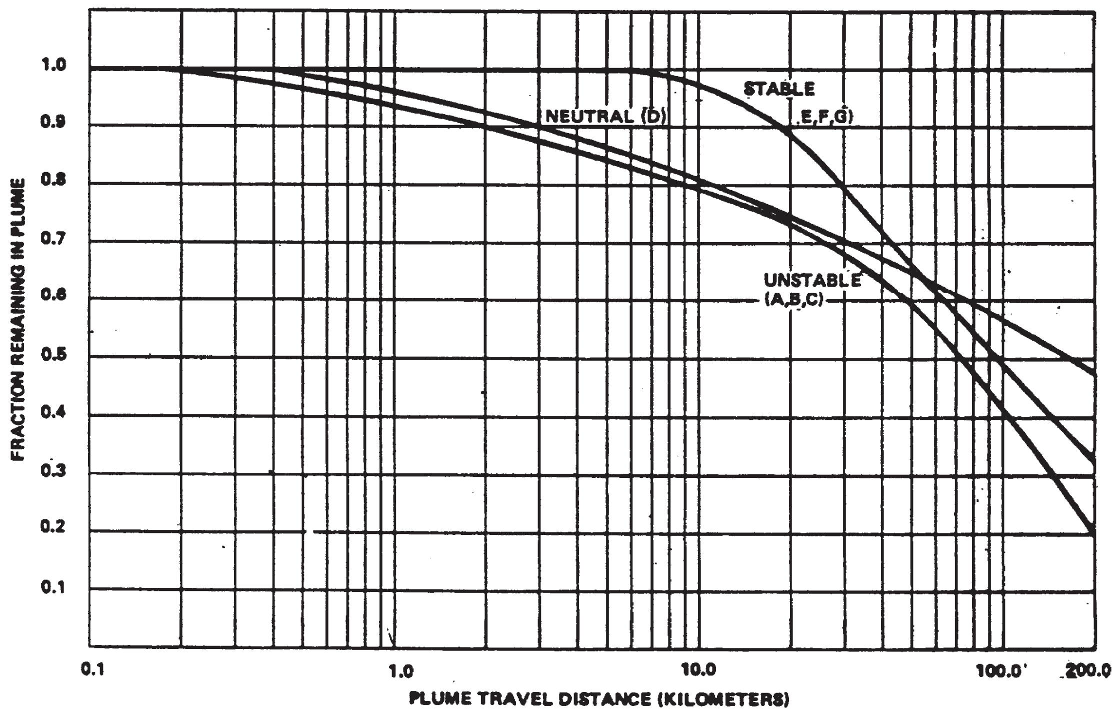
This figure intentionally left blank.
Refer to the definition for K_r (terrain recirculation factor) in section 8.1.1 for applicable plant data.

Figure 8-2. Terrain Recirculation Factor (K_r)



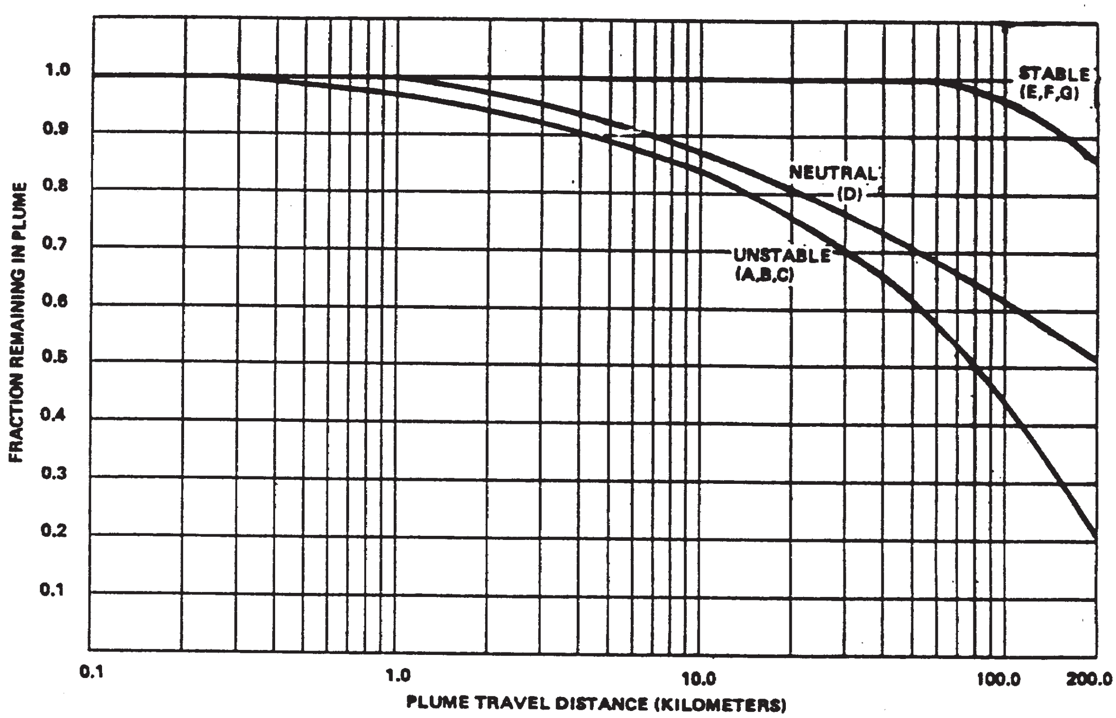
This graph is reproduced from Reference 5 (Figure 2).

Figure 8-3. Plume Depletion Effect for Ground Level Releases



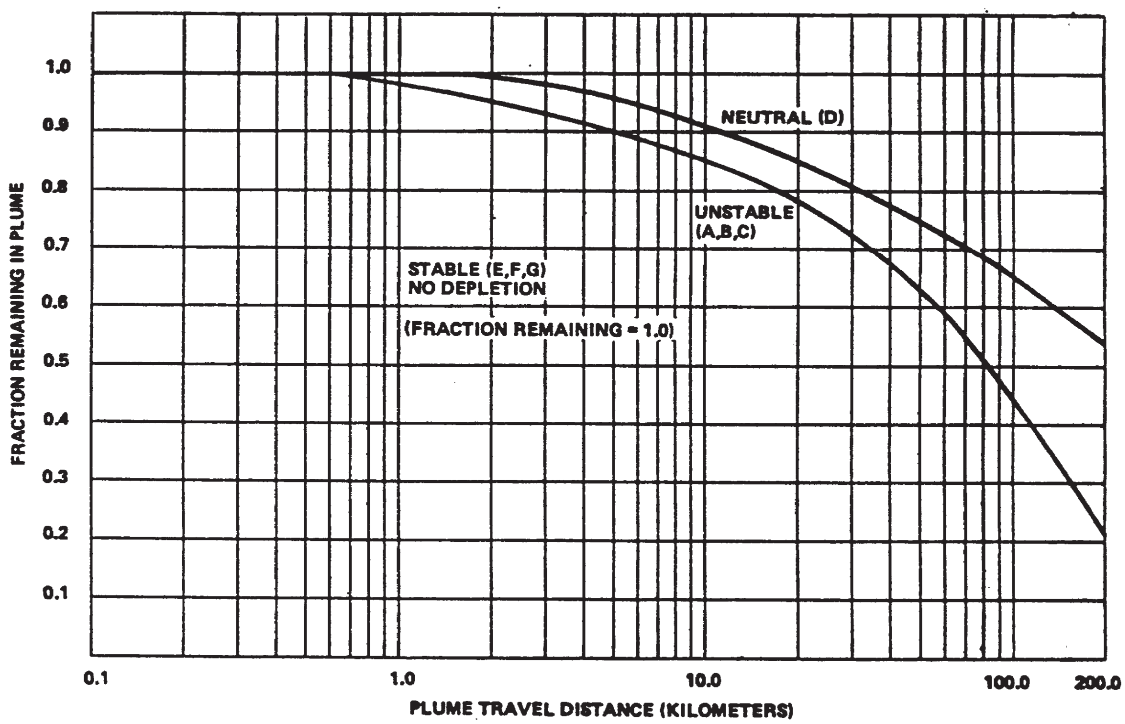
This graph is reproduced from Reference 5 (Figure 3).

Figure 8-4. Plume Depletion Effect for 30-Meter Releases



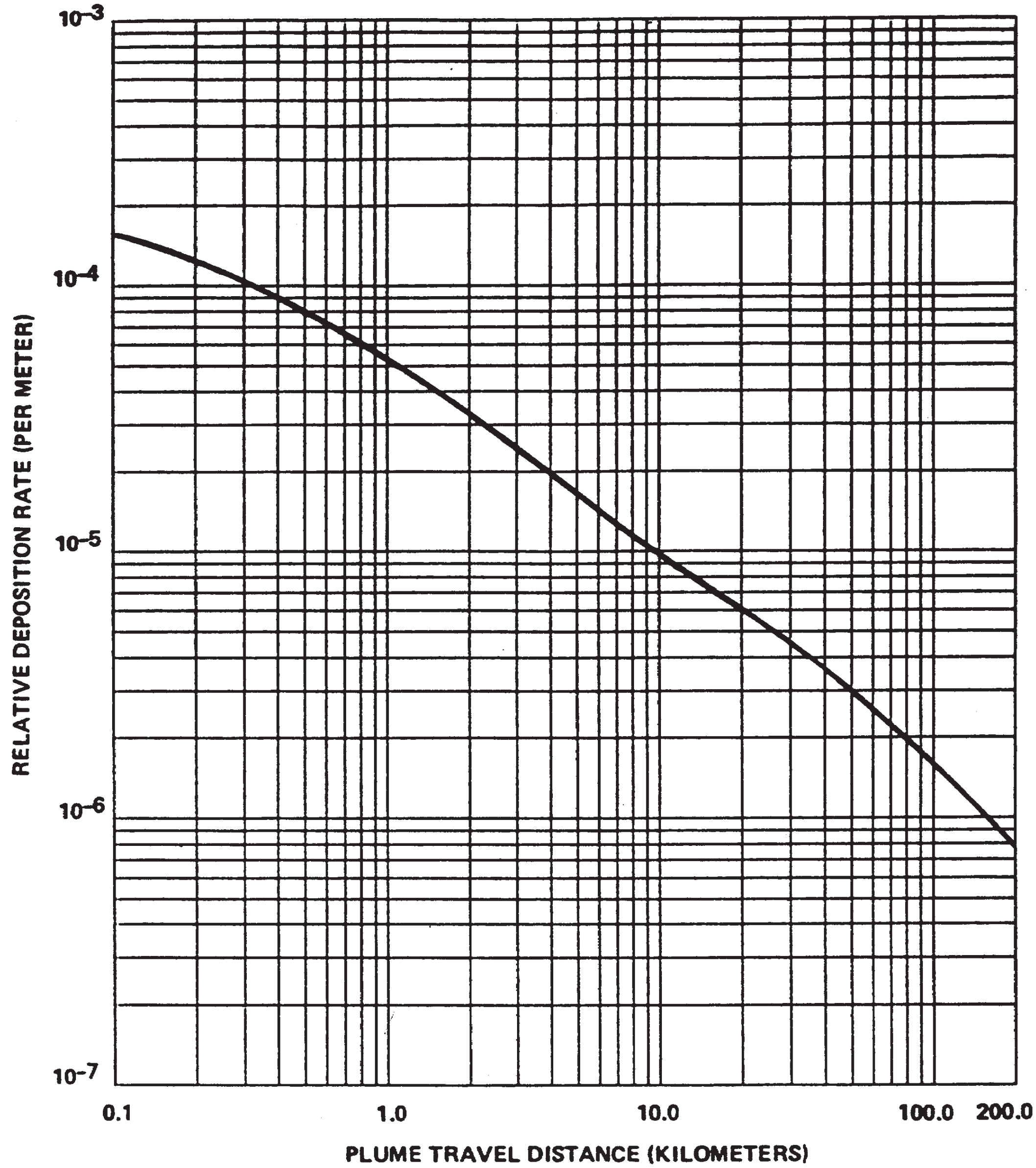
This graph is reproduced from Reference 5 (Figure 4).

Figure 8-5. Plume Depletion Effect for 60-Meter Releases



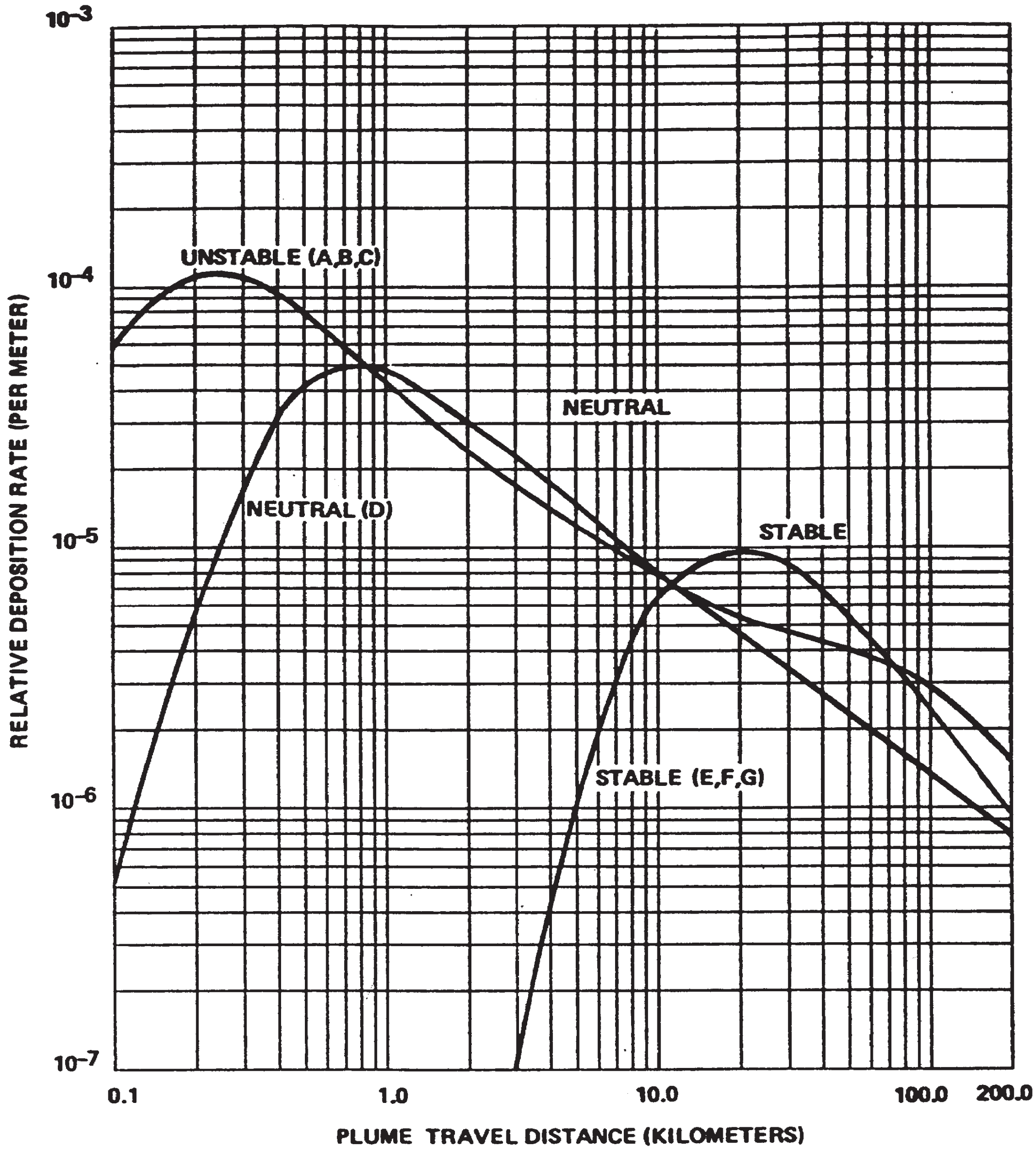
This graph is reproduced from Reference 5 (Figure 5).

Figure 8-6. Plume Depletion Effect for 100-Meter Releases



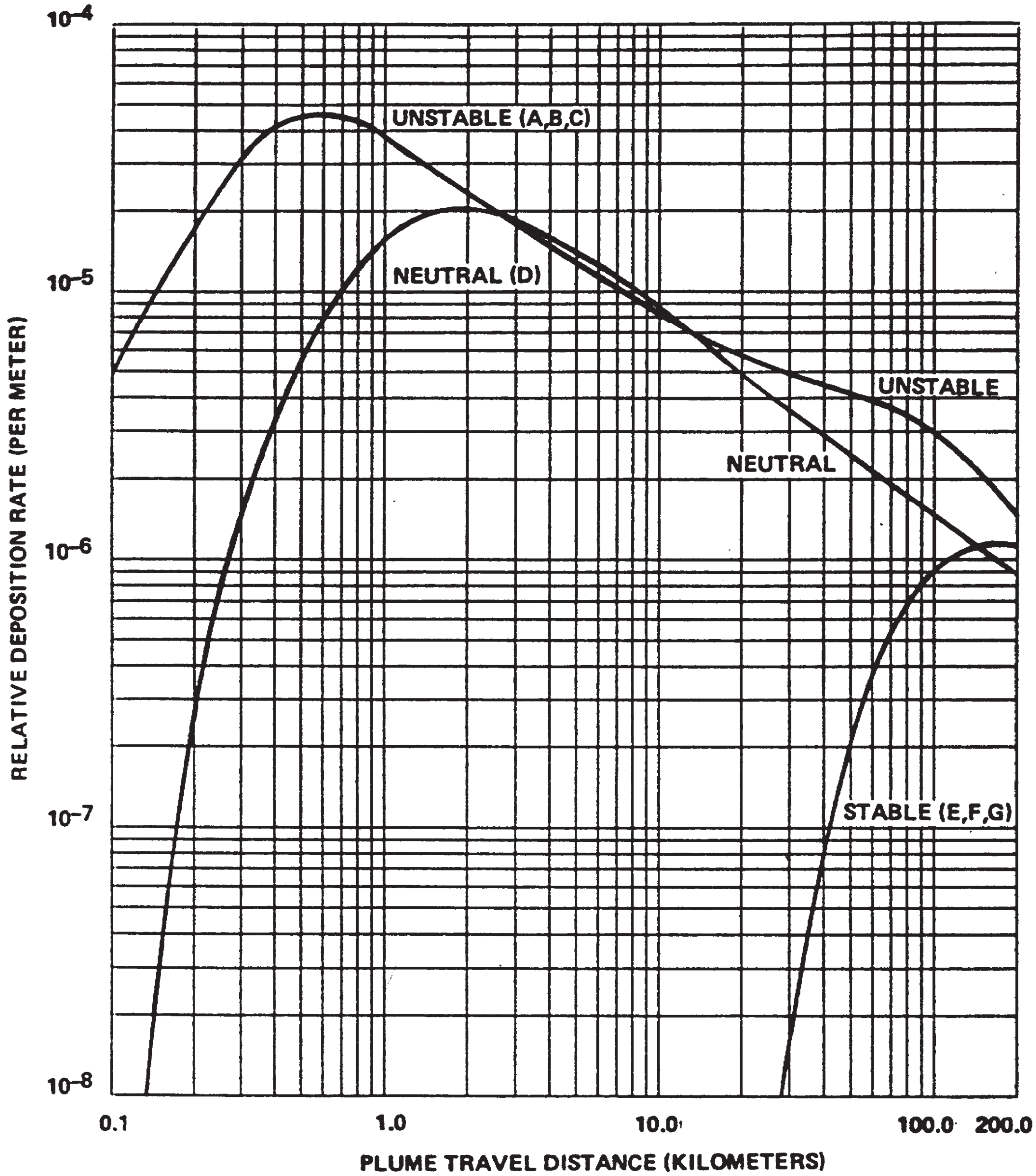
This graph is reproduced from Reference 5 (Figure 6).

Figure 8-7. Relative Deposition for Ground-Level Releases



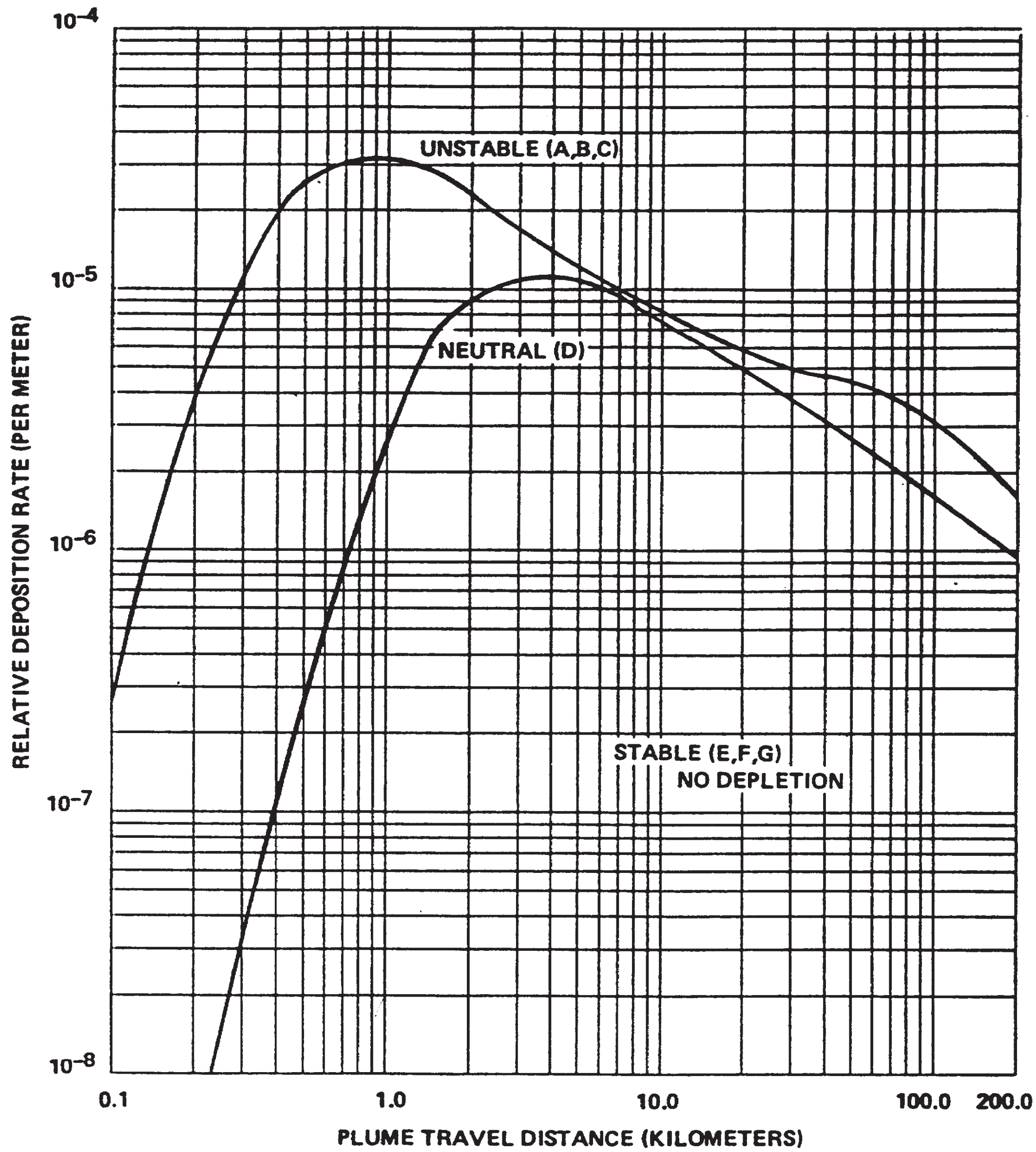
This graph is reproduced from Reference 5 (Figure 7).

Figure 8-8. Relative Deposition for 30-Meter Releases



This graph is reproduced from Reference 5 (Figure 8).

Figure 8-9. Relative Deposition for 60-Meter Releases



This graph is reproduced from Reference 5 (Figure 9).

Figure 8-10. Relative Deposition for 100-Meter (or Greater) Releases

CHAPTER 9
METHODS AND PARAMETERS FOR CALCULATION OF GASEOUS EFFLUENT PATHWAY DOSE FACTORS, R_{aipj}

9.1 INHALATION PATHWAY FACTOR

For the inhalation pathway, R_{aipj} in (mrem/y) per (μCi/m^3) is calculated as follows (Reference 1, Section 5.3.1.1):

$$R_{aipj} = K_1 \cdot (BR)_a \cdot (DFA)_{aij} \quad \textbf{(9.1)}$$

where:

K_1 = the units conversion factor: 10^6 pCi/μCi.

$(BR)_a$ = the breathing rate of receptor age group a, in m^3/y, from Table 9-5.

$(DFA)_{aij}$ = the inhalation dose factor for receptor age group a, radionuclide i, and organ j, in mrem/pCi, from Table 9-7 through Table 9-10.

9.2 GROUND PLANE PATHWAY FACTOR

For the ground plane external exposure pathway, R_{aipj} in (m^2·mrem/y) per (μCi/s) is calculated as follows (Reference 1, Section 5.3.1.2):

$$R_{aipj} = K_1 \cdot K_2 \cdot (SHF) \cdot (DFG)_{ij} \cdot \left(\frac{1 - e^{-\lambda_i t}}{\lambda_i} \right) \qquad \textbf{(9.2)}$$

where:

K_1 = the units conversion factor: 10^6 pCi/μCi.

K_2 = the units conversion factor: 8760 h/y.

(SHF) = the shielding factor due to structure (dimensionless). The value used for (SHF) is 0.7, from (Reference 3, Table E–15).

$(DFG)_{ij}$ = the ground plane dose factor for radionuclide i and organ j, in (mrem/h) per (pCi/m^2), from Table 9-15. Dose factors are the same for all age groups, and those for the total body also apply to all organs other than skin.

λ_i = the radioactive decay constant for radionuclide i, in s^{-1}. Values of λ_i used in effluent calculations should be based on decay data from a recognized and current source, such as Reference 20.

t = the exposure time, in s. The value used for t is 4.73 x 10^8 s (= 15 y), from (Reference 1, Section 5.3.1.2).

9.3 GARDEN VEGETATION PATHWAY FACTOR

For radionuclides other than tritium in the garden vegetation consumption pathway, R_{aipj} in ($m^2 \cdot$mrem/y) per (μCi/s) is calculated as follows (Reference 1, Section 5.3.1.5):

$$R_{aipj} = K_1 \cdot \frac{r}{Y_v(\lambda_i + \lambda_w)} \cdot (DFL)_{aij} \cdot \left(U_{aL} f_L e^{-\lambda_i t_L} + U_{aS} f_g e^{-\lambda_i t_{hv}}\right) \qquad \textbf{(9.3)}$$

where:

K_1	=	the units conversion factor: 10^6 pCi/μCi.
r	=	the fraction of deposited activity retained on the edible parts of garden vegetation (dimensionless). The value used for r is 1.0 for radioiodines and 0.2 for particulates, from (Reference 3, Table E–1).
Y_v	=	the areal density (agricultural productivity) of growing leafy garden vegetation, in kg/m^2, from Table 9-1.
λ_i	=	the radioactive decay constant for radionuclide i, in s^{-1}. Values of λ_i used in effluent calculations should be based on decay data from a recognized and current source, such as Reference 20.
λ_w	=	the rate constant for removal of activity on leaf and plant surfaces by weathering, in s^{-1}, from Table 9-1.
$(DFL)_{aij}$	=	the ingestion dose factor for receptor age group a, radionuclide i, and organ j, in mrem/pCi, from Table 9-11 through Table 9-14.
U_{aL}	=	the consumption rate of fresh leafy garden vegetation by a receptor in age group a, in kg/y, from Table 9-5.
U_{aS}	=	the consumption rate of stored garden vegetation by a receptor in age group a, in kg/y, from Table 9-5.
f_L	=	the fraction of the annual intake of fresh leafy garden vegetation that is grown locally (dimensionless), from Table 9-1.
f_g	=	the fraction of the annual intake of stored garden vegetation that is grown locally (dimensionless), from Table 9-1.
t_L	=	the average time between harvest of fresh leafy garden vegetation and its consumption, in s, from Table 9-1.
t_{hv}	=	the average time between harvest of stored garden vegetation and its consumption, in s, from Table 9-1.

For tritium in the garden vegetation consumption pathway, R_{aipj} in (mrem/y) per (μCi/m^3) is calculated as follows (Reference 1, Section 5.3.1.5), based on the concentration in air rather than deposition onto the ground:

$$R_{aipj} = K_1 \cdot K_3 \cdot (DFL)_{aij} \cdot (U_{aL} f_L + U_{aS} f_g) \cdot 0.75 \cdot \left(\frac{0.5}{H}\right) \quad \textbf{(9.4)}$$

where:

K_3 = = the units conversion factor: 10^3 g/kg.

H = = the absolute humidity of atmospheric air, in g/m^3, from Table 9-1.

0.75 = = the fraction of the mass of total garden vegetation that is water (dimensionless).

0.5 = = the ratio of the specific activity of tritium in garden vegetation water to that in atmospheric water (dimensionless).

and other parameters are as defined above.

Table 9-1. Miscellaneous Parameters for the Garden Vegetation Pathway

The following parameter values are for use in calculating R_{aipj} for the garden vegetation pathway only. The terms themselves are defined in section 9.3.

Parameter	Value	Reference
Y_v	2.0 kg/m^2	Ref. 3, Table E-15
λw	5.73×10^{-7} s^{-1} (14-day half-life)	Ref. 1, page 33
f_L	1.0	Ref. 1, page 36
f_g	0.76	Ref. 1, page 33
t_L	8.6×10^4 s (1 day)	Ref. 3, Table E-15
t_{hv}	5.18×10^6 s (60 days)	Ref. 3, Table E-15
H	8 g/m^3	Ref. 3

9.4 GRASS-COW-MILK PATHWAY FACTOR

For radionuclides other than tritium in the grass-cow-milk pathway, R_{aipj} in ($m^2 \cdot$mrem/y) per (μCi/s) is calculated as follows (Reference 1, Section 5.3.1.3):

$$R_{aipj} = K_1 \cdot \frac{r}{(\lambda_i + \lambda_w)} \cdot Q_F \cdot U_{ap} \cdot F_{mi} \cdot (DFL)_{aij} \cdot \left[\frac{f_p f_s}{Y_p} + \frac{(1 - f_p f_s)\, e^{-\lambda_i t_{hm}}}{Y_s} \right] \cdot e^{-\lambda_i t_f} \qquad \textbf{(9.5)}$$

where:

K_1	=	the units conversion factor: 10^6 pCi/μCi.
r	=	the fraction of deposited activity retained on the edible parts of vegetation (dimensionless). The value used for r is 1.0 for radioiodines and 0.2 for particulates, from (Reference 3, Table E–1).
λ_i	=	the radioactive decay constant for radionuclide i, in s^{-1}. Values of λ_i used in effluent calculations should be based on decay data from a recognized and current source, such as Reference 20.
λ_w	=	the rate constant for removal of activity on leaf and plant surfaces by weathering, in s^{-1}, from Table 9-2.
Q_F	=	the cow's consumption rate of feed, in kg/d, from Table 9-2.
U_{ap}		the consumption rate of cow milk by a receptor in age group a, in L/y, from Table 9-5.
F_{mi}	=	the stable element transfer coefficient applicable to radionuclide i, for cow's milk, in d/L, from Table 9-6.
$(DFL)_{aij}$	=	the ingestion dose factor for receptor age group a, radionuclide i, and organ j, in mrem/pCi, from Table 9-11 through Table 9-14.
f_p	=	the fraction of the year that the cow is on pasture (dimensionless), from Table 9-2.
f_s	=	the fraction of the cow's feed that is pasture grass while the cow is on pasture (dimensionless), from Table 9-2.
Y_p	=	the areal density (agricultural productivity) of growing pasture feed grass, in kg/m^2, from Table 9-2.
Y_s	=	the areal density (agricultural productivity) of growing stored feed, in kg/m^2, from Table 9-2.
t_{hm}	=	the transport time from harvest of stored feed to its consumption by the cow, in s, from Table 9-2.

t_f = the transport time from consumption of feed by the cow, to consumption of milk by the receptor, in s, from Table 9-2.

For tritium in the grass-cow-milk pathway, R_{aipj} in (mrem/y) per (μCi/m^3) is calculated as follows (Reference 1, Section 5.3.1.5), based on the concentration in air rather than deposition onto the ground:

$$R_{aipj} = K_1 \cdot K_3 \cdot Q_F \cdot U_{ap} \cdot F_{mi} \cdot (DFL)_{aij} \cdot 0.75 \cdot \left(\frac{0.5}{H}\right) \qquad \textbf{(9.6)}$$

where:

K_3 = the units conversion factor: 10^3 g/kg.

H = the absolute humidity of atmospheric air, in g/m^3, from Table 9-2.

0.75 = the fraction of the mass of total vegetation that is water (dimensionless).

0.5 = the ratio of the specific activity of tritium in vegetation water to that in atmospheric water (dimensionless).

and other parameters are as defined above.

Table 9-2. Miscellaneous Parameters for the Grass-Cow-Milk Pathway

The following parameter values are for use in calculating R_{aipj} for the grass-cow-milk pathway only. The terms themselves are defined in section 9.4.

Parameter	Value	Reference
λ_w	5.73×10^{-7} s^{-1} (14-day half-life)	Ref. 1, page 33
Q_F	50 kg/d	Ref. 3, Table E-3
f_p	1.0	Ref. 1, page 33
f_s	1.0	Ref. 1, page 33
Y_p	0.7 kg/m^2	Ref. 3, Table E-15
Y_s	2.0 kg/m^2	Ref. 3, Table E-15
t_{hm}	7.78×10^6 s (90 days)	Ref. 3, Table E-15
t_f	1.73×10^5 s (2 days)	Ref. 3, Table E-15
H	8 g/m^3	Ref. 3

9.5 GRASS-GOAT-MILK PATHWAY FACTOR

For radionuclides other than tritium in the grass-goat-milk pathway, R_{aipj} in (m^2·mrem/y) per (μCi/s) is calculated as follows (Reference 1, Section 5.3.1.3):

$$R_{aipj} = K_1 \cdot \frac{r}{(\lambda_i + \lambda_w)} \cdot Q_F \cdot U_{ap} \cdot F_{m\,i} \cdot (DFL)_{aij} \cdot \left[\frac{f_p f_s}{Y_p} + \frac{(1 - f_p f_s)\, e^{-\lambda_i t_{hm}}}{Y_s} \right] \cdot e^{-\lambda_i t_f} \qquad \textbf{(9.7)}$$

where:

K_1	=	the units conversion factor: 10^6 pCi/μCi.
r	=	the fraction of deposited activity retained on the edible parts of vegetation (dimensionless). The value used for r is 1.0 for radioiodines and 0.2 for particulates, from (Reference 3, Table E–1).
λ_i	=	the radioactive decay constant for radionuclide i, in s^{-1}. Values of λ_i used in effluent calculations should be based on decay data from a recognized and current source, such as Reference 20.
λ_w		the rate constant for removal of activity on leaf and plant surfaces by weathering, in s^{-1}, from Table 9-3.
Q_F	=	the goat's consumption rate of feed, in kg/d, from Table 9-3.
U_{ap}	=	the consumption rate of goat milk by a receptor in age group a, in L/y, from Table 9-5.
F_{mi}	=	the stable element transfer coefficient applicable to radionuclide i, for goat's milk, in d/L, from Table 9-6.
$(DFL)_{aij}$	=	the ingestion dose factor for receptor age group a, radionuclide i, and organ j, in mrem/pCi, from Table 9-11 through Table 9-14.
f_p	=	the fraction of the year that the goat is on pasture (dimensionless), from Table 9-3.
f_s	=	the fraction of the goat's feed that is pasture grass while the goat is on pasture (dimensionless), from Table 9-3.
Y_p	=	the areal density (agricultural productivity) of growing pasture feed grass, in kg/m^2, from Table 9-3.
Y_s	=	the areal density (agricultural productivity) of growing stored feed, in kg/m^2, from Table 9-3.
t_{hm}	=	the transport time from harvest of stored feed to its consumption by the goat, in s, from Table 9-3.

t_f = the transport time from consumption of feed by the goat, to consumption of milk by the receptor, in s, from Table 9-3.

For tritium in the grass-goat-milk pathway, R_{aipj} in (mrem/y) per (μCi/m^3) is calculated as follows (Reference 1, Section 5.3.1.5), based on the concentration in air rather than deposition onto the ground:

$$R_{aipj} = K_1 \cdot K_3 \cdot Q_F \cdot U_{ap} \cdot F_{m\,i} \cdot (DFL)_{aij} \cdot 0.75 \cdot \left(\frac{0.5}{H}\right) \quad \textbf{(9.8)}$$

where:

K_3 = the units conversion factor: 10^3 g/kg.

H = the absolute humidity of atmospheric air, in g/m^3, from Table 9-3.

0.75 = the fraction of the mass of total vegetation that is water (dimensionless).

0.5 = the ratio of the specific activity of tritium in vegetation water to that in atmospheric water (dimensionless).

and other parameters are as defined above.

Table 9-3. Miscellaneous Parameters for the Grass-Goat-Milk Pathway

The following parameter values are for use in calculating R_{aipj} for the grass-goat-milk pathway only. The terms themselves are defined in section 9-5.

Parameter	Value	Reference
λ_w	5.73×10^{-7} s^{-1} (14-day half-life)	Ref. 1, page 33
Q_F	6 kg/d	Ref. 3, Table E-3
f_p	1.0	Ref. 1, page 33
f_s	1.0	Ref. 1, page 33
Y_p	0.7 kg/m^2	Ref. 3, Table E-15
Y_s	2.0 kg/m^2	Ref. 3, Table E-15
t_{hm}	7.78×10^6 s (90 days)	Ref. 3, Table E-15
t_f	1.73×10^5 s (2 days)	Ref. 3, Table E-15
H	8 g/m^3	Ref. 3

9.6 GRASS-COW-MEAT PATHWAY FACTOR

For radionuclides other than tritium in the grass-cow-meat pathway, R_{aipj} in ($m^2 \cdot$mrem/y) per (μCi/s) is calculated as follows (Reference 1, Section 5.3.1.4):

$$R_{aipj} = K_1 \cdot \frac{r}{(\lambda_i + \lambda_w)} \cdot Q_F \cdot U_{ap} \cdot F_{fi} \cdot (DFL)_{aij} \cdot \left[\frac{f_p f_s}{Y_p} + \frac{(1 - f_p f_s)\, e^{-\lambda_i t_{hm}}}{Y_s} \right] \cdot e^{-\lambda_i t_f} \qquad \textbf{(9.9)}$$

where:

K_1 = the units conversion factor: 10^6 pCi/μCi.

r = the fraction of deposited activity retained on the edible parts of vegetation (dimensionless). The value used for r is 1.0 for radioiodines and 0.2 for particulates, from (Reference 3, Table E–1).

λ_i = the radioactive decay constant for radionuclide i, in s^{-1}. Values of λ_i used in effluent calculations should be based on decay data from a recognized and current source, such as Reference 20.

λ_w = the rate constant for removal of activity on leaf and plant surfaces by weathering, in s^{-1}, from Table 9-4.

Q_F = the cow's consumption rate of feed, in kg/d, from Table 9-4.

U_{ap} = the consumption rate of meat by a receptor in age group a, in kg/y, from Table 9-5.

F_{fi} = the stable element transfer coefficient applicable to radionuclide i, for meat, in d/kg, from Table 9-6.

$(DFL)_{aij}$ = the ingestion dose factor for receptor age group a, radionuclide i, and organ j, in mrem/pCi, from Table 9-11 through Table 9-14.

f_p = the fraction of the year that the cow is on pasture (dimensionless), from Table 9-4.

f_s = the fraction of the cow's feed that is pasture grass while the cow is on pasture (dimensionless), from Table 9-4.

Y_p = the areal density (agricultural productivity) of growing pasture feed grass, in kg/m^2, from Table 9-4.

Y_s = the areal density (agricultural productivity) of growing stored feed, in kg/m^2, from Table 9-4.

t_{hm} = the transport time from harvest of stored feed to its consumption by the cow, in s, from Table 9-4.

t_f = the transport time from consumption of feed by the cow, to consumption of meat by the receptor, in s, from Table 9-4.

For tritium in the grass-cow-meat pathway, R_{aipj} in (mrem/y) per (μCi/m^3) is calculated as follows (Reference 1, Section 5.3.1.4), based on the concentration in air rather than deposition onto the ground:

$$R_{aipj} = K_1 \cdot K_3 \cdot Q_F \cdot U_{ap} \cdot F_{f\,i} \cdot (DFL)_{aij} \cdot 0.75 \cdot \left(\frac{0.5}{H}\right) \quad \textbf{(9.10)}$$

where:

K_3 = the units conversion factor: 10^3 g/kg.

H = the absolute humidity of atmospheric air, in g/m^3, from Table 9-4.

0.75 = the fraction of the mass of total vegetation that is water (dimensionless).

0.5 = the ratio of the specific activity of tritium in vegetation water to that in atmospheric water (dimensionless).

and other parameters are as defined above.

Table 9-4. Miscellaneous Parameters for the Grass-Cow-Meat Pathway

The following parameter values are for use in calculating R_{aipj} for the grass-cow-meat pathway only. The terms themselves are defined in section 9-6.

Parameter	Value	Reference
λ_w	5.73×10^{-7} s^{-1} (14-day half-life)	Ref. 1, page 33
Q_F	50 kg/d	Ref. 3, Table E-3
f_p	1.0	Ref. 1, page 33
f_s	1.0	Ref. 1, page 33
Y_p	0.7 kg/m^2	Ref. 3, Table E-15
Y_s	2.0 kg/m^2	Ref. 3, Table E-15
t_{hm}	7.78×10^6 s (90 days)	Ref. 3, Table E-15
t_f	1.73×10^6 s (20 days)	Ref. 3, Table E-15
H	8 g/m^3	Ref. 3

Table 9-5. Individual Usage Factors

Usage Factor	Receptor Age Group			
	Infant	Child	Teenager	Adult
Milk Consumption Rate, U_{ap} (L/y)	330	330	400	310
Meat Consumption Rate, U_{ap} (kg/y)	0	41	65	110
Fresh Leafy Garden Vegetation Consumption Rate, U_{aL} (kg/y)	0	26	42	64
Stored Garden Vegetation Consumption Rate, U_{aS} (kg/y)	0	520	630	520
Breathing Rate, $(BR)_a$ (m^3/y)	1400	3700	8000	8000

All values are from Reference 3, Table E-5.

Table 9-6. Stable Element Transfer Data

Element	Cow Milk F_m (d/L)*	Goat Milk F_m (d/L)+	Meat F_f (d/kg)*
H	1.0 E-02	1.7 E-01	1.2 E-02
C	1.2 E-02	1.0 E-01	3.1 E-02
Na	4.0 E-02	4.0 E-02	3.0 E-02
P	2.5 E-02	2.5 E-01	4.6 E-02
Cr	2.2 E-03	2.2 E-03	2.4 E-03
Mn	2.5 E-04	2.5 E-04	8.0 E-04
Fe	1.2 E-03	1.3 E-04	4.0 E-02
Co	1.0 E-03	1.0 E-03	1.3 E-02
Ni	6.7 E-03	6.7 E-03	5.3 E-02
Cu	1.4 E-02	1.3 E-02	8.0 E-03
Zn	3.9 E-02	3.9 E-02	3.0 E-02
Br	5.0 E-02	5.0 E-02	2.6 E-02
Rb	3.0 E-02	3.0 E-02	3.1 E-02
Sr	8.0 E-04	1.4 E-02	6.0 E-04
Y	1.0 E-05	1.0 E-05	4.6 E-03
Zr	5.0 E-06	5.0 E-06	3.4 E-02
Nb	2.5 E-03	2.5 E-03	2.8 E-01
Mo	7.5 E-03	7.5 E-03	8.0 E-03
Tc	2.5 E-02	2.5 E-02	4.0 E-01
Ru	1.0 E-06	1.0 E-06	4.0 E-01
Rh	1.0 E-02	1.0 E-02	1.5 E-03
Ag	5.0 E-02	5.0 E-02	1.7 E-02
Sb	1.5 E-03	1.5 E-03	4.0 E-03
Te	1.0 E-03	1.0 E-03	7.7 E-02
I	6.0 E-03	6.0 E-02	2.9 E-03
Cs	1.2 E-02	3.0 E-01	4.0 E-03
Ba	4.0 E-04	4.0 E-04	3.2 E-03
La	5.0 E-06	5.0 E-06	2.0 E-04
Ce	1.0 E-04	1.0 E-04	1.2 E-03
Pr	5.0 E-06	5.0 E-06	4.7 E-03
Nd	5.0 E-06	5.0 E-06	3.3 E-03
W	5.0 E-04	5.0 E-04	1.3 E-03
Np	5.0 E-06	5.0 E-06	2.0 E-04

* - Values from Reference 3 (Table E-1) except as follows: Reference 2 (Table C-5) for Br and Sb.

\+ - Values from Reference 3, Table E-2 for H, C, P, Fe, Cu, Sr, I, and Cs in goat milk, and Table E-1 for all other elements in cow milk, except as follows: Reference 2 (Table C-5) for Br and Sb in cow milk.

Table 9-7. Inhalation Dose Factors for the Infant Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	4.62E-07	4.62E-07	4.62E-07	4.62E-07	4.62E-07	4.62E-07
C-14	1.89E-05	3.79E-06	3.79E-06	3.79E-06	3.79E-06	3.79E-06	3.79E-06
Na-24	7.54E-06	7.54E-06	7.54E-06	7.54E-06	7.54E-06	7.54E-06	7.54E-06
P-32	1.45E-03	8.03E-05	5.53E-05	No Data	No Data	No Data	1.15E-05
Cr-51	No Data	No Data	6.39E-08	4.11E-08	9.45E-09	9.17E-06	2.55E-07
Mn-54	No Data	1.81E-05	3.56E-06	No Data	3.56E-06	7.14E-04	5.04E-06
Mn-56	No Data	1.10E-09	1.58E-10	No Data	7.86E-10	8.95E-06	5.12E-05
Fe-55	1.41E-05	8.39E-06	2.38E-06	No Data	No Data	6.21E-05	7.82E-07
Fe-59	9.69E-06	1.68E-05	6.77E-06	No Data	No Data	7.25E-04	1.77E-05
Co-58	No Data	8.71E-07	1.30E-06	No Data	No Data	5.55E-04	7.95E-06
Co-60	No Data	5.73E-06	8.41E-06	No Data	No Data	3.22E-03	2.28E-05
Ni-63	2.42E-04	1.46E-05	8.29E-06	No Data	No Data	1.49E-04	1.73E-06
Ni-65	1.71E-09	2.03E-10	8.79E-11	No Data	No Data	5.80E-06	3.58E-05
Cu-64	No Data	1.34E-09	5.53E-10	No Data	2.84E-09	6.64E-06	1.07E-05
Zn-65	1.38E-05	4.47E-05	2.22E-05	No Data	2.32E-05	4.62E-04	3.67E-05
Zn-69	3.85E-11	6.91E-11	5.13E-12	No Data	2.87E-11	1.05E-06	9.44E-06
Br-83	No Data	No Data	2.72E-07	No Data	No Data	No Data	No Data
Br-84	No Data	No Data	2.86E-07	No Data	No Data	No Data	No Data
Br-85	No Data	No Data	1.46E-08	No Data	No Data	No Data	No Data
Rb-86	No Data	1.36E-04	6.30E-05	No Data	No Data	No Data	2.17E-06
Rb-88	No Data	3.98E-07	2.05E-07	No Data	No Data	No Data	2.42E-07
Rb-89	No Data	2.29E-07	1.47E-07	No Data	No Data	No Data	4.87E-08
Sr-89	2.84E-04	No Data	8.15E-06	No Data	No Data	1.45E-03	4.57E-05
Sr-90	2.92E-02	No Data	1.85E-03	No Data	No Data	8.03E-03	9.36E-05
Sr-91	6.83E-08	No Data	2.47E-09	No Data	No Data	3.76E-05	5.24E-05

All values are in (mrem/pCi inhaled). They are obtained from Reference 3 (Table E-10). Neither Reference 2 nor Reference 3 contains data for Rh–105, Sb–124, or Sb–125.

Table 9-7 (contd). Inhalation Dose Factors for the Infant Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Sr-92	7.50E-09	No Data	2.79E-10	No Data	No Data	1.70E-05	1.00E-04
Y-90	2.35E-06	No Data	6.30E-08	No Data	No Data	1.92E-04	7.43E-05
Y-91m	2.91E-10	No Data	9.90E-12	No Data	No Data	1.99E-06	1.68E-06
Y-91	4.20E-04	No Data	1.12E-05	No Data	No Data	1.75E-03	5.02E-05
Y-92	1.17E-08	No Data	3.29E-10	No Data	No Data	1.75E-05	9.04E-05
Y-93	1.07E-07	No Data	2.91E-09	No Data	No Data	5.46E-05	1.19E-04
Zr-95	8.24E-05	1.99E-05	1.45E-05	No Data	2.22E-05	1.25E-03	1.55E-05
Zr-97	1.07E-07	1.83E-08	8.36E-09	No Data	1.85E-08	7.88E-05	1.00E-04
Nb-95	1.12E-05	4.59E-06	2.70E-06	No Data	3.37E-06	3.42E-04	9.05E-06
Mo-99	No Data	1.18E-07	2.31E-08	No Data	1.89E-07	9.63E-05	3.48E-05
Tc-99m	9.98E-13	2.06E-12	2.66E-11	No Data	2.22E-11	5.79E-07	1.45E-06
Tc-101	4.65E-14	5.88E-14	5.80E-13	No Data	6.99E-13	4.17E-07	6.03E-07
Ru-103	1.44E-06	No Data	4.85E-07	No Data	3.03E-06	3.94E-04	1.15E-05
Ru-105	8.74E-10	No Data	2.93E-10	No Data	6.42E-10	1.12E-05	3.46E-05
Ru-106	6.20E-05	No Data	7.77E-06	No Data	7.61E-05	8.26E-03	1.17E-04
Rh-105	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Ag-110m	7.13E-06	5.16E-06	3.57E-06	No Data	7.80E-06	2.62E-03	2.36E-05
Sb-124	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Sb-125	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Te-125m	3.40E-06	1.42E-06	4.70E-07	1.16E-06	No Data	3.19E-04	9.22E-06
Te-127m	1.19E-05	4.93E-06	1.48E-06	3.48E-06	2.68E-05	9.37E-04	1.95E-05
Te-127	1.59E-09	6.81E-10	3.49E-10	1.32E-09	3.47E-09	7.39E-06	1.74E-05
Te-129m	1.01E-05	4.35E-06	1.59E-06	3.91E-06	2.27E-05	1.20E-03	4.93E-05
Te-129	5.63E-11	2.48E-11	1.34E-11	4.82E-11	1.25E-10	2.14E-06	1.88E-05
Te-131m	7.62E-08	3.93E-08	2.59E-08	6.38E-08	1.89E-07	1.42E-04	8.51E-05
Te-131	1.24E-11	5.87E-12	3.57E-12	1.13E-11	2.85E-11	1.47E-06	5.87E-06

Table 9-7 (contd). Inhalation Dose Factors for the Infant Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Te-132	2.66E-07	1.69E-07	1.26E-07	1.99E-07	7.39E-07	2.43E-04	3.15E-05
I-130	4.54E-06	9.91E-06	3.98E-06	1.14E-03	1.09E-05	No Data	1.42E-06
I-131	2.71E-05	3.17E-05	1.40E-05	1.06E-02	3.70E-05	No Data	7.56E-07
I-132	1.21E-06	2.53E-06	8.99E-07	1.21E-04	2.82E-06	No Data	1.36E-06
I-133	9.46E-06	1.37E-05	4.00E-06	2.54E-03	1.60E-05	No Data	1.54E-06
I-134	6.58E-07	1.34E-06	4.75E-07	3.18E-05	1.49E-06	No Data	9.21E-07
I-135	2.76E-06	5.43E-06	1.98E-06	4.97E-04	6.05E-06	No Data	1.31E-06
Cs-134	2.83E-04	5.02E-04	5.32E-05	No Data	1.36E-04	5.69E-05	9.53E-07
Cs-136	3.45E-05	9.61E-05	3.78E-05	No Data	4.03E-05	8.40E-06	1.02E-06
Cs-137	3.92E-04	4.37E-04	3.25E-05	No Data	1.23E-04	5.09E-05	9.53E-07
Cs-138	3.61E-07	5.58E-07	2.84E-07	No Data	2.93E-07	4.67E-08	6.26E-07
Ba-139	1.06E-09	7.03E-13	3.07E-11	No Data	4.23E-13	4.25E-06	3.64E-05
Ba-140	4.00E-05	4.00E-08	2.07E-06	No Data	9.59E-09	1.14E-03	2.74E-05
Ba-141	1.12E-10	7.70E-14	3.55E-12	No Data	4.64E-14	2.12E-06	3.39E-06
Ba-142	2.84E-11	2.36E-14	1.40E-12	No Data	1.36E-14	1.11E-06	4.95E-07
La-140	3.61E-07	1.43E-07	3.68E-08	No Data	No Data	1.20E-04	6.06E-05
La-142	7.36E-10	2.69E-10	6.46E-11	No Data	No Data	5.87E-06	4.25E-05
Ce-141	1.98E-05	1.19E-05	1.42E-06	No Data	3.75E-06	3.69E-04	1.54E-05
Ce-143	2.09E-07	1.38E-07	1.58E-08	No Data	4.03E-08	8.30E-05	3.55E-05
Ce-144	2.28E-03	8.65E-04	1.26E-04	No Data	3.84E-04	7.03E-03	1.06E-04
Pr-143	1.00E-05	3.74E-06	4.99E-07	No Data	1.41E-06	3.09E-04	2.66E-05
Pr-144	3.42E-11	1.32E-11	1.72E-12	No Data	4.80E-12	1.15E-06	3.06E-06
Nd-147	5.67E-06	5.81E-06	3.57E-07	No Data	2.25E-06	2.30E-04	2.23E-05
W-187	9.26E-09	6.44E-09	2.23E-09	No Data	No Data	2.83E-05	2.54E-05
Np-239	2.65E-07	2.37E-08	1.34E-08	No Data	4.73E-08	4.25E-05	1.78E-05

Table 9-8. Inhalation Dose Factors for the Child Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	3.04E-07	3.04E-07	3.04E-07	3.04E-07	3.04E-07	3.04E-07
C-14	9.70E-06	1.82E-06	1.82E-06	1.82E-06	1.82E-06	1.82E-06	1.82E-06
Na-24	4.35E-06	4.35E-06	4.35E-06	4.35E-06	4.35E-06	4.35E-06	4.35E-06
P-32	7.04E-04	3.09E-05	2.67E-05	No Data	No Data	No Data	1.14E-05
Cr-51	No Data	No Data	4.17E-08	2.31E-08	6.57E-09	4.59E-06	2.93E-07
Mn-54	No Data	1.16E-05	2.57E-06	No Data	2.71E-06	4.26E-04	6.19E-06
Mn-56	No Data	4.48E-10	8.43E-11	No Data	4.52E-10	3.55E-06	3.33E-05
Fe-55	1.28E-05	6.80E-06	2.10E-06	No Data	No Data	3.00E-05	7.75E-07
Fe-59	5.59E-06	9.04E-06	4.51E-06	No Data	No Data	3.43E-04	1.91E-05
Co-58	No Data	4.79E-07	8.55E-07	No Data	No Data	2.99E-04	9.29E-06
Co-60	No Data	3.55E-06	6.12E-06	No Data	No Data	1.91E-03	2.60E-05
Ni-63	2.22E-04	1.25E-05	7.56E-06	No Data	No Data	7.43E-05	1.71E-06
Ni-65	8.08E-10	7.99E-11	4.44E-11	No Data	No Data	2.21E-06	2.27E-05
Cu-64	No Data	5.39E-10	2.90E-10	No Data	1.63E-09	2.59E-06	9.92E-06
Zn-65	1.15E-05	3.06E-05	1.90E-05	No Data	1.93E-05	2.69E-04	4.41E-06
Zn-69	1.81E-11	2.61E-11	2.41E-12	No Data	1.58E-11	3.84E-07	2.75E-06
Br-83	No Data	No Data	1.28E-07	No Data	No Data	No Data	No Data
Br-84	No Data	No Data	1.48E-07	No Data	No Data	No Data	No Data
Br-85	No Data	No Data	6.84E-09	No Data	No Data	No Data	No Data
Rb-86	No Data	5.36E-05	3.09E-05	No Data	No Data	No Data	2.16E-06
Rb-88	No Data	1.52E-07	9.90E-08	No Data	No Data	No Data	4.66E-09
Rb-89	No Data	9.33E-08	7.83E-08	No Data	No Data	No Data	5.11E-10
Sr-89	1.62E-04	No Data	4.66E-06	No Data	No Data	5.83E-04	4.52E-05
Sr-90	2.73E-02	No Data	1.74E-03	No Data	No Data	3.99E-03	9.28E-05
Sr-91	3.28E-08	No Data	1.24E-09	No Data	No Data	1.44E-05	4.70E-05

All values are in (mrem/pCi inhaled). They are obtained from Reference 3 (Table E-9). Neither Reference 2 nor Reference 3 contains data for Rh–105, Sb–124, or Sb–125.

Table 9-8 (contd). Inhalation Dose Factors for the Child Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Sr-92	3.54E-09	No Data	1.42E-10	No Data	No Data	6.49E-06	6.55E-05
Y-90	1.11E-06	No Data	2.99E-08	No Data	No Data	7.07E-05	7.24E-05
Y-91m	1.37E-10	No Data	4.98E-12	No Data	No Data	7.60E-07	4.64E-07
Y-91	2.47E-04	No Data	6.59E-06	No Data	No Data	7.10E-04	4.97E-05
Y-92	5.50E-09	No Data	1.57E-10	No Data	No Data	6.46E-06	6.46E-05
Y-93	5.04E-08	No Data	1.38E-09	No Data	No Data	2.01E-05	1.05E-04
Zr-95	5.13E-05	1.13E-05	1.00E-05	No Data	1.61E-05	6.03E-04	1.65E-05
Zr-97	5.07E-08	7.34E-09	4.32E-09	No Data	1.05E-08	3.06E-05	9.49E-05
Nb-95	6.35E-06	2.48E-06	1.77E-06	No Data	2.33E-06	1.66E-04	1.00E-05
Mo-99	No Data	4.66E-08	1.15E-08	No Data	1.06E-07	3.66E-05	3.42E-05
Tc-99m	4.81E-13	9.41E-13	1.56E-11	No Data	1.37E-11	2.57E-07	1.30E-06
Tc-101	2.19E-14	2.30E-14	2.91E-13	No Data	3.92E-13	1.58E-07	4.41E-09
Ru-103	7.55E-07	No Data	2.90E-07	No Data	1.90E-06	1.79E-04	1.21E-05
Ru-105	4.13E-10	No Data	1.50E-10	No Data	3.63E-10	4.30E-06	2.69E-05
Ru-106	3.68E-05	No Data	4.57E-06	No Data	4.97E-05	3.87E-03	1.16E-04
Rh-105	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Ag-110m	4.56E-06	3.08E-06	2.47E-06	No Data	5.74E-06	1.48E-03	2.71E-05
Sb-124	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Sb-125	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Te-125m	1.82E-06	6.29E-07	2.47E-07	5.20E-07	No Data	1.29E-04	9.13E-06
Te-127m	6.72E-06	2.31E-06	8.16E-07	1.64E-06	1.72E-05	4.00E-04	1.93E-05
Te-127	7.49E-10	2.57E-10	1.65E-10	5.30E-10	1.91E-09	2.71E-06	1.52E-05
Te-129m	5.19E-06	1.85E-06	8.22E-07	1.71E-06	1.36E-05	4.76E-04	4.91E-05
Te-129	2.64E-11	9.45E-12	6.44E-12	1.93E-11	6.94E-11	7.93E-07	6.89E-06
Te-131m	3.63E-08	1.60E-08	1.37E-08	2.64E-08	1.08E-07	5.56E-05	8.32E-05
Te-131	5.87E-12	2.28E-12	1.78E-12	4.59E-12	1.59E-11	5.55E-07	3.60E-07

Table 9-8 (contd). Inhalation Dose Factors for the Child Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Te-132	1.30E-07	7.36E-08	7.12E-08	8.58E-08	4.79E-07	1.02E-04	3.72E-05
I-130	2.21E-06	4.43E-06	2.28E-06	4.99E-04	6.61E-06	No Data	1.38E-06
I-131	1.30E-05	1.30E-05	7.37E-06	4.39E-03	2.13E-05	No Data	7.68E-07
I-132	5.72E-07	1.10E-06	5.07E-07	5.23E-05	1.69E-06	No Data	8.65E-07
I-133	4.48E-06	5.49E-06	2.08E-06	1.04E-03	9.13E-06	No Data	1.48E-06
I-134	3.17E-07	5.84E-07	2.69E-07	1.37E-05	8.92E-07	No Data	2.58E-07
I-135	1.33E-06	2.36E-06	1.12E-06	2.14E-04	3.62E-06	No Data	1.20E-06
Cs-134	1.76E-04	2.74E-04	6.07E-05	No Data	8.93E-05	3.27E-05	1.04E-06
Cs-136	1.76E-05	4.62E-05	3.14E-05	No Data	2.58E-05	3.93E-06	1.13E-06
Cs-137	2.45E-04	2.23E-04	3.47E-05	No Data	7.63E-05	2.81E-05	9.78E-07
Cs-138	1.71E-07	2.27E-07	1.50E-07	No Data	1.68E-07	1.84E-08	7.29E-08
Ba-139	4.98E-10	2.66E-13	1.45E-11	No Data	2.33E-13	1.56E-06	1.56E-05
Ba-140	2.00E-05	1.75E-08	1.17E-06	No Data	5.71E-09	4.71E-04	2.75E-05
Ba-141	5.29E-11	2.95E-14	1.72E-12	No Data	2.56E-14	7.89E-07	7.44E-08
Ba-142	1.35E-11	9.73E-15	7.54E-13	No Data	7.87E-15	4.44E-07	7.41E-10
La-140	1.74E-07	6.08E-08	2.04E-08	No Data	No Data	4.94E-05	6.10E-05
La-142	3.50E-10	1.11E-10	3.49E-11	No Data	No Data	2.35E-06	2.05E-05
Ce-141	1.06E-05	5.28E-06	7.83E-07	No Data	2.31E-06	1.47E-04	1.53E-05
Ce-143	9.89E-08	5.37E-08	7.77E-09	No Data	2.26E-08	3.12E-05	3.44E-05
Ce-144	1.83E-03	5.72E-04	9.77E-05	No Data	3.17E-04	3.23E-03	1.05E-04
Pr-143	4.99E-06	1.50E-06	2.47E-07	No Data	8.11E-07	1.17E-04	2.63E-05
Pr-144	1.61E-11	4.99E-12	8.10E-13	No Data	2.64E-12	4.23E-07	5.32E-08
Nd-147	2.92E-06	2.36E-06	1.84E-07	No Data	1.30E-06	8.87E-05	2.22E-05
W-187	4.41E-09	2.61E-09	1.17E-09	No Data	No Data	1.11E-05	2.46E-05
Np-239	1.26E-07	9.04E-09	6.35E-09	No Data	2.63E-08	1.57E-05	1.73E-05

Table 9-9. Inhalation Dose Factors for the Teenager Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	1.59E-07	1.59E-07	1.59E-07	1.59E-07	1.59E-07	1.59E-07
C-14	3.25E-06	6.09E-07	6.09E-07	6.09E-07	6.09E-07	6.09E-07	6.09E-07
Na-24	1.72E-06	1.72E-06	1.72E-06	1.72E-06	1.72E-06	1.72E-06	1.72E-06
P-32	2.36E-04	1.37E-08	8.95E-06	No Data	No Data	No Data	1.16E-05
Cr-51	No Data	No Data	1.69E-08	9.37E-09	3.84E-09	2.62E-06	3.75E-07
Mn-54	No Data	6.39E-06	1.05E-06	No Data	1.59E-06	2.48E-04	8.35E-06
Mn-56	No Data	2.12E-10	3.15E-11	No Data	2.24E-10	1.90E-06	7.18E-06
Fe-55	4.18E-06	2.98E-06	6.93E-07	No Data	No Data	1.55E-05	7.99E-07
Fe-59	1.99E-06	4.62E-06	1.79E-06	No Data	No Data	1.91E-04	2.23E-05
Co-58	No Data	2.59E-07	3.47E-07	No Data	No Data	1.68E-04	1.19E-05
Co-60	No Data	1.89E-06	2.48E-06	No Data	No Data	1.09E-03	3.24E-05
Ni-63	7.25E-05	5.43E-06	2.47E-06	No Data	No Data	3.84E-05	1.77E-06
Ni-65	2.73E-10	3.66E-11	1.59E-11	No Data	No Data	1.17E-06	4.59E-06
Cu-64	No Data	2.54E-10	1.06E-10	No Data	8.01E-10	1.39E-06	7.68E-06
Zn-65	4.82E-06	1.67E-05	7.80E-06	No Data	1.08E-05	1.55E-04	5.83E-06
Zn-69	6.04E-12	1.15E-11	8.07E-13	No Data	7.53E-12	1.98E-07	3.56E-08
Br-83	No Data	No Data	4.30E-08	No Data	No Data	No Data	No Data
Br-84	No Data	No Data	5.41E-08	No Data	No Data	No Data	No Data
Br-85	No Data	No Data	2.29E-09	No Data	No Data	No Data	No Data
Rb-86	No Data	2.38E-05	1.05E-05	No Data	No Data	No Data	2.21E-06
Rb-88	No Data	6.82E-08	3.40E-08	No Data	No Data	No Data	3.65E-15
Rb-89	No Data	4.40E-08	2.91E-08	No Data	No Data	No Data	4.22E-17
Sr-89	5.43E-05	No Data	1.56E-06	No Data	No Data	3.02E-04	4.64E-05
Sr-90	1.35E-02	No Data	8.35E-04	No Data	No Data	2.06E-03	9.56E-05
Sr-91	1.10E-08	No Data	4.39E-10	No Data	No Data	7.59E-06	3.24E-05

All values are in (mrem/pCi inhaled). They are obtained from Reference 3 (Table E-8). Neither Reference 2 nor Reference 3 contains data for Rh–105, Sb–124, or Sb–125.

Table 9-9 (contd). Inhalation Dose Factors for the Teenager Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Sr-92	1.19E-09	No Data	5.08E-11	No Data	No Data	3.43E-06	1.49E-05
Y-90	3.73E-07	No Data	1.00E-08	No Data	No Data	3.66E-05	6.99E-05
Y-91m	4.63E-11	No Data	1.77E-12	No Data	No Data	4.00E-07	3.77E-09
Y-91	8.26E-05	No Data	2.21E-06	No Data	No Data	3.67E-04	5.11E-05
Y-92	1.84E-09	No Data	5.36E-11	No Data	No Data	3.35E-06	2.06E-05
Y-93	1.69E-08	No Data	4.65E-10	No Data	No Data	1.04E-05	7.24E-05
Zr-95	1.82E-05	5.73E-06	3.94E-06	No Data	8.42E-06	3.36E-04	1.86E-05
Zr-97	1.72E-08	3.40E-09	1.57E-09	No Data	5.15E-09	1.62E-05	7.88E-05
Nb-95	2.32E-06	1.29E-06	7.08E-07	No Data	1.25E-06	9.39E-05	1.21E-05
Mo-99	No Data	2.11E-08	4.03E-09	No Data	5.14E-08	1.92E-05	3.36E-05
Tc-99m	1.73E-13	4.83E-13	6.24E-12	No Data	7.20E-12	1.44E-07	7.66E-07
Tc-101	7.40E-15	1.05E-14	1.03E-13	No Data	1.90E-13	8.34E-08	1.09E-16
Ru-103	2.63E-07	No Data	1.12E-07	No Data	9.29E-07	9.79E-05	1.36E-05
Ru-105	1.40E-10	No Data	5.42E-11	No Data	1.76E-10	2.27E-06	1.13E-05
Ru-106	1.23E-05	No Data	1.55E-06	No Data	2.38E-05	2.01E-03	1.20E-04
Rh-105	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Ag-110m	1.73E-06	1.64E-06	9.99E-07	No Data	3.13E-06	8.44E-04	3.41E-05
Sb-124	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Sb-125	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Te-125m	6.10E-07	2.80E-07	8.34E-08	1.75E-07	No Data	6.70E-05	9.38E-06
Te-127m	2.25E-06	1.02E-06	2.73E-07	5.48E-07	8.17E-06	2.07E-04	1.99E-05
Te-127	2.51E-10	1.14E-10	5.52E-11	1.77E-10	9.10E-10	1.40E-06	1.01E-05
Te-129m	1.74E-06	8.23E-07	2.81E-07	5.72E-07	6.49E-06	2.47E-04	5.06E-05
Te-129	8.87E-12	4.22E-12	2.20E-12	6.48E-12	3.32E-11	4.12E-07	2.02E-07
Te-131m	1.23E-08	7.51E-09	5.03E-09	9.06E-09	5.49E-08	2.97E-05	7.76E-05
Te-131	1.97E-12	1.04E-12	6.30E-13	1.55E-12	7.72E-12	2.92E-07	1.89E-09

Table 9-9 (contd). Inhalation Dose Factors for the Teenager Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Te-132	4.50E-08	3.63E-08	2.74E-08	3.07E-08	2.44E-07	5.61E-05	5.79E-05
I-130	7.80E-07	2.24E-06	8.96E-07	1.86E-04	3.44E-06	No Data	1.14E-06
I-131	4.43E-06	6.14E-06	3.30E-06	1.83E-03	1.05E-05	No Data	8.11E-07
I-132	1.99E-07	5.47E-07	1.97E-07	1.89E-05	8.65E-07	No Data	1.59E-07
I-133	1.52E-06	2.56E-06	7.78E-07	3.65E-04	4.49E-06	No Data	1.29E-06
I-134	1.11E-07	2.90E-07	1.05E-07	4.94E-06	4.58E-07	No Data	2.55E-09
I-135	4.62E-07	1.18E-06	4.36E-07	7.76E-05	1.86E-06	No Data	8.69E-07
Cs-134	6.28E-05	1.41E-04	6.86E-05	No Data	4.69E-05	1.83E-05	1.22E-06
Cs-136	6.44E-06	2.42E-05	1.71E-05	No Data	1.38E-05	2.22E-06	1.36E-06
Cs-137	8.38E-05	1.06E-04	3.89E-05	No Data	3.80E-05	1.51E-05	1.06E-06
Cs-138	5.82E-08	1.07E-07	5.58E-08	No Data	8.28E-08	9.84E-09	3.38E-11
Ba-139	1.67E-10	1.18E-13	4.87E-12	No Data	1.11E-13	8.08E-07	8.06E-07
Ba-140	6.84E-06	8.38E-09	4.40E-07	No Data	2.85E-09	2.54E-04	2.86E-05
Ba-141	1.78E-11	1.32E-14	5.93E-13	No Data	1.23E-14	4.11E-07	9.33E-14
Ba-142	4.62E-12	4.63E-15	2.84E-13	No Data	3.92E-15	2.39E-07	5.99E-20
La-140	5.99E-08	2.95E-08	7.82E-09	No Data	No Data	2.68E-05	6.09E-05
La-142	1.20E-10	5.31E-11	1.32E-11	No Data	No Data	1.27E-06	1.50E-06
Ce-141	3.55E-06	2.37E-06	2.71E-07	No Data	1.11E-06	7.67E-05	1.58E-05
Ce-143	3.32E-08	2.42E-08	2.70E-09	No Data	1.08E-08	1.63E-05	3.19E-05
Ce-144	6.11E-04	2.53E-04	3.28E-05	No Data	1.51E-04	1.67E-03	1.08E-04
Pr-143	1.67E-06	6.64E-07	8.28E-08	No Data	3.86E-07	6.04E-05	2.67E-05
Pr-144	5.37E-12	2.20E-12	2.72E-13	No Data	1.26E-12	2.19E-07	2.94E-14
Nd-147	9.83E-07	1.07E-06	6.41E-08	No Data	6.28E-07	4.65E-05	2.28E-05
W-187	1.50E-09	1.22E-09	4.29E-10	No Data	No Data	5.92E-06	2.21E-05
Np-239	4.23E-08	3.99E-09	2.21E-09	No Data	1.25E-08	8.11E-06	1.65E-05

Table 9-10. Inhalation Dose Factors for the Adult Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	1.58E-07	1.58E-07	1.58E-07	1.58E-07	1.58E-07	1.58E-07
C-14	2.27E-06	4.26E-07	4.26E-07	4.26E-07	4.26E-07	4.26E-07	4.26E-07
Na-24	1.28E-06	1.28E-06	1.28E-06	1.28E-06	1.28E-06	1.28E-06	1.28E-06
P-32	1.65E-04	9.64E-06	6.26E-06	No Data	No Data	No Data	1.08E-05
Cr-51	No Data	No Data	1.25E-08	7.44E-09	2.85E-09	1.80E-06	4.15E-07
Mn-54	No Data	4.95E-06	7.87E-07	No Data	1.23E-06	1.75E-04	9.67E-06
Mn-56	No Data	1.55E-10	2.29E-11	No Data	1.63E-10	1.18E-06	2.53E-06
Fe-55	3.07E-06	2.12E-06	4.93E-07	No Data	No Data	9.01E-06	7.54E-07
Fe-59	1.47E-06	3.47E-06	1.32E-06	No Data	No Data	1.27E-04	2.35E-05
Co-58	No Data	1.98E-07	2.59E-07	No Data	No Data	1.16E-04	1.33E-05
Co-60	No Data	1.44E-06	1.85E-06	No Data	No Data	7.46E-04	3.56E-05
Ni-63	5.40E-05	3.93E-06	1.81E-06	No Data	No Data	2.23E-05	1.67E-06
Ni-65	1.92E-10	2.62E-11	1.14E-11	No Data	No Data	7.00E-07	1.54E-06
Cu-64	No Data	1.83E-10	7.69E-11	No Data	5.78E-10	8.48E-07	6.12E-06
Zn-65	4.05E-06	1.29E-05	5.82E-06	No Data	8.62E-06	1.08E-04	6.68E-06
Zn-69	4.23E-12	8.14E-12	5.65E-13	No Data	5.27E-12	1.15E-07	2.04E-09
Br-83	No Data	No Data	3.01E-08	No Data	No Data	No Data	2.90E-08
Br-84	No Data	No Data	3.91E-08	No Data	No Data	No Data	2.05E-13
Br-85	No Data	No Data	1.60E-09	No Data	No Data	No Data	No Data
Rb-86	No Data	1.69E-05	7.37E-06	No Data	No Data	No Data	2.08E-06
Rb-88	No Data	4.84E-08	2.41E-08	No Data	No Data	No Data	4.18E-19
Rb-89	No Data	3.20E-08	2.12E-08	No Data	No Data	No Data	1.16E-21
Sr-89	3.80E-05	No Data	1.09E-06	No Data	No Data	1.75E-04	4.37E-05
Sr-90	1.24E-02	No Data	7.62E-04	No Data	No Data	1.20E-03	9.02E-05
Sr-91	7.74E-09	No Data	3.13E-10	No Data	No Data	4.56E-06	2.39E-05

All values are in (mrem/pCi inhaled). They are obtained from Reference 3 (Table E-7), except as follows: Reference 2 (Table C–1) for Rh–105, Sb-124, and Sb-125.

Table 9-10 (contd). Inhalation Dose Factors for the Adult Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Sr-92	8.43E-10	No Data	3.64E-11	No Data	No Data	2.06E-06	5.38E-06
Y-90	2.61E-07	No Data	7.01E-09	No Data	No Data	2.12E-05	6.32E-05
Y-91m	3.26E-11	No Data	1.27E-12	No Data	No Data	2.40E-07	1.66E-10
Y-91	5.78E-05	No Data	1.55E-06	No Data	No Data	2.13E-04	4.81E-05
Y-92	1.29E-09	No Data	3.77E-11	No Data	No Data	1.96E-06	9.19E-06
Y-93	1.18E-08	No Data	3.26E-10	No Data	No Data	6.06E-06	5.27E-05
Zr-95	1.34E-05	4.30E-06	2.91E-06	No Data	6.77E-06	2.21E-04	1.88E-05
Zr-97	1.21E-08	2.45E-09	1.13E-09	No Data	3.71E-09	9.84E-06	6.54E-05
Nb-95	1.76E-06	9.77E-07	5.26E-07	No Data	9.67E-07	6.31E-05	1.30E-05
Mo-99	No Data	1.51E-08	2.87E-09	No Data	3.64E-08	1.14E-05	3.10E-05
Tc-99m	1.29E-13	3.64E-13	4.63E-12	No Data	5.52E-12	9.55E-08	5.20E-07
Tc-101	5.22E-15	7.52E-15	7.38E-14	No Data	1.35E-13	4.99E-08	1.36E-21
Ru-103	1.91E-07	No Data	8.23E-08	No Data	7.29E-07	6.31E-05	1.38E-05
Ru-105	9.88E-11	No Data	3.89E-11	No Data	1.27E-10	1.37E-06	6.02E-06
Ru-106	8.64E-06	No Data	1.09E-06	No Data	1.67E-05	1.17E-03	1.14E-04
Rh-105	9.24E-10	6.73E-10	4.43E-10	No Data	2.86E-09	2.41E-06	1.09E-05
Ag-110m	1.35E-06	1.25E-06	7.43E-07	No Data	2.46E-06	5.79E-04	3.78E-05
Sb-124	3.90E-06	7.36E-08	1.55E-06	9.44E-09	No Data	3.10E-04	5.08E-05
Sb-125	8.26E-06	8.91E-08	1.66E-06	7.34E-09	No Data	2.75E-04	1.26E-05
Te-125m	4.27E-07	1.98E-07	5.84E-08	1.31E-07	1.55E-06	3.92E-05	8.83E-06
Te-127m	1.58E-06	7.21E-07	1.96E-07	4.11E-07	5.72E-06	1.20E-04	1.87E-05
Te-127	1.75E-10	8.03E-11	3.87E-11	1.32E-10	6.37E-10	8.14E-07	7.17E-06
Te-129m	1.22E-06	5.84E-07	1.98E-07	4.30E-07	4.57E-06	1.45E-04	4.79E-05
Te-129	6.22E-12	2.99E-12	1.55E-12	4.87E-12	2.34E-11	2.42E-07	1.96E-08
Te-131m	8.74E-09	5.45E-09	3.63E-09	6.88E-09	3.86E-08	1.82E-05	6.95E-05
Te-131	1.39E-12	7.44E-13	4.49E-13	1.17E-12	5.46E-12	1.74E-07	2.30E-09

Table 9-10 (contd). Inhalation Dose Factors for the Adult Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Te-132	3.25E-08	2.69E-08	2.02E-08	2.37E-08	1.82E-07	3.60E-05	6.37E-05
I-130	5.72E-07	1.68E-06	6.60E-07	1.42E-04	2.61E-06	No Data	9.61E-07
I-131	3.15E-06	4.47E-06	2.56E-06	1.49E-03	7.66E-06	No Data	7.85E-07
I-132	1.45E-07	4.07E-07	1.45E-07	1.43E-05	6.48E-07	No Data	5.08E-08
I-133	1.08E-06	1.85E-06	5.65E-07	2.69E-04	3.23E-06	No Data	1.11E-06
I-134	8.05E-08	2.16E-07	7.69E-08	3.73E-06	3.44E-07	No Data	1.26E-10
I-135	3.35E-07	8.73E-07	3.21E-07	5.60E-05	1.39E-06	No Data	6.56E-07
Cs-134	4.66E-05	1.06E-04	9.10E-05	No Data	3.59E-05	1.22E-05	1.30E-06
Cs-136	4.88E-06	1.83E-05	1.38E-05	No Data	1.07E-05	1.50E-06	1.46E-06
Cs-137	5.98E-05	7.76E-05	5.35E-05	No Data	2.78E-05	9.40E-06	1.05E-06
Cs-138	4.14E-08	7.76E-08	4.05E-08	No Data	6.00E-08	6.07E-09	2.33E-13
Ba-139	1.17E-10	8.32E-14	3.42E-12	No Data	7.78E-14	4.70E-07	1.12E-07
Ba-140	4.88E-06	6.13E-09	3.21E-07	No Data	2.09E-09	1.59E-04	2.73E-05
Ba-141	1.25E-11	9.41E-15	4.20E-13	No Data	8.75E-15	2.42E-07	1.45E-17
Ba-142	3.29E-12	3.38E-15	2.07E-13	No Data	2.86E-15	1.49E-07	1.96E-26
La-140	4.30E-08	2.17E-08	5.73E-09	No Data	No Data	1.70E-05	5.73E-05
La-142	8.54E-11	3.88E-11	9.65E-12	No Data	No Data	7.91E-07	2.64E-07
Ce-141	2.49E-06	1.69E-06	1.91E-07	No Data	7.83E-07	4.52E-05	1.50E-05
Ce-143	2.33E-08	1.72E-08	1.91E-09	No Data	7.60E-09	9.97E-06	2.83E-05
Ce-144	4.29E-04	1.79E-04	2.30E-05	No Data	1.06E-04	9.72E-04	1.02E-04
Pr-143	1.17E-06	4.69E-07	5.80E-08	No Data	2.70E-07	3.51E-05	2.50E-05
Pr-144	3.76E-12	1.56E-12	1.91E-13	No Data	8.81E-13	1.27E-07	2.69E-18
Nd-147	6.59E-07	7.62E-07	4.56E-08	No Data	4.45E-07	2.76E-05	2.16E-05
W-187	1.06E-09	8.85E-10	3.10E-10	No Data	No Data	3.63E-06	1.94E-05
Np-239	2.87E-08	2.82E-09	1.55E-09	No Data	8.75E-09	4.70E-06	1.49E-05

Table 9-11. Ingestion Dose Factors for the Infant Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	3.08E-07	3.08E-07	3.08E-07	3.08E-07	3.08E-07	3.08E-07
C-14	2.37E-05	5.06E-06	5.06E-06	5.06E-06	5.06E-06	5.06E-06	5.06E-06
Na-24	1.01E-05	1.01E-05	1.01E-05	1.01E-05	1.01E-05	1.01E-05	1.01E-05
P-32	1.70E-03	1.00E-04	6.59E-05	No Data	No Data	No Data	2.30E-05
Cr-51	No Data	No Data	1.41E-08	9.20E-09	2.01E-09	1.79E-08	4.11E-07
Mn-54	No Data	1.99E-05	4.51E-06	No Data	4.41E-06	No Data	7.31E-06
Mn-56	No Data	8.18E-07	1.41E-07	No Data	7.03E-07	No Data	7.43E-05
Fe-55	1.39E-05	8.98E-06	2.40E-06	No Data	No Data	4.39E-06	1.14E-06
Fe-59	3.08E-05	5.38E-05	2.12E-05	No Data	No Data	1.59E-05	2.57E-05
Co-58	No Data	3.60E-06	8.98E-06	No Data	No Data	No Data	8.97E-06
Co-60	No Data	1.08E-05	2.55E-05	No Data	No Data	No Data	2.57E-05
Ni-63	6.34E-04	3.92E-05	2.20E-05	No Data	No Data	No Data	1.95E-06
Ni-65	4.70E-06	5.32E-07	2.42E-07	No Data	No Data	No Data	4.05E-05
Cu-64	No Data	6.09E-07	2.82E-07	No Data	1.03E-06	No Data	1.25E-05
Zn-65	1.84E-05	6.31E-05	2.91E-05	No Data	3.06E-05	No Data	5.33E-05
Zn-69	9.33E-08	1.68E-07	1.25E-08	No Data	6.98E-08	No Data	1.37E-05
Br-83	No Data	No Data	3.63E-07	No Data	No Data	No Data	No Data
Br-84	No Data	No Data	3.82E-07	No Data	No Data	No Data	No Data
Br-85	No Data	No Data	1.94E-08	No Data	No Data	No Data	No Data
Rb-86	No Data	1.70E-04	8.40E-05	No Data	No Data	No Data	4.35E-06
Rb-88	No Data	4.98E-07	2.73E-07	No Data	No Data	No Data	4.85E-07
Rb-89	No Data	2.86E-07	1.97E-07	No Data	No Data	No Data	9.74E-08
Sr-89	2.51E-03	No Data	7.20E-05	No Data	No Data	No Data	5.16E-05
Sr-90	1.85E-02	No Data	4.71E-03	No Data	No Data	No Data	2.31E-04
Sr-91	5.00E-05	No Data	1.81E-06	No Data	No Data	No Data	5.92E-05

All values are in (mrem/pCi ingested). They are obtained from Reference 3 (Table E-14). Neither Reference 2 nor Reference 3 contains data for Rh–105, Sb–124, or Sb–125.

Table 9-11 (contd). Ingestion Dose Factors for the Infant Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Sr-92	1.92E-05	No Data	7.13E-07	No Data	No Data	No Data	2.07E-04
Y-90	8.69E-08	No Data	2.33E-09	No Data	No Data	No Data	1.20E-04
Y-91m	8.10E-10	No Data	2.76E-11	No Data	No Data	No Data	2.70E-06
Y-91	1.13E-06	No Data	3.01E-08	No Data	No Data	No Data	8.10E-05
Y-92	7.65E-09	No Data	2.15E-10	No Data	No Data	No Data	1.46E-04
Y-93	2.43E-08	No Data	6.62E-10	No Data	No Data	No Data	1.92E-04
Zr-95	2.06E-07	5.02E-08	3.56E-08	No Data	5.41E-08	No Data	2.50E-05
Zr-97	1.48E-08	2.54E-09	1.16E-09	No Data	2.56E-09	No Data	1.62E-04
Nb-95	4.20E-08	1.73E-08	1.00E-08	No Data	1.24E-08	No Data	1.46E-05
Mo-99	No Data	3.40E-05	6.63E-06	No Data	5.08E-05	No Data	1.12E-05
Tc-99m	1.92E-09	3.96E-09	5.10E-08	No Data	4.26E-08	2.07E-09	1.15E-06
Tc-101	2.27E-09	2.86E-09	2.83E-08	No Data	3.40E-08	1.56E-09	4.86E-07
Ru-103	1.48E-06	No Data	4.95E-07	No Data	3.08E-06	No Data	1.80E-05
Ru-105	1.36E-07	No Data	4.58E-08	No Data	1.00E-06	No Data	5.41E-05
Ru-106	2.41E-05	No Data	3.01E-06	No Data	2.85E-05	No Data	1.83E-04
Rh-105	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Ag-110m	9.96E-07	7.27E-07	4.81E-07	No Data	1.04E-06	No Data	3.77E-05
Sb-124	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Sb-125	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Te-125m	2.33E-05	7.79E-06	3.15E-06	7.84E-06	No Data	No Data	1.11E-05
Te-127m	5.85E-05	1.94E-05	7.08E-06	1.69E-05	1.44E-04	No Data	2.36E-05
Te-127	1.00E-06	3.35E-07	2.15E-07	8.14E-07	2.44E-06	No Data	2.10E-05
Te-129m	1.00E-04	3.43E-05	1.54E-05	3.84E-05	2.50E-04	No Data	5.97E-05
Te-129	2.84E-07	9.79E-08	6.63E-08	2.38E-07	7.07E-07	No Data	2.27E-05
Te-131m	1.52E-05	6.12E-06	5.05E-06	1.24E-05	4.21E-05	No Data	1.03E-04
Te-131	1.76E-07	6.50E-08	4.94E-08	1.57E-07	4.50E-07	No Data	7.11E-06

Table 9-11 (contd). Ingestion Dose Factors for the Infant Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Te-132	2.08E-05	1.03E-05	9.61E-06	1.52E-05	6.44E-05	No Data	3.81E-05
I-130	6.00E-06	1.32E-05	5.30E-06	1.48E-03	1.45E-05	No Data	2.83E-06
I-131	3.59E-05	4.23E-05	1.86E-05	1.39E-02	4.94E-05	No Data	1.51E-06
I-132	1.66E-06	3.37E-06	1.20E-06	1.58E-04	3.76E-06	No Data	2.73E-06
I-133	1.25E-05	1.82E-05	5.33E-06	3.31E-03	2.14E-05	No Data	3.08E-06
I-134	8.69E-07	1.78E-06	6.33E-07	4.15E-05	1.99E-06	No Data	1.84E-06
I-135	3.64E-06	7.24E-06	2.64E-06	6.49E-04	8.07E-06	No Data	2.62E-06
Cs-134	3.77E-04	7.03E-04	7.10E-05	No Data	1.81E-04	7.42E-05	1.91E-06
Cs-136	4.59E-05	1.35E-04	5.04E-05	No Data	5.38E-05	1.10E-05	2.05E-06
Cs-137	5.22E-04	6.11E-04	4.33E-05	No Data	1.64E-04	6.64E-05	1.91E-06
Cs-138	4.81E-07	7.82E-07	3.79E-07	No Data	3.90E-07	6.09E-08	1.25E-06
Ba-139	8.81E-07	5.84E-10	2.55E-08	No Data	3.51E-10	3.54E-10	5.58E-05
Ba-140	1.71E-04	1.71E-07	8.81E-06	No Data	4.06E-08	1.05E-07	4.20E-05
Ba-141	4.25E-07	2.91E-10	1.34E-08	No Data	1.75E-10	1.77E-10	5.19E-06
Ba-142	1.84E-07	1.53E-10	9.06E-09	No Data	8.81E-11	9.26E-11	7.59E-07
La-140	2.11E-08	8.32E-09	2.14E-09	No Data	No Data	No Data	9.77E-05
La-142	1.10E-09	4.04E-10	9.67E-11	No Data	No Data	No Data	6.86E-05
Ce-141	7.87E-08	4.80E-08	5.65E-09	No Data	1.48E-08	No Data	2.48E-05
Ce-143	1.48E-08	9.82E-06	1.12E-09	No Data	2.86E-09	No Data	5.73E-05
Ce-144	2.98E-06	1.22E-06	1.67E-07	No Data	4.93E-07	No Data	1.71E-04
Pr-143	8.13E-08	3.04E-08	4.03E-09	No Data	1.13E-08	No Data	4.29E-05
Pr-144	2.74E-10	1.06E-10	1.38E-11	No Data	3.84E-11	No Data	4.93E-06
Nd-147	5.53E-08	5.68E-08	3.48E-09	No Data	2.19E-08	No Data	3.60E-05
W-187	9.03E-07	6.28E-07	2.17E-07	No Data	No Data	No Data	3.69E-05
Np-239	1.11E-08	9.93E-10	5.61E-10	No Data	1.98E-09	No Data	2.87E-05

Table 9-12. Ingestion Dose Factors for the Child Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	2.03E-07	2.03E-07	2.03E-07	2.03E-07	2.03E-07	2.03E-07
C-14	1.21E-05	2.42E-06	2.42E-06	2.42E-06	2.42E-06	2.42E-06	2.42E-06
Na-24	5.80E-06	5.80E-06	5.80E-06	5.80E-06	5.80E-06	5.80E-06	5.80E-06
P-32	8.25E-04	3.86E-05	3.18E-05	No Data	No Data	No Data	2.28E-05
Cr-51	No Data	No Data	8.90E-09	4.94E-09	1.35E-09	9.02E-09	4.72E-07
Mn-54	No Data	1.07E-05	2.85E-06	No Data	3.00E-06	No Data	8.98E-06
Mn-56	No Data	3.34E-07	7.54E-08	No Data	4.04E-07	No Data	4.84E-05
Fe-55	1.15E-05	6.10E-06	1.89E-06	No Data	No Data	3.45E-06	1.13E-06
Fe-59	1.65E-05	2.67E-05	1.33E-05	No Data	No Data	7.74E-06	2.78E-05
Co-58	No Data	1.80E-06	5.51E-06	No Data	No Data	No Data	1.05E-05
Co-60	No Data	5.29E-06	1.56E-05	No Data	No Data	No Data	2.93E-05
Ni-63	5.38E-04	2.88E-05	1.83E-05	No Data	No Data	No Data	1.94E-06
Ni-65	2.22E-06	2.09E-07	1.22E-07	No Data	No Data	No Data	2.56E-05
Cu-64	No Data	2.45E-07	1.48E-07	No Data	5.92E-07	No Data	1.15E-05
Zn-65	1.37E-05	3.65E-05	2.27E-05	No Data	2.30E-05	No Data	6.41E-06
Zn-69	4.38E-08	6.33E-08	5.85E-09	No Data	3.84E-08	No Data	3.99E-06
Br-83	No Data	No Data	1.71E-07	No Data	No Data	No Data	No Data
Br-84	No Data	No Data	1.98E-07	No Data	No Data	No Data	No Data
Br-85	No Data	No Data	9.12E-09	No Data	No Data	No Data	No Data
Rb-86	No Data	6.70E-05	4.12E-05	No Data	No Data	No Data	4.31E-06
Rb-88	No Data	1.90E-07	1.32E-07	No Data	No Data	No Data	9.32E-09
Rb-89	No Data	1.17E-07	1.04E-07	No Data	No Data	No Data	1.02E-09
Sr-89	1.32E-03	No Data	3.77E-05	No Data	No Data	No Data	5.11E-05
Sr-90	1.70E-02	No Data	4.31E-03	No Data	No Data	No Data	2.29E-04
Sr-91	2.40E-05	No Data	9.06E-07	No Data	No Data	No Data	5.30E-05

All values are in (mrem/pCi ingested). They are obtained from Reference 3 (Table E-13). Neither Reference 2 nor Reference 3 contains data for Rh–105, Sb–124, or Sb–125.

Table 9-12 (contd). Ingestion Dose Factors for the Child Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Sr-92	9.03E-06	No Data	3.62E-07	No Data	No Data	No Data	1.71E-04
Y-90	4.11E-08	No Data	1.10E-09	No Data	No Data	No Data	1.17E-04
Y-91m	3.82E-10	No Data	1.39E-11	No Data	No Data	No Data	7.48E-07
Y-91	6.02E-07	No Data	1.61E-08	No Data	No Data	No Data	8.02E-05
Y-92	3.60E-09	No Data	1.03E-10	No Data	No Data	No Data	1.04E-04
Y-93	1.14E-08	No Data	3.13E-10	No Data	No Data	No Data	1.70E-04
Zr-95	1.16E-07	2.55E-08	2.27E-08	No Data	3.65E-08	No Data	2.66E-05
Zr-97	6.99E-09	1.01E-09	5.96E-10	No Data	1.45E-09	No Data	1.53E-04
Nb-95	2.25E-08	8.76E-09	6.26E-09	No Data	8.23E-09	No Data	1.62E-05
Mo-99	No Data	1.33E-05	3.29E-06	No Data	2.84E-05	No Data	1.10E-05
Tc-99m	9.23E-10	1.81E-09	3.00E-08	No Data	2.63E-08	9.19E-10	1.03E-06
Tc-101	1.07E-09	1.12E-09	1.42E-08	No Data	1.91E-08	5.92E-10	3.56E-09
Ru-103	7.31E-07	No Data	2.81E-07	No Data	1.84E-06	No Data	1.89E-05
Ru-105	6.45E-08	No Data	2.34E-08	No Data	5.67E-07	No Data	4.21E-05
Ru-106	1.17E-05	No Data	1.46E-06	No Data	1.58E-05	No Data	1.82E-04
Rh-105	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Ag-110m	5.39E-07	3.64E-07	2.91E-07	No Data	6.78E-07	No Data	4.33E-05
Sb-124	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Sb-125	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Te-125m	1.14E-05	3.09E-06	1.52E-06	3.20E-06	No Data	No Data	1.10E-05
Te-127m	2.89E-05	7.78E-06	3.43E-06	6.91E-06	8.24E-05	No Data	2.34E-05
Te-127	4.71E-07	1.27E-07	1.01E-07	3.26E-07	1.34E-06	No Data	1.84E-05
Te-129m	4.87E-05	1.36E-05	7.56E-06	1.57E-05	1.43E-04	No Data	5.94E-05
Te-129	1.34E-07	3.74E-08	3.18E-08	9.56E-08	3.92E-07	No Data	8.34E-06
Te-131m	7.20E-06	2.49E-06	2.65E-06	5.12E-06	2.41E-05	No Data	1.01E-04
Te-131	8.30E-08	2.53E-08	2.47E-08	6.35E-08	2.51E-07	No Data	4.36E-07

Table 9-12 (contd). Ingestion Dose Factors for the Child Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Te-132	1.01E-05	4.47E-06	5.40E-06	6.51E-06	4.15E-05	No Data	4.50E-05
I-130	2.92E-06	5.90E-06	3.04E-06	6.50E-04	8.82E-06	No Data	2.76E-06
I-131	1.72E-05	1.73E-05	9.83E-06	5.72E-03	2.84E-05	No Data	1.54E-06
I-132	8.00E-07	1.47E-06	6.76E-07	6.82E-05	2.25E-06	No Data	1.73E-06
I-133	5.92E-06	7.32E-06	2.77E-06	1.36E-03	1.22E-05	No Data	2.95E-06
I-134	4.19E-07	7.78E-07	3.58E-07	1.79E-05	1.19E-06	No Data	5.16E-07
I-135	1.75E-06	3.15E-06	1.49E-06	2.79E-04	4.83E-06	No Data	2.40E-06
Cs-134	2.34E-04	3.84E-04	8.10E-05	No Data	1.19E-04	4.27E-05	2.07E-06
Cs-136	2.35E-05	6.46E-05	4.18E-05	No Data	3.44E-05	5.13E-06	2.27E-06
Cs-137	3.27E-04	3.13E-04	4.62E-05	No Data	1.02E-04	3.67E-05	1.96E-06
Cs-138	2.28E-07	3.17E-07	2.01E-07	No Data	2.23E-07	2.40E-08	1.46E-07
Ba-139	4.14E-07	2.21E-10	1.20E-08	No Data	1.93E-10	1.30E-10	2.39E-05
Ba-140	8.31E-05	7.28E-08	4.85E-06	No Data	2.37E-08	4.34E-08	4.21E-05
Ba-141	2.00E-07	1.12E-10	6.51E-09	No Data	9.69E-11	6.58E-10	1.14E-07
Ba-142	8.74E-08	6.29E-11	4.88E-09	No Data	5.09E-11	3.70E-11	1.14E-09
La-140	1.01E-08	3.53E-09	1.19E-09	No Data	No Data	No Data	9.84E-05
La-142	5.24E-10	1.67E-10	5.23E-11	No Data	No Data	No Data	3.31E-05
Ce-141	3.97E-08	1.98E-08	2.94E-09	No Data	8.68E-09	No Data	2.47E-05
Ce-143	6.99E-09	3.79E-06	5.49E-10	No Data	1.59E-09	No Data	5.55E-05
Ce-144	2.08E-06	6.52E-07	1.11E-07	No Data	3.61E-07	No Data	1.70E-04
Pr-143	3.93E-08	1.18E-08	1.95E-09	No Data	6.39E-09	No Data	4.24E-05
Pr-144	1.29E-10	3.99E-11	6.49E-12	No Data	2.11E-11	No Data	8.59E-08
Nd-147	2.79E-08	2.26E-08	1.75E-09	No Data	1.24E-08	No Data	3.58E-05
W-187	4.29E-07	2.54E-07	1.14E-07	No Data	No Data	No Data	3.57E-05
Np-239	5.25E-09	3.77E-10	2.65E-10	No Data	1.09E-09	No Data	2.79E-05

Table 9-13. Ingestion Dose Factors for the Teenager Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	1.06E-07	1.06E-07	1.06E-07	1.06E-07	1.06E-07	1.06E-07
C-14	4.06E-06	8.12E-07	8.12E-07	8.12E-07	8.12E-07	8.12E-07	8.12E-07
Na-24	2.30E-06	2.30E-06	2.30E-06	2.30E-06	2.30E-06	2.30E-06	2.30E-06
P-32	2.76E-04	1.71E-05	1.07E-05	No Data	No Data	No Data	2.32E-05
Cr-51	No Data	No Data	3.60E-09	2.00E-09	7.89E-10	5.14E-09	6.05E-07
Mn-54	No Data	5.90E-06	1.17E-06	No Data	1.76E-06	No Data	1.21E-05
Mn-56	No Data	1.58E-07	2.81E-08	No Data	2.00E-07	No Data	1.04E-05
Fe-55	3.78E-06	2.68E-06	6.25E-07	No Data	No Data	1.70E-06	1.16E-06
Fe-59	5.87E-06	1.37E-05	5.29E-06	No Data	No Data	4.32E-06	3.24E-05
Co-58	No Data	9.72E-07	2.24E-06	No Data	No Data	No Data	1.34E-05
Co-60	No Data	2.81E-06	6.33E-06	No Data	No Data	No Data	3.66E-05
Ni-63	1.77E-04	1.25E-05	6.00E-06	No Data	No Data	No Data	1.99E-06
Ni-65	7.49E-07	9.57E-08	4.36E-08	No Data	No Data	No Data	5.19E-06
Cu-64	No Data	1.15E-07	5.41E-08	No Data	2.91E-07	No Data	8.92E-06
Zn-65	5.76E-06	2.00E-05	9.33E-06	No Data	1.28E-05	No Data	8.47E-06
Zn-69	1.47E-08	2.80E-08	1.96E-09	No Data	1.83E-08	No Data	5.16E-08
Br-83	No Data	No Data	5.74E-08	No Data	No Data	No Data	No Data
Br-84	No Data	No Data	7.22E-08	No Data	No Data	No Data	No Data
Br-85	No Data	No Data	3.05E-09	No Data	No Data	No Data	No Data
Rb-86	No Data	2.98E-05	1.40E-05	No Data	No Data	No Data	4.41E-06
Rb-88	No Data	8.52E-08	4.54E-08	No Data	No Data	No Data	7.30E-15
Rb-89	No Data	5.50E-08	3.89E-08	No Data	No Data	No Data	8.43E-17
Sr-89	4.40E-04	No Data	1.26E-05	No Data	No Data	No Data	5.24E-05
Sr-90	8.30E-03	No Data	2.05E-03	No Data	No Data	No Data	2.33E-04
Sr-91	8.07E-06	No Data	3.21E-07	No Data	No Data	No Data	3.66E-05

All values are in (mrem/pCi ingested). They are obtained from Reference 3 (Table E-12). Neither Reference 2 nor Reference 3 contains data for Rh–105, Sb–124, or Sb–125.

Table 9-13 (contd). Ingestion Dose Factors for the Teenager Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Sr-92	3.05E-06	No Data	1.30E-07	No Data	No Data	No Data	7.77E-05
Y-90	1.37E-08	No Data	3.69E-10	No Data	No Data	No Data	1.13E-04
Y-91m	1.29E-10	No Data	4.93E-12	No Data	No Data	No Data	6.09E-09
Y-91	2.01E-07	No Data	5.39E-09	No Data	No Data	No Data	8.24E-05
Y-92	1.21E-09	No Data	3.50E-11	No Data	No Data	No Data	3.32E-05
Y-93	3.83E-09	No Data	1.05E-10	No Data	No Data	No Data	1.17E-04
Zr-95	4.12E-08	1.30E-08	8.94E-09	No Data	1.91E-08	No Data	3.00E-05
Zr-97	2.37E-09	4.69E-10	2.16E-10	No Data	7.11E-10	No Data	1.27E-04
Nb-95	8.22E-09	4.56E-09	2.51E-09	No Data	4.42E-09	No Data	1.95E-05
Mo-99	No Data	6.03E-06	1.15E-06	No Data	1.38E-05	No Data	1.08E-05
Tc-99m	3.32E-10	9.26E-10	1.20E-08	No Data	1.38E-08	5.14E-10	6.08E-07
Tc-101	3.60E-10	5.12E-10	5.03E-09	No Data	9.26E-09	3.12E-10	8.75E-17
Ru-103	2.55E-07	No Data	1.09E-07	No Data	8.99E-07	No Data	2.13E-05
Ru-105	2.18E-08	No Data	8.46E-09	No Data	2.75E-07	No Data	1.76E-05
Ru-106	3.92E-06	No Data	4.94E-07	No Data	7.56E-06	No Data	1.88E-04
Rh-105	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Ag-110m	2.05E-07	1.94E-07	1.18E-07	No Data	3.70E-07	No Data	5.45E-05
Sb-124	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Sb-125	No Data	No Data	No Data	No Data	No Data	No Data	No Data
Te-125m	3.83E-06	1.38E-06	5.12E-07	1.07E-06	No Data	No Data	1.13E-05
Te-127m	9.67E-06	3.43E-06	1.15E-06	2.30E-06	3.92E-05	No Data	2.41E-05
Te-127	1.58E-07	5.60E-08	3.40E-08	1.09E-07	6.40E-07	No Data	1.22E-05
Te-129m	1.63E-05	6.05E-06	2.58E-06	5.26E-06	6.82E-05	No Data	6.12E-05
Te-129	4.48E-08	1.67E-08	1.09E-08	3.20E-08	1.88E-07	No Data	2.45E-07
Te-131m	2.44E-06	1.17E-06	9.76E-07	1.76E-06	1.22E-05	No Data	9.39E-05
Te-131	2.79E-08	1.15E-08	8.72E-09	2.15E-08	1.22E-07	No Data	2.29E-09

Table 9-13 (contd). Ingestion Dose Factors for the Teenager Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Te-132	3.49E-06	2.21E-06	2.08E-06	2.33E-06	2.12E-05	No Data	7.00E-05
I-130	1.03E-06	2.98E-06	1.19E-06	2.43E-04	4.59E-06	No Data	2.29E-06
I-131	5.85E-06	8.19E-06	4.40E-06	2.39E-03	1.41E-05	No Data	1.62E-06
I-132	2.79E-07	7.30E-07	2.62E-07	2.46E-05	1.15E-06	No Data	3.18E-07
I-133	2.01E-06	3.41E-06	1.04E-06	4.76E-04	5.98E-06	No Data	2.58E-06
I-134	1.46E-07	3.87E-07	1.39E-07	6.45E-06	6.10E-07	No Data	5.10E-09
I-135	6.10E-07	1.57E-06	5.82E-07	1.01E-04	2.48E-06	No Data	1.74E-06
Cs-134	8.37E-05	1.97E-04	9.14E-05	No Data	6.26E-05	2.39E-05	2.45E-06
Cs-136	8.59E-06	3.38E-05	2.27E-05	No Data	1.84E-05	2.90E-06	2.72E-06
Cs-137	1.12E-04	1.49E-04	5.19E-05	No Data	5.07E-05	1.97E-05	2.12E-06
Cs-138	7.76E-08	1.49E-07	7.45E-08	No Data	1.10E-07	1.28E-08	6.76E-11
Ba-139	1.39E-07	9.78E-11	4.05E-09	No Data	9.22E-11	6.74E-11	1.24E-06
Ba-140	2.84E-05	3.48E-08	1.83E-06	No Data	1.18E-08	2.34E-08	4.38E-05
Ba-141	6.71E-08	5.01E-11	2.24E-09	No Data	4.65E-11	3.43E-11	1.43E-13
Ba-142	2.99E-08	2.99E-11	1.84E-09	No Data	2.53E-11	1.99E-11	9.18E-20
La-140	3.48E-09	1.71E-09	4.55E-10	No Data	No Data	No Data	9.82E-05
La-142	1.79E-10	7.95E-11	1.98E-11	No Data	No Data	No Data	2.42E-06
Ce-141	1.33E-08	8.88E-09	1.02E-09	No Data	4.18E-09	No Data	2.54E-05
Ce-143	2.35E-09	1.71E-06	1.91E-10	No Data	7.67E-10	No Data	5.14E-05
Ce-144	6.96E-07	2.88E-07	3.74E-08	No Data	1.72E-07	No Data	1.75E-04
Pr-143	1.31E-08	5.23E-09	6.52E-10	No Data	3.04E-09	No Data	4.31E-05
Pr-144	4.30E-11	1.76E-11	2.18E-12	No Data	1.01E-11	No Data	4.74E-14
Nd-147	9.38E-09	1.02E-08	6.11E-10	No Data	5.99E-09	No Data	3.68E-05
W-187	1.46E-07	1.19E-07	4.17E-08	No Data	No Data	No Data	3.22E-05
Np-239	1.76E-09	1.66E-10	9.22E-11	No Data	5.21E-10	No Data	2.67E-05

Table 9-14. Ingestion Dose Factors for the Adult Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	1.05E-07	1.05E-07	1.05E-07	1.05E-07	1.05E-07	1.05E-07
C-14	2.84E-06	5.68E-07	5.68E-07	5.68E-07	5.68E-07	5.68E-07	5.68E-07
Na-24	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06
P-32	1.93E-04	1.20E-05	7.46E-06	No Data	No Data	No Data	2.17E-05
Cr-51	No Data	No Data	2.66E-09	1.59E-09	5.86E-10	3.53E-09	6.69E-07
Mn-54	No Data	4.57E-06	8.72E-07	No Data	1.36E-06	No Data	1.40E-05
Mn-56	No Data	1.15E-07	2.04E-08	No Data	1.46E-07	No Data	3.67E-06
Fe-55	2.75E-06	1.90E-06	4.43E-07	No Data	No Data	1.06E-06	1.09E-06
Fe-59	4.34E-06	1.02E-05	3.91E-06	No Data	No Data	2.85E-06	3.40E-05
Co-58	No Data	7.45E-07	1.67E-06	No Data	No Data	No Data	1.51E-05
Co-60	No Data	2.14E-06	4.72E-06	No Data	No Data	No Data	4.02E-05
Ni-63	1.30E-04	9.01E-06	4.36E-06	No Data	No Data	No Data	1.88E-06
Ni-65	5.28E-07	6.86E-08	3.13E-08	No Data	No Data	No Data	1.74E-06
Cu-64	No Data	8.33E-08	3.91E-08	No Data	2.10E-07	No Data	7.10E-06
Zn-65	4.84E-06	1.54E-05	6.96E-06	No Data	1.03E-05	No Data	9.70E-06
Zn-69	1.03E-08	1.97E-08	1.37E-09	No Data	1.28E-08	No Data	2.96E-09
Br-83	No Data	No Data	4.02E-08	No Data	No Data	No Data	5.79E-08
Br-84	No Data	No Data	5.21E-08	No Data	No Data	No Data	4.09E-13
Br-85	No Data	No Data	2.14E-09	No Data	No Data	No Data	No Data
Rb-86	No Data	2.11E-05	9.83E-06	No Data	No Data	No Data	4.16E-06
Rb-88	No Data	6.05E-08	3.21E-08	No Data	No Data	No Data	8.36E-19
Rb-89	No Data	4.01E-08	2.82E-08	No Data	No Data	No Data	2.33E-21
Sr-89	3.08E-04	No Data	8.84E-06	No Data	No Data	No Data	4.94E-05
Sr-90	7.58E-03	No Data	1.86E-03	No Data	No Data	No Data	2.19E-04
Sr-91	5.67E-06	No Data	2.29E-07	No Data	No Data	No Data	2.70E-05

All values are in (mrem/pCi ingested). They are obtained from Reference 3 (Table E–11), except as follows: Reference 2 (Table A–3) for Rh–105, Sb–124, and Sb–125.

Table 9-14 (contd). Ingestion Dose Factors for the Adult Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Sr-92	2.15E-06	No Data	9.30E-08	No Data	No Data	No Data	4.26E-05
Y-90	9.62E-09	No Data	2.58E-10	No Data	No Data	No Data	1.02E-04
Y-91m	9.09E-11	No Data	3.52E-12	No Data	No Data	No Data	2.67E-10
Y-91	1.41E-07	No Data	3.77E-09	No Data	No Data	No Data	7.76E-05
Y-92	8.45E-10	No Data	2.47E-11	No Data	No Data	No Data	1.48E-05
Y-93	2.68E-09	No Data	7.40E-11	No Data	No Data	No Data	8.50E-05
Zr-95	3.04E-08	9.75E-09	6.60E-09	No Data	1.53E-08	No Data	3.09E-05
Zr-97	1.68E-09	3.39E-10	1.55E-10	No Data	5.12E-10	No Data	1.05E-04
Nb-95	6.22E-09	3.46E-09	1.86E-09	No Data	3.42E-09	No Data	2.10E-05
Mo-99	No Data	4.31E-06	8.20E-07	No Data	9.76E-06	No Data	9.99E-06
Tc-99m	2.47E-10	6.98E-10	8.89E-09	No Data	1.06E-08	3.42E-10	4.13E-07
Tc-101	2.54E-10	3.66E-10	3.59E-09	No Data	6.59E-09	1.87E-10	1.10E-21
Ru-103	1.85E-07	No Data	7.97E-08	No Data	7.06E-07	No Data	2.16E-05
Ru-105	1.54E-08	No Data	6.08E-09	No Data	1.99E-07	No Data	9.42E-06
Ru-106	2.75E-06	No Data	3.48E-07	No Data	5.31E-06	No Data	1.78E-04
Rh-105	1.22E-07	8.86E-08	5.83E-08	No Data	3.76E-07	No Data	1.41E-05
Ag-110m	1.60E-07	1.48E-07	8.79E-08	No Data	2.91E-07	No Data	6.04E-05
Sb-124	2.81E-06	5.30E-08	1.11E-06	6.79E-09	No Data	2.18E-06	7.95E-05
Sb-125	2.23E-06	2.40E-08	4.48E-07	1.98E-09	No Data	2.33E-04	1.97E-05
Te-125m	2.68E-06	9.71E-07	3.59E-07	8.06E-07	1.09E-05	No Data	1.07E-05
Te-127m	6.77E-06	2.42E-06	8.25E-07	1.73E-06	2.75E-05	No Data	2.27E-05
Te-127	1.10E-07	3.95E-08	2.38E-08	8.15E-08	4.48E-07	No Data	8.68E-06
Te-129m	1.15E-05	4.29E-06	1.82E-06	3.95E-06	4.80E-05	No Data	5.79E-05
Te-129	3.14E-08	1.18E-08	7.65E-09	2.41E-08	1.32E-07	No Data	2.37E-08
Te-131m	1.73E-06	8.46E-07	7.05E-07	1.34E-06	8.57E-06	No Data	8.40E-05
Te-131	1.97E-08	8.23E-09	6.22E-09	1.62E-08	8.63E-08	No Data	2.79E-09

Table 9-14 (contd). Ingestion Dose Factors for the Adult Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Te-132	2.52E-06	1.63E-06	1.53E-06	1.80E-06	1.57E-05	No Data	7.71E-05
I-130	7.56E-07	2.23E-06	8.80E-07	1.89E-04	3.48E-06	No Data	1.92E-06
I-131	4.16E-06	5.95E-06	3.41E-06	1.95E-03	1.02E-05	No Data	1.57E-06
I-132	2.03E-07	5.43E-07	1.90E-07	1.90E-05	8.65E-07	No Data	1.02E-07
I-133	1.42E-06	2.47E-06	7.53E-07	3.63E-04	4.31E-06	No Data	2.22E-06
I-134	1.06E-07	2.88E-07	1.03E-07	4.99E-06	4.58E-07	No Data	2.51E-10
I-135	4.43E-07	1.16E-06	4.28E-07	7.65E-05	1.86E-06	No Data	1.31E-06
Cs-134	6.22E-05	1.48E-04	1.21E-04	No Data	4.79E-05	1.59E-05	2.59E-06
Cs-136	6.51E-06	2.57E-05	1.85E-05	No Data	1.43E-05	1.96E-06	2.92E-06
Cs-137	7.97E-05	1.09E-04	7.14E-05	No Data	3.70E-05	1.23E-05	2.11E-06
Cs-138	5.52E-08	1.09E-07	5.40E-08	No Data	8.01E-08	7.91E-09	4.65E-13
Ba-139	9.70E-08	6.91E-11	2.84E-09	No Data	6.46E-11	3.92E-11	1.72E-07
Ba-140	2.03E-05	2.55E-08	1.33E-06	No Data	8.67E-09	1.46E-08	4.18E-05
Ba-141	4.71E-08	3.56E-11	1.59E-09	No Data	3.31E-11	2.02E-11	2.22E-17
Ba-142	2.13E-08	2.19E-11	1.34E-09	No Data	1.85E-11	1.24E-11	3.00E-26
La-140	2.50E-09	1.26E-09	3.33E-10	No Data	No Data	No Data	9.25E-05
La-142	1.28E-10	5.82E-11	1.45E-11	No Data	No Data	No Data	4.25E-07
Ce-141	9.36E-09	6.33E-09	7.18E-10	No Data	2.94E-09	No Data	2.42E-05
Ce-143	1.65E-09	1.22E-06	1.35E-10	No Data	5.37E-10	No Data	4.56E-05
Ce-144	4.88E-07	2.04E-07	2.62E-08	No Data	1.21E-07	No Data	1.65E-04
Pr-143	9.20E-09	3.69E-09	4.56E-10	No Data	2.13E-09	No Data	4.03E-05
Pr-144	3.01E-11	1.25E-11	1.53E-12	No Data	7.05E-12	No Data	4.33E-18
Nd-147	6.29E-09	7.27E-09	4.35E-10	No Data	4.25E-09	No Data	3.49E-05
W-187	1.03E-07	8.61E-08	3.01E-08	No Data	No Data	No Data	2.82E-05
Np-239	1.19E-09	1.17E-10	6.45E-11	No Data	3.65E-10	No Data	2.40E-05

Table 9-15. External Dose Factors for Standing on Contaminated Ground

Nuclide	T. Body	Skin
H-3	0.00	0.00
C-14	0.00	0.00
Na-24	2.50E-08	2.90E-08
P-32	0.00	0.00
Cr-51	2.20E-10	2.60E-10
Mn-54	5.80E-09	6.80E-09
Mn-56	1.10E-08	1.30E-08
Fe-55	0.00	0.00
Fe-59	8.00E-09	9.40E-09
Co-58	7.00E-09	8.20E-09
Co-60	1.70E-08	2.00E-08
Ni-63	0.00	0.00
Ni-65	3.70E-09	4.30E-09
Cu-64	1.50E-09	1.70E-09
Zn-65	4.00E-09	4.60E-09
Zn-69	0.00	0.00
Br-83	6.40E-11	9.30E-11
Br-84	1.20E-08	1.40E-08
Br-85	0.00	0.00
Rb-86	6.30E-10	7.20E-10
Rb-88	3.50E-09	4.00E-09
Rb-89	1.50E-08	1.80E-08
Sr-89	5.60E-13	6.50E-13
Sr-90	0.00	0.00

Nuclide	T. Body	Skin
Sr-91	7.10E-09	8.30E-09
Sr-92	9.00E-09	1.00E-08
Y-90	2.20E-12	2.60E-12
Y-91m	3.80E-09	4.40E-09
Y-91	2.40E-11	2.70E-11
Y-92	1.60E-09	1.90E-09
Y-93	5.70E-10	7.80E-10
Zr-95	5.00E-09	5.80E-09
Zr-97	5.50E-09	6.40E-09
Nb-95	5.10E-09	6.00E-09
Mo-99	1.90E-09	2.20E-09
Tc-99m	9.60E-10	1.10E-09
Tc-101	2.70E-09	3.00E-09
Ru-103	3.60E-09	4.20E-09
Ru-105	4.50E-09	5.10E-09
Ru-106	1.50E-09	1.80E-09
Rh-105	6.60E-10	7.70E-10
Ag-110m	1.80E-08	2.10E-08
Sb-124	1.30E-08	1.50E-08
Sb-125	3.10E-09	3.50E-09
Te-125m	3.50E-11	4.80E-11
Te-127m	1.10E-12	1.30E-12
Te-127	1.00E-11	1.10E-11
Te-129m	7.70E-10	9.00E-10

All values are in (mrem/h) per (pCi/m^2). They are obtained from Reference 3 (Table E-6), except as follows: Reference 2 (Table A–7) for Rh-105, Sb-124, and Sb-125.

Table 9-15 (contd). External Dose Factors for Standing on Contaminated Ground

Nuclide	T.Body	Skin
Te-129	7.10E-10	8.40E-10
Te-131m	8.40E-09	9.90E-09
Te-131	2.20E-09	2.60E-06
Te-132	1.70E-09	2.00E-09
I-130	1.40E-08	1.70E-08
I-131	2.80E-09	3.40E-09
I-132	1.70E-08	2.00E-08
I-133	3.70E-09	4.50E-09
I-134	1.60E-08	1.90E-08
I-135	1.20E-08	1.40E-08
Cs-134	1.20E-08	1.40E-08
Cs-136	1.50E-08	1.70E-08
Cs-137	4.20E-09	4.90E-09
Cs-138	2.10E-08	2.40E-08
Ba-139	2.40E-09	2.70E-09
Ba-140	2.10E-09	2.40E-09
Ba-141	4.30E-09	4.90E-09
Ba-142	7.90E-09	9.00E-09
La-140	1.50E-08	1.70E-08
La-142	1.50E-08	1.80E-08
Ce-141	5.50E-10	6.20E-10
Ce-143	2.20E-09	2.50E-09
Ce-144	3.20E-10	3.70E-10
Pr-143	0.00	0.00
Pr-144	2.00E-10	2.30E-10
Nd-147	1.00E-09	1.20E-09
W-187	3.10E-09	3.60E-09
Np-239	9.50E-10	1.10E-09

CHAPTER 10
DEFINITIONS OF EFFLUENT CONTROL TERMS

The terms defined in this chapter are used in the presentation of the above chapters. These terms are shown in all capital letters to indicate that they are specifically defined.

10.1 TERMS SPECIFIC TO THE ODCM

The following terms are used in the ODCM, but are not found in the Technical Specifications:

ACTION(S)

An ACTION shall be that part of a control that prescribes remedial measures required under designated conditions.

BATCH RELEASE

A BATCH RELEASE is the discharge of wastes of a discrete volume. Prior to sampling for analyses, each liquid batch shall be isolated and then thoroughly mixed by a method described in the ODCM to assure representative sampling.

COMPOSITE SAMPLE

A COMPOSITE SAMPLE is one which contains material from multiple waste releases, in which the quantity of sample is proportional to the quantity of waste discharged, and in which the method of sampling employed results in a specimen that is representative of the wastes released. Prior to analyses, all liquid samples that are to be aliquotted for a COMPOSITE SAMPLE shall be mixed thoroughly, in order for the COMPOSITE SAMPLE to be representative of the effluent release.

When assessing the consequences of a waste release at the pre-release or post-release stage, the most recent available COMPOSITE SAMPLE results for the applicable release pathway may be used.

CONTINUOUS RELEASE

A CONTINUOUS RELEASE is the discharge of wastes of a non-discrete volume, e.g., from a volume within a system that has an input flow during the continuous release. To be representative of the quantities and concentrations of radioactive materials in CONTINUOUS RELEASES of liquid effluents, samples shall be collected in proportion to the rate of flow of the effluent stream or to the quantity of liquid waste discharged.

FREQUENCY NOTATION

The FREQUENCY NOTATION specified for the performance of surveillance requirements shall correspond to the intervals defined below, with a maximum allowable extension not to exceed 25% of the surveillance interval.

NOTATION	FREQUENCY
S (Once per shift)	At least once per 12 hours.
D (Daily)	At least once per 24 hours.
W (Weekly)	At least once per 7 days.
M (Monthly)	At least once per 31 days.
SM (Semi-Monthly)	At least twice per calendar month*

Q (Quarterly)	At least once per 92 days.
SA (Semi–annually)	At least once per 184 days.
R (Refueling)	At least once per 18 months.
S/U (Startup)	Prior to each reactor startup.
NA	Not applicable.
P (Prior)	Completed prior to each release.

*Semi-monthly sampling means one sample on two different weeks of every calendar month. No other grace period applies.

GASEOUS WASTE PROCESSING SYSTEM

A GASEOUS WASTE PROCESSING SYSTEM shall be any system designed and installed to reduce radioactive gaseous effluents by collecting Reactor Coolant System offgases from the Reactor Coolant System and providing for delay or holdup for the purpose of reducing the total radioactivity prior to release to the environment.

LIQUID RADWASTE TREATMENT SYSTEM

A LIQUID RADWASTE TREATMENT SYSTEM is any system designed and installed to reduce radioactive materials in liquid effluents by systematic collection, retention, and processing through filtration, evaporation, separation and/or ion exchange treatment. This system consists of at least one collection tank, one evaporator or demineralizer system, one post-treatment tank and associated components providing for treatment flow and functional control.

MAJOR CHANGES TO RADIOACTIVE WASTE TREATMENT SYSTEMS

For the purposes of the ODCM, MAJOR CHANGES TO RADIOACTIVE WASTE TREATMENT SYSTEMS include the following changes to such systems:

(1) Major changes in process equipment, components, structures, or effluent monitoring instrumentation as described in the Final Safety Analysis Report (FSAR) or as evaluated in the Nuclear Regulatory Commission staff's Safety Evaluation Report (SER) (e.g., deletion of evaporators and installation of demineralizers);

(2) Changes in the design of radwaste treatment systems that could significantly increase quantities of effluents released from those previously considered in the FSAR and SER;

(3) Changes in system design which may invalidate the accident analysis as described in the SER (e.g., changes in tank capacity that would alter the curies released); or

(4) Changes in system design that could potentially result in a significant increase in occupational exposure of operating personnel (e.g., use of temporary equipment without adequate shielding provisions).

MEMBER(S) OF THE PUBLIC[1]

A MEMBER OF THE PUBLIC means any individual except when that individual is receiving an *occupational dose*[2]. This category may include persons who use portions of the site for recreational, occupational, or other purposes not associated with the plant.

MINIMUM DETECTABLE CONCENTRATION

The MINIMUM DETECTABLE CONCENTRATION (MDC) is defined, for purposes of the controls in this ODCM, as the smallest concentration of radioactive material in a sample that will yield a net count above system background and that will be detected with 95-percent probability, with only 5-percent probability of falsely concluding that a blank observation represents a "real" signal.

For a particular measurement system, which may include radiochemical separation, the MDC for a given radionuclide is determined as follows (Reference 18):

where:

MDC = the *a priori* MINIMUM DETECTABLE CONCENTRATION (μCi per unit mass or volume).

$$MDC = \frac{\dfrac{2.71}{t_s} + 3.29\sqrt{R_b\left(\dfrac{1}{t_s} + \dfrac{1}{t_b}\right)}}{E \cdot V \cdot 2.22 \times 10^6 \cdot Y \cdot e^{-\lambda \Delta t}}$$

R_b = the background counting rate, or the counting rate of a blank sample, as appropriate (counts per minute).

t_s = the length of the sample counting period (minutes).

t_b = the length of the background counting period (minutes).

E = the counting efficiency (counts per disintegration)

V = the sample size (units of mass or volume).

2.22×10^6 = the number of disintegrations per minute per μCi.

Y = the fractional radiochemical yield, when applicable.

λ = the radioactive decay constant for the given radionuclide (h^{-1}). Values of λ used in effluent calculations should be based on decay data from a recognized and current source, such as Reference 20.

Δt = for effluent samples, the elapsed time between the midpoint of sample collection and the time of counting (h); for environmental samples, the elapsed time between the end of sample collection and the time of counting (h).

[1] The italicized terms in this definition, which are not otherwise used in this ODCM, shall have the definitions assigned to them by 10 CFR 20.1003.

[2] Except as delineated in other parts of 10 CFR chapter I.

Typical values of E, V, Y, and Δt should be used in the calculation. It should be recognized that the MDC is defined as an *a priori* (before the fact) limit representing the capability of a measurement system, and not as an *a posteriori* (after the fact) limit for a particular measurement.

PRINCIPAL GAMMA EMITTERS

The PRINCIPAL GAMMA EMITTERS for which the MINIMUM DETECTABLE CONCENTRATION (MDC) limit applies include exclusively the following radionuclides:

- For liquid radioactive effluents: Mn–54, Fe–59, Co–58, Co–60, Zn–65, Mo–99, Cs-134, Cs–137, and Ce–141. Ce–144 shall also be measured, but with an MDC of 5 x 10^{-6} μCi/mL.

- For gaseous radioactive effluents: In noble gas releases, Kr–87, Kr–88, Xe–133, Xe–133m, Xe–135, Xe–138; and in particulate releases, Mn–54, Fe–59, Co–58, Co-60, Zn–65, Mo–99, Cs–134, Cs–137, Ce–141, and Ce–144.

- For environmental media: The gamma emitters specifically listed in Table 4-3.

These lists do not mean that only these nuclides are to be considered. Other gamma peaks that are identifiable, together with those of the above nuclides, shall also be analyzed and reported in the Radioactive Effluent Release Report, the Annual Radiological Environmental Operating Report, or other applicable report(s).

SITE BOUNDARY

For the purpose of effluent controls defined in the ODCM, the SITE BOUNDARY shall be as shown in Figure 4-1.

SOURCE CHECK

A SOURCE CHECK shall be the qualitative assessment of channel response when the channel sensor is exposed to a source of increased radioactivity.

UNRESTRICTED AREA

The UNRESTRICTED AREA shall be any area access to which is neither limited nor controlled by the licensee, or any area within the SITE BOUNDARY used for residential quarters or for industrial, commercial, institutional, and/or recreational purposes.

VENTILATION EXHAUST TREATMENT SYSTEM

The VENTILATION EXHAUST TREATMENT SYSTEM is any system designed and installed to reduce gaseous radioiodine or radioactive material in particulate form in effluents, by passing ventilation or vent exhaust gases through charcoal adsorbers and/or HEPA filters, for the purpose of removing iodines or particulates from the gaseous exhaust stream prior to the release to the environment. (Such a system is not considered to have any effect on any noble gas effluents). Engineered Safety Feature (ESF) atmospheric cleanup systems are not considered to be VENTILATION EXHAUST TREATMENT SYSTEM components.

10.2 TERMS DEFINED IN THE TECHNICAL SPECIFICATIONS

The following terms are defined in the Technical Specifications, Section 1.0. Because they are used throughout the Limits of Operation sections of the ODCM, they are presented here for convenience. In the event of discrepancies between the definitions below and those in the Technical Specifications, the Technical Specification definitions shall take precedence.

CHANNEL CALIBRATION

A CHANNEL CALIBRATION shall be the adjustment, as necessary, of the channel, such that it responds within the required range and accuracy to known values of input. The CHANNEL CALIBRATION shall encompass the entire channel including the required sensor, alarm, interlock, and/or trip functions and may be performed by any series of sequential, overlapping, or total channel steps, so that the entire channel is calibrated.

CHANNEL CHECK

A CHANNEL CHECK shall be the qualitative assessment of channel behavior during operation by observation. This determination shall include, where possible, comparison of the channel indication and/or status with other indications and/or status derived from independent instrument channels measuring the same parameter.

CHANNEL FUNCTIONAL TEST (CFT)

A CHANNEL FUNCTIONAL TEST shall be the injection of a simulated signal into the channel as close to the sensor as practicable to verify FUNCTIONALITY of required alarm, interlock, and/or trip functions. The CHANNEL FUNCTIONAL TEST shall include adjustments, as necessary, of the required alarm, interlock, and/or trip setpoints, so that the setpoints are within the required range and accuracy.

DOSE EQUIVALENT I–131

DOSE EQUIVALENT I–131 shall be that concentration of I–131 (μCi/g) which alone would produce the same thyroid dose as the quantity and isotopic mixture of I–131, I–132, I–133, I–134, and I–135 actually present. The thyroid dose conversion factors used for this calculation shall be those listed in EPA Federal Guidance Report No. 11, “Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion,” EPA-520/1-88-020, September 1988.

MODE (or OPERATIONAL MODE)

An OPERATIONAL MODE shall correspond to any one inclusive combination of core reactivity condition, power level, average reactor coolant temperature, and reactor vessel head closure bolt tensioning specified in Section 1.0 of the Technical Specifications with fuel in the reactor vessel.

FUNCTIONAL (or FUNCTIONALITY)

FUNCTIONALITY exists when a system, subsystem, train, component or device is capable of performing its specified function(s), and when all necessary attendant instrumentation, controls, electrical power, cooling or seal water, lubrication or other auxiliary equipment that are required for the system, subsystem, train, component or device to perform its function(s) are also capable of performing their related support function(s).

RATED THERMAL POWER

RATED THERMAL POWER shall be a total reactor core heat transfer rate to the reactor coolant of 3565 MWt.

THERMAL POWER

THERMAL POWER shall be the total reactor core heat transfer rate to the reactor coolant.

Edwin I. Hatch Nuclear Plant – Units 1&2
Joseph M. Farley Nuclear Plant – Units 1&2
Vogtle Electric Generating Plant – Units 1&2
Vogtle Electric Generating Plant – Unit 3
Annual Non-Radiological Environmental Operating Reports and Annual Radioactive Effluent Release Reports for 2022

Enclosure 10

Vogtle Electric Generating Plant – Unit 3
Offsite Dose Calculation Manual – Version 3

OFFSITE DOSE CALCULATION MANUAL

FOR

SOUTHERN NUCLEAR OPERATING COMPANY

VOGTLE ELECTRIC GENERATING PLANT UNITS 3 & 4

REVISION 3.0

MAY 2022

Department Manager	SYEF M. HOQUE /	5-11-22 Date
Plant Manager	PATRICK MARTINO /	5-11-22 Date

Contents

Attachments

List of Tables

List of Figures

1.0 INTRODUCTION

The Offsite Dose Calculation Manual (ODCM) is a supporting document of the Technical Specifications. As such, it describes the methodology and parameters to be used in the calculation of offsite doses due to radioactive liquid and gaseous effluents, and in the calculation of liquid and gaseous effluent monitoring instrumentation alarm setpoints. In addition, it contains the following:

- the controls required by the Technical Specifications governing the radioactive effluent and radiological environmental monitoring programs.
- schematics of liquid and gaseous radioactive waste effluent treatment systems, which include designation of release points to UNRESTRICTED AREAS.
- a list and maps indicating the specific sample locations for the Radiological Environmental Monitoring Program (REMP).
- specifications and descriptions of the information that must be included in the Annual Radiological Environmental Operating Report and the Annual Radioactive Effluent Release Report required by the Technical Specifications.

The ODCM will be maintained at the plant for use as a reference guide and training document of accepted methodologies and calculations. Changes in the calculational methods or parameters will be incorporated into the ODCM to ensure that it represents current methodology in all applicable areas. Any computer software used to perform the calculations described will be maintained current with the ODCM.

Equations and methods used in the ODCM are based on those presented in NUREG-0133 (Reference 24), in Regulatory Guide 1.109 (References 10 and 11), in Regulatory Guide 1.111 (References 12 and 13), and in Regulatory Guide 1.113 (Reference 15).

This ODCM follows NEI 07-09A, “Generic FSAR Template Guidance for the Offsite Dose Calculation Manual (ODCM) Program Description,” Revision 0 (Reference 43), which has been evaluated and approved by the Nuclear Regulatory Commission (NRC). Deviations from NEI 07-09A are justified and documented in the Licensing Document Change Request.

2.0 PURPOSE

This ODCM establishes requirements for the Radioactive Effluent and Radiological Environmental Monitoring Programs. Methodology and parameters are provided to calculate offsite doses resulting from radioactive gaseous and liquid effluents, to calculate gaseous and liquid effluent monitoring alarm/trip setpoints, and to conduct the REMP. Requirements are established for the Annual Radiological Environmental Operating Report and the Annual Radioactive Effluent Release Report required by VEGP Units 3 and 4 Technical Specifications. Calculation of offsite doses due to radioactive liquid and gaseous effluents are performed to assure that:

- Concentration of radioactive liquid effluents to the UNRESTRICTED AREA will be limited to ten times the effluent concentration values of 10 CFR 20, Appendix B, Table 2, Column 2, for radionuclides other than dissolved or entrained noble gases and 2 x 10^{-4} μCi/ml total activity for dissolved or entrained noble gases.
- Exposure to the maximum exposed MEMBER OF THE PUBLIC in the UNRESTRICTED AREA from radioactive liquid effluents will not result in doses greater than the liquid dose limits of 10 CFR 50, Appendix I.
- The air dose in UNRESTRICTED AREAS due to noble gases released in gaseous effluents from each unit at or beyond the SITE BOUNDARY shall be limited to:
  - During any calendar quarter less than or equal to 5 mrads for gamma radiation and less than or equal to 10 mrads for beta radiation
  - During any calendar year less than or equal to 10 mrads for gamma radiation and less than or equal to 20 mrads for beta radiation
- Dose rate at and beyond the SITE BOUNDARY from radioactive gaseous effluents will be limited to:
  - Noble gases: less than or equal to a dose rate of 500 mrem/year to the whole body and less than or equal to a dose rate of 3000 mrem/year to the skin
  - I-131, I-133, and H-3, and-all radionuclides in particulate form with half-lives greater than 8 days: less than or equal to a dose rate of 1500 mrem/year to any organ
- Exposure from radioactive gaseous effluents to the maximum exposed MEMBER OF THE PUBLIC in the UNRESTRICTED AREA will not result in doses greater than the gaseous dose limits of 10 CFR 50, Appendix I.
- Exposure to a MEMBER OF THE PUBLIC will not exceed 40 CFR 190 dose limits (Reference 4 and 23).

3.0 SCOPE

This ODCM becomes effective upon each Commission finding in accordance with 10 CFR 52.103(g) for VEGP Units 3 and 4, respectively. However, implementation of the various “At all times” applicability requirements is only required at initial fuel load for the applicable unit.

Instructions in the ODCM are applicable to Units 3 or 4 as pertinent to the circumstances. Accordingly, unit numbers are not included with equipment numbers.

4.0 DEFINITIONS

Defined terms used in the body of the ODCM are identified by SMALL CAPS.

ACTION(S)

ACTION shall be that part of a Specification that prescribes Required Actions to be taken under designated Conditions within specified Completion Times.

BATCH RELEASE

A BATCH RELEASE is the discharge of wastes of a discrete volume. Prior to sampling for analyses, each liquid batch shall be isolated and then thoroughly mixed by a method described in the ODCM to assure representative sampling.

CHANNEL CALIBRATION

A CHANNEL CALIBRATION shall be the adjustment, as necessary, of the channel output such that it responds within the necessary range and accuracy to known values of the parameter that the channel monitors. The CHANNEL CALIBRATION shall encompass all devices in the channel required for FUNCTIONALITY.

Calibration of instrument channels with resistance temperature detector (RTD) or thermocouple sensors may consist of an in place qualitative assessment of sensor behavior and normal calibration of the remaining adjustable devices in the channel. The CHANNEL CALIBRATION may be performed by means of any series of sequential, overlapping, or total channel steps.

CHANNEL CHECK

A CHANNEL CHECK shall be the qualitative assessment, by observation, of channel behavior during operation. This determination shall include, where possible, comparison of the channel indication and status to other indications or status derived from independent instrument channels measuring the same parameter.

CHANNEL FUNCTIONAL TEST (CFT)

A CFT shall be the injection of a simulated or actual signal into the channel as close to the sensor as practicable to verify FUNCTIONALITY of all devices in the channel required for channel FUNCTIONALITY. The CFT shall include adjustments, as necessary, of the required alarm, interlock, and trip setpoints required for channel FUNCTIONALITY such that the setpoints are within the necessary range and accuracy. The CFT may be performed by means of any series of sequential, overlapping, or total channel steps.

CRITICAL ORGAN

That organ, which has been determined to be the maximum exposed organ based on an effluent pathway analysis, thereby ensuring the dose and dose rate limitations to any organ will not be exceeded. Dose calculations to the critical organ will be evaluated in accordance with Technical Specifications dose rate limits specified for any organ to verify these limits have not been exceeded. CRITICAL ORGAN is evaluated as part of the any organ wording used in Technical Specifications and the ODCM.

CRITICAL RECEPTOR

Represents the MEMBER(S) OF THE PUBLIC in the UNRESTRICTED AREA who as a result of the combination of age group and existing local dose exposure pathways has the potential to receive the highest dose.

COMPOSITE SAMPLE

A COMPOSITE SAMPLE is one in which the quantity of sample is proportional to the quantity of waste discharged, and in which the method of liquid sampled is proportional to the quantity of liquid waste discharged and in which the method of sampling employed results in a specimen that is representative of the liquids released. Prior to analyses, all liquid samples that are to be aliquotted for a COMPOSITE SAMPLE shall be mixed thoroughly, in order for the COMPOSITE SAMPLE to be representative of the effluent release.

CONTINUOUS RELEASE

A CONTINUOUS RELEASE is the discharge of wastes of a non-discrete volume, e.g., from a volume within a system that has an input flow during the CONTINUOUS RELEASE. To be representative of the quantities and concentrations of radioactive materials in CONTINUOUS RELEASEs of liquid effluents, samples shall be collected in proportion to the rate of flow of the effluent stream or to the quantity of liquid waste discharged.

DISPERSION AND DEPOSITION NOMENCLATURE

X = chi, the concentration of radioactive material in air at a given instant (curies per cubic meter)

D = deposition, the quantity of deposited radioactive material per unit area (curies per square meter)

Q = emission rate (curies per second)

DOSE EQUIVALENT I-131

DOSE EQUIVALENT I-131 shall be that concentration of I-131 (microcuries/gram) that alone would produce the same committed effective dose equivalent as the quantity and isotopic mixture of I-130, I-131, I-132, I-133, I-134, and I-135 actually present. The dose conversion factors used for this calculation shall be those listed in Table 2.1 of EPA Federal Guidance Report No. 11, “Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion,” EPA-520/1-88-020, September 1988.

FREQUENCY NOTATION

The FREQUENCY NOTATION specified for the performance of surveillance requirements shall correspond to the intervals defined below, with a maximum allowable extension not to exceed 25% of the surveillance interval.

NOTATION	FREQUENCY
S – Once per shift	At least once per 12 hours
D – Daily	At least once per 24 hours
W – Weekly	At least once per 7 days
M – Monthly	At least once per 31 days
Q – Quarterly	At least once per 92 days
SA – Semi-annually	At least once per 184 days
R – Refueling	At least once per 18 months (based on a plant’s nominal refueling cycle)
S/U – Start-up	Prior to each reactor start-up
P – Prior to release	Completed prior to each release
NA – Not applicable	Not applicable
DR – During the release	At least once during each release

Note:

- Frequencies are allowed a maximum extension of 25 percent.

FUNCTIONAL (OR FUNCTIONALITY)

A system, subsystem, train, component, or device shall be FUNCTIONAL or have FUNCTIONALITY when it is capable of performing its specified function(s) and when all necessary attendant instrumentation, controls, normal or emergency electrical power, cooling and seal water, lubrication, and other auxiliary equipment that are required for the system, subsystem, train, component, or device to perform its function(s) are also capable of performing their related support function(s).

IMMEDIATELY

When “IMMEDIATELY” is used as a Completion Time, the required ACTION should be pursued without delay and in a controlled manner.

GASEOUS WASTE MANAGEMENT SYSTEM

A system designed and installed to reduce radioactive gaseous effluents by collecting primary coolant system off gases from the primary system and providing for delay or holdup for the purpose of reducing the total radioactivity prior to release to the environment.

LIQUID WASTE MANAGEMENT SYSTEM

A system designed and installed to reduce radioactive materials in liquid effluents by systematic collection, retention, and processing prior to release to the environment.

MAXIMUM EXPOSED INDIVIDUAL(S)

Individuals characterized as maximum with regard to food consumption, occupancy, and other usage of the region in the vicinity of the plant site. As such, they represent individuals with habits that are considered to be reasonable deviations from the average for the population in general. Additionally, in physiological or metabolic respects, the MAXIMUM EXPOSED INDIVIDUALS are assumed to have those characteristics that represent the averages for their corresponding age group in the general population.

MEMBER(S) OF THE PUBLIC

Individuals who, by virtue of their occupational status, have no formal association with the site. This category includes non-employees of the licensee who are permitted to use portions of the site for recreational, occupational, or other purposes not associated with site functions. This category does not include non-employees such as vending machine servicemen or postal workers who, as part of their formal job function, occasionally enter an area that is controlled by the licensee to protect individuals from exposure to radiation and radioactive materials.

MINIMUM DETECTABLE CONCENTRATION (MDC)

The smallest concentration of radioactive material in a sample that will yield a net count (above system background) that can be detected with 95 percent probability with only 5 percent probability of falsely concluding that a blank observation represents a "real" signal or a blank represents a “real” signal. See Attachment 11 for equation. MDC will be used instead of Lower Limit of Detection (LLD).

MODE (OR OPERATIONAL MODE)

An OPERATIONAL MODE shall correspond to any one inclusive combination of core reactivity condition, power level, average reactor coolant temperature, and reactor vessel head closure bolt tensioning specified in Table 1.1-1 of the Technical Specifications (Reference 45) with fuel in the reactor vessel.

PRINCIPAL GAMMA EMITTERS

The PRINCIPAL GAMMA EMITTERS for which the MINIMUM DETECTABLE CONCENTRATION applies include exclusively the following radionuclides:

- For liquid radioactive effluents: Mn-54, Fe-59, Co-58, Co-60, Zn-65, Mo-99, Cs-134, Cs-137, and Ce-141. Ce-144 shall also be measured, but with an MDC of 5×10^{-6} μCi/mL
- For gaseous radioactive effluents: In noble gas releases, Kr-87, Kr-88, Xe-133, Xe-133m, Xe-135, Xe-138; and in particulate releases, Mn-54, Fe-59, Co-58, Co-60, Zn-65, Mo-99, Cs-134, Cs-137, Ce-141, and Ce-144.
- For environmental media: The gamma emitters specifically listed in Attachment 11.

These lists do not mean that only these nuclides are to be considered. Other gamma peaks that are identifiable, together with those of the above nuclides, shall also be analyzed and reported in the Annual Radioactive Effluent Release Report, the Annual Radiological Environmental Operating Report, or other applicable report(s).

PURGE - PURGING

The controlled discharge of air or gas from a confinement to maintain temperature, pressure, humidity, concentration, or other operating condition, so that replacement air or gas is required to purify the confinement.

RATED THERMAL POWER

RATED THERMAL POWER shall be a total reactor core heat transfer rate to the reactor coolant as defined in the VEGP Units 3 and 4 Technical Specification. (Ref. 45).

SITE BOUNDARY

That line beyond which the licensee does not own, lease, or otherwise control the land. See Figure 1.1-201 in the UFSAR (Reference 44).

SOURCE CHECK

A SOURCE CHECK shall be the qualitative assessment of channel response when the channel sensor is exposed to a source of increased radioactivity.

SPECIAL REPORT

A report to NRC to comply with Subsections 6.2, 6.3, 6.5, 6.6, and 6.7.5 of this ODCM.

THERMAL POWER

THERMAL POWER shall be a total reactor heat transfer rate to the reactor coolant.

UNRESTRICTED AREA

Any area at or beyond the SITE BOUNDARY, access to which is neither limited nor controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials, or any area within the SITE BOUNDARY used for residential quarters or for industrial, commercial, institutional and/or recreational purposes.

VENTILATION EXHAUST TREATMENT SYSTEM

Any system designed and installed to reduce radioactive releases to the environment. The system typically consists of charcoal absorbers and filters for the purpose of removing iodine and particulates from the gaseous effluent prior to release to the environment.

5.0 RESPONSIBILITIES

Responsibility for implementation is identified in UFSAR Section 13.1 Organizational Structure, Section 13.2 Training, Section 13.4 Operational Programs, and as-applicable, Sections 17.1, 17.2, 17.3 and 17.5 for Quality Assurance (Ref 44).

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6.0 INSTRUCTIONS

Meteorological, liquid, and gaseous pathway analyses are presented in Meteorological, Liquid, and Gaseous Pathway Analysis (Attachment 13).

6.1 SAMPLING AND MONITORING CRITERIA

6.1.1 Surveys, sampling, and analyses shall use instruments calibrated for the type and range of radiation monitored and the type of discharge monitored.

6.1.2 Installed monitoring systems shall be calibrated for the type and range of radiation or parameter monitored.

6.1.3 A sufficient number of survey points shall be used, or samples taken to adequately assess the status of the discharge monitored.

6.1.4 Samples shall be representative of the volume and type of discharge monitored.

6.1.5 Surveys, sampling, analyses, and monitoring records shall be accurately and legibly documented, and sufficiently detailed that the meaning and intent of the records are clear.

6.1.6 Surveys, analyses, and monitoring records shall be reviewed for trends, completeness, and accuracy.

6.2 LIQUID RADIOACTIVE WASTE EFFLUENTS

6.2.1 Liquid Effluent Concentration Limitations

a. Requirement

In accordance with Technical Specification 5.5.2.a.2 and 5.5.2.a.3, liquid waste concentrations discharged from the site shall not exceed the following limits:

1. For radionuclides (other than dissolved or entrained noble gases), liquid effluent concentrations released to UNRESTRICTED AREAS shall not exceed ten times the effluent concentration values specified in 10 CFR 20, Appendix B, Table 2, Column 2.
2. For dissolved or entrained noble gases, concentrations shall not exceed 2 x 10^{-4} µCi/mL total activity.

b. Applicability

This limit applies at all times.

c. ACTION

If the concentration of liquid effluent exceeds the limits in Section 6.2.1.a., IMMEDIATELY reduce concentrations to within limits.

d. Basis

The concentration of radioactive materials released in liquid waste effluents to UNRESTRICTED AREAS will be less than ten times the concentration levels specified in 10 CFR 20, Appendix B, Table 2, Column 2. The concentration limit for dissolved or entrained noble gases is based upon the assumption that Xe-135 is the controlling radioisotope and its maximum permissible concentration in air (submersion) was converted to an equivalent concentration in water using the methods described in International Commission on Radiological Protection Publication 2 (1959). The concentration of 2 x 10^{-4} will be used for a mixture of dissolved or entrained noble gases, not otherwise identified in liquid releases (Reference 24).

e. Concentration Limit Calculations

Concentrations of radioactive materials in liquid waste released to UNRESTRICTED AREAS shall be calculated as follows (equation adapted from addendum to Reference 24):

$$\left(\frac{c \cdot f}{F + f}\right) \leq TF \cdot C_{ECL} \qquad \text{Eqn 6.2.1-1}$$

where:

C_{ECL}	=	the Effluent Concentration Limit (ECL) corresponding to the mix of radionuclides in the effluent being considered for discharge, in µCi/mL.
c	=	the setpoint, in µCi/mL, of the radioactivity monitor measuring the concentration of radioactivity in the effluent line prior to dilution and subsequent release. The setpoint represents a concentration which, if exceeded, could result in concentrations exceeding the limits of 6.2.1.a in the UNRESTRICTED AREA.
f	=	the effluent flow rate at the location of the radioactivity monitor, in gallons per minute (gpm).
F	=	the dilution stream flow rate that can be assured prior to the release point to the UNRESTRICTED AREA, in gpm.

TF = the tolerance factor selected to allow flexibility in the establishment of a practical monitor setpoint which could accommodate effluent releases at concentrations higher than the ECL values stated in 10 CFR 20, Appendix B, Table 2, Column 2; the tolerance factor must not exceed a value of 10 per Section 6.2.1.a.

While equation 6.2.1-1 shows the relationships of the critical parameters that determine the setpoint, it cannot be applied practically to a mixture of radionuclides with different Effluent Concentration Limits (ECLs). For a mixture of radionuclides, equation 6.2.1-1 is satisfied in a practicable manner based on the calculated ECL fraction of the radionuclide mixture and the dilution stream flowrate that can be assured for the duration of the release (F_d), by calculating the maximum permissible effluent flowrate (f_m) and the radioactivity monitor setpoint (c).

The setpoint method presented in 6.2.2.g is applicable to the release of only one tank of the LIQUID WASTE MANAGEMENT SYSTEM per reactor unit at a given time. Liquid releases must be controlled administratively to ensure that this condition is met; otherwise, the setpoint method may not ensure that the limits of Section 6.2.1.a are not exceeded.

6.2.2 Liquid Monitoring Instrumentation

a. REQUIREMENT

In accordance with Technical Specification 5.5.2.a.1, radioactive liquid effluent monitoring instrumentation channels shown on Radioactive Liquid Effluent Monitoring Instrumentation (Attachment 1) shall be FUNCTIONAL with their alarm/trip setpoints set to ensure that Step 6.2.1.a. limits are not exceeded.

b. APPLICABILITY

This limit applies at all times.

c. ACTION

1. The Alarm/Trip Setpoints for these instruments shall be calculated and adjusted in accordance with the methodology and parameters in Section 6.2.2.g to ensure that the alarm/trip will occur prior to exceeding the limits of Section 6.2.1.a.
2. If a radioactive liquid effluent monitoring instrumentation channel alarm/trip setpoint is less conservative than required by Section 6.2.2.a., perform one of the following:
   (a) IMMEDIATELY suspend release of radioactive liquid effluents monitored by the affected channel
   (b) Declare the channel non-FUNCTIONAL

d. REQUIREMENT

In accordance with Technical Specification 5.5.2.a.1, each radioactive liquid effluent monitoring instrumentation channel shall be demonstrated FUNCTIONAL by performing a CHANNEL CHECK, SOURCE CHECK, CHANNEL CALIBRATION, and CHANNEL FUNCTIONAL TEST at the frequencies shown in Radioactive Liquid Effluent Monitoring Instrumentation Surveillance Requirements (Attachment 2).

1. If the number of FUNCTIONAL channels is less than the minimum required by the tables in Radioactive Liquid Effluent Monitoring Instrumentation (Attachment 1) perform the ACTION shown in those tables.
2. Return the instruments to FUNCTIONAL status within 30 days. If unsuccessful and the channel is required to be in service, then explain in the next Annual Radioactive Effluent Release Report why the non-FUNCTIONALITY was not corrected in a timely manner.

e. BASIS

The radioactive liquid effluent instrumentation is provided to monitor and control, as applicable, the releases of radioactive materials in liquid effluents during actual or potential releases of liquid effluents. The FUNCTIONALITY and use of this instrumentation is consistent with the requirements of General Design Criteria 60, 63, and 64 of Appendix A to 10 CFR Part 50.

f. APPLICABLE MONITORS

Liquid effluent monitors, and liquid monitors that can become liquid effluent monitors under abnormal conditions, for which alarm/trip setpoints shall be determined, are:

Table 6.2.2-1 Liquid Effluent Monitors Requiring Setpoints

Release Point	Instrument Number	Typical Release Allocation Fraction	Setpoint Method
Liquid Radwaste Discharge	WLS-JE-RE229	0.18	§6.2.2.g.1 – 6.2.2.g.5
Waste Water Discharge	WWS-JE-RE021	0.03	§6.2.2.g.6
Service Water Blowdown	SWS-JE-R008	0.03	§6.2.2.g.6

See Attachments 1 and 2 for more information.

Figure 6.2.2-1 shows a simplified system schematic depicting the location of WLS-JE-RE229. Figure 6.2.2-2 shows a simplified system schematic depicting the locations of monitors WWS-JE-RE021, and SWS-JE-RE008.
The steam generator blowdown de-ionization effluent monitor, BDS-JE-RE010, and steam generator de-ionization brine monitor, BDS-JE-RE011, are shown on Figure 6.2.2-2, but they are process monitors and not the subject of this document.

g. SETPOINT CALCULATIONS

Maximum setpoint values for radioactive waste system discharge monitors shall be calculated by the following five steps.

For monitors on streams that are not expected to have significant quantity of radioactivity, the method in 6.2.2.g.6 shall be used.

1. Step 1: Determine the radionuclide concentrations in the liquid waste being considered for release in accordance with the sampling and analysis requirements of Section 6.1.

   All liquid radioactive wastes treated by the LIQUID WASTE MANAGEMENT SYSTEM are collected in waste monitor tanks for sampling and analysis. Prior to discharge, these tanks shall be sampled and analyzed for radioactivity in accordance with plant procedures. The total concentration of the liquid waste is determined by the results of all required analyses on the collected sample, as follows:

$$\sum_i C_i = C_a + \sum_s C_s + C_f + C_t + \sum_g C_g \qquad \text{Eqn 6.2.2-1}$$

where:

C_i	=	the total concentration of radionuclides in the liquid waste to be discharged
C_a	=	the gross concentration of alpha emitters in the liquid waste, not less than that measured in the most recent applicable COMPOSITE SAMPLE
C_s	=	the concentration of strontium radioisotope *s* (Sr-89 or Sr-90) in the liquid waste, not less than that measured in the most recent applicable COMPOSITE SAMPLE
C_f	=	the concentration of Fe-55 in the liquid waste, not less than that measured in the most recent applicable COMPOSITE SAMPLE
C_t	=	the concentration of H-3 in the liquid waste, not less than that measured in the most recent applicable COMPOSITE SAMPLE
C_g	=	the concentration of gamma emitter *g* in the liquid waste as measured by gamma ray spectroscopy performed on the sample for the release under consideration

The C_g term will be included in the analysis of each waste sample; terms for gross concentrations of alpha emitters, Sr-89, Sr-90, Fe-55, and tritium will be included in accordance with the sampling and analysis program required for the waste stream (see Section 6.1). For each analysis, only radionuclides identified and detected above background for the given measurement should be included in the calculation. When using the alternate setpoint methodology of section 6.2.2.g.5.(b), the historical maximum values of C_a, C_s, C_f, and C_t shall be used.

2. Step 2: Determine the required dilution factor for the mix of radionuclides detected in the waste.

Measured radionuclide concentrations are used to calculate ECL fractions. The ECL fractions are used along with a safety factor to calculate the required dilution factor; this is the minimum ratio of dilution flowrate to waste flowrate that must be maintained throughout the release to ensure that the limits of Section 6.2.1 are not exceeded at the point of discharge into the UNRESTRICTED AREA. The required dilution factor, *RDF*, is calculated as the sum of the required dilution factors required for gamma emitters (RDF_γ) and for non-gamma-emitters ($RDF_{n\gamma}$):

$$RDF = \left[\sum_{i} \frac{C_i}{ECL_i}\right] \div [(SF)(TF)]$$

$$RDF = RDF_\gamma + RDF_{n\gamma}$$

Eqn 6.2.2-2

where:

$$RDF_\gamma = \frac{\left[\sum_g \frac{C_g}{ECL_g}\right]}{(SF)(TF)}$$

Eqn 6.2.2-3

$$RDF_{n\gamma} = \frac{\left[\frac{C_a}{ECL_a} + \sum_s \frac{C_s}{ECL_s} + \frac{C_f}{ECL_f} + \frac{C_t}{ECL_t}\right]}{(SF)(TF)}$$

Eqn 6.2.2-4

RDF	=	Required dilution factor.
RDF_γ	=	Required dilution factor for gamma-emitters.
$RDF_{n\gamma}$	=	Required dilution factor for non-gamma-emitters.
C_i	=	the measured concentration of radionuclide i as defined in step 1, in μCi/mL. The C_a, C_s, C_f, and C_t terms will be included in the calculation as appropriate
ECL_i	=	the Effluent Concentration Limit for radionuclide i from 10 CFR Part 20, Appendix B, Table 2, Column 2 (except for noble gases as discussed below). In the absence of information regarding the solubility classification of a given radionuclide in the waste stream, the solubility class with the lowest ECL shall be assumed. For dissolved or entrained noble gases, the concentration shall be limited to $2x10^{-4}$ μCi/mL. For gross alpha, the ECL shall be $2x10^{-9}$ μCi/mL; if specific alpha-emitting radionuclides are measured, the ECL for the specific radionuclide(s) should be used.
ECLs	=	the Effluent Concentration Limit for Sr-89 or Sr-90, in μCi/mL, from 10

CFR 20, Appendix B, Table 2, Column 2,

ECL_f = the Effluent Concentration Limit for Fe-55, in µCi/mL, from 10 CFR 20, Appendix B, Table 2, Column 2

ECL_g = the Effluent Concentration Limit for the mix of non-noble gas gamma radionuclides, in µCi/mL, from 10 CFR 20, Appendix B, Table 2, Column 2

ECL_a = the Effluent Concentration Limit for the mix of alpha radionuclides, in µCi/mL, from 10 CFR 20, Appendix B, Table 2, Column 2

ECL_t = the Effluent Concentration Limit for tritium (H-3) in µCi/mL, from 10 CFR 20, Appendix B, Table 2, Column 2

SF = the safety factor selected to compensate for statistical fluctuations and errors of measurement. The value for the safety factor must be between 0 and 1. A value of 0.25 is reasonable for liquid releases; a more precise value may be developed if desired.

TF = 10, the tolerance factor previously defined in section 6.2.1.

3. Step 3: Determine the release-specific assured dilution stream flowrate.

Determine the dilution stream flowrate that can be assured during the release period, designated F_d; this value is the setpoint for the dilution stream flowrate measurement device. If simultaneous radioactive releases are planned from the same or different reactor units, the dilution stream must be allocated among all the simultaneous releases. There will only be one such release per unit at a given time, unless there is detectable radioactivity in one of the normally low-radioactivity streams (see Section 6.2.2.g.6). Typical allocation factors can be found in Table 6.2.2-1 but the following method can also be used to calculate allocation of the dilution stream to multiple release paths:

$$F_{dp} = F_d \cdot AF_p \qquad \text{Eqn 6.2.2-5}$$

where:

F_{dp} = the dilution flowrate allocated to release pathway *p*, in gpm.

AF_p = the dilution allocation factor for release pathway *p*. AF_p may be assigned any value between 0 and 1 for each active release pathway, under the condition that the sum of the AF_p for all active release pathways for the entire plant site does not exceed 1.

F_d = the assured minimum dilution flow, in gpm.

In the normal case in which the only release pathways with detectable radioactivity are the LIQUID WASTE MANAGEMENT SYSTEMS of each unit for Vogtle Units 1,2,3 and 4, AF_p for any unit may be assigned the value of 0.25 to permit releases from any unit to be made without regard to releases from other units; If only one unit's LIQUID WASTE MANAGEMENT SYSTEM is releasing at a given time, its AF_p may be increased proportionately. If more precise allocation factor values are desired, they may be determined based on the relative radiological impact of each active release pathway. This may be approximated by multiplying the *RDF* of each effluent stream by its respective planned release flowrate, and comparing these values. If only one release is being made on the entire site, its AF_p may be assigned the value of 1, making F_{dp} equal to F_d.

For the case where *RDF*≤1, the planned release meets the limits of Section 6.2.1 without dilution, and could be released with any desired effluent flowrate and dilution flowrate. However, in order to maintain individual doses due to liquid effluent releases as low as is reasonably achievable, no releases with detectable radioactivity should be made if the assured dilution flowrate, F_d, is less than 6,000 gpm.

4. Step 4: Determine the maximum allowable waste discharge flowrate.

For the case where *RDF* > 1, the maximum permissible effluent discharge flowrate for this release pathway, f_{mp} (in gpm), is calculated as follows:

$$f_{mp} = \frac{F_{dp}}{RDF - 1} \qquad \text{Eqn 6.2.2-6}$$

For the case RDF≤1, Eqn 6.2.2-6 is not valid. However, as discussed above, when RDF≤1, the release may be made at full discharge pump capacity; the radioactivity monitor setpoint must still be calculated in accordance with Step 5 below.

CAUTION 1: Discharge flowrates are limited by the discharge pump capacity. When the calculated maximum permissible release flowrate exceeds the pump capacity, the release may be made at full capacity. Discharge flowrates less than the pump capacity must be achieved by throttling, if this is available; if throttling is not available, the release may not be made as planned.

CAUTION 2: If, at the time of the planned release, there is detectable radioactivity due to plant operations in the dilution stream, the diluting capacity of the dilution stream is diminished. (In addition, sampling and analysis of the other radioactive effluents affecting the dilution stream must be sufficient to ensure that the liquid effluent dose limits specified in the controls of Section 6.2.1 are not exceeded.) Under these conditions, Eqn 6.2.2-6 must be modified to account for the radioactivity present in the dilution stream prior to the introduction of the planned release:

$$f_{mp} = \frac{F_{dp}}{(RDF - 1)} \left\{ 1 - \sum_r \left[\frac{f_r}{F_d} \sum_i \left(\frac{C_{ir}}{ECL_i} \right) \right] \right\} \qquad \text{Eqn 6.2.2-7}$$

where:

C_{ir} = the measured concentration of radionuclide *i* in release pathway *p* that is contributing to radioactivity in the dilution stream

f_r = the effluent discharge flowrate of release pathway *p*

If the entire dilution stream contains detectable activity due to plant operations, whether or not its source is identified, $f_r = F_d$, *and* C_{ir} is the concentration in the total dilution system. This note does not apply: a) if the *RDF* of the planned release is ≤1 or b) if the release contributing radioactivity to the dilution stream has been accounted for by the assignment of an allocation factor.

5. Step 5: Determine the maximum radioactivity monitor setpoint concentration.

Based on the values determined in previous steps, the radioactivity monitor setpoint for the planned release is calculated to ensure that the limits of Section 6.2.1 will not be exceeded. Because the radioactivity monitor responds primarily to gamma radiation, the monitor setpoint c_p for release pathway *p* (in µCi/mL) is based on the concentration of gamma emitters in the waste stream, as follows:

$$c_p = A_p \sum_g C_g \qquad \text{Eqn 6.2.2-8}$$

where:

A_p = A unit-less adjustment factor which will allow the setpoint to be established in a practical manner to prevent spurious alarms while allowing a margin between measured concentrations and the limits of Section 6.2.1.

C_g = the concentration of gamma emitter *g* in the liquid waste as measured by gamma ray spectroscopy performed on the sample for the release under consideration, in µCi/mL

(a). Step 5a: Calculate A_p

If the concentration of gamma emitters in the effluent to be released is sufficient that the high alarm setpoint can be established at a level that will prevent spurious alarms, A_p should be calculated as follows:

$$A_p = \frac{ADF}{RDF} \qquad \text{Eqn 6.2.2-9}$$

$$A_p = \frac{1}{RDF} \cdot \frac{(F_{dp} + f_{ap})}{f_{ap}} \qquad \text{Eqn 6.2.2-10}$$

where:

ADF = the assured dilution factor

f_{ap} = the anticipated actual discharge flowrate for the planned release (in gpm), a value less than f_{mp}. The release must then be controlled so that the actual effluent discharge flowrate does not exceed f_{ap} at any time.

(b). Step 5b: Alternatively, A_p may be calculated as follows:

$$A_p = \frac{ADF - RDF_{n\gamma}}{RDF_{\gamma}} \qquad \text{Eqn 6.2.2-11}$$

(c). Step 5c: Evaluate the computed value of A_p as follows:

If $A_p \geq 1$, calculate the monitor setpoint, c_p. However, if c_p is within approximately 10 percent of C_g, it may be impractical to use this value of c_p. This situation indicates that measured concentrations are approaching values which would cause limits of Section 6.2.1.a to be exceeded. Therefore, steps should be taken to reduce potential concentrations at the point of discharge; these steps may include decreasing the planned effluent discharge flowrate, increasing the dilution stream flowrate, postponing simultaneous releases, and/or decreasing the effluent concentrations by further processing the liquid planned for release. Alternatively, allocation factors for the active liquid release pathways may be reassigned. When one or more of these actions has been taken, repeat Steps 1-5 to calculate a new radioactivity monitor setpoint.

If $A_p < 1$, the release may not be made as planned. Consider the alternatives discussed in the paragraph above, and calculate a new radioactivity monitor setpoint based on the results of the actions taken.

NOTE: The setpoint calculated above is in the units is in µCi/mL. The monitor actually measures a count rate, subtracts a predetermined background count rate, and multiplies by a calibration factor to convert from count rate to µCi/mL.

Initial calibration of the monitors by the manufacturer and Southern Nuclear Operating Company utilized National Institute of Standards and Technology (NIST)-traceable liquid solutions with gamma ray emissions over an appropriate range, in the exact geometry of each production monitor. The calibration factor is a function of the radionuclide mix in the liquid to be released, and will be calculated for the monitor based on the results of the prerelease sample results from the laboratory gamma-ray spectrometer system. The mix-dependent calibration factor will be used as the gain factor in the radiation monitoring system, or used to modify the calculated base monitor setpoint so that the default calibration factor in the radiation monitoring system can be left unchanged.

Notwithstanding the initial calibration, monitor calibration data for conversion between count rate and concentration may include operational data obtained from determining the monitor response to stream concentrations measured by liquid sample analysis. In all cases, monitor background must be controlled so that the monitor is capable of responding to concentrations in the range of the setpoint value.

6. Setpoints for Monitors on Normally Low-Radioactivity Streams

Radioactivity in these streams (identified in Table 6.2.2-1 as applying to this section) is expected to be at very low levels, generally below detection limits. Accordingly, the purpose of these monitors is to alarm upon the occurrence of significant radioactivity in these streams, and to terminate or divert the release where this is possible.

(a). Normal Conditions: When radioactivity in one of these streams is at its normal low level, its radioactivity monitor setpoint should be established as close to background as practical to prevent spurious alarms, and yet alarm should an inadvertent release occur. This may require some trial and error, starting with approximately twice the reading on the monitor under normal conditions. Examination of the historical averages on the monitor should provide guidance.

(b). Conditions Requiring an Elevated Setpoint:

Under the following conditions, radionuclide concentrations must be determined and an elevated radioactivity monitor setpoint determined for these pathways:

- For streams that can be diverted or isolated, a new monitor setpoint must be established when it is desired to discharge the stream directly to the dilution water even though the radioactivity in the stream exceeds the level which would normally be diverted or isolated.

- Special consideration must be given to Step 3. An allocation factor must be assigned to the normally low-radioactivity release pathway under consideration, and allocation factors for other release pathways discharging simultaneously must be adjusted downward (if necessary) to ensure that the sum of the allocation factors does not exceed 1.

- Sampling and analysis of the normally low-radioactivity streams (Section 6.2.5) must be sufficient to ensure that the liquid effluent dose limits specified in the controls of Section 6.2.1 are not exceeded. A new discharge permit (Section 6.4.2) must be prepared.

- For streams that cannot be diverted or isolated, a new monitor setpoint must be established whenever the radioactivity in the stream becomes detectable above the background levels of the applicable laboratory analyses or the associated radioactivity monitor detects activity in the stream at levels above the established alarm setpoint.

When an elevated monitor setpoint is required for any of these effluent streams, it should be determined in the same manner as described in Section 6.2.2.g. However, special consideration must be given to Section 6.2.2.g.3. An allocation factor must be assigned to the normally low-radioactivity release pathway under consideration, and allocation factors for other release pathways discharging simultaneously must be adjusted downward (if necessary) to ensure that the sum of the allocation factors does not exceed 1. Sampling and analysis of the normally low-radioactivity streams must be sufficient to ensure that the liquid effluent dose limits specified in the controls of Section 6.2.3.a are not exceeded.

7. Figure 6.2.2-1 provides a simplified flow schematic of the liquid radioactive waste effluent from the treatment system to the point of release. Figure 6.2.2-2 depicts other water discharge pathways with radiation monitors. The Figure 6.2.2-2 pathways are expected to have low probability of containing radioactivity.

Figure 6.2.2-1 Liquid Radwaste System

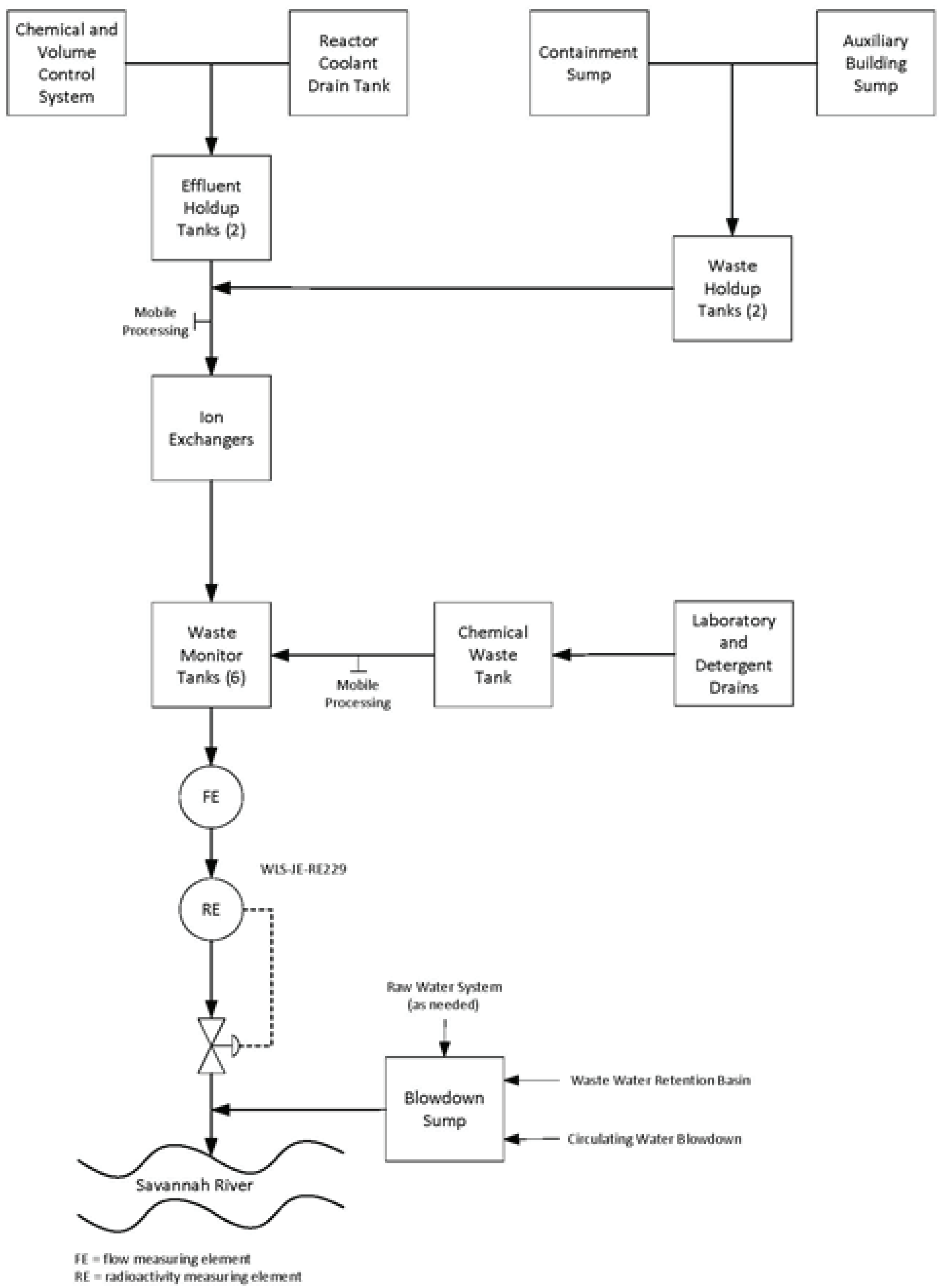
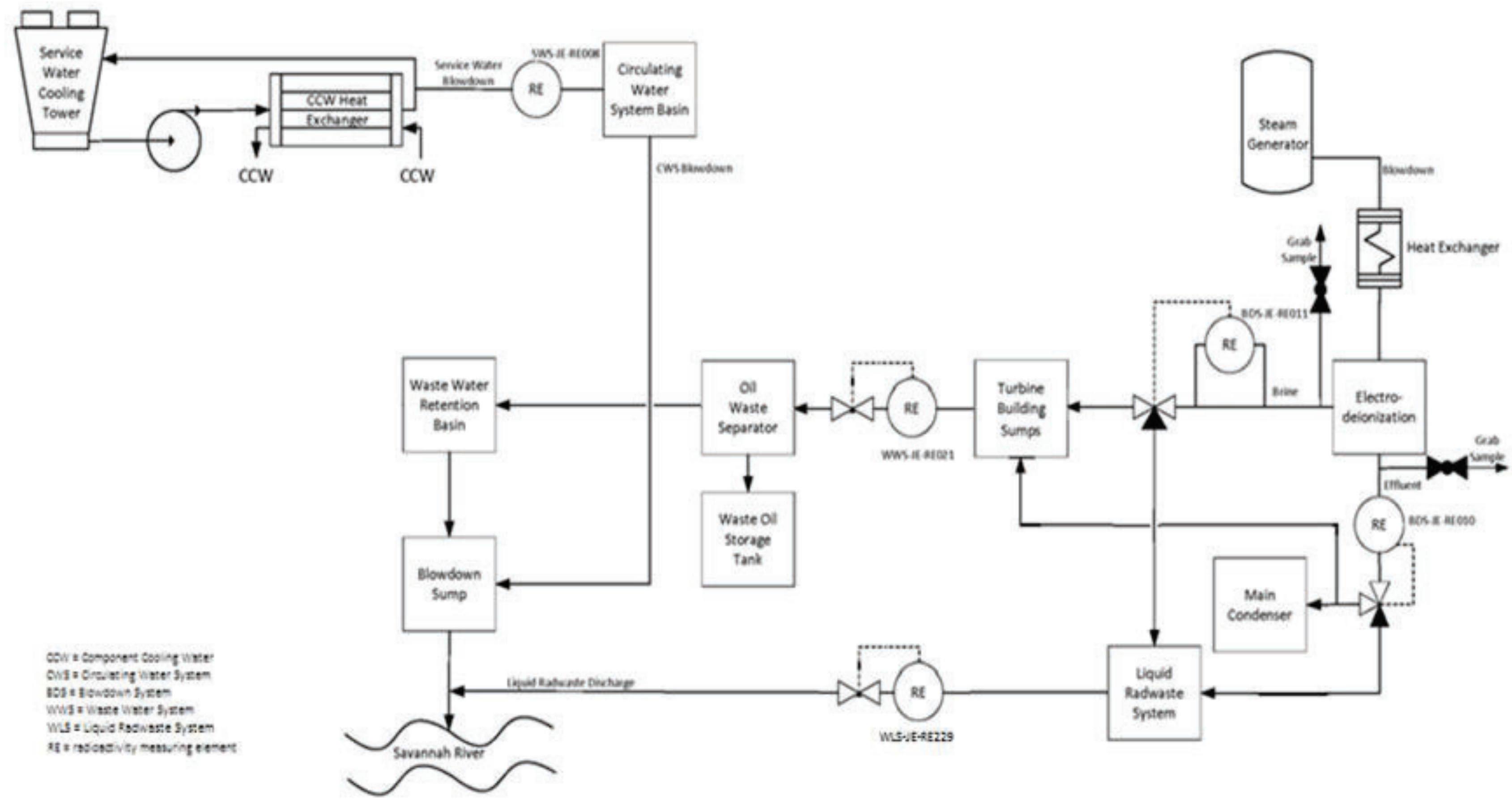


Figure 6.2.2-2 Monitored Liquid Effluent Flowpaths



6.2.3 Liquid Effluent Dose Limit

The following sub-sections present the methods required for liquid effluent dose calculations, in deepening levels of detail. Applicable site-specific pathways and parameter values for the calculation of D_{τ}, (Section 6.2.3.e), $A_{i\tau}$, (Section 6.2.3.f) and CF_{iv} (Section 6.2.3.g) are summarized in Attachment 13.

a. REQUIREMENT

1. In accordance with Technical Specification 5.5.2.a.4 and 5.5.2.a.5, at least once per 31 days, perform the dose calculations in Section 6.2.3.e to ensure the dose or dose commitment to the maximally exposed MEMBER OF THE PUBLIC from radioactive materials in liquid releases (from each reactor unit) to UNRESTRICTED AREAS is limited to:

   (a) During any calendar quarter:
      (1) Less than or equal to 1.5 mrem to the total body
      (2) Less than or equal to 5 mrem to any organ

   (b) During any calendar year:
      (1) Less than or equal to 3 mrem to the total body
      (2) Less than or equal to 10 mrem to any organ

2. In accordance with Technical Specification 5.5.2.a.5, dose projections must be made at least once each 31 days, per Section 6.3.5.e.

b. APPLICABILITY

This limit applies at all times.

c. ACTION

If the calculated dose from release of radioactive materials in liquid effluents exceeds any of the above limits, prepare and submit to the NRC, within 30 days, a SPECIAL REPORT that identifies causes for exceeding limits and defines corrective actions taken to reduce releases of radioactive materials in liquid effluents to ensure that subsequent releases will be in compliance with the above limits. At least once per 31 days, cumulative dose contributions from liquid effluents for the current calendar quarter and the current calendar year shall be determined, for each unit, in accordance with Section 6.2.3.e.

d. BASIS

This control is provided to implement the requirements of Sections II.A, III.A and IV.A of Appendix I, 10 CFR Part 50. The limits stated in Section 6.2.3.a implement the guides set forth in Section II.A of Appendix I. The ACTIONS stated in Section 6.2.3.c provide the required operating flexibility and at the same time implement the guides set forth in Section IV.A of Appendix I to assure that the releases of radioactive material in liquid effluents will be kept "as low as is reasonably achievable." Also, for fresh water sites with drinking water supplies that can be potentially affected by plant operations, there is reasonable assurance that the operation of the facility will not result in radionuclide concentrations in the finished drinking water that are in excess of the requirements of 40 CFR Part 141. The dose calculations in Section 6.2.3.e implement the requirements in Section III.A of Appendix I, which state that conformance with the guides of Appendix I be shown by calculational procedures based on models and data, such that the actual exposure of a MEMBER OF THE PUBLIC through appropriate pathways is unlikely to be substantially underestimated. The equations specified in Section 6.2.3.e for calculating the doses due to the actual release rates of radioactive materials in liquid effluents are consistent with the methodology provided in NUREG-0133 (Reference 24), Regulatory Guide 1.109 (Reference 11) and Regulatory Guide 1.113 (Reference 15).

This control applies to the release of liquid effluents from each unit at the site. The liquid effluents from shared LIQUID WASTE MANAGEMENT SYSTEMS are to be proportioned between the units.

e. DOSE CONTRIBUTION CALCULATIONS

Dose contribution to the MAXIMUM EXPOSED INDIVIDUAL shall be calculated for all radionuclides identified in liquid effluents released to UNRESTRICTED AREAS based on (equation from Reference 24, page 15):

$$D_\tau = \sum_i A_{i\tau}\left[\sum_{l=1}^{m}(\Delta t_l C_{il} F_l)\right] \qquad \text{Eqn 6.2.3-1}$$

where:

D_τ = the cumulative dose commitment to the total body or to any organ τ, in mrem, due to radioactivity in liquid effluents released during the total of the m time periods Δt_l.

$A_{i\tau}$ = the site-related adult ingestion dose commitment factor, for the total body or for any organ τ, due to identified radionuclide i, in (mrem/hr per uCi/ml). Methods for the calculation of $A_{i\tau}$ and resulting values are presented in Eqn 6.2.3-3 and Attachment 13, Section 2.3.

Δt_l = the length of time period l, over which C_{il} and F_l are averaged for liquid releases, in hours, *h.*

C_{il} = the average concentration of radionuclide i in undiluted liquid effluent during time period l, in μCi/mL. Only radionuclides identified and detected above background in their respective samples should be included in the calculation.

F_l = the near-field average dilution factor in the receiving water of the UNRESTRICTED AREA:

$$F_l = \frac{f_t}{F_t \cdot Z} \qquad \text{Eqn 6.2.3-2}$$

where:

f_t = the average undiluted liquid waste flowrate actually observed during the period of radioactivity release, in gpm.

F_t = the average dilution stream flowrate observed during the period of radioactivity release, in gpm. If simultaneous releases from more than one unit occur, the dilution stream flowrate F_t must be allocated between them. In such cases, F_t, is unit-specific.

Z = the applicable dilution factor for the receiving water body, in the near field of the discharge structure, during the period of radioactivity release, which is set as 10, for May through December, and 20, for January through April (Reference 38).

NOTE: In Eqn. 6.2.3-2, the product ($F_t \cdot Z$) is limited to 1,000 cubic feet per second (cfs) (= 448,000 gpm) or less. (Reference 24, Section 4.3.)

f. Calculation of $A_{i\tau}$

The site-related adult ingestion dose commitment factor, $A_{i\tau}$ is calculated as follows (equation adapted from NUREG-0133, (Reference 24, page 16), by addition of the irrigated garden vegetation pathway, which currently, however, does not exist. $A_{i\tau}$ formulas for Drinking Water, Fish Ingestion, and Shoreline Exposure can be found in Attachment 13, Section 2.2.

$$A_{i\tau} = 1.14 \times 10^5 \left(\frac{U_w}{D_w} e^{-\lambda_i t_w} + U_f BF_i e^{-\lambda_i t_f} + \boldsymbol{U_s} \mathbf{W} \boldsymbol{T_i}(\boldsymbol{e^{-\lambda_i t_s}})(\mathbf{1} - \boldsymbol{e^{-\lambda_i t_b}}) + U_v CF_{iv}\right) DF_{i\tau} \quad \text{Eqn 6.2.3-3}$$

where:

1.14 x 10^5	= =	a unit conversion factor determined by: 10^6 pCi/μCi x 10^3 mL/L x 1 y/8760 h
U_w	=	the adult age group drinking water consumption rate applicable to the plant, which is 730 L/yr per Reg Guide 1.109, Table E-5 (Reference 11).
D_w	=	the dilution factor from the near field of the discharge structure for the plant site to the potable water intake location, which is 8 for VEPG 3&4 (Reference 47).
λ_i	=	the decay constant for radionuclide *i* (h^{-1}) Attachment 8, Table A8-11.
t_w	=	the transit time from release to receptor for potable water consumption, which is 16 hours per VEGP 3&4 UFSAR Table 11.2-201 (Reference 44).
U_f	=	the adult age group fish consumption applicable to the plant site, which is 21 kg/yr per Reg Guide 1.109, Table E-5 (Reference 11).
BF_i	=	the bioaccumulation factor for radionuclide i applicable to freshwater fish in the Savannah River near the discharge in (pCi/kg)/(pCi/L) = L/kg. These values are obtained from Reg Guide 1.109, Table A-1 (Reference 11) except as follows: Reference 41 for P; Reference 10 (Table A-8) for Ag; and Reference 49 for Nb and Sb. For specific values applicable to the plant site, see Attachment 8 Table A8-10.
t_f	=	the transit time from release to receptor for fish consumption, which is 24 hours per Reg Guide 1.109, Section A.2 (Reference 11).
$\boldsymbol{U_s}$	=	The age group standing on contaminated sediment rate applicable to the plant site in hours/year per Reg Guide 1.109, Table E-5 (Reference 11).
W	=	Shoreline shore-width factor, which is 0.2 and unitless per Table A-2 Reg Guide 1.109 (Reference 11).
$\boldsymbol{T_i}$	=	Radiological half-life of nuclide (i) in days Attachment 8 Table A8-11.
$\boldsymbol{t}_s$	=	the transit time from release to reach point of exposure for shoreline deposits, which is 0 hours Reg Guide 1.109, Table E-15, Equation A-7 (Reference 11).
$\boldsymbol{t_b}$		the period of long-term buildup for activity in sediment or soil (nominally 15 yr) per Reg Guide 1.109, Table E-15 (Reference 11).
U_v	=	the adult consumption rate for irrigated garden vegetation applicable to the plant site, which is 0 kg/yr since there are no river-irrigated gardens

CF_{iv} = the concentration factor for radionuclide *i* in irrigated garden vegetation. Although this parameter is not currently needed, it can be calculated from Reg Guide 1.109 (Reference 11) by adapting equations A-8 and A-9 for radionuclides other than tritium. For tritium, use equations A-9 and A-10. Methods for calculation of CF_{iv} are presented below in Section 6.2.3.g.

$DF_{i\tau}$ = the dose conversion factor for radionuclide *i* for adults in organ τ in mrem/pCi ingested. The values can be obtained from Reg Guide 1.109, Revision 1, Table E-11 (Reference 11) except for Rh-105, Sb-124, and Sb-125, which can be obtained from LADTAP II or GASPAR II (References 30 and 31). .

g. Calculation of CF_{iv}

The concentration factor for radionuclide i in irrigated garden vegetation, CF_{iv} in (L/kg), is calculated as follows:

- For radionuclides other than tritium (equation adapted from Reference 11, equations A–8 and A–9):

$$CF_{iv} = M \times I \left[\frac{r\left(1 - e^{-\lambda_{Ei} t_e}\right)}{Y_v \lambda_{Ei}} + \frac{f_I V_{iv}\left(1 - e^{-\lambda_i t_b}\right)}{P \lambda_i} \right] e^{-\lambda_i t_h} \qquad \text{Eqn 6.2.3-4}$$

- For tritium (equation from Reference 11, A–10):

$$CF_{iv} = C_w \qquad \text{Eqn 6.2.3-5}$$

where:

M = the additional river dilution factor from the near field of the discharge structure for the plant site to the point of irrigation water usage.

I = the average irrigation rate during the growing season (L)/($m^2 \cdot$h).

r = the fraction of irrigation-deposited activity retained on the edible portions of leafy garden vegetation.

Y_v = the areal density (agricultural productivity) of leafy garden vegetation (kg/m^2).

f_I = the fraction of the year that garden vegetation is irrigated.

V_{iv} = the crop to soil concentration factor applicable to radionuclide i (pCi/kg garden vegetation)/(pCi/kg soil).

P = the effective surface density of soil (kg/m^2).

λ_i = the decay constant for radionuclide i (h^{-1}). Values of λ_i used in effluent calculations should be based on decay data from a recognized and current source, such as (Reference 46).

λ_w = the rate constant for removal of activity from plant leaves by weathering (h^{-1}).

λ_{Ei} = the effective removal rate for activity deposited on crop leaves (h^{-1}) calculated as: $\lambda_{Ei} = \lambda_i + \lambda_w$.

t_e = the period of leafy garden vegetation exposure during the growing season (h).

t_b = the period of long-term buildup of activity in soil (h).

t_h = the time between harvest of garden vegetation and human consumption (h).

C_w = is the concentration of tritium in water used for irrigation, in pCi/L.

h. COMPOSITE ANALYSES

For radionuclides not determined in each batch or weekly composite, dose contribution to current monthly or calendar quarter cumulative summation may be approximated by assuming an average monthly concentration based on previous monthly or quarterly composite analyses. However, for reporting purposes, calculated dose contribution shall be based on the actual composite analyses.

6.2.4 LIQUID WASTE MANAGEMENT SYSTEM

Historical data pertaining to the volumes and radioactivity of liquid effluents released in connection with specific site functions, such as maintenance or refueling outages, shall be used in projections as appropriate. Figure 6.2.2-1 provides a simplified flow schematic of the liquid radioactive waste effluent from the treatment system to the point of release. Figure 6.2.2-2 depicts other water discharge pathways with radiation monitors. The Figure 6.2.2-2 pathways are expected to have low probability of containing radioactivity. A detailed description of the system can be found in the Vogtle 3&4 UFSAR, Subsection 11.2 (Ref. 44).

a. Requirement

In accordance with Technical Specification 5.5.2.a.6:

1. The LIQUID WASTE MANAGEMENT SYSTEM and GASEOUS WASTE MANAGEMENT SYSTEM shall be used to reduce releases of radioactivity when the projected dose, in a period of 31 days, would exceed 2% of the guidelines for the annual dose or dose commitment, conforming to 10 CFR 50, Appendix I.
2. The LIQUID WASTE MANAGEMENT SYSTEM shall be FUNCTIONAL. The appropriate portions of the system shall be used to reduce radioactivity when the projected doses due to the liquid effluent, from each unit, to UNRESTRICTED AREAS would exceed 0.06 mrem to the total body or 0.2 mrem to any organ of a MEMBER OF THE PUBLIC in 31 days.

b. APPLICABILITY

This limit applies at all times.

c. ACTION

If radioactive liquid waste is discharged without treatment and in excess of the above limits prepare and submit to the NRC, within 30 days, a SPECIAL REPORT that includes the following:

1. An explanation of why liquid radioactive waste was being discharged without treatment, identification of any non-FUNCTIONAL equipment or sub-system, and the reason for the non-FUNCTIONALITY.
2. Actions taken to restore non-FUNCTIONAL equipment to FUNCTIONAL status.
3. Summary description of actions taken to prevent recurrence.

d. Basis

The FUNCTIONALITY of the LIQUID WASTE MANAGEMENT SYSTEM ensures that this system will be available for use whenever liquid effluents require treatment prior to release to the UNRESTRICTED AREAS. The requirement that the appropriate portions of this system be used when specified provides assurance that the releases of radioactive materials in liquid effluents will be kept “as low as is reasonably achievable.” This control implements the requirements of 10 CFR Part 50.36a, General Design Criterion 60 of Appendix A to 10 CFR Part 50, and the design objective given in Section II.D of Appendix I to 10 CFR Part 50. The specified limits governing the use of appropriate portions of the LIQUID WASTE MANAGEMENT SYSTEM were specified as a suitable fraction of the dose design objectives set forth in Section II.A of Appendix I, 10 CFR Part 50, for liquid effluents.

This control applies to the release of radioactive materials in liquid effluents from Vogtle 3 and 4 at the site.

e. Projected Total Body or Organ Dose Calculation

Projected 31-day doses to individuals due to liquid effluents may be determined as follows:

$$D_{\tau p} = \frac{D_{\tau c}}{t} \cdot 31 + D_{\tau a} \qquad \text{Eqn 6.2.4-1}$$

where:

$D_{\tau p}$ = the projected dose to the total body or organ τ, for the next 31 days of liquid releases

$D_{\tau c}$ = the cumulative dose to the total body or organ τ, for liquid releases that have occurred in the elapsed portion of the current quarter, plus the release under consideration, per Eqn 6.2.3-1

t = the number of whole or partial days elapsed into the current quarter, including the time to the end of the release under consideration (even if the release continues into the next quarter)

$D_{\tau a}$ = the anticipated dose contribution to the total body or any organ τ, due to any planned activities during the next 31-day period, if those activities will result in liquid releases that are in addition to routine liquid effluents. If only routine liquid effluents are anticipated, $D_{\tau a}$ may be set to zero.

f. Dose Projections for Specific Releases

Dose projections may be performed for a particular release by performing a prerelease dose calculation assuming that the planned release will proceed as anticipated. For individual dose projections due to liquid releases, follow the methodology of Section 6.2.3.e, using sample analysis results for the source to be released, and parameter values expected to exist during the release period.

6.2.5 Liquid Sampling

Radioactive liquid wastes shall be sampled and analyzed according to the requirements in Radioactive Liquid Waste Sampling and Analysis Program (Attachment 3).

6.3 GASEOUS RADIOACTIVE WASTE EFFLUENTS

6.3.1 Gaseous Effluent Dose Rate Limitation

a. Requirement

In accordance with Technical Specifications 5.5.2.a.3 and 5.5.2.a.7, the licensee shall conduct operations so that the dose rate due to radioactive materials released in gaseous effluents from the site to areas at and beyond the SITE BOUNDARY shall be limited to:

1. The dose rate limit for noble gases shall be less than or equal to 500 mrem/year to the total body and less than or equal to 3,000 mrem/year to the skin.
2. The dose rate limit for I-131, I-133, for tritium, and for all radionuclides in particulate form with half-lives greater than 8 days shall be less than or equal to 1,500 mrem/year to any organ.

b. APPLICABILITY

This limit applies at all times.

c. ACTION

1. If dose rates exceed Section 6.3.1.a limits, IMMEDIATELY decrease the release rate to within the above limits.
2. Dose rates due to noble gases in gaseous effluents shall be determined to be within Section 6.3.1.a.1 limits.
3. Dose rates due to I-131, I-133, tritium, and all radionuclides in particulate form with half-lives greater than 8 days, in gaseous effluents shall be determined to be within the above limits by obtaining representative samples and performing analyses in accordance with the sampling and analysis program specified in the Radioactive Gaseous Waste Sampling and Analysis Program (Attachment 4).

d. Basis

This control is provided to ensure that the dose at any time at and beyond the SITE BOUNDARY from gaseous effluents from Vogtle 1,2,3 and 4 will be within the annual dose limits of 10 CFR Part 20 to UNRESTRICTED AREAS. The annual dose limits are the doses associated with the concentrations of 10 CFR Part 20, Appendix B, Table 2, Column 1. These limits provide reasonable assurance that radioactive material discharged in gaseous effluents will not result in the exposure of a MEMBER OF THE PUBLIC in an UNRESTRICTED AREA, either within or outside the SITE BOUNDARY, to annual average concentrations exceeding the limits specified in Appendix B, Table 2 of 10 CFR Part 20 (10 CFR Part 20.1302). For MEMBERS OF THE PUBLIC who may at times be within the SITE BOUNDARY, the occupancy of the MEMBER OF THE PUBLIC will usually be sufficiently low to compensate for any increase in the atmospheric diffusion factor above that for the SITE BOUNDARY.

This control applies to the release of gaseous effluents from all reactors at the site (Vogtle 1,2,3 and 4).

e. Calculations of Gaseous Effluent Dose Rates

1. The dose rate limit for noble gases shall be determined to be within the limit by limiting the release rate to the lesser of:

$$\sum_{v}\left\{\left(\overline{\chi/Q}\right)_{vb}\sum_{i}[K_i Q_{iv}]\right\} \leq 500\,\frac{\text{mrem}}{\text{yr}}\text{ to the total body} \qquad \text{Eqn 6.3.1-1}$$

where:

$\left(\overline{\chi/Q}\right)_{vb}$ = for each vent release pathway, *v*, the highest calculated annual average relative concentration for any area at or beyond the SITE BOUNDARY, in s/m^3. Values are provided in Attachment 13 Table A13.1.3-1.

K_i = the total body dose factor due to gamma emissions for each identified noble gas radionuclide, *i*, in mrem/yr per µCi/m^3. Factors are listed in Gaseous Effluent Dose Factors (Attachment 5 Table A5.1-1).

Q_{iv} = the release rate of noble gas radionuclide *i* in µCi/s through vent release pathway, *v*. $Q_{iv} = f_{tv} \times \chi_{iv}$

f_{tv} = the maximum anticipated flowrate for release pathway, *v,* during the period, *t*, of the release, in cc/s.

χ_{iv} the concentration of radionuclide, *i,* in release through vent pathway *v*, in µCi/cc.

or:

$$\sum_{v}\left\{\left(\overline{\chi/Q}\right)_{vb}\sum_{i}[(L_i + 1.1\,\cdot\,M_i)Q_{iv}]\right\} \leq 3000\,\frac{\text{mrem}}{\text{yr}}\text{ to the skin} \qquad \text{Eqn 6.3.1-2}$$

where:

L_i = the skin dose factor due to beta emissions for each identified noble gas radionuclide, in mrem/yr per µCi/m^3. Factors are listed in Gaseous Effluent Dose Factors (Attachment 5).

M_i = the air dose factor due to gamma emissions for each identified noble gas radionuclide, in mrad/yr per µCi/m^3 (Attachment 5).

1.1 = a unit conversion constant in mrem/mrad to convert air dose to skin dose.

2. The dose rate limit for I-131, I-133, tritium, and for all radionuclides in particulate form with half-lives greater than 8 days, shall be determined to be within the limit by restricting the release rate to:

$$\sum_{v}\left\{\left(\overline{\chi/Q}\right)_{vb}\sum_{i}\left[P_{io}\acute{Q}_{iv}\right]\right\} \leq 1500\,\frac{\text{mrem}}{\text{yr}}\text{ to any organ} \qquad \text{Eqn 6.3.1-3}$$

where:

P_{io}	=	the site-specific inhalation dose for radionuclide *i* and organ *o*, in mrem/yr per µCi/m^3. The values may be calculated from Attachment 13, Section 3.3.1.
$\acute{Q}_{iv}$	=	the release rate of radionuclide *i* from the vent release pathway *v*, in µCi/s. For the purpose of implementing the controls of Section 6.3.1.a.2, only I-131, I-133, tritium, and all radionuclides in particulate form with half-lives greater than 8 days should be included in this calculation.

3. If the ACTION statement in Section 6.5.1.c is invoked, calculate the inhalation dose (Section 6.3.4) and noble gas plume dose (see the reformulation of Eqn 6.3.1-1 below) to a MEMBER OF THE PUBLIC at a location within the SITE BOUNDARY using an appropriate occupancy factor. Currently, the Unit 4 Construction area in the NE sector at 0.25 miles. Select the X/Q for the Unit 4 Construction area (Section 1.0 of this attachment) using an occupancy of 2102 hours per year (0.24).

The noble gas total body dose is as follows (reformulated from Eqn 6.3.1-1)

$$D_N = 3.17 \times 10^{-8} \sum_v \left\{ \left(\overline{\chi/Q}\right)_{vb} \sum_i \left[K_i \tilde{Q}_{iv} \right] \right\} \qquad \text{Eqn 6.3.1-4}$$

where:

D_N	=	The external whole-body dose to an individual at the controlling receptor location, due to gamma ray emissions from noble gas radionuclides discharged from the site in gaseous effluents in gaseous effluents, in mrem.
3.17 x 10^{-8}	=	a units conversion factor: 1 y/(3.15 x 10^7 s)
$\left(\overline{\chi/Q}\right)_{vb}$	=	for each vent release pathway, *v*, the highest calculated annual average relative concentration for any area at or beyond the SITE BOUNDARY, in s/m^3. Values are provided in Attachment 13 Table A13.1.3-1.
K_i	=	the total body dose factor due to gamma emissions for each identified noble gas radionuclide, in mrem/yr per µCi/m^3. Factors are listed in Gaseous Effluent Dose Factors (Attachment 5).
$\tilde{Q}_{iv}$	=	the cumulative release of noble gas radionuclide *i* from release pathway v, (µCi), during the period of interest.

6.3.2 Gaseous Monitoring Instrumentation

a. REQUIREMENT

1. The radioactive gaseous effluent monitoring instrumentation channels shown in Radioactive Gaseous Effluent Monitoring Instrumentation (Attachment 6) shall be FUNCTIONAL with alarm/trip setpoints set to ensure that Section 6.3.1.a.1 noble gas dose rate limits are not exceeded. Alarm/trip setpoints of these channels shall be determined and adjusted in accordance with Section 6.3.2.f.
2. Each radioactive gaseous effluent monitoring instrumentation channel shall be demonstrated FUNCTIONAL by CHANNEL CHECKS, SOURCE CHECKS, CHANNEL CALIBRATIONS, and CHANNEL FUNCTIONAL TESTS at the frequencies shown in Radioactive Gaseous Effluent Monitoring Instrumentation Surveillance Requirements (Attachment 7).

b. APPLICABILITY

This limit applies at all times.

c. ACTION

1. If a radioactive gaseous effluent monitoring instrumentation channel alarm/trip setpoint is less conservative than required by Section 6.3.2.a.1, IMMEDIATELY:
   (a) Suspend the release of radioactive gaseous effluents monitored by the affected channel or declare the channel non-FUNCTIONAL, or
   (b) Change the setpoint so it is acceptably conservative.
2. If the number of FUNCTIONAL channels is less than the minimum required by tables in Radioactive Gaseous Effluent Monitoring Instrumentation (Attachment 6) take the ACTION shown in those tables.
3. Return instruments to FUNCTIONAL status within 30 days. If unsuccessful, explain in the next Annual Radioactive Effluent Release Report why the non-FUNCTIONALITY was not corrected in a timely manner.

d. BASIS

The radioactive gaseous effluent instrumentation is provided to monitor and control, as applicable, the releases of radioactive materials in gaseous effluents during actual or potential releases of gaseous effluents. The Alarm/Trip Setpoints for these instruments shall be calculated and adjusted in accordance with the methodology and parameters in Section 6.3.2.f to ensure that the alarm/trip will occur prior to exceeding the limits of Section 6.3.1.a.1. The FUNCTIONALITY and use of this instrumentation is consistent with the requirements of General Design Criteria 60, 63, and 64 of Appendix A to 10 CFR Part 50.

NOTE: According to NUREG-0133, the radioactive effluent radiation monitor alarm/trip setpoints should be based on the radioactive noble gases. It may not be practicable to apply instantaneous alarm/trip setpoints to integrating monitors sensitive to radioiodines, radioactive materials in particulate form, and radionuclides other than noble gases.

e. APPLICABLE MONITORS

Radioactive gaseous effluent monitors for which alarm/trip setpoints shall be determined are:

Table 6.3.2-1 Gaseous Effluent Monitors Requiring Setpoints

Release Point	Instrument Number	Setpoint Method	Release Height
Final Release Stream Noble Gas Monitors			
Plant Vent Gas (Normal Range)	VFS-JE-RE103	§6.3.2.f	Ground level
Plant Vent Gas (Accident Mid-Range)	VFS-JE-RE104A	§6.3.2.f	Ground level
Plant Vent Gas (Accident High Range)	VFS-JE-RE104B	§6.3.2.f	Ground level
Turbine Island Vent Discharge	TDS-JE-RE001A/B	§6.3.2.f	Ground level

Table 6.3.2-2 Typical Noble Gas Monitor Release Allocation Fractions for Units 3&4

Unit 3		Unit 4	
Release Point	**AG**	**Release Point**	**AG**
Plant Vent	0.15	Plant Vent	0.15
Turbine Island Vent Discharge	0.05	Turbine Island Vent Discharge	0.05

f. Setpoint Calculations for the Final Noble Gas Monitor on Each Release Pathway

1. Setpoint calculations for each monitor listed in Section 6.3.2.e for final release streams shall maintain this relationship:

$$\mathrm{C} = \text{the lesser of} \begin{Bmatrix} AG_v \cdot SF \cdot X \cdot R_t \\ AG_v \cdot SF \cdot X \cdot R_k \end{Bmatrix} \qquad \text{Eqn 6.3.2-1}$$

where:

C	=	the setpoint, in μCi/cc, of the radioactivity monitor measuring the concentration of radioactivity in the effluent line prior to release. The setpoint represents a concentration which, if exceeded, could result in dose rates exceeding the limits of Section 6.3.1.a at or beyond the SITE BOUNDARY.
AGv	=	an administrative allocation factor applied to divide the release limit among all the gaseous release pathways for Vogtle 1,2,3 and 4. Typical allocation fractions are listed in Table 6.3.2-2 for Vogtle 3&4. Vogtle 1&2 allocation fractions are listed in site procedures.
SF	=	the safety factor selected to compensate for statistical fluctuations and errors of measurement.
X	=	the noble gas concentration for the release under consideration.
R_t	=	the ratio of the dose rate limit for the total body, 500 mrem/y, to the dose rate to the total body for the conditions of the release under consideration.
R_k	=	the ratio of the dose rate limit for the skin, 3000 mrem/y, to the dose rate to the skin for the conditions of the release under consideration.

Equation 6.3.2-1 shows the relationships of the critical parameters that determine the setpoint. However, in order to apply the methodology presented in the equation to a mixture of noble gas radionuclides, radionuclide-specific concentrations and dose factors must be taken into account under conditions of maximum flowrate for the release point and annual average meteorology.

The basic setpoint method presented below is applicable to the radioactivity monitor nearest the point of release for the release pathway. For monitors measuring the radioactivity in source streams that merge with other streams prior to subsequent monitoring and release, the modifications presented in Section 6.3.2.g must be applied.

2. Setpoint values shall be determined by:

   (a) Step 1: Determine the concentration, X_{iv}, of each noble gas radionuclide *i* in the gaseous stream *v* being considered for release, in accordance with the sampling and analysis requirements of Section 6.3.1. Then sum these concentrations to determine the total noble gas concentration, $\sum \chi_{iv}$. If there are no detectable radionuclides, use the setpoint defined in the site's procedure.

(b) Step 2: Determine R_t, the ratio of the dose rate limit for the total body, 500 mrem/year, to the total body dose rate due to noble gases detected in the release under consideration, as follows:

$$R_t = \frac{500}{(\overline{X/Q})_{vb} \sum_i [K_i \cdot Q_{iv}]} \quad \text{Eqn 6.3.2-2}$$

where:

500 = The dose rate limit for the total body, 500 mrem/yr.

$\left(\overline{\chi/Q}\right)_{vb}$ = for each vent release pathway, *v*, the highest calculated annual average relative concentration for any area at or beyond the SITE BOUNDARY, in s/m^3. (Values are provided in Attachment 13, Table A13.1.3-1).

K_i = the total body dose factor due to gamma emissions for each identified noble gas radionuclide, in mrem/yr per µCi/m^3. Factors are listed in Gaseous Effluent Dose Factors (Attachment 5).

Q_{iv} = the release rate of noble gas radionuclide *i* in µCi/s, equal to the product of f_{av} and χ_{iv}.

f_{av} = the maximum anticipated flowrate for release pathway *v* during the period of the release, in cc/s.

χ_{iv} = the concentration of radionuclide *i* in release through vent pathway *v*, in µCi/cc.

(c) Step 3: Determine R_k, the ratio of the dose rate limit for the skin, 3000 mrem/year, to the skin dose rate due to noble gases detected in the release under consideration, as follows:

$$R_k = \frac{3000}{(\overline{X/Q})_{vb} \sum_i [(L_i + 1.1M_i) \cdot Q_{iv}]} \quad \text{Eqn 6.3.2-3}$$

where:

3,000 = the dose rate limit for the total body, 3,000 mrem/yr

L_i = the skin dose factor due to beta emissions for each identified noble gas radionuclide, in mrem/yr per µCi/m^3. Factors are listed in Gaseous Effluent Dose Factors (Attachment 5)

M_i = the air dose factor due to gamma emissions for each identified noble gas radionuclide, in mrad/yr per µCi/m^3 (Attachment 5)

1.1 = a unit conversion constant in mrem/mrad to convert air dose to skin dose

All other terms previously defined.

(d) Step 4: Determine the maximum noble gas radioactivity monitor setpoint concentration, c_{nv}, for vent pathway, v, where “n” represents noble gas.
Based on the values determined in previous steps, the radioactivity monitor setpoint for the planned release is calculated to ensure that the limits of Section 6.3.1.a will not be exceeded. Because the radioactivity monitor responds primarily to radiation from noble gas radionuclides, the monitor setpoint c_{nv}, (in µCi/cc) is based on the concentration of all noble gases in the waste stream, as follows:

$$c_{nv} = the \quad lesser \quad of \begin{cases} AG_v \cdot SF \cdot \sum_i X_{iv} \cdot R_t \\ AG_v \cdot SF \cdot \sum_i X_{iv} \cdot R_k \end{cases} \qquad \text{Eqn 6.3.2-4}$$

where:

c_{nv}	=	the calculated setpoint, in µCi/cc, for the noble gas monitor serving gaseous release pathway v.
AG_v	=	the administrative allocation factor for gaseous release pathway *v*, applied to divide the release limit among all the gaseous release pathways for Vogtle Units 1-4. The allocation factor may be assigned any value between 0 and 1, under the condition that the sum of the allocation factors for all simultaneously active final release pathways for Vogtle Units 1-4 does not exceed 1. Typical allocation fractions are listed in Table 6.3.2-2 for Vogtle 3&4. Vogtle 1&2 allocation fractions are located in site procedures. Section 6.3.2.h provides methods for calculating more precise values if desired.
SF	=	the safety factor selected to compensate for statistical fluctuations and errors of measurement. The value for the safety factor must be between 0 and 1. A value of 0.5 is reasonable for gaseous releases; a more precise value may be developed if desired.
X_{iv}	=	the measured concentration of radionuclide *i* in release through vent pathway *v*, as defined in Step 1, in µCi/cc

The values of R_t and R_k to be used in the calculation are those which were determined in Steps 2 and 3 above.

(e) Step 5: Determine whether the release is possible, as follows:

If $c_{nv} \geq \sum_i X_{iv}$ the release is permissible. However, if c_{nv} is within approximately 10 percent of $\sum_i X_{iv}$, it may be impractical to use this value of c_{nv}. This situation indicates that measured concentrations are approaching values which would cause the limits of Section 6.3.1.a to be exceeded. Therefore, steps should be taken to reduce contributing source terms of gaseous radioactive material, or to adjust the allocation of the limits among the active release points. The setpoint calculations (steps 1-4) must then be repeated with parameters that reflect the modified conditions.

If $c_{nv} < \sum_i X_{iv}$ the release may not be made as planned. Consider the alternatives discussed in the paragraph above, and calculate a new setpoint based on the results of the actions taken.

(f) Use of the Calculated Setpoint

The setpoint calculated above is in the unit µCi/cc. The monitor actually measures a count rate, subtracts a predetermined background count rate, and multiplies by a calibration factor to convert from count rate to µCi/cc.

Initial calibration by the manufacturer and Southern Nuclear Operating Company of the gaseous effluent monitors specified in Section 6.3.2 utilized at least one NIST-traceable gaseous radionuclide source in the exact geometry of each production monitor. The point and gaseous sources used covered an appropriate beta particle end point energy range. The calibration factor is a function of the radionuclide mix in the gas to be released, and normally will be calculated for the monitor based on the results of the sample results from the laboratory gamma-ray spectrometer system. The mix-dependent calibration factor will be used as the gain factor in the radiation monitoring system, or used to modify the calculated base monitor setpoint so that the default calibration factor in the radiation monitoring system can be left unchanged.

Notwithstanding the initial calibration, monitor calibration data for conversion between count rate and concentration may include operational data obtained from determining the monitor response to stream concentrations measured by sample analysis.

In all cases, monitor background must be controlled so that the monitor is capable of responding to concentrations in the range of the setpoint value. Contributions to the monitor background may include any or all of the following factors: ambient background radiation, plant-related radiation levels at the monitor location (which may change between shutdown and power conditions), and internal background due to contamination of the monitor's sample chamber.

g. Setpoints for Noble Gas Monitors on Effluent Source Streams

Table 6.3.2-1 lists certain gaseous release pathways as being source streams. As may be seen in Figures 6.3.2-1 and 6.3.2-2, these are streams that merge with other streams, prior to passing a final radioactivity monitor and being released. These source streams are components of the Plant Vent flow. Unlike the final monitors, the source stream monitors measure radioactivity in effluent streams. Most source stream monitors have flow which can be terminated either manually or automatically.

1. Setpoints of the Monitor on the Source Stream:

(a) Step 1: Determine the concentration X_{is} of each noble gas radionuclide i in source streams (in µCi/cc) according to the results of its required sample analyses.

(b) Step 2: Determine r_t, the ratio of the dose rate limit for the total body, 500 mrem/y, to the total body dose rate due to noble gases detected in the source stream under consideration. Use the X_{is} values and the maximum anticipated source stream flowrate f_{as} in equation 6.3.2-2 to determine the total body dose rate for the source stream, substituting r_t for R_t.

The SITE BOUNDARY relative dispersion value used in Steps 2 and 3 for the source stream is the same as the $\overline{(X/Q)}_{vb}$ that applies to the respective merged stream. This is because the $\overline{(X/Q)}$ value is determined by the meteorology of the plant site and the physical attributes of the release point, and is unaffected by whether or not a given source stream is operating.

(c) Step 3: Determine r_k, the ratio of the dose rate limit for the skin, 3000 mrem/y, to the skin dose rate due to noble gases detected in the source stream under consideration. Use the X_{is} values and the maximum anticipated source stream flow rate f_{as} in equation 6.3.2-3 to determine the skin dose rate for the source stream, substituting r_k for R_k.

(d) Step 4: Determine the maximum noble gas radioactivity monitor setpoint concentration, as follows:

$$c_{ns} = the \quad lesser \quad of \begin{cases} AG_s \cdot SF \cdot \sum_i X_{is} \cdot r_t \\ \\ AG_s \cdot SF \cdot \sum_i X_{is} \cdot r_k \end{cases} \qquad \text{Eqn 6.3.2-5}$$

where:

c_{ns}	=	the calculated setpoint, in µCi/cc, for the noble gas monitor serving gaseous release pathway s.
AG_s	=	the administrative allocation factor for gaseous release pathway *v*, the sum of all the AG_s values for source streams contributing to the final release point must not exceed the release point's allocation factor Ag_v.
X_{is}	=	the measured concentration of noble gas radionuclide i in gaseous source stream s, as defined in Step 1, in µCi/cc.

The values of r_t and r_k to be used in the calculation are those which were determined in Steps 2 and 3 above. The safety factor, SF, was defined previously.

(e) Step 5: Determine whether the release is permissible, as follows:

If $c_{ns} \geq \sum_i X_{is}$, the release is permissible. However, if c_{ns} is within about 10 percent of $\sum_i X_{is}$, it may be impractical to use this value of c_{ns}. This situation indicates that measured concentrations are approaching values which would cause the limits of Section 6.3.1.a to be exceeded. Therefore, steps should be taken to reduce contributing source terms of gaseous radioactive material, or to adjust the allocation of the limits among the active release points. The setpoint calculations (steps 1–4) must then be repeated with parameters that reflect the modified conditions.

If $c_{ns} < \sum_i X_{is}$, the release may not be made as planned. Consider the alternatives discussed in the paragraph above, and calculate a new setpoint based on the results of the actions taken.

2. Effect on the Setpoint of the Monitor on the Merged Stream:

   Before beginning a release from a monitored source stream, a setpoint must be determined for the source stream monitor as presented in Section 6.3.2.g.1. In addition, whether or not the source stream has its own effluent monitor, the previously-determined maximum allowable setpoint for the downstream final monitor on the merged stream must be redetermined. This is accomplished by repeating the steps of Section 6.3.2, with the following modifications.

   Modification 1: The new maximum anticipated flowrate of the merged stream is the sum of the old merged stream maximum flowrate, and the maximum flowrate of the source stream being considered for release.

$$(f_{av})_{new} = (f_{av})_{old} + f_{as} \quad \text{Eqn 6.3.2-6}$$

   Modification 2: The new concentration of noble gas radionuclide i in the merged stream includes both the contribution of the merged stream *without* the source stream, *and* the source stream being considered for release.

$$(X_{iv})_{new} = \frac{(f_{av})_{old} \times (X_{iv})_{old} + f_{as} \times X_{is}}{(f_{av})_{new}} \quad \text{Eqn 6.3.2-7}$$

h. Determination of Allocation Factors, AG

When simultaneous gaseous releases are conducted, an administrative allocation factor must be applied to divide the release limit among the active gaseous release pathways. This is to assure that the dose rate limit for areas at and beyond the SITE BOUNDARY (Section 6.3.2.a) will not be exceeded by simultaneous releases. The allocation factor for any pathway may be assigned any value between 0 and 1, under the following two conditions:

- The sum of the allocation factors for all simultaneously active final release paths for Vogtle Units 1-4 may not exceed 1.
- The sum of the allocation factors for all simultaneously-active source streams merging into a given final release pathway may not exceed the allocation factor of that final release pathway.

Any of the following three methods may be used to assign the allocation factors to the active gaseous release pathways:

1. For ease of implementation, AG_v may be equal for all release pathways:

$$AG_v = \frac{1}{N} \quad \text{Eqn 6.3.2-8}$$

where N = the number of simultaneously active gaseous release pathways.

2. AG_v for a given release pathway may be selected based on an estimate of the portion of the total SITE BOUNDARY dose rate (from all simultaneous releases) that is contributed by the release pathway. During periods when a given building or release pathway is not subject to gaseous radioactive releases, it may be assigned an allocation factor of zero.

3. AG_v for a given release pathway may be selected based on a calculation of the portion of the total SITE BOUNDARY dose rate that is contributed by the release pathway, as follows:

$$AG_v = \frac{\left(\overline{X/Q}\right)_{vb} \sum_i \left(K_i Q_{iv}\right)}{\sum_{r=1}^{N}\left[\left(\overline{X/Q}\right)_{rb} \sum_i \left(K_i Q_{ir}\right)\right]} \qquad \text{Eqn 6.3.2-9}$$

where:

$\left(\overline{\chi/Q}\right)_{vb}$	= =	the annual average SITE BOUNDARY relative concentration applicable to the gaseous pathway release pathway *v* for which the allocation factor is being determined, in s/m^3
K_i	=	the total body dose factor due to gamma emissions from noble gas radionuclide *i*, in (mrem/yr)/(µCi/m^3) from Attachment 5
Q_{iv}	=	the release rate of noble gas radionuclide *i* from release pathway *v*, in µCi/s, calculated as the product of X_{iv} and f_{av}
χ_{iv}	=	the concentration of noble gas radionuclide *i* applicable to the gaseous release pathway v for which the allocation factor is being determined, in µCi/cc
f_{av}	=	the discharge flowrate applicable to gaseous release pathway v for which the allocation factor is being determined, in cc/s
$\left(\overline{\chi/Q}\right)_{rb}$	= =	the annual average SITE BOUNDARY relative concentration applicable to active gaseous release pathway *r*, in s/m^3
Q_{ir}	=	the release rate of noble gas radionuclide *i* from release pathway *r*, in µCi/s, calculated as the product of X_{ir} and f_{ar}
χ_{ir}	=	the concentration of noble gas radionuclide *i* applicable to active gaseous release pathway *r*, in µCi/cc
f_{ar}	=	the discharge flowrate applicable to active gaseous release pathway *r*, in cc/s
N	=	the number of simultaneously active gaseous release pathways (including pathway *v* that is of interest)

NOTE: Although equations 6.3.2-8 and 6.3.2-9 are written to illustrate the assignment of the allocation factors for final release pathways, they may also be used to assign allocation factors to the source streams that merge into a given final release pathway.

i. Figures 6.3.2-1 and 6.2.3-2 provide simplified flow schematics of the gaseous release pathways, including source streams and final release streams.

Figure 6.3.2-1 Monitored Gaseous Release Pathways Through the Plant Vent

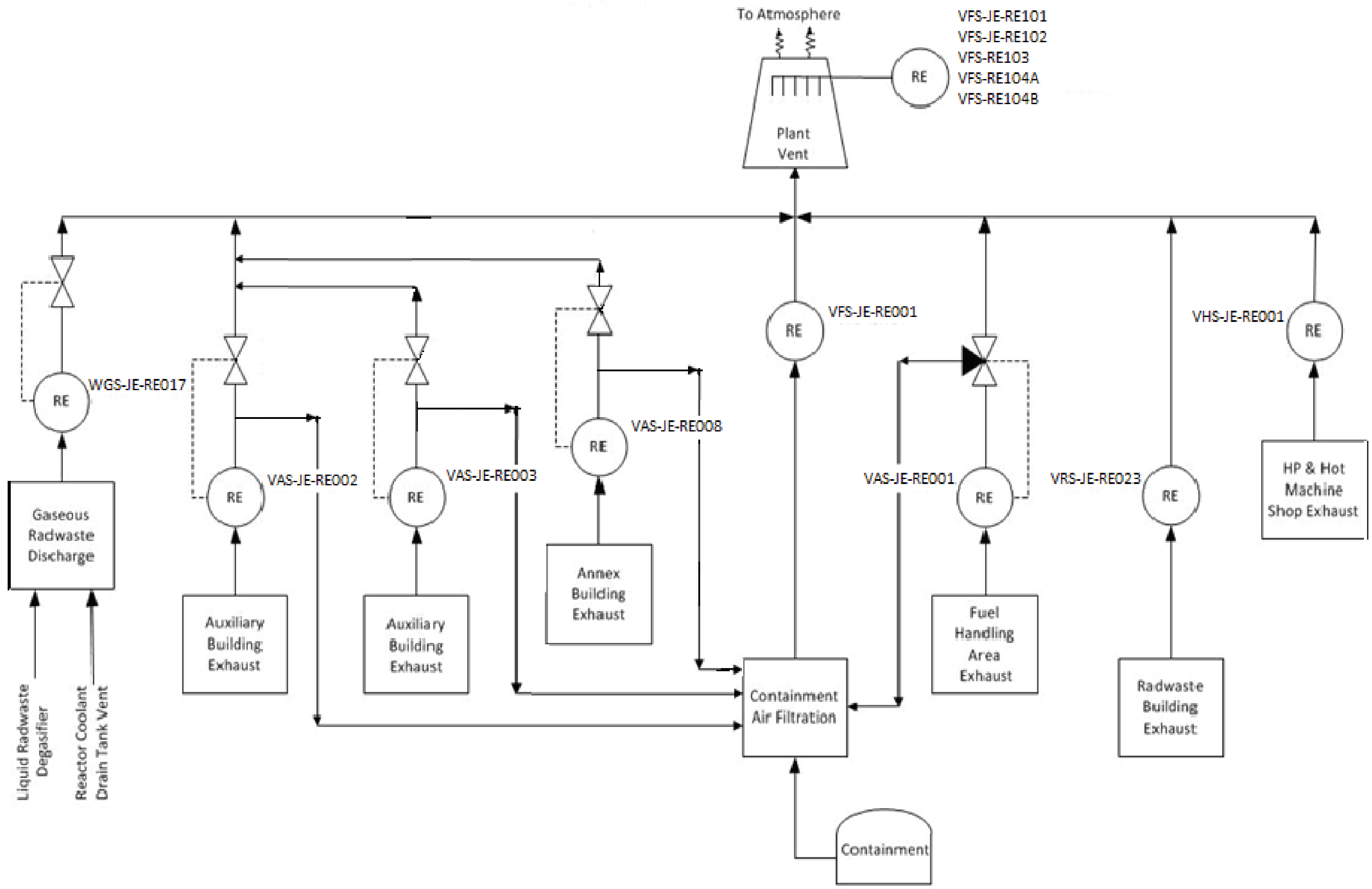
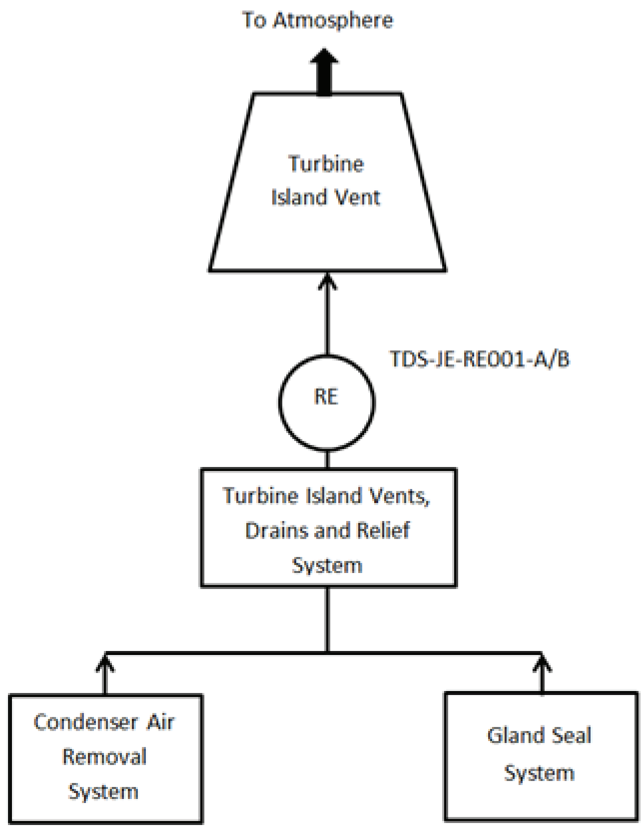


Figure 6.3.2-2 Turbine Island Release Pathway



6.3.3 Gaseous Effluent Compliance Calculations

a. Requirement

1. In accordance with Technical Specifications 5.5.2.a.5 and 5.5.2.a.8, the air dose due to noble gases released in gaseous effluents from each reactor unit at or beyond the SITE BOUNDARY shall be limited to:
   (a) During any calendar quarter less than or equal to 5 mrads for gamma radiation and less than or equal to 10 mrads for beta radiation
   (b) During any calendar year less than or equal to 10 mrads for gamma radiation and less than or equal to 20 mrads for beta radiation
2. Cumulative dose contributions for noble gases for the current calendar quarter and current calendar year shall be determined for each reactor unit in accordance with Section 6.3.3.e at least once per 31 days.
3. In accordance with Technical Specification 5.5.2.a.5, dose projections must be made at least once each 31 days, per Section 6.3.5.e.

b. APPLICABILITY

This limit applies at all times.

c. ACTION

If the calculated air dose from radioactive noble gases in gaseous effluents exceeds any of the above limits, prepare and submit to the NRC, within 30 days, a SPECIAL REPORT that identifies the causes for exceeding the limits and defines corrective actions that have been taken to reduce releases and the proposed corrective actions to be taken to assure that subsequent releases will be in compliance with the limits in Section 6.3.3.a.

d. Basis

This control is provided to implement the requirements of Sections II.B, III.A and IV.A of Appendix I, 10 CFR Part 50. Section 6.3.3 implements the guides set forth in Section II.B of Appendix I. The ACTION statements in Section 6.3.3.c provide the required operating flexibility and at the same time implement the guides set forth in Section IV.A of Appendix I, assuring that the releases of radioactive material in gaseous effluents to UNRESTRICTED AREAS will be kept “as low as is reasonably achievable.” The ACTION requirements in Section 6.3.3.c implement the requirements in Section III.A of Appendix I, which require that conformance with the guides of Appendix I be shown by calculational procedures based on models and data such that the actual exposure of a MEMBER OF THE PUBLIC through appropriate pathways is unlikely to be substantially underestimated. The dose calculations established in Section 6.3.3.e for calculating the doses due to the actual releases of noble gases in gaseous effluents are consistent with the methodology provided in Regulatory Guide 1.109 (Reference 11), and Regulatory Guide 1.111 (Reference 13). The equations in Section 6.3.3.e provided for determining the air doses at the SITE BOUNDARY are based upon the historical annual average atmospheric conditions.

e. Noble Gas Effluent Air Dose Calculation

The air dose to areas at or beyond the SITE BOUNDARY due to noble gases from each reactor unit shall be determined by the following:

For gamma radiation:

$$D_g = 3.17 \times 10^{-8} \sum_{v} \left\{ \left(\overline{\chi/Q} \right)_{vb} \sum_{i} \left[M_i \tilde{Q}_{iv} \right] \right\} \qquad \text{Eqn 6.3.3-1}$$

where:

3.17×10^{-8} = The inverse of the number of seconds in a year.

D_g = the air dose due to gamma emissions from noble gas radionuclides, in mrad.

M_i = the air dose factor due to gamma emission from noble gas radionuclides, in (mrad/yr)/(μCi/m³). Dose factors are provided in Attachment 5.

$\tilde{Q}_{iv}$ = the cumulative release of noble gas radionuclide *i* from release pathway *v*, in μCi, during the period of interest.

$\left(\overline{\chi/Q} \right)_{vb}$ = values are provided in Attachment 13, Table A13.1.3-1.

All other terms were defined previously.

For beta radiation:

$$D_\beta = 3.17 \times 10^{-8} \sum_{v} \left\{ \left(\overline{\chi/Q} \right)_{vb} \sum_{i} \left[N_i \tilde{Q}_{iv} \right] \right\} \qquad \text{Eqn 6.3.3-2}$$

where:

N_i = the air dose factor due to beta emission from noble gas radionuclides, in (mrad/yr)/(μCi/m³). Dose factors are provided in Attachment 5.

$\left(\overline{\chi/Q} \right)_{vb}$ = values are provided in Attachment 13, Table A13.1.3-1.

All other terms are defined as above for gamma radiation.

f. Dose Rates Due to Iodine-131, Iodine-133, Tritium, and Radionuclides in Particulate Form with Half-Lives Greater than 8 Days

For the purpose of implementing the controls of Section 6.3.1.a.2, the dose rates due to Iodine-131, Iodine-133, tritium, and all radionuclides in particulate form with half-lives greater than 8 days, in areas at or beyond the SITE BOUNDARY, due to releases of gaseous effluents from the site, shall be calculated as follows:

$$DR_{\mathrm{o}} = \sum_{v} \left\{ \left(\overline{\chi/Q} \right)_{vb} \sum_{i} \left[P_{io} \tilde{Q}_{iv} \right] \right\} \qquad \text{Eqn 6.3.3-3}$$

where:

DR_o = the dose rate to organ o at the time of the release, in mrem/y.

P_{io} = the site-specific dose factor for radionuclide i and organ o, in (mrem/y)/(μCi/m^3). Since the dose rate limits specified in Section 6.3.1.a.2 apply only to the child age group exposed to the inhalation pathway, the values of P_{io} may be obtained from Attachment A13.3.3-4, "R_{aipj} for Inhalation Pathway, Child Age Group."

$\tilde{Q}_{iv}$ = the release rate of radionuclide i from gaseous release pathway v, in μCi/s. For the purpose of implementing the controls of Section 6.3.1.a.2, only I–131, I–133, tritium, and all radionuclides in particulate form with half-lives greater than 8 days should be included in this calculation.

$\left(\overline{\chi/Q} \right)_{vb}$ = values are provided in Attachment 13, Table A13.1.3-1.

All other terms were defined previously.

6.3.4 I-131, I-133, H-3 & Radionuclides In Particulate Form Effluent Dose Limit

a. Requirement

1. In accordance with Technical Specifications 5.5.2.a.5 and 5.5.2.a.9, methods shall be implemented to ensure that the dose to any organ of a MEMBER OF THE PUBLIC from I-131, I-133, tritium, and all radionuclides in particulate form with half-lives greater than 8 days, in gaseous effluents released from each unit to areas at and beyond the SITE BOUNDARY shall be:
   (a) During any calendar quarter less than or equal to 7.5 mrem to any organ
   (b) During any calendar year less than or equal to 15 mrem to any organ
2. Cumulative dose contributions to a MEMBER OF THE PUBLIC from I-131, I-133, tritium, and radionuclides in particulate form with half-lives greater than 8 days, in gaseous effluents released to areas at and beyond the SITE BOUNDARY for the current calendar quarter and current calendar year shall be determined at least once per 31 days in accordance with Section 6.3.4.e.
3. In accordance with Technical Specification 5.5.2.a.5, dose projections must be made at least once each 31 days, per Section 6.3.5.e.

b. APPLICABILITY

This limit applies at all times.

c. ACTION

If the calculated dose from the release of I-131, I-133, tritium, and radionuclides in particulate form, with half-lives greater than 8 days, in gaseous effluents exceeds any of the above limits, prepare and submit to the NRC within 30 days, a SPECIAL REPORT that contains:

1. Cause(s) for exceeding limits.
2. Corrective action(s) taken to reduce releases.
3. Proposed corrective action(s) to be taken to assure that subsequent releases will be in compliance with limits stated in Section 6.3.4.a.

d. Basis

This control is provided to implement the requirements of Section II.C, III.A and IV.A of Appendix I, 10 CFR Part 50. The limits stated in Section 6.3.4.a are the guides set forth in Section II.C of Appendix I. The ACTION statements in Section 6.3.4.c provide the required operating flexibility and at the same time implement the guides set forth in Section IV.A of Appendix I to assure that the releases of radioactive materials in gaseous effluents to UNRESTRICTED AREAS will be kept "as low as is reasonably achievable." The calculational methods specified in Section 6.3.4.e implement the requirements in Section III.A of Appendix I that conformance with the guides of Appendix I be shown by calculational procedures based on models and data, such that the actual exposure of a MEMBER OF THE PUBLIC through appropriate pathways is unlikely to be substantially underestimated. The calculational methods in Section 6.3.4.e for calculating the doses due to the actual releases of the subject materials are consistent with the methodology provided in Regulatory Guide 1.109 (Reference 11), and Regulatory Guide 1.111 (Reference 13). These equations provide for determining the actual doses based upon the historical annual average atmospheric conditions. The release specifications for radioiodines, radioactive materials in particulate form and radionuclides other than noble gases are dependent on the existing radionuclide pathways to man, in the areas at and beyond the SITE BOUNDARY. The pathways which were examined in the development of these calculations were: 1) individual inhalation of airborne radionuclides, 2) deposition of radionuclides onto green leafy garden vegetation with subsequent consumption by man, 3) deposition onto grassy areas where milk animals and meat producing animals graze with consumption of the milk and meat by man, and 4) deposition on the ground with subsequent exposure of man.

e. Dose Calculations

Gaseous releases associated with anticipated operational occurrences and unplanned and unmonitored releases shall be included in the determination of a release. Historical data pertaining to the volumes and radioactive concentrations of gaseous effluents released in connection to specific plant functions, such as containment PURGE, shall be used in the estimates as appropriate.

The dose received by an individual due to gaseous releases from each reactor unit (Vogtle Unit 3 or 4), to areas at or beyond the SITE BOUNDARY, depends on the individual's location, age group, and exposure pathways. The MEMBER OF THE PUBLIC expected to receive the highest dose in the plant vicinity is referred to as the controlling receptor. The dosimetrically-significant attributes of the currently-defined controlling receptor are presented in Attachment 13,Table A13.1.3-1.

Doses to a MEMBER OF THE PUBLIC due to gaseous releases of I–131, I–133, tritium, and all radionuclides in particulate form from each unit shall be calculated as follows (equation adapted from Reference 11, page 29, by considering only long-term releases):

$$D_{oa} = 3.17 \times 10^{-8} \sum_{p} \left\{ \sum_{i} R_{aipo} \sum_{v} \left[W_{vip} \acute{\tilde{Q}}_{iv} \right] \right\} \quad \text{Eqn 6.3.4-1}$$

where:

D_{oa} = the dose to organ *o* of an individual in age group *a* due to gaseous releases of I-131, I-133, tritium, and all radionuclides in particulate form with half-lives greater than 8 days, in mrem. As demonstrated in the Site Safety Analysis Report for Units 3 and 4 (Reference 38), the CRITICAL ORGAN is the child's thyroid.

3.17×10^{-8} = The inverse of the number of seconds in a year.

R_{aipo} = the site-specific dose factor for age group *a*, radionuclide *i* exposure pathway *p*, and organ *o*, (in mrem/ρCi depending on pathway). The values may be obtained from Attachment 8 for the child age group and CRITICAL ORGAN thyroid. Attachment 13 describes how to generalize the calculation to other age groups, CRITICAL ORGANs, and pathways.

W_{vip} = the annual average relative dispersion or deposition at the location of the controlling receptor, for release pathway *v*, as appropriate to exposure pathway p and radionuclide *i*.

For all tritium pathways and for the inhalation of any radionuclide, W_{vip} is $\left(\overline{\chi/Q}\right)_{vp}$, the annual average relative dispersion factor for release pathway *v* at the location of the controlling receptor (s/m^3). For the ground-plane exposure pathway and for all ingestion-related pathways for radionuclides other than tritium, W_{vip} is $\left(\overline{D/Q}\right)_{vp}$ the annual average relative deposition factor for release pathway v at the location of the controlling receptor (m^{-2}). Values of $\left(\overline{\chi/Q}\right)_{vp}$ and $\left(\overline{D/Q}\right)_{vp}$ for use in calculating dose to the currently-defined controlling receptor are included in Attachment 13, A13.3.3-1.

$\acute{\tilde{Q}}_{iv}$ = The cumulative release of radionuclide i from release pathway *v* during the period of interest in μCi. For the purpose of implementing the controls of

Section 6.3.4.a, only I-131, I-133, tritium, and all radionuclides in particulate form with half-lives greater than 8 days should be included in this calculation. In any dose assessment using the methods of this subsection, only radionuclides detectable above background in their respective samples should be included in the calculation.

Because the MEMBER OF THE PUBLIC dose limit is on a per-unit basis, the summations extend over all gaseous final release pathways for a given unit. There are no common gaseous release pathways. The gaseous final release pathways at the plant site are identified in Table 6.3.2-1.

6.3.5 GASEOUS WASTE MANAGEMENT SYSTEM

Historical data pertaining to the volumes and radioactive concentrations of gaseous effluents released in connection with specific plant functions, such as containment PURGE shall be used to calculate projected doses, as appropriate.

The plant vent is the primary pathway for the release of radioactive materials into the atmosphere. As shown in Figure 6.3.2-1, the plant vent receives exhaust from:

- Radwaste Building
- Annex Building
- Health Physics and Hot Machine Shop
- Containment Air and Filtration
- Auxiliary Building
- Fuel Handling Area
- Gaseous Radwaste Treatment

The turbine building vent receives discharge from the condenser vacuum pumps and the gland seal system, as shown in Figure 6.3.2-2. Primary to secondary leakage in the steam generator can result in radioactive materials being released directly into the atmosphere. A detailed description of the system can be found in the Vogtle 3&4 UFSAR, Subsection 11.3 (Ref. 44).

a. REQUIREMENT

In accordance with Technical Specification 5.5.2.a.6:

1. The GASEOUS WASTE MANAGEMENT SYSTEM and LIQUID WASTE MANAGEMENT SYSTEM shall be used to reduce releases of radioactivity when the dose, in a period of 31 days, would exceed 2% of the guidelines for the annual dose or dose commitment, conforming to 10 CFR 50, Appendix I.
   The GASEOUS WASTE MANAGEMENT SYSTEM shall be FUNCTIONAL. The appropriate portions of the system shall be used to reduce radioactivity when the projected doses due to gaseous effluent releases, from each unit, to areas at and beyond the SITE BOUNDARY would exceed 0.2 mrad to air from gamma radiation, 0.4 mrad to air from beta radiation, or 0.3 mrem to any organ of a MEMBER OF THE PUBLIC.
2. Doses due to gaseous releases from each unit shall be projected at least once per 31 days, when the GASEOUS WASTE MANAGEMENT SYSTEM is not being fully utilized, based on the calculations in Section 6.3.5.e.

b. APPLICABILITY

This limit applies at all times.

c. ACTION

If gaseous waste that exceeds the limits in Section 6.3.5.a is discharged without treatment, prepare and submit to the NRC within 30 days, a SPECIAL REPORT that includes:

1. An explanation why gaseous radioactive waste was being discharged without treatment, identification of any non-FUNCTIONAL equipment or subsystems, and the reason for the non-FUNCTIONALITY.
2. Actions taken to restore the non-FUNCTIONAL equipment to FUNCTIONAL status.
3. Summary description of actions taken to prevent recurrence.

d. BASIS

The FUNCTIONALITY of the GASEOUS WASTE MANAGEMENT SYSTEM ensures that the system will be available for use whenever gaseous effluents require treatment prior to release to the environment. The requirement that the appropriate portions of this system be used, when specified, provides reasonable assurance that the releases of radioactive materials in gaseous effluents will be kept "as low as is reasonably achievable." This control implements the requirements of 10 CFR Part 50.36a, General Design Criterion 60 of Appendix A to 10 CFR Part 50, and the design objectives given in Section II.D of Appendix I to 10 CFR Part 50. The specified limits governing the use of appropriate portions of the system were specified as a suitable fraction of the dose design objectives set forth in Section II.B and II.C of Appendix I, 10 CFR Part 50, for gaseous effluents.

This control applies to the release of radioactive materials in gaseous effluents from each unit at the site. For units with shared radwaste treatment systems, the gaseous effluents from the shared system are proportioned among the units sharing that system.

e. Thirty-One Day Dose Projections

In order to meet the requirements of the limit for operation of the GASEOUS WASTE MANAGEMENT SYSTEM (see Section 6.3.5.a), dose projections must be made at least once each 31 days; this applies during periods in which a discharge to areas at and beyond the SITE BOUNDARY of gaseous effluents containing radioactive materials occurs or is expected.

1. Projected Gamma Dose

Determine the projected 31-day gamma air dose using the equation derived in Section 6.3.3.e. Projected gamma air dose may be determined as follows:

$$D_{\gamma p} = \left(\frac{D_{\gamma c}}{t}\right) \cdot 31 + D_{\gamma a} \qquad \text{Eqn 6.3.5-1}$$

where:

$D_{\gamma p}$	=	the projected air dose due to gamma emission from noble gases, for the next 31 days of gaseous releases.
$D_{\gamma c}$	=	the cumulative air dose due to gamma emissions from noble gas releases that have occurred in the elapsed portion of the current quarter, plus the release under consideration.
$D_{\gamma a}$	=	the anticipated air dose due to gamma emissions from noble gas releases, contributed by any planned activities during the next 31-day period, if those activities will result in gaseous release that are in addition to routine gaseous effluents. If only routine gaseous effluents are anticipated, $D_{\gamma a}$, may be set to zero.
t	=	The number of whole or partial days elapsed into the current quarter, including the time to the end of the release under consideration (even if the release continues into the next quarter).

2. PROJECTED BETA DOSE

Determine the projected 31-day beta air dose using the equation derived in Section 6.3.3.e. Projected beta air dose may be determined as follows:

$$D_{\beta p} = \left(\frac{D_{\beta c}}{t}\right) \cdot 31 + D_{\beta a} \qquad \text{Eqn 6.3.5-2}$$

where:

$D_{\beta p}$ = the projected air dose due to beta emission from noble gases, for the next 31 days of gaseous releases.

$D_{\beta c}$ = the cumulative air dose due to beta emissions from noble gas releases that have occurred in the elapsed portion of the current quarter, plus the release under consideration.

$D_{\beta a}$ = the anticipated air dose due to beta emissions from noble gas releases, contributed by any planned activities during the next 31-day period, if those activities will result in gaseous release that are in addition to routine gaseous effluents. If only routine gaseous effluents are anticipated, $D_{\beta a}$, may be set to zero.

t = The number of whole or partial days elapsed into the current quarter, including the time to the end of the release under consideration (even if the release continues into the next quarter).

3. Projected Maximum Exposed Member of the Public Dose

Determine the projected maximum exposed MEMBER OF THE PUBLIC using the equation derived in Section 6.3.3.e. Projected dose to individuals may be determined as follows:

$$D_{op} = \left(\frac{D_{oc}}{t}\right) \cdot 31 + D_{oa} \qquad \text{Eqn 6.3.5-3}$$

where:

D_{op} = the projected dose due to the total body or organ *o*, due to releases of I-131, I-133, tritium, and particulates for the next 31 days of gaseous releases.

D_{oc} = the cumulative dose to the total body or organ *o* due to releases of I-131, I-133, tritium, and particulates that have occurred in the elapsed portion of the current quarter, plus the release under consideration.

D_{oa} = the anticipated dose to the total body or organ *o*, due to releases of I-131, I-133, H-3, and particulates, contributed by any planned activities during the next 31-day period, if those activities will result in gaseous release that are in addition to routine gaseous effluents. If only routine gaseous effluents are anticipated, D_{oa}, may be set to zero.

t = The number of whole or partial days elapsed into the current quarter, including the time to the end of the release under consideration (even if the release continues into the next quarter).

6.4 RADIOACTIVE LIQUID AND GASEOUS RELEASE PERMITS

The licensee shall maintain procedures for liquid and gaseous release permits to ensure effluent dose limits are not exceeded when making releases.

The Chemistry Department samples and analyzes liquid and gaseous effluents, determines radiation monitor setpoints for liquid and gaseous effluents, performs dose calculations for liquid and gaseous effluents. The Operations Department authorizes and performs the releases of liquid and gaseous effluents. The Effluent Management System is a software package used by the Chemistry Department to manage the calculations and development of release permits.

6.4.1 Liquid Waste BATCH RELEASE Permits

Vogtle 3&4 implementing procedures control BATCH RELEASEs of radioactive liquids. Examples of BATCH RELEASEs include:

- Liquid Radwaste Discharge from waste monitor tanks (for every release)

Liquid releases associated with anticipated operational occurrences and unplanned and unmonitored releases shall be characterized using sampling and analytical procedures to assess the amounts of radioactivity released or currently being released to the environment and for determining doses to offsite receptors. See Attachment 3 for sampling and analysis requirements.

6.4.2 Liquid Waste CONTINUOUS RELEASE Permit

Vogtle 3&4 implementing procedures control CONTINUOUS RELEASEs of radioactive liquids. A CONTINUOUS RELEASE Permit is required for:

- Waste Water Retention Basin (when radioactivity present)
- Service Water blowdown (when radioactivity is present)

See Attachment 3 for sampling and analysis requirements.

6.4.3 Waste Gas Release Permits

Vogtle 3&4 implementing procedures control initiating waste gas releases, which typically includes the continuous plant vent release, but could also include, for example, the turbine island vent discharge during primary-to-secondary leaks.

6.4.4 Reactor Containment Release Permits

Vogtle 3&4 implementing procedures control initiating containment PURGES. Release Permits shall be valid from start of PURGE until: a) routine termination, b) terminated for cause, or c) receipt of radiation monitoring system (VFS-JE-RE001) high alarm.

6.4.5 Miscellaneous Gaseous Release Permit

Gaseous releases associated with anticipated operational occurrences and unplanned and unmonitored releases shall be characterized using sampling and analytical procedures to assess the amounts of radioactivity released or currently being released to the environment and for determining doses to offsite receptors.

An example of a miscellaneous gaseous release pathway is an open containment equipment hatch.

Occasionally other atmospheric release points may be important, such as main steam line atmospheric dumps, off-normal releases, and other secondary system leaks. An estimate will be made of any such unmonitored effluent releases prior to off-site dose calculation. These release estimates will be based on the mass of secondary coolant lost and the nuclide concentrations in the secondary coolant.

Based on the release characteristics, short-term meteorological data dispersion value (X/Q) may need to be used instead of those found in Attachment 13, Table A13.1.3-1. Use the guidance provided in Regulatory Guide 1.111 (Ref. 12) to determine dispersion values to be used for the release.

6.4.6 Radioactive Liquid and Gaseous Release Controls

a. Notifications of pending releases shall be made by Operations with a request to Chemistry to initiate the appropriate release permit prior to any release.

b. A representative sample shall be obtained of the source to be released.

c. Vogtle 3&4 implementing procedures control the performance of required sample collection and analyses.

d. The calculation and recording of the maximum authorized release rate, percent of ODCM/Technical Specification limits, and applicable conditions or controls pertaining to each release on the release permit.

e. Vogtle 3&4 implementing procedures control notifications of responsible personnel or if it is determined that a release may not be within the effluent dose limits.

f. The release permit shall include:

   1. Verification that the correct source is authorized for release.
   2. Identification of maximum authorized release rate.
   3. The percent of ODCM/Technical Specifications limits the release represents.
   4. Identification of any indicated controls or conditions applicable to the release.

g. Vogtle 3&4 implementing procedures control in initiating the release and identify information as appropriate, such as:

   1. Date and time release was started
   2. Starting tank/sump level
   3. Beginning pressure
   4. Release flow rate
   5. Dilution water or air flow rate

h. Vogtle 3&4 implementing procedures control terminating the release and identify information needed for completing permit, for example:

   1. Date and time release was stopped
   2. Tank/sump ending level
   3. Release flow rate just prior to termination
   4. Ending pressure
   5. Volume released

6.5 TOTAL DOSE LIMIT TO PUBLIC FROM URANIUM FUEL CYCLE SOURCES

6.5.1 Total Dose Determination

a. Requirement

In accordance with Technical Specifications 5.5.2.a.10, the annual (calendar year) dose or dose commitment to any MEMBER OF THE PUBLIC, beyond the SITE BOUNDARY, due to releases of radioactivity and radiation from uranium fuel cycle sources, conforming to 40 CFR 190. The dose or dose commitment to a MEMBER OF THE PUBLIC shall not exceed 25 mrem to the total body or any organ, except the thyroid, which shall not exceed 75 mrem.

b. Applicability

At all times

c. ACTION

1. If the calculated doses from release of radioactive materials in liquid or gaseous effluents exceed twice the limits in Sections 6.2.3.a., 6.3.3.a., or 6.3.4.a., calculate (including direct radiation contribution from Vogtle Units 1,2,3 and 4 and from outside storage tanks) whether limits in Section 6.5.1 have been exceeded.
2. If the limits in Section 6.5.1 have been exceeded, prepare and submit to the NRC within 30 days, a SPECIAL REPORT that defines the corrective action to be taken to reduce subsequent releases and to prevent recurrence, and includes a schedule for achieving conformance with the limits. SPECIAL REPORTS, as defined in 10 CFR 20.2203(a) (4), shall include:
   (a) An analysis that estimates the radiation exposure (dose) to a MEMBER OF THE PUBLIC, beyond the SITE BOUNDARY, from uranium fuel cycle sources, including all effluent pathways and direct radiation, for the calendar year that includes the releases covered by the report.
   (b) A description of the levels of radiation and concentrations of radioactive material involved, and the cause of the exposure levels or concentrations.
   (c) If the estimated dose exceeds the limits in Section 6.5.1, and if the release condition that violates 40 CFR 190 has not already been corrected, the SPECIAL REPORT shall include a request for a variance in accordance with the provisions of 40 CFR 190. Submittal of the report is considered a timely request, and a variance is granted until staff action on the request is complete.

d. Basis

This control is provided to meet the dose limitations and reporting requirements of 40 CFR 190. The control requires the preparation and submittal of a SPECIAL REPORT whenever the calculated doses from plant radioactive effluents exceed the limits of Section 6.5. For sites containing up to 4 reactors, it is highly unlikely that the resultant dose to a MEMBER OF THE PUBLIC will exceed the dose limits of 40 CFR 190 if the individual reactors remain within twice the dose design objectives of Appendix I and if direct radiation doses from the units, such as direct exposure from outside storage tanks, are kept small. The SPECIAL REPORT will describe a course of action which should result in the limitation of dose to a MEMBER OF THE PUBLIC for a calendar year to within the 40 CFR 190 limits. For the purposes of the SPECIAL REPORT, it may be assumed that the dose commitment to the MEMBER OF THE PUBLIC from other uranium fuel cycle sources is negligible with the exception that dose contributions from other uranium fuel cycle facilities at the same site or within a radius of 5 miles must be considered. If the dose to any MEMBER OF THE PUBLIC is estimated to exceed the requirements of 40 CFR 190, the SPECIAL REPORT with a request for variance (provided the release conditions resulting in violation of 40 CFR 190 have not already been corrected), in accordance with the provisions of 40 CFR 190.11 and 10 CFR 20.2203(a)(4), is considered to be a timely request and fulfills the requirements of 40 CFR 190 until NRC staff action is completed. The variance only relates to the limits of 40 CFR 190, and does not apply in any way to the requirements for dose limitation as addressed in other sections of this ODCM. An individual is not considered a MEMBER OF THE PUBLIC during any period in which he/she is engaged in carrying out any operation which is part of the nuclear fuel cycle.

6.5.2 Calculation of Total Dose

There are no other uranium fuel cycle facilities within 5 miles of the plant site. Therefore, for the purpose of demonstrating compliance with the limits of Section 6.5.1.a, the total dose to a MEMBER OF THE PUBLIC in the vicinity of the Vogtle 1,2,3 and 4 due to uranium fuel cycle sources shall be determined as follows:

$$D_{Tk} = D_L + D_G + D_D + D_N \qquad \text{Eqn 6.5.2-1}$$

where:

D_{Tk} = the total dose or dose commitment to the total body or organ k, in mrem

D_L = the dose to the same organ due to radioactivity discharged from the plant site in liquid effluents, calculated in accordance with Section 6.2.3, in mrem

D_G = the dose to the same organ due to non-noble-gas radionuclides discharged from the plant site in gaseous effluents, calculated for the controlling receptor in accordance with Section 6.3.4, in mrem.

D_D = the direct radiation dose to the whole-body of an individual at the controlling receptor location, due to radioactive materials retained within the SITE BOUNDARY, in mrem. Values of direct radiation dose may be determined by measurement, calculation, or a combination of the two.

D_N = the external whole-body dose to an individual at the controlling receptor location, due to gamma ray emissions from noble gas radionuclides discharged from the plant site in gaseous effluents, in mrem.

D_N is calculated as follows:

$$D_N = 3.17 \times 10^{-8} \sum_v \left\{ \left(\overline{\chi/Q} \right)_{vp} \sum_i \left[K_i \tilde{Q}_{iv} \right] \right\} \qquad \text{Eqn 6.5.2-2}$$

where:

3.17×10^{-8} = a units conversion factor: 1 y/(3.15×10^7 s)

$\tilde{Q}_{iv}$ = the cumulative release of noble gas radionuclide i from release pathway v (μCi), during the period of interest

K_i = the total-body dose factor due to gamma emissions from noble gas radionuclide i (mrem/yr)/(μCi/m^3), from Attachment 5

$\overline{(X/Q)}_{vp}$ = annual average relative dispersion factor [s/m^3] for release pathway v, at the location of the controlling receptor, from Section 1.3 of Attachment 13, Table A13.1.3-1.

As defined above, D_L and D_G are for different age groups, while D_D and D_N are not age group specific. When a more precise determination of D_{Tk} is desired, values of D_L and D_G may be calculated for all four age groups, and those values used in Eqn 6.5.2-1 to determine age group specific values of D_{Tk}; the largest value of D_{Tk} for any age group may then be compared to the limits of Section 6.5.1.

6.5.3 Potential Doses to MEMBERS OF THE PUBLIC Due To Activities Inside the SITE BOUNDARY

To support the reporting requirements of Section 6.7.2.b, an assessment of the radiation doses from radioactive liquid and gaseous effluents to MEMBER OF THE PUBLIC due to their activities inside the SITE BOUNDARY shall be performed as specified below, at least once per calendar year.

For the purpose of performing the calculations, the dose to a MEMBER OF THE PUBLIC inside the SITE BOUNDARY shall be determined at the locations, and for the receptor age groups, defined in Attachment 13, Table A13.1.3-1. The dose to such a receptor at any one of the defined locations shall be determined as follows:

$$D_{lk} = [D_A + D_S + D_P] \times F_o \qquad \text{Eqn 6.5.3-1}$$

where:

D_{lk} = the total dose to the total body or organ k, in mrem.

D_A = the dose to the same organ due to inhalation of non-noble-gas radionuclides discharged from the Vogtle 1,2,3 and 4 in gaseous effluents, calculated in accordance with Section 6.3.4.e, in mrem. The $\overline{(X/Q)}$ value to be used is given for each receptor location in Attachment 13, Table A13.1.3-1; depleted $\overline{(X/Q)}$ values may be used in calculations for non-noble-gas radionuclides.

D_S = the dose to the same organ due to ground plane deposition of non-noble-gas radionuclides discharged from the Vogtle 1,2,3 and 4 in gaseous effluents, calculated in accordance with Section 6.3.4.e, in mrem. The $\overline{(D/Q)}$ value to be used is given for each receptor location in Attachment 13, Table A13.1.3-1.

D_P = the external whole-body dose due to gamma ray emissions from noble gas radionuclides discharged from the Vogtle 1,2,3 and 4 in gaseous effluents, calculated using equation Eqn 6.5.2-2, in mrem. The $\overline{(X/Q)}$ values that are to be used are given for each receptor location in Attachment 13, Table A13.1.3-1.

F_o = the occupancy factor for the given location, which is the fraction of the year that one individual MEMBER OF THE PUBLIC is assumed to be present at the receptor location [unitless]. Values of F_o for each receptor location are included in Table Attachment 13, Table A13.1.3-1.

6.5.4 Dose Calculations to Support Other Requirements

Case 1: A radiological impact assessment may be required to support evaluation of a reportable event.

Dose calculations may be performed using the equations in Section 6.3.4.e, with the substitution of the dispersion and deposition parameters [(X/Q) and (D/Q)] for the period covered by the report, and using the appropriate pathway dose factors (R_{aipj}) for the receptor of interest. Methods for calculating (X/Q) and (D/Q) from meteorological data are presented in Attachment 13, Section 1.3.1 and 1.3.2.

Case 2: A dose calculation is required to evaluate the results of the Land Use Census, under the provisions of Section 6.6.2

In the event that the Land Use Census reveals that exposure pathways have changed at previously-identified locations, or if new locations are identified, it may be necessary to calculate doses at two or more locations to determine which should be designated as the controlling receptor. Such dose calculations may be performed using the equations in Section 6.3.4.e, with the substitution of the annual average dispersion and deposition values [$\overline{(X/Q)}$ and $\overline{(D/Q)}$] for the locations of interest, and using the appropriate pathway dose factors (R_{aipj}) for the receptors of interest.

Methods for calculating (X/Q) and (D/Q) from meteorological data are presented in Attachment 13 Section 1.3.1 and 1.3.2.

Case 3: Under Section 6.5.2, a dose calculation may be required to support the determination of a component of the total dose to a receptor other than that currently defined as the controlling receptor.

Dose calculations would be performed using the equations in Section 6.3.4.e, with the dispersion and deposition parameters and appropriate values of (R_{aipj}) for the receptor of interest.

Appropriate values of the dispersion and deposition parameters, if not found in Attachment 13, Table A13.1.3-1, would need to be calculated. Methods for calculating (X/Q) and (D/Q) from meteorological data are presented in Attachment 13, Section 1.3.1 and 1.3.2.

6.6 RADIOLOGICAL ENVIRONMENTAL MONITORING

6.6.1 Monitoring Program

a. Requirement

1. The REMP shall be conducted as specified in Attachment 9, "Radiological Environmental Monitoring Program."
2. Samples shall be collected from specific locations specified in Environmental Sampling Locations (Attachment 10).
3. Samples shall be analyzed in accordance with:
   (a) REMP (Attachment 9) requirements
   (b) Detection capabilities required by Detection Capabilities for Environmental Sample Analysis (Attachment 11)
   (c) Guidance of the Radiological Assessment Branch Technical Position on Environmental Monitoring dated November 1979, Revision No. 1 (Reference 29) or latest guidance

b. APPLICABILITY

At all times

c. ACTION

1. If the REMP is not being conducted as required in Section 6.6.1.a, report the situation by preparing and submitting to the NRC, in the Annual Radiological Environmental Operating Report required by Technical Specifications Section 5.6.1 Administrative Controls a description of the reasons for not conducting the program as required, and the plan for precluding recurrence.
2. If, when averaged over any calendar quarter, the confirmed measured level of radioactivity (as a result of plant effluents in an environmental sampling medium) exceeds the reporting levels of Reporting Levels for Radioactivity Concentrations in Environmental Samples (Attachment 12), prepare and submit to the NRC within 30 days a SPECIAL REPORT that:
   (a) Identifies the causes for exceeding the limits, and
   (b) Defines the corrective actions to be taken to reduce radioactive effluents so that the potential annual dose to a MEMBER OF THE PUBLIC is less than the calendar year limits of Sections 6.2.3.a, 6.3.3.a, and 6.3.4.a. The methodology and parameters used to estimate the potential annual dose to a MEMBER OF THE PUBLIC shall be indicated in the SPECIAL REPORT.

   When more than one of the radionuclides listed in Reporting Levels for Radioactivity Concentrations in Environmental Samples (Attachment 12) are detected in the sampling medium, the report shall be submitted if

$$\frac{concentration\ 1}{reporting\ level\ 1} + \frac{concentration\ 2}{reporting\ level\ 2} + \frac{concentration\ 3}{reporting\ level\ 3}\ etc.\ \geq 1$$

   Confirmed is defined by reanalysis of the original sample, or analysis of a duplicate or new sample, as appropriate. The results of the confirmatory analysis shall be completed at the earliest time consistent with the analysis.

3. When radionuclides other than those listed in Reporting Levels for Radioactivity Concentrations in Environmental Samples (Attachment 12) are detected and are the result of plant effluents, this SPECIAL REPORT shall be submitted if the potential annual dose to a MEMBER OF THE PUBLIC is equal to or greater than the calendar year limits of Sections 6.2.3.a, 6.3.3.a, and 6.3.4.a. The report is not required if the measured level of radioactivity was not the result of plant effluents; however, in such an event, report and describe the condition in the Annual Radiological Environmental Operating Report.
4. If milk or fresh leafy vegetable samples are unavailable from one or more of the sample locations required by Environmental Sampling Locations (Attachment 10), identify locations for obtaining replacement samples and add them to the REMP within 30 days. The specific

locations from which samples were unavailable may then be deleted from the monitoring program. Identify the cause of the unavailability of samples and identify the new locations for obtaining replacement samples in the next Annual Radioactive Effluent Release Report, in accordance to Technical Specification 5.6.2. Include in the report a revised figure and table for the ODCM to reflect the new locations.

d. Basis

The REMP required by this control provides representative measurements of radiation and of radioactive materials in those exposure pathways, and for those radionuclides, which lead to the highest potential radiation exposures of MEMBERS OF THE PUBLIC resulting from the plant operation. The REMP implements Section IV.B.2, Appendix I, 10 CFR 50, and thereby supplements the radiological effluent monitoring program by measuring concentrations of radioactive materials and levels of radiation, which may then be compared with those expected on the basis of the effluent measurements and modeling of the environmental exposure pathways.

e. Monitoring Locations

Monitoring locations are identified in Attachment 10. The following figures depict the locations:
Figure 6.6.1-1, "Terrestrial Locations Near the SITE BOUNDARY"
Figure 6.6.1-2, "Terrestrial and Aquatic Stations within 5 Miles of Units 3 and 4"
Figure 6.6.1-3, "Terrestrial Stations Beyond 5 Miles of Units 3 and 4"
Figure 6.6.1-4, "Drinking Water Stations"
Ground Water monitoring wells are not mapped in this ODCM, but they are in a separate document entitled, "Vogtle Electric Generating Plant Ground Water Protection Program."

6.6.2 Land Use Census

a. Requirement

1. A land use census shall be conducted and shall identify, within a distance of 5 miles, the location in each of the 16 meteorological sectors of the following:
   (a) Nearest milk animal (cow or goat)
   (b) Nearest residence
   (c) Nearest garden greater than 500 ft^2 that produces broad leaf vegetation
2. The land use census shall be conducted during the growing season, at least once per 12 months, using methods that will provide the best results (e.g., door-to-door survey, aerial survey, local agriculture authorities). Land use census results shall be included in the Annual Radiological Environmental Operating Report.
3. In lieu of the garden census, broad leaf vegetation sampling of at least three different kinds of vegetation may be performed at the SITE BOUNDARY in each of two different direction sectors with the highest predicted ground deposition (D/Qs). Specifications for broad leaf vegetation sampling in the REMP (Attachment 9) shall be followed, including analysis of control samples.

b. APPLICABILITY

At all times

c. ACTION

1. If a land use census identifies locations that yield a calculated dose or dose commitment greater than the values currently being calculated in 6.3.4.a.2, identify the new locations in the next Annual Radioactive Effluent Release Report, in accordance with Technical Specifications 5.6.2.
2. If a land use census identifies locations that yield a calculated dose or dose commitment (via the same exposure pathway) 20 percent greater than at a location from which samples are currently being obtained, add the new locations to the Radiological Environmental Monitoring Program within 30 days. Sampling locations, excluding the control station location, that have the lowest calculated dose or dose commitments (via the same exposure pathway) may be deleted from the monitoring program if new sampling locations are added. Identify new locations in the next Annual Radioactive Effluent Release Report and include in the report revised figures and tables reflecting the new locations, in accordance to Technical Specification 5.6.2.

d. Basis

This control is provided to ensure that changes in the use of UNRESTRICTED AREAS are identified and that modifications to the REMP are made if required by the results of this census. This census satisfies the requirements of Section IV.B.3 of Appendix I to 10 CFR Part 50. Restricting the census to gardens of greater than 500 square feet provides assurance that significant exposure pathways via leafy vegetables will be identified and monitored since a garden of this size is the minimum required to produce the quantity (26 kilograms per year) of leafy vegetables assumed in Regulatory Guide 1.109 for consumption by a child. To determine this minimum garden size, the following assumptions were made: (1) 20 percent of the garden was used for growing broad leaf vegetation (i.e., similar to lettuce and cabbage) and (2) a vegetation yield of 2 kilograms per square meter was obtained.

Figure 6.6.1-1 Terrestrial Locations Near the Site Boundary

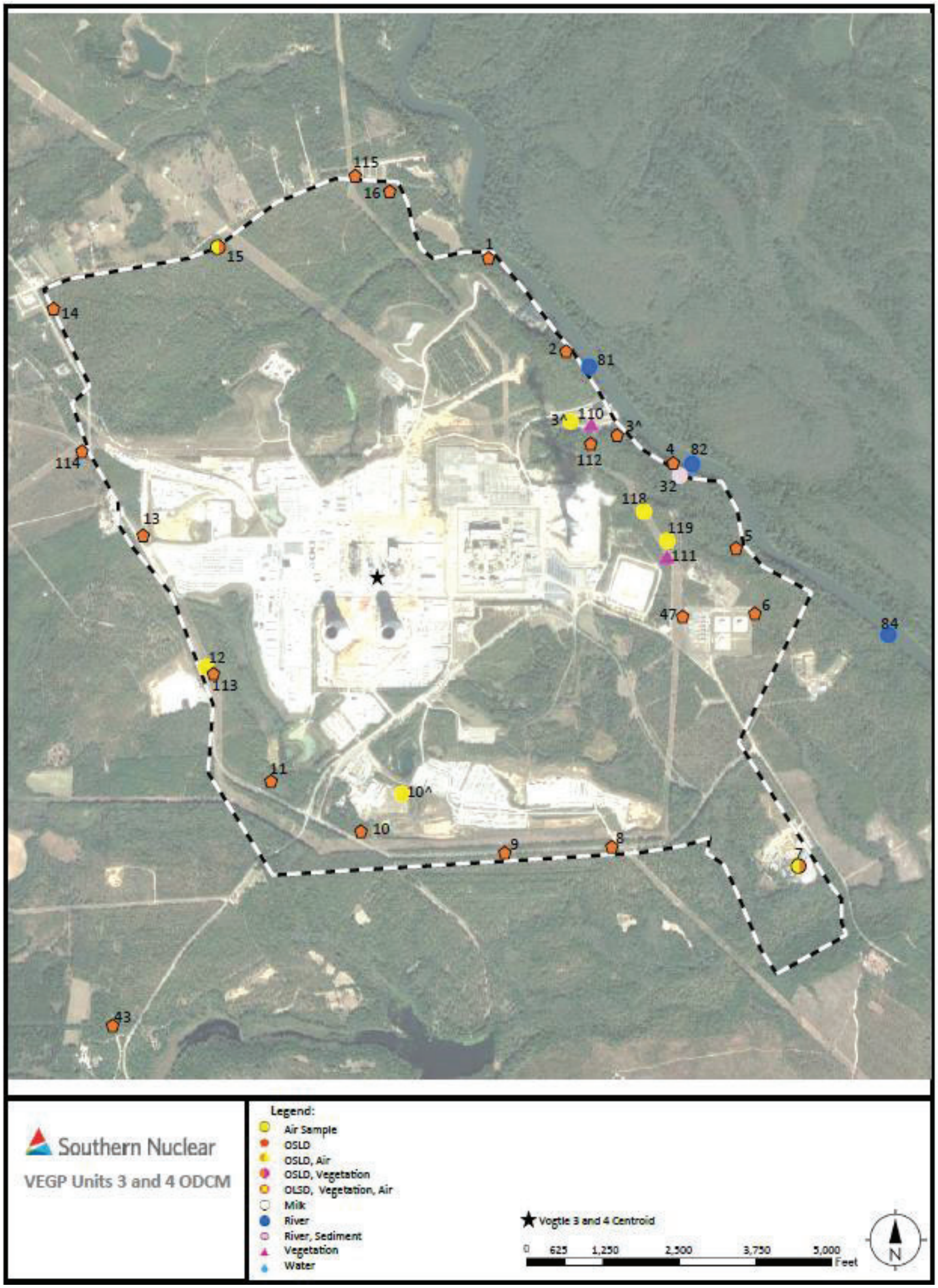


Figure 6.6.1-2 Terrestrial and Aquatic Stations within 5 Miles

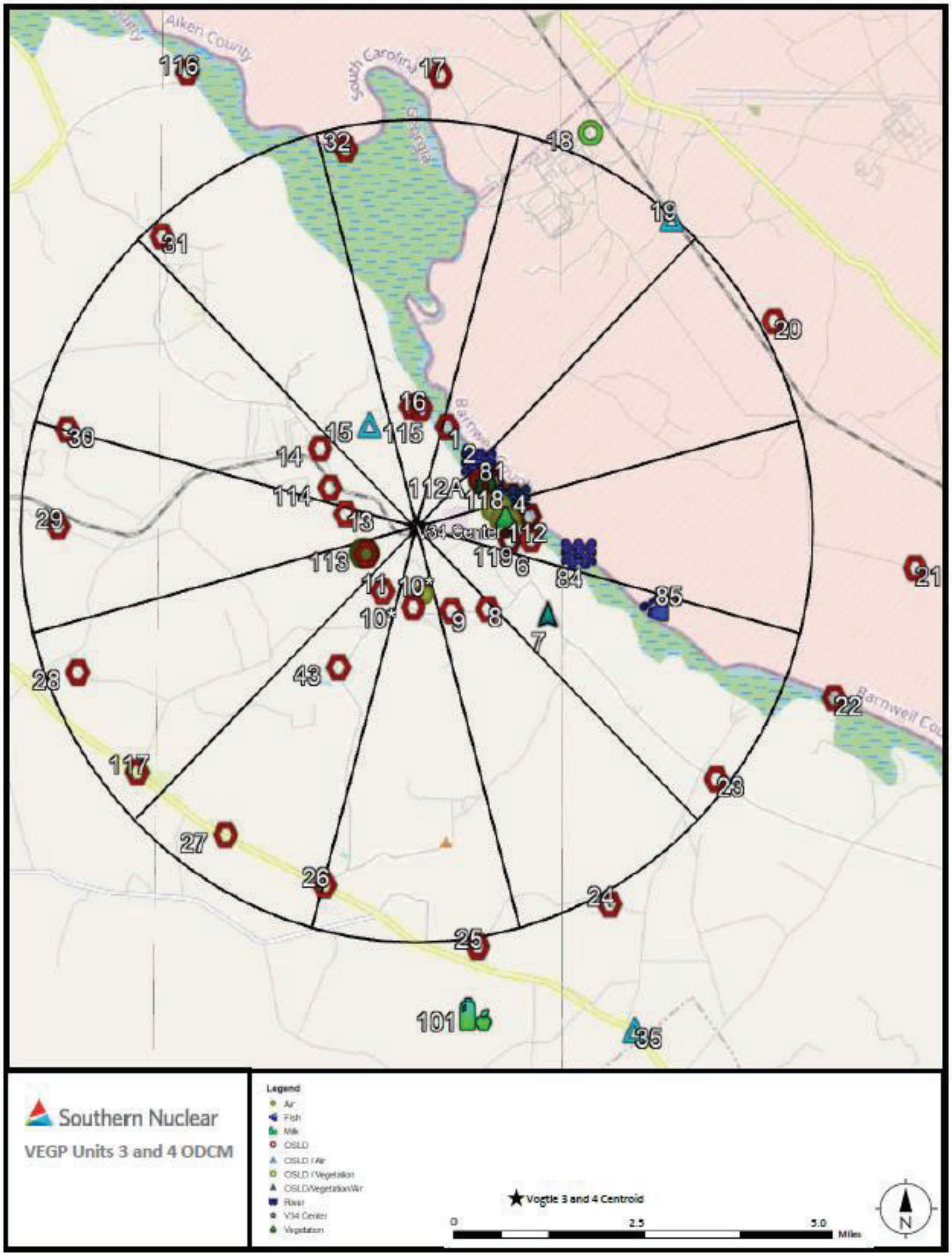


Figure 6.6.1-3 Terrestrial Stations Beyond 5 Miles

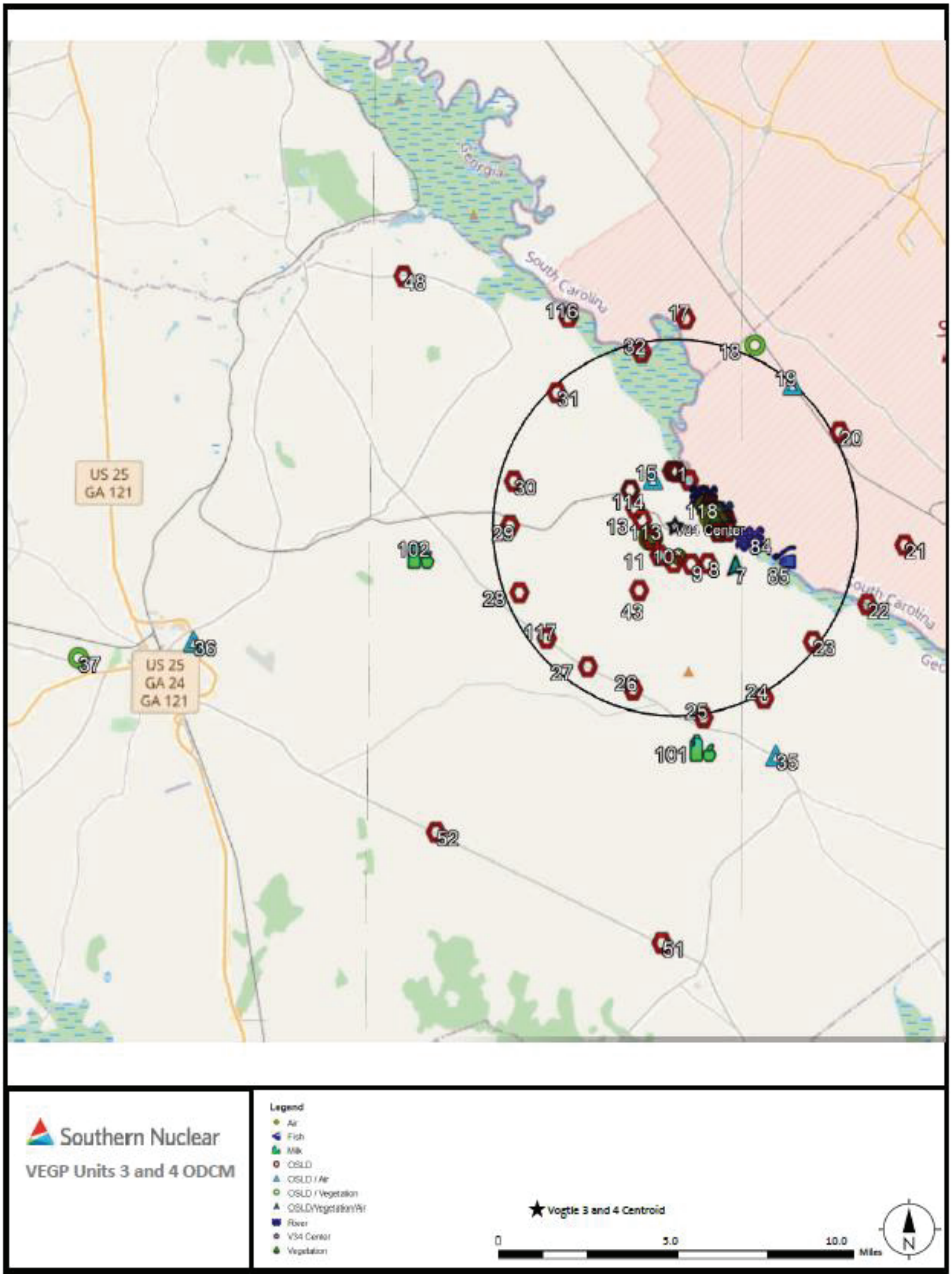
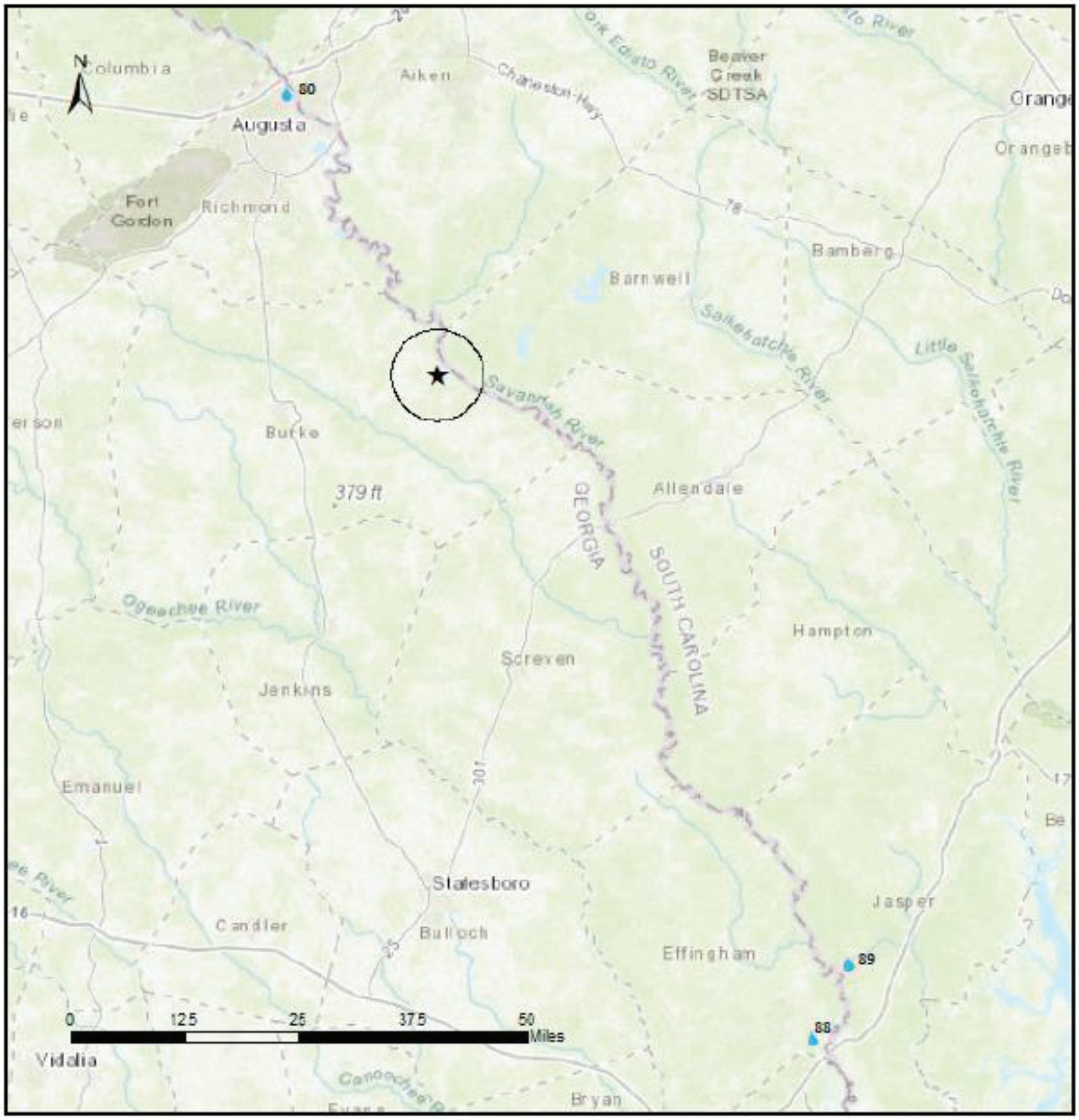


Figure 6.6.1-4   Drinking Water Stations



Southern Nuclear
VEGP Units 3 and 4 ODCM

Legend:
- Air Sample
- OSLD
- OSLD, Air
- OSLD, Vegetation
- OLSD, Vegetation, Air
- Milk
- River
- River, Sediment
- Vegetation
- Water

★ Vogtle 3 and 4 Centroid

Figure 6.6.1-4 Drinking Water Stations

6.6.3 Interlaboratory Comparison Program

a. REQUIREMENT

Radioactive materials (which contain nuclides produced at the site), supplied as part of an Interlaboratory Comparison Program, shall be analyzed, given the environmental media identified in Attachment 9.

b. APPLICABILITY

At all times

c. ACTION

An Interlaboratory Comparison shall be performed at least biennially.

If analyses are not performed as required by Section 6.6.3, report in the Annual Radiological Environmental Operating Report the corrective actions taken to prevent recurrence.

d. BASIS

The requirement for participation in an Inter-laboratory Comparison Program is provided to ensure that independent checks on the precision and accuracy of the measurements of radioactive material in environmental sample matrices are performed as part of the quality assurance program for environmental monitoring, in order to demonstrate that the results are reasonably valid for the purposes of Section IV.B.2, Appendix I, 10 CFR 50.

e. RESULTS

Results shall be reported in the Annual Radiological Environmental Monitoring Report. The discussion of acceptance criteria and corrective actions for any analysis that do not meet the acceptance criteria should be included.

6.7 REPORTING REQUIREMENTS

6.7.1 Annual Radiological Environmental Operating Report

In accordance with Technical Specifications 5.6.1, Annual Radiological Environmental Operating Reports covering the operation of Vogtle Units 3&4 during the previous calendar year shall be submitted by May 15 of each year. A single submittal may be made for Vogtle Units 1,2,3 and 4. Annual Radiological Environmental Operating Reports shall include:

a. Summaries, interpretations, and analysis of trends of results of radiological environmental surveillance activities for the report period, including:

   1. a comparison (as appropriate) with preoperational studies, operational controls, and previous environmental surveillance reports
   2. an assessment of the observed impacts of the plant operation on the environment
   3. results of land use census per Section 6.6.2

b. Results of analysis of radiological environmental samples and of environmental radiation measurements taken per Section 6.6.1, Monitoring Program. Results shall be summarized and tabulated in the format of the table in the Radiological Assessment Branch Technical Position on Environmental Monitoring.

   1. If some individual results are not available for inclusion with the report, the report shall be submitted, noting and explaining reasons for missing results.
   2. Missing data shall be submitted in a supplementary report as soon as possible.

c. a summary description of the Radiological Environmental Monitoring Program

d. at least two legible maps covering sampling locations, keyed to a table giving distances and directions from a point midway between the centers of Vogtle 3&4 reactors. One map shall cover sampling locations near the SITE BOUNDARY; a second shall include more distant sampling locations.

e. results of the Vogtle 3&4 participation in the Inter-laboratory Comparison Program, per Section 6.6.3

f. discussion of deviations from the Vogtle 3&4 environmental sampling schedule per the REMP (Attachment 9)

g. discussion of analyses in which the MDC required by Detection Capabilities for Environmental Sample Analysis (Attachment 11) was not achievable

h. any sample results from any ground water wells described in the environmental program, whether the results were required by the environmental program or not

6.7.2 Annual Radioactive Effluent Release Report

In accordance with Technical Specifications 5.6.2, Radioactive Effluent Release Reports covering operation of Vogtle Units 3&4 during the previous 12 months of operation shall be submitted prior to May 1 of each year. A single submittal may be made for Vogtle Units 1,2,3 and 4, and should combine those sections that are common to all units. Radioactive Effluent Release Reports shall include:

a. REQUIREMENT

1. a summary of quantities of radioactive liquid and gaseous effluents and solid waste released. Data shall be summarized on a quarterly basis following the format of Regulatory Guide 1.21, Revision 1 (Reference 8), for liquid and gaseous effluents. Data shall be summarized on a semiannual basis following the format of Appendix B of Regulatory Guide 1.21, Revision 1, for solid waste.
2. an assessment of radiation doses to the maximum exposed MEMBERS OF THE PUBLIC due to the radioactive liquid and gaseous effluents released from the site during the previous calendar year. This assessment shall be in accordance with Section 6.7.2.b.
3. a list and description of unplanned and/or unmonitored releases from the site to UNRESTRICTED AREAS, during the reporting period, which meet the following criteria:
   (a) unplanned and/or unmonitored releases that exceeded the limits in Sections 6.2.1 and 6.3.1
   (b) unplanned and/or unmonitored releases which require a Condition Report and involve the discharge of contents of the wrong waste monitor tank
   (c) unplanned and/or unmonitored releases from large leaks due to unexpected valve or pipe failures that result in a quantity of release such that a 10 CFR 50.72, Immediate Notification Requirements for Operating Nuclear Power Reactors or 10 CFR 50.73, Licensee Event Report System, report is required
   (d) unplanned releases and/or unmonitored as determined by Chemistry management, which may or may not require a Condition Report
4. Major Changes (Section 6.7.6) to radioactive liquid, gaseous, and solid waste treatment systems during the reporting period
5. changes to the ODCM
6. a listing of new locations for dose calculations or environmental monitoring identified by the land use census (See Section 6.6.2)
7. a summary of radioactive leaks or spills meeting the following criteria:
   (a) an unintended spill or leak with the potential to reach ground water, as defined in NEI 07-07 (Reference 36), and
   (b) The spill or leak must be greater than 100 gallons in volume or the volume cannot be quantified but is estimated to be greater than 100 gallons, or
   (c) any spill or leak, regardless of volume or activity deemed by the licensee to be reportable.
8. any ground water sample results from locations not part of the Radiological Environmental Monitoring Program.

b. Dose Assessment

1. Radiation dose to individuals due to radioactive liquid and gaseous effluents from Vogtle 3&4 during the previous calendar year shall either be calculated in accordance with this ODCM or in accordance with Regulatory Guide 1.109 (Reference 11) and NUREG-0133 (Reference 24). Population doses shall not be included in dose assessments.

2. The dose to the maximum exposed MEMBER OF THE PUBLIC due to radioactive liquid and gaseous effluents from Vogtle 1,2,3 and 4 shall be incorporated with the dose assessment performed above. If the dose to the maximum exposed MEMBER OF THE PUBLIC exceeds twice the limits of 6.2.3.a.1, 6.3.3.a.1, or 6.3.4.a.1, the dose assessment shall include the contribution from direct radiation.

NOTE: NUREG-0543 (Reference 23) states: "There is reasonable assurance that sites with up to four operating reactors that have releases within Appendix I design objective values are also in conformance with the EPA Uranium Fuel Cycle Standard, 40 CFR Part 190."

3. Meteorological conditions during the previous calendar year or historical annual average atmospheric dispersion conditions shall be used to determine gaseous, radioiodines, tritium, and particulates with half-lives greater than 8 days, pathway doses.

   A description of the meteorological instrumentation can be found in the VEGP 3&4 UFSAR 2.3.3 (Ref. 44). Methodology used to calculate dispersion factors can be found in Attachment 13 Section 1.0.

6.7.3 Annual Meteorological Data

a. The report shall include an annual summary of hourly meteorological data collected over the previous year. This annual summary may be either in the form of an hour-by-hour listing of wind speed, wind direction, and atmospheric stability, and precipitation (if measured); or in the form of joint frequency distributions of wind speed, wind direction, and atmospheric stability.

b. In lieu of submission with the Radioactive Effluent Release Report, the licensee has the option of retaining this summary of required meteorological data on site in a file that shall be provided to the NRC upon request.

c. Applicability

   At all times

6.7.4 Changes to the ODCM

In accordance with Technical Specifications Section 5.5.1, “Offsite Dose Calculation Manual,” licensee initiated changes to the ODCM shall be:

a. Reviewed and approved by the appropriate level of management prior to implementation in accordance with Southern Nuclear Operating Company and site procedures on licensing document changes.

   1. The ODCM change may be initiated by the plant Chemistry Department, Fleet Chemistry or the Environmental Affairs Department.
   2. The Chemistry Department shall provide support for management and Plant Review Board reviews, including providing any associated licensing applicability and evaluation documents.
   3. The ODCM shall become effective after approval of the plant manager.

b. Records of reviews shall be retained as site records. Documentation shall include:

   1. Sufficient information to support changes, together with appropriate analyses or evaluations justifying changes.
   2. A determination that a change will not adversely impact the accuracy or reliability of effluent doses or setpoint calculations, and will maintain the level of radioactive effluent control required by:

      (a) 10 CFR 20 Subpart D
      (b) 40 CFR 190
      (c) 10 CFR 50.36a
      (d) 10 CFR 50, Appendix I

c. Submitted to the NRC in the form of a complete, legible copy of the changed portion of the ODCM as a part of, or concurrent with the Annual Radioactive Effluent Release Report for the period of the report in which any change was made. Each change shall be identified by markings in the margin of the affected pages, clearly indicating the area of the page that was changed, and shall indicate the date (e.g., month/year) the change was implemented.

6.7.5 Ground Water Protection Initiative

a. The NEI Industry Ground Water Protection Initiative was established to address operating experience with ground water contamination at several nuclear power stations.

b. Notifications and Reports

1. Informal communication shall be made to state/local/NRC officials by the end of the next business day for:

(a) any spill or leak meeting the requirements of Section 6.7.2.a.7.

(b) any ground water sample result exceeding the reporting levels of Reporting Levels for Radioactivity Concentrations in Environmental Samples (Attachment 12).

2. A 30-day report shall be submitted to the NRC and a copy concurrently forwarded to state and local officials for any ground water sampling result, whether on site or off site, exceeding the reporting levels of Reporting Levels for Radioactivity Concentrations in Environmental Samples (Attachment 12) and having the potential to reach ground water or surface water that is or could be used as a source of drinking water. A 30-day report is only required on the initial discovery of a contaminated ground water plume.

c. Any spill or leak for which an informal notification is made in accordance with Section 6.7.5.b. shall be summarized in the Annual Radioactive Effluent Report.

d. Any groundwater sample result from a ground water source that is not part of the Radiological Environmental Monitoring Program shall be included in the Annual Radioactive Effluent Report.

e. Any groundwater sample result from any ground water well described in the Radiological Environmental Monitoring Program shall be included in the Annual Radiological Environmental Operating Report.

f. Applicability

At all times

6.7.6 MAJOR CHANGES (TO RADIOACTIVE WASTE TREATMENT SYSTEMS)

For the purposes of the ODCM, Major Changes to radioactive waste treatment systems include the following changes to such systems:

a. Major Changes in process equipment, components, structures, or effluent monitoring instrumentation as described in the Updated Final Safety Analysis Report (UFSAR; Reference 44) or as evaluated in the Nuclear Regulatory Commission staff's Safety Evaluation Report (SER) (e.g., deletion of evaporators and installation of demineralizers);

b. Changes in the design of radioactive waste treatment systems that could significantly increase quantities of effluents released from those previously considered in the UFSAR and SER;

c. Changes in system design which may invalidate the accident analysis as described in the SER (e.g., changes in tank capacity that would alter the curies released); or

d. Changes in system design that could potentially result in a significant increase in occupational exposure of operating personnel (e.g., use of temporary equipment without adequate shielding provisions).

6.8 RECORDS

The licensee shall maintain all records associated with the implementation of the ODCM in accordance with site records management system.

7.0 REFERENCES

1. 10 CFR Part 20, "Standards for Protection Against Radiation."
   a. 10 CFR 20.1301, "Dose Limits for Individual Members of the Public."
   b. 10 CFR 20.1302, "Compliance with Dose Limits for Individual Members of the Public."
   c. 10 CFR 20.2202, "Notification of Incidents."
   d. 10 CFR 20.2203, "Reports of Exposures, Radiation Levels, and Concentrations of Radioactive Material Exceeding the Constraints or Limits."
   e. 10 CFR Part 20, Appendix B, "Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage."

2. 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities"
   a. 10 CFR 50.34a, "Design Objectives for Equipment to Control Releases of Radioactive Material in Effluents—Nuclear Power Plants."
   b. 10 CFR 50.36a, "Technical Specifications on Effluents from Nuclear Power Reactors."
   c. 10 CFR 50.72, "Immediate Notification Requirements for Operating Nuclear Power Reactors."
   d. 10 CFR 50.73, "Licensee Event Report System."
   e. 10 CFR Part 50, Appendix I, "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion 'As Low as is Reasonably Achievable' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents."

3. 10 CFR Part 100, “Reactor Site Criteria”

4. 40 CFR, Part 190, “Environmental Radiation Protection Standards for Nuclear Power Operations” as implemented under 10 CFR Part 20.1301 (e).

5. Generic Letter 89-01 “Implementation of Programmatic Controls for Radiological Effluent Technical Specifications (RETS) in the Administrative Controls Section of the Technical Specifications and the Relocation of Procedural Details of RETS to the Offsite Dose Calculation Manual or to the Process Control Program” as contained in NUREG-1301 and NUREG-1302

6. IE Bulletin No. 80-10, “Contamination of Nonradioactive System and Resulting Potential for Unmonitored, Uncontrolled Release of Radioactivity to Environment,” May 6, 1980.

7. IE Information Notice No. 91-40, “Contamination of Nonradioactive System and Resulting Possibility for Unmonitored, Uncontrolled Release to Environment,” June 19, 1991.

8. Regulatory Guide 1.21, Revision 1, “Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Reactors, U.S. Nuclear Regulatory Commission, June 1974.

9. Regulatory Guide 1.33, “Quality Assurance Program Requirements (Operation).”

10. Regulatory Guide 1.109, “Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR 50, Appendix I,” U.S. Nuclear Regulatory Commission, March 1976.

11. Regulatory Guide 1.109, Revision 1, “Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR 50, Appendix I,” U.S. Nuclear Regulatory Commission, October 1977.

12. Regulatory Guide 1.111, “Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors,” U.S. Nuclear Regulatory Commission, March 1976.

13. Regulatory Guide 1.111, Revision 1, “Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors,” U.S. Nuclear Regulatory Commission, July 1977.

14. Regulatory Guide 1.112 Revision 1, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Light-Water-Cooled Nuclear Power Reactors, March 2007

15. Regulatory Guide 1.113, “Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I,” April 1977.

16. Regulatory Guide 1.143, “Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants.”

17. Regulatory Guide 1.206, “Combined License Applications for Nuclear Power Plants (LWR Edition).”

18. Regulatory Guide 4.1, “Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants.”

19. Not Used

20. Regulatory Guide 4.13, Performance, Testing, and Procedural Specifications for Thermoluminescence Dosimetry: Environmental Applications Rev. 1, July 1977

21. Regulatory Guide 4.15, Rev 1 “Quality Assurance for Radiological Monitoring Programs (Inception through Normal Operations to License Termination) – Effluent Streams and the Environment.” February 1979

22. Regulatory Guide 8.8, Revision 3, “Information Relevant to Ensuring That Occupational Radiation Exposures at Nuclear Stations Will Be As Low As Is Reasonably Achievable,” June 1978.

23. NUREG-0543, February 1980, Methods for Demonstrating LWR Compliance With the EPA Uranium Fuel Cycle Standard (40 CFR Part 190)

24. NUREG-0133, “Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants,” U.S. Nuclear Regulatory Commission, October 1978.

25. NUREG-1301, “Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors,” [This NUREG includes Generic Letter 89-01 Supplement No.1.]

26. NUREG-0800, Standard Review Plan, 11.5 “Process and Effluent Radiological Monitoring Instrumentation and sampling Systems” Rev 4 March 2007

27. NUREG/CR-3332, “Radiological Assessment,” U.S. Nuclear Regulatory Commission, 1983

28. NUREG/CR-4007, “Lower Limit of Detection: Definition and Elaboration of a Proposed Position of Radiological Effluent and Environmental Measurements,” U.S. Nuclear Regulatory Commission, September 1984.

29. “Radiological Assessment Branch Technical Position,” U.S. Nuclear Regulatory Commission, November 1979 as contained in NUREG-1301 and NUREG-1302.

30. NUREG/CR-4013, "LADTAP II—Technical Reference and User Guide," U.S. Nuclear Regulatory Commission, April 1986.

31. NUREG/CR-4653, "GASPAR II—Technical Reference and User Guide," U.S. Nuclear Regulatory Commission, March 1987

32. Report of the International Commission on Radiological Protection (ICRP) Committee II on Permissible Dose for Internal Radiation (1959)

33. ANSI/HPS N13.1-1999, "Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stacks and Ducts of Nuclear Facilities," 1999.

34. ANSI N42.18-2004, "Specification and Performance of On-Site Instrumentation for Continuously Monitoring Radioactivity in Effluents," 2004.

35. DOE/TIC-11026, "Radioactive Decay Data Tables," 1981

36. NEI 07-07, Industry Ground Water Protection Initiative – Final Guidance Document

37. NUREG/CR-2919, "XOQDOQ, Program for the Meteorological Evaluation of Routine Effluent Releases at Nuclear Power Stations," U.S. Nuclear Regulatory Commission, September 1982.

38. Southern Nuclear Operating Company, Early Site Permit Application, Part 2, "Site Safety Analysis Report," Revision 5, December 2008. ML091540845

39. W.R. Stokes III, T.W. Hale, J.L. Pearman, and G.R. Buell, 'Water Resources Data, Georgia, Water Year 1983," U.S. Geological Survey Water Data Report GA-83-1, June 1984.

40. Direct communication with the Water Resources Division, U.S. Geological Survey, U.S. Department of the Interior, February 1985.

41. Bernd Kahn, et al., "Bioaccumulation of P-32 in Bluegill and Catfish," NUREG/CR-3981, February 1985.

42. Vogtle Electric Generating Plant Units 1 and 2 Updated Final Safety Analysis Report, Georgia Power Company.

43. NEI (Nuclear Energy Institute), Generic FSAR Template Guidance for Offsite Dose Calculation Manual (ODCM) Program Description, NEI 07-09A, Revision 0, March 2009.

44. Southern Nuclear Operating Company, Vogtle Electric Generating Plant Units 3 and 4 Updated Final Safety Analysis Report.

45. Vogtle Electric Generating Plants Unit 3 and 4 Technical Specifications

46. D.C. Kocher, "Radioactive Decay Data Tables," U.S. DOE Report DOE/TIC-11026, 1981.

47. W.R. Stokes III, T.W. Hale, J.L. Pearman, and G.R. Buell, "Water Resources Data, Georgia, Water Year 1983," U.S. Geological Survey Water Data Report GA-83-1, June 1984

48. J.E. Till and H.R. Meyer, eds., Radiological Assessment, U.S. NRC Report NUREG/CR-3332, 1983.

49. RS-461, Memo from S.E. Ewald, Georgia Power Company, to C.C. Eckert, Georgia Power Company, May 9, 1988.

50. Letter to Mary Beth Lloyd, Southern Nuclear Operating Company, from Steven Bearce, Southern Company Services, February 2, 2009.

51. EV-13-1797, EACRS Intracompany Correspondence, “Vogtle REMP Drinking Water Sampling Stations”.

52. EV-14-0226, EACRS Intracompany Correspondence, “Vogtle 1 and 2 Tritium Monitoring Well Update”.

53. Vogtle Early Site Permit Application, Part 3 - Environmental Report, Revision 2, Southern Nuclear Operating Company.

54. Not Used

55. Letter to Southern Company Services from Pickard, Lowe, and Garrick, Inc., Washington, D.C., April 27, 1988.

ATTACHMENT 1: RADIOACTIVE LIQUID EFFLUENT MONITORING INSTRUMENTATION (page 1 of 2)

Instrument	FUNCTIONALITY Requirements[a]		
	Minimum Channels FUNCTIONAL	Applicability	ACTION[b]
1. Radwaste Monitors Providing Alarm and Automatic Termination of Release			
a. Liquid Radwaste Discharge (WLS-JE-RE229)	1	At all times	37
b. Waste Water Discharge (WWS-JE-RE021)	1	At all times	38
2. Radwaste Monitors Providing Alarm, but Not Automatic Termination of Release			
a. Service Water Blowdown (SWS-JE-RE008)	1	At all times	39
3. Flowrate Measurement Devices			
a. Liquid Radwaste Effluent Flow (WLS-JE-FT232)	1	At all times	40
b. Cooling Tower Blowdown (CWS-JE-FT508)	1	At all times	40
c. Waste Water Retention Basin (WWS-JE-FT502A) (WWS-JE-FT502B)	1 1	At all times	40

a. All requirements in this table apply to each unit.
b. ACTIONS are on the next page.

ATTACHMENT 1 (continued, page 2 of 2)

ACTION 37 — With the number of channels FUNCTIONAL less than required by the Minimum Channels FUNCTIONAL requirement, effluent releases may continue provided that prior to initiating a release:

a. at least two independent samples are analyzed in accordance with the sampling and analysis program of Section 6.1, and

b. at least two technically qualified members of the Facility Staff independently verify the discharge line valving and the release rate calculations.

c. Otherwise, suspend release of radioactive effluents via this pathway.

ACTION 38 — With the number of channels FUNCTIONAL less than required by the Minimum Channels FUNCTIONAL requirement, effluent releases via this pathway may continue provided grab samples are analyzed for radioactivity in accordance with Attachment 3:

a. at least once per 12 hours when the specific activity of the secondary coolant is greater than 0.01 μCi/gram DOSE EQUIVALENT I-131.

b. at least once per 24 hours when the specific activity of the secondary coolant is less than or equal to 0.01 μCi/gram DOSE EQUIVALENT I-131.

ACTION 39 — With the number of channels FUNCTIONAL less than required by the Minimum Channels FUNCTIONAL requirement, effluent releases via this pathway may continue provided that, at least once per 12 hours, grab samples are collected and analyzed for gross radioactivity at a MINIMUM DETECTABLE Concentration of no more than 1.0E-07 uCi/mL.

ACTION 40 — With the number of channels FUNCTIONAL less than required by the Minimum Channels FUNCTIONAL requirement, effluent releases via this pathway may continue provided the flowrate is estimated at least once per 4 hours during actual releases. Pump performance curves generated in place may be used to estimate flow.

ATTACHMENT 2: RADIOACTIVE LIQUID EFFLUENT MONITORING INSTRUMENTATION SURVEILLANCE REQUIREMENTS (page 1 of 2)

Channel Description	CHANNEL CHECK	SOURCE CHECK	CHANNEL CALIBRATION	CHANNEL FUNCTIONAL TEST
Radwaste Monitors Providing Alarm and Automatic Termination of Release[d]				
a. Liquid Radwaste Discharge (WLS-JE-RE229)	D	P	R[b]	Q[a(1), a(2)]
b. Waste Water Discharge (WWS-JE-RE021)	D	M	R[b]	Q[a(1), a(2)]
Radwaste Monitors Providing Alarm, but Not Automatic Termination of Release[d]				
Service Water Blowdown (SWS-JE-RE008)	D	M	R[b]	Q[a(2)]
Flowrate Measurement Devices[d]				
a. Liquid Radwaste Discharge (WLS-JE-FT232)	D[c]	NA	R	Q
b. Dilution flow to blowdown sump (CWS-JE-FT508)	D[c]	NA	R	Q
c. Waste Water Retention Basin (WWS-JE-FT502A) (WWS-JE-FT502B)	D[c]	NA	R	Q

ATTACHMENT 2 (continued, page 2 of 2)

a. In addition to the basic functions of a CHANNEL **FUNCTIONAL** TEST:

(1) The CHANNEL **FUNCTIONAL** TEST shall demonstrate that automatic isolation of this pathway and control room annunciation occur if the instrument indicates measured levels above the alarm/trip setpoint.

(2) The CHANNEL **FUNCTIONAL** TEST shall also demonstrate that control room annunciation occurs if any of the following conditions exist:

(a) Instrument indicates measured levels above the alarm/trip setpoint, or

(b) Circuit failure, or

(c) Instrument indicates a downscale failure, or

(d) Instrument controls not set in operate mode.

b. The initial CHANNEL CALIBRATION shall be performed using one or more of the reference standards certified by the National Institute of Standards and Technology or using standards that have been obtained from suppliers that participate in measurements assurance activities with NIST. These standards shall permit calibrating the system over its intended range of energy and measurement range. For subsequent CHANNEL CALIBRATION, sources that have been related to the initial calibration shall be used.

c. CHANNEL CHECK shall consist of verifying indication of flow during periods of release. CHANNEL CHECK shall be made at least once per 24 hours on days on which CONTINUOUS RELEASES, periodic, or BATCH RELEASEs are made.

d. All requirements in this table apply to each unit.

ATTACHMENT 3: RADIOACTIVE LIQUID WASTE SAMPLING AND ANALYSIS PROGRAM[a]

Liquid Release Type	Sampling Frequency	Minimum Analysis Frequency	Type of Activity Analysis	Minimum Detectable Concentration (MDC)[b]
Batch Releases				
Waste Monitor Tank	P Each BATCH	P Each BATCH	Principal Gamma Emitters I-131	5.0 E-7 1.0 E-6
	P Each BATCH	P Each BATCH	Dissolved and entrained gases (Gamma Emitters)	1.0 E-5
	P Each BATCH	M COMPOSITE	H-3 Gross Alpha	1.0 E-5 1.0 E-7
	P Each BATCH	Q COMPOSITE	Sr-89, Sr-90 Fe-55	5.0 E-8 1.0 E-6
Continuous Releases				
Waste Water Retention Basin[d] (WWRB) Service Water Blowdown[e]	Continuous[c]	W COMPOSITE	Principal Gamma Emitters I-131	5.0 E-7 1.0 E-6
	M Grab Sample	M	Dissolved and entrained gases (Gamma Emitters)	1.0 E-5
	Continuous[c]	M COMPOSITE	H-3 Gross Alpha	1.0 E-5 1.0 E-7
	Continuous[c]	Q COMPOSITE	Sr-89, Sr-90 Fe-55	5.0 E-8 1.0 E-6

a. All requirements in this table apply to each unit.
b. MDC is to be calculated as defined in Reference 28. See Attachment 11. Units are in µCi/mL.
c. To be representative of the quantities and concentrations of radioactive materials in liquid effluents, samples shall be collected continuously in proportion to the rate of flow of the effluent stream. Prior to analysis, all samples taken for the composite shall be thoroughly mixed in order for the Composite Sample to be representative of the effluent release.
d. The WWRB will not be considered a release point until there is a confirmed primary to secondary leak. Once a primary to secondary leak has been confirmed, this composite shall be analyzed as specified until the leak is repaired. This surveillance will continue until three consecutive weekly Composite Samples have shown no activity above the MDC.
e. When radioactivity is present.

ATTACHMENT 4: RADIOACTIVE GASEOUS WASTE SAMPLING AND ANALYSIS PROGRAM (page 1 of 2)

Gaseous Release Type	Sampling FREQUENCY	Minimum Analysis FREQUENCY	Type of Activity Analysis	MINIMUM DETECTABLE CONCENTRATION (MDC)
Plant Vent	M[a,b,d] Grab Sample	M[a]	PRINCIPAL GAMMA EMITTERS (Noble Gas) H-3 (oxide)	1 E-4 1 E-6
Containment PURGE	P[a] Each PURGE Grab Sample	P[a] Each PURGE M	PRINCIPAL GAMMA EMITTERS (Noble Gas) H-3 (oxide)	1 E-4 1 E-6
Turbine Island Vent	M Grab Sample	M	PRINCIPAL GAMMA EMITTERS (Noble Gas)	1 E-4

ATTACHMENT 4 (continued, page 2 of 2)

Gaseous Release Type	Sampling Frequency	Minimum Analysis Frequency	Type of Activity Analysis	Minimum Detectable Concentration (MDC)
Plant Vent and Turbine Island Vent[f]	Continuous[e]	W[c] charcoal or silver zeolite sample	I-131	1 E-12
		W[c] particulate sample	Principal Gamma Emitters	1 E-11
		W COMPOSITE Particulate Sample	Gross Alpha	1 E-11
		Q COMPOSITE Particulate Sample	Sr-89, Sr-90	1 E-11
		Continuous Noble Gas Monitor	Gross Noble Gases (Beta or Gamma)	1 E-06

a. Sampling and analysis shall also be performed following shutdown, startup, or a thermal power change greater than or equal to 15% of the Rated Thermal Power within a one-hour period. This requirement does not apply if (1) analysis shows that the Dose Equivalent I-131 concentration in the primary coolant has not increased more than a factor of 3; and (2) the noble gas monitor shows that effluent activity has not increased more than a factor of 3.

b. Tritium grab samples shall be taken at least once per 24 hours when the refueling cavity is flooded.

c. Samples shall be changed at least once per 7 days and analyses shall be completed within 48 hours after changing (or after removal from sampler). Sampling shall also be performed at least once per 24 hours for at least 7 days following each shutdown, startup, or thermal power change greater than or equal to 15% of Rated Thermal Power in one hour, and analyses shall be completed within 48 hours of changing. When samples collected for 24 hours are analyzed, the corresponding MDC (see Attachment 11 for equation) may be increased by a factor of 10. This requirement does not apply if (1) analysis shows that the Dose Equivalent I-131 concentration in the primary coolant has not increased more than a factor of 3; and (2) the noble gas monitor shows that effluent activity has not increased more than a factor of 3.

d. Tritium grab samples shall be taken at least once per 7 days from the plant vent, whenever spent fuel is in the spent fuel pool.

e. The ratio of the sample flowrate to the sampled stream flowrate shall be known for the time period covered by each dose or dose rate calculation made in accordance with controls specified in Sections 6.3.1.a, 6.3.3.a, 6.3.4.a.

f. A sample is taken within one month of initial criticality, and at least weekly thereafter to determine the identity and quantity for principal nuclides being released. A similar analysis of samples is performed following each refueling, process change, or other occurrence that could alter the mixture of radionuclides.

ATTACHMENT 5: GASEOUS EFFLUENT DOSE FACTORS

Table A5.1-1 Dose Factors for Exposure to a Semi-Infinite Cloud of Noble Gases

Noble Gas Radionuclide	K_i Total Body mrem/yr per μCi/m³	L_i Skin mrem/yr per μCi/m³	M_i Gamma Air mrad/yr per μCi/m³	N_i Beta Air mrad/yr per μCi/m³
Kr-83m	7.56 E-02	0.00 E+00	1.93 E+01	2.88 E+02
Kr-85m	1.17 E+03	1.46 E+03	1.23 E+03	1.97 E+03
Kr-85	1.61 E+01	1.34 E+03	1.72 E+01	1.95 E+03
Kr-87	5.92 E+03	9.73 E+03	6.17 E+03	1.03 E+04
Kr-88	1.47 E+04	2.37 E+03	1.52 E+04	2.93 E+03
Kr-89	1.66 E+04	1.01 E+04	1.73 E+04	1.06 E+04
Kr-90	1.56 E+04	7.29 E+03	1.63 E+04	7.83 E+03
Xe-131m	9.15 E+01	4.76 E+02	1.56 E+02	1.11 E+03
Xe-133m	2.51 E+02	9.94 E+02	3.27 E+02	1.48 E+03
Xe-133	2.94 E+02	3.06 E+02	3.53 E+02	1.05 E+03
Xe-135m	3.12 E+03	7.11 E+02	3.36 E+03	7.39 E+02
Xe-135	1.81 E+03	1.86 E+03	1.92 E+03	2.46 E+03
Xe-137	1.42 E+03	1.22 E+04	1.51 E+03	1.27 E+04
Xe-138	8.83 E+03	4.13 E+03	9.21 E+03	4.75 E+03
Ar-41	8.84 E+03	2.69 E+03	9.30 E+03	3.28 E+03

K_i = The total body dose factor for gamma emissions for each identified noble gas radionuclide *i* in mrem/yr per microcurie/m³

L_i = The skin dose factor due to beta emissions for each identified noble gas radionuclide *i* in mrem/yr per microcurie/m³

M_i = The air dose factor for release due to gamma emissions for each identified noble gas radionuclide i, in mrad/yr per microcurie/m³

N_i = The air dose factor for release due to beta emissions for each identified noble gas radionuclide *i*, in mrad/yr per microcurie/m³.

All values in this table were obtained from Reference 11 Table B-1, with units converted.

ATTACHMENT 6: RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION

1. Radioactive Monitors providing Alarm but No Automatic Termination of Release

Instrument	**Minimum** FUNCTIONAL **Channels**	**Applicability**	**ACTION**
Plant Vent (each unit)			
Noble Gas Channel VFS-JE-RE103 (Normal Range) VFS-JE-RE104A (Accident Mid-Range) VFS-JE-RE104B (Accident High Range)	 1 1 1	At all times	47
Iodine Sampler/Monitor VFS-JE-RE102	1	At all times	51
Particulate Sampler/Monitor VFS-JE-RE101	1	At all times	51
Flowrate Monitor VFS-JE-FT105	1	At all times	46
Turbine Island Vent Discharge (each unit)			
Noble Gas Monitor TDS-JE-RE001A (Low Range) TDS-JE-RE001B (High Range)	1 1	During releases	47
Iodine Sampler and Particulate Sampler[a]	1	During releases	51
Flowrate Monitor TDS-JE-FT002	1	During releases	46

ATTACHMENT 6 (continued, page 2 of 2)

a. There is no Iodine or Particulate sampler installed on the Turbine Island Vent Discharge Monitor and ACTION 51 will be followed during confirmed primary-to-secondary leak.

ACTION 46 With the number of channels FUNCTIONAL less than required by the Minimum Channels FUNCTIONAL requirement, effluent releases via this pathway may continue provided the flowrate is estimated at least once per 4 hours.

ACTION 47 With the number of channels FUNCTIONAL less than required by the Minimum Channels FUNCTIONAL requirement, effluent releases via this pathway may continue provided grab samples are taken at least once per 12 hours and these samples are analyzed for radioactivity within 24 hours.

ACTION 48 (Not Used)

ACTION 49 (Not Used)

ACTION 50 (Not Used)

ACTION 51 With the number of channels FUNCTIONAL less than required by the Minimum Channels FUNCTIONAL requirement, effluent releases via the affected pathway may continue provided one of the following is available: 1) samples are continuously collected with the installed skid, or 2) samples are continuously collected with auxiliary sampling equipment.

ATTACHMENT 7: RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION SURVEILLANCE REQUIREMENTS

Channel Description	CHANNEL CHECK	SOURCE CHECK	CHANNEL CALIBRATION	CHANNEL FUNCTIONAL TEST	MODES
Plant Vent (each unit)					
Noble Gas Monitor VFS-JE-RE103 VFS-JE-RE104A VFS-JE-RE104B	D	M	R[b]	Q[a2]	At all times
Iodine Sampler/Monitor VFS-JE-RE102	W[c]	NA	R	R[a2]	At all times
Particulate Sampler/Monitor VFS-JE-RE101	W[c]	NA	R	R[a2]	At all times
Flowrate Monitor VFS-JE-FT105	D	NA	R	Q	At all times
Turbine Island Vent Discharge (each unit)					
Noble Gas Monitor TDS-JE-RE001A TDS-JE-RE001B	D	M	R[b]	Q[a2]	During Release
Flowrate Monitor TDS-JE-FT002	D	NA	R	Q	During Release

ATTACHMENT 7 (continued, page 2 of 2)

a. In addition to the basic functions of a CHANNEL **FUNCTIONAL** TEST:

(1) The CHANNEL **FUNCTIONAL** TEST shall demonstrate that automatic isolation of this pathway and control room annunciation occur if the instrument indicates measured levels above the alarm/trip setpoint.

(2) The CHANNEL **FUNCTIONAL** TEST shall also demonstrate that control room annunciation occurs if any of the following conditions exist:

(a) Instrument indicates measured levels above the alarm/trip setpoint, or

(b) Circuit failure, or

(c) Instrument indicates a downscale failure, or

(d) Instrument controls not set in operate mode.

b. The initial CHANNEL CALIBRATION shall be performed using one or more of the reference standards certified by the National Institute of Standards and Technology or using standards that have been obtained from suppliers that participate in measurements assurance activities with NIST. These standards shall permit calibrating the system over its intended range of energy and measurement range. For subsequent CHANNEL CALIBRATION, sources that have been related to the initial calibration shall be used.

c. The CHANNEL CHECK shall consist of visually verifying that the collection device (i.e., particulate filter or charcoal cartridge, etc.) is in place for sampling.

ATTACHMENT 8: CRITICAL ORGAN DOSE FACTORS,BIOACCUMULATION FACTORS, RADIOACTIVE DECAY CONSTANTS, AND STABLE ELEMENT TRANSFER FACTORS

Dose factors, bioaccumulation factors, radioactive decay constants, and stable element transfer factors are provided for all organs and age groups. Liquid pathways include drinking water, freshwater fish, and sediment. Gaseous pathways include inhalation, garden vegetation, grass-cow-meat, grass-cow-milk, and ground plane. The grass-cow-milk and grass-goat-milk pathways have not been active at the Vogtle site. The resulting dose factors R_{aipj} and A_{IT} are in Attachment 13.

Attachment 13 describes how to generalize the calculation to other age groups, CRITICAL ORGANS, and pathways. Radionuclides not identified do not have dose factors in Reg Guide 1.109 (References 10, 11) or NUREG/CR-4013, NUREG/CR-4653 (References 30, 31).. The radionuclides used in the calculation in Section 6.3.4.e are I-131, I-133, H-3, C-14, and particulates with half-lives greater than 8 days. These particulates are: Cr-51, Te-125m, Te-127m, Te-129m. Nevertheless, all radionuclides with parameters in Reg Guide 1.109 (References 10, 11) are included. C-14 is treated as a gas in pathways involving vegetation, milk, and meat. The following tables represent the input values to derive the inhalation, ground plan, and ingestion pathways in Attachment 13.

Table A8-1 Inhalation Dose Factors for the Infant Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00E+00	2.63E-07	2.63E-07	2.63E-07	2.63E-07	2.63E-07	2.63E-07
C-14	1.89E-05	3.79E-06	3.79E-06	3.79E-06	3.79E-06	3.79E-06	3.79E-06
Na-24	7.54E-06	7.54E-06	7.54E-06	7.54E-06	7.54E-06	7.54E-06	7.54E-06
P-32	1.45E-03	8.03E-05	5.53E-05	0.00E+00	0.00E+00	0.00E+00	1.15E-05
Cr-51	0.00E+00	0.00E+00	6.39E-08	4.11E-08	9.45E-09	9.17E-06	2.55E-07
Mn-54	0.00E+00	1.81E-05	3.56E-06	0.00E+00	3.56E-06	7.14E-04	5.04E-06
Mn-56	0.00E+00	1.10E-09	1.58E-10	0.00E+00	7.86E-10	8.95E-06	5.12E-05
Fe-55	1.41E-05	8.39E-06	2.38E-06	0.00E+00	0.00E+00	6.21E-05	7.82E-07
Fe-59	9.69E-06	1.68E-05	6.77E-06	0.00E+00	0.00E+00	7.25E-04	1.77E-05
Co-57	0.00E+00	4.65E-07	4.58E-07	0.00E+00	0.00E+00	2.71E-04	3.47E-06
Co-58	0.00E+00	8.71E-07	1.30E-06	0.00E+00	0.00E+00	5.55E-04	7.95E-06
Co-60	0.00E+00	5.73E-06	8.41E-06	0.00E+00	0.00E+00	3.22E-03	2.28E-05
Ni-63	2.42E-04	1.46E-05	8.29E-06	0.00E+00	0.00E+00	1.49E-04	1.73E-06
Ni-65	1.71E-09	2.03E-10	8.79E-11	0.00E+00	0.00E+00	5.80E-06	3.58E-05
Cu-64	0.00E+00	1.34E-09	5.53E-10	0.00E+00	2.84E-09	6.64E-06	1.07E-05
Zn-65	1.38E-05	4.47E-05	2.22E-05	0.00E+00	2.32E-05	4.62E-04	3.67E-05
Zn-69m	8.98E-09	1.84E-08	1.67E-09	0.00E+00	7.45E-09	1.91E-05	2.92E-05
Zn-69	3.85E-11	6.91E-11	5.13E-12	0.00E+00	2.87E-11	1.05E-06	9.44E-06
Br-82	0.00E+00	0.00E+00	9.49E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-83	0.00E+00	0.00E+00	2.72E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	2.86E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	1.46E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	1.36E-04	6.30E-05	0.00E+00	0.00E+00	0.00E+00	2.17E-06
Rb-88	0.00E+00	3.98E-07	2.05E-07	0.00E+00	0.00E+00	0.00E+00	2.42E-07
Rb-89	0.00E+00	2.29E-07	1.47E-07	0.00E+00	0.00E+00	0.00E+00	4.87E-08
Sr-89	2.84E-04	0.00E+00	8.15E-06	0.00E+00	0.00E+00	1.45E-03	4.57E-05
Sr-90	1.11E-02	0.00E+00	2.23E-04	0.00E+00	0.00E+00	8.03E-03	9.36E-05
Sr-91	6.83E-08	0.00E+00	2.47E-09	0.00E+00	0.00E+00	3.76E-05	5.24E-05
Sr-92	7.50E-09	0.00E+00	2.79E-10	0.00E+00	0.00E+00	1.70E-05	1.00E-04
Y-90	2.35E-06	0.00E+00	6.30E-08	0.00E+00	0.00E+00	1.92E-04	7.43E-05
Y-91m	2.91E-10	0.00E+00	9.90E-12	0.00E+00	0.00E+00	1.99E-06	1.68E-06
Y-91	4.20E-04	0.00E+00	1.12E-05	0.00E+00	0.00E+00	1.75E-03	5.02E-05
Y-92	1.17E-08	0.00E+00	3.29E-10	0.00E+00	0.00E+00	1.75E-05	9.04E-05
Y-93	1.07E-07	0.00E+00	2.91E-09	0.00E+00	0.00E+00	5.46E-05	1.19E-04
Zr-95	8.24E-05	1.99E-05	1.45E-05	0.00E+00	2.22E-05	1.25E-03	1.55E-05
Zr-97	1.07E-07	1.83E-08	8.36E-09	0.00E+00	1.85E-08	7.88E-05	1.00E-04
Nb-95	1.12E-05	4.59E-06	2.70E-06	0.00E+00	3.37E-06	3.42E-04	9.05E-06
Mo-99	0.00E+00	1.18E-07	2.31E-08	0.00E+00	1.89E-07	9.63E-05	3.48E-05
Tc-99m	9.98E-13	2.06E-12	2.66E-11	0.00E+00	2.22E-11	5.79E-07	1.45E-06
Tc-101	4.65E-14	5.88E-14	5.80E-13	0.00E+00	6.99E-13	4.17E-07	6.03E-07
Ru-103	1.44E-06	0.00E+00	4.85E-07	0.00E+00	3.03E-06	3.94E-04	1.15E-05
Ru-105	8.74E-10	0.00E+00	2.93E-10	0.00E+00	6.42E-10	1.12E-05	3.46E-05
Ru-106	6.20E-05	0.00E+00	7.77E-06	0.00E+00	7.61E-05	8.26E-03	1.17E-04
Rh-105	8.26E-09	5.41E-09	3.63E-09	0.00E+00	1.50E-08	2.08E-05	1.37E-05
Ag-110m	7.13E-06	5.16E-06	3.57E-06	0.00E+00	7.80E-06	2.62E-03	2.36E-05
Cd-113m	0.00E+00	6.67E-04	2.64E-05	0.00E+00	5.80E-04	1.40E-03	1.65E-05
Sb-124	2.71E-05	3.97E-07	8.56E-06	7.18E-08	0.00E+00	1.89E-03	4.22E-05
Sb-125	3.69E-05	3.41E-07	7.78E-06	4.45E-08	0.00E+00	1.17E-03	1.05E-05
Sb-126	3.08E-06	6.01E-08	1.11E-06	2.35E-08	0.00E+00	6.88E-04	5.33E-05

All values are in (mrem/pCi inhaled). They are obtained from Reference 11 (Table E-10), Reference 30, and Reference 31.

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Table A8-1 (contd) Inhalation Dose Factors for the Infant Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Sb-127	2.82E-07	5.04E-09	8.76E-08	3.60E-09	0.00E+00	1.54E-04	3.78E-05
Te-125m	3.40E-06	1.42E-06	4.70E-07	1.16E-06	0.00E+00	3.19E-04	9.22E-06
Te-127m	1.19E-05	4.93E-06	1.48E-06	3.48E-06	2.68E-05	9.37E-04	1.95E-05
Te-127	1.59E-09	6.81E-10	3.49E-10	1.32E-09	3.47E-09	7.39E-06	1.74E-05
Te-129m	1.01E-05	4.35E-06	1.59E-06	3.91E-06	2.27E-05	1.20E-03	4.93E-05
Te-129	5.63E-11	2.48E-11	1.34E-11	4.82E-11	1.25E-10	2.14E-06	1.88E-05
Te-131m	7.62E-08	3.93E-08	2.59E-08	6.38E-08	1.89E-07	1.42E-04	8.51E-05
Te-131	1.24E-11	5.87E-12	3.57E-12	1.13E-11	2.85E-11	1.47E-06	5.87E-06
Te-132	2.66E-07	1.69E-07	1.26E-07	1.99E-07	7.39E-07	2.43E-04	3.15E-05
I-129	2.16E-05	1.59E-05	1.16E-05	1.04E-02	1.88E-05	0.00E+00	2.12E-07
I-130	4.54E-06	9.91E-06	3.98E-06	1.14E-03	1.09E-05	0.00E+00	1.42E-06
I-131	2.71E-05	3.17E-05	1.40E-05	1.06E-02	3.70E-05	0.00E+00	7.56E-07
I-132	1.21E-06	2.53E-06	8.99E-07	1.21E-04	2.82E-06	0.00E+00	1.36E-06
I-133	9.46E-06	1.37E-05	4.00E-06	2.54E-03	1.60E-05	0.00E+00	1.54E-06
I-134	6.58E-07	1.34E-06	4.75E-07	3.18E-05	1.49E-06	0.00E+00	9.21E-07
I-135	2.76E-06	5.43E-06	1.98E-06	4.97E-04	6.05E-06	0.00E+00	1.31E-06
Cs-134	2.83E-04	5.02E-04	5.32E-05	0.00E+00	1.36E-04	5.69E-05	9.53E-07
Cs-135	1.00E-04	8.66E-05	4.73E-06	0.00E+00	2.58E-05	1.01E-05	2.18E-07
Cs-136	3.45E-05	9.61E-05	3.78E-05	0.00E+00	4.03E-05	8.40E-06	1.02E-06
Cs-137	3.92E-04	4.37E-04	3.25E-05	0.00E+00	1.23E-04	5.09E-05	9.53E-07
Cs-138	3.61E-07	5.58E-07	2.84E-07	0.00E+00	2.93E-07	4.67E-08	6.26E-07
Ba-139	1.06E-09	7.03E-13	3.07E-11	0.00E+00	4.23E-13	4.25E-06	3.64E-05
Ba-140	4.00E-05	4.00E-08	2.07E-06	0.00E+00	9.59E-09	1.14E-03	2.74E-05
Ba-141	1.12E-10	7.70E-14	3.55E-12	0.00E+00	4.64E-14	2.12E-06	3.39E-06
Ba-142	2.84E-11	2.36E-14	1.40E-12	0.00E+00	1.36E-14	1.11E-06	4.95E-07
La-140	3.61E-07	1.43E-07	3.68E-08	0.00E+00	0.00E+00	1.20E-04	6.06E-05
La-142	7.36E-10	2.69E-10	6.46E-11	0.00E+00	0.00E+00	5.87E-06	4.25E-05
Ce-141	1.98E-05	1.19E-05	1.42E-06	0.00E+00	3.75E-06	3.69E-04	1.54E-05
Ce-143	2.09E-07	1.38E-07	1.58E-08	0.00E+00	4.03E-08	8.30E-05	3.55E-05
Ce-144	2.28E-03	8.65E-04	1.26E-04	0.00E+00	3.84E-04	7.03E-03	1.06E-04
Pr-143	1.00E-05	3.74E-06	4.99E-07	0.00E+00	1.41E-06	3.09E-04	2.66E-05
Pr-144	3.42E-11	1.32E-11	1.72E-12	0.00E+00	4.80E-12	1.15E-06	3.06E-06
Nd-147	5.67E-06	5.81E-06	3.57E-07	0.00E+00	2.25E-06	2.30E-04	2.23E-05
Eu-152	7.83E-04	1.77E-04	1.72E-04	0.00E+00	5.94E-04	1.48E-03	9.88E-06
W-187	9.26E-09	6.44E-09	2.23E-09	0.00E+00	0.00E+00	2.83E-05	2.54E-05
Np-239	2.65E-07	2.37E-08	1.34E-08	0.00E+00	4.73E-08	4.25E-05	1.78E-05

Table A8-2 Inhalation Dose Factors for the Child Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00E+00	1.73E-07	1.73E-07	1.73E-07	1.73E-07	1.73E-07	1.73E-07
C-14	9.70E-06	1.82E-06	1.82E-06	1.82E-06	1.82E-06	1.82E-06	1.82E-06
Na-24	4.35E-06	4.35E-06	4.35E-06	4.35E-06	4.35E-06	4.35E-06	4.35E-06
P-32	7.04E-04	3.09E-05	2.67E-05	0.00E+00	0.00E+00	0.00E+00	1.14E-05
Cr-51	0.00E+00	0.00E+00	4.17E-08	2.31E-08	6.57E-09	4.59E-06	2.93E-07
Mn-54	0.00E+00	1.16E-05	2.57E-06	0.00E+00	2.71E-06	4.26E-04	6.19E-06
Mn-56	0.00E+00	4.48E-10	8.43E-11	0.00E+00	4.52E-10	3.55E-06	3.33E-05
Fe-55	1.28E-05	6.80E-06	2.10E-06	0.00E+00	0.00E+00	3.00E-05	7.75E-07
Fe-59	5.59E-06	9.04E-06	4.51E-06	0.00E+00	0.00E+00	3.43E-04	1.91E-05
Co-57	0.00E+00	2.44E-07	2.88E-07	0.00E+00	0.00E+00	1.37E-04	3.58E-06
Co-58	0.00E+00	4.79E-07	8.55E-07	0.00E+00	0.00E+00	2.99E-04	9.29E-06
Co-60	0.00E+00	3.55E-06	6.12E-06	0.00E+00	0.00E+00	1.91E-03	2.60E-05
Ni-63	2.22E-04	1.25E-05	7.56E-06	0.00E+00	0.00E+00	7.43E-05	1.71E-06
Ni-65	8.08E-10	7.99E-11	4.44E-11	0.00E+00	0.00E+00	2.21E-06	2.27E-05
Cu-64	0.00E+00	5.39E-10	2.90E-10	0.00E+00	1.63E-09	2.59E-06	9.92E-06
Zn-65	1.15E-05	3.06E-05	1.90E-05	0.00E+00	1.93E-05	2.69E-04	4.41E-06
Zn-69m	4.26E-09	7.28E-09	8.59E-10	0.00E+00	4.22E-09	7.36E-06	2.71E-05
Zn-69	1.81E-11	2.61E-11	2.41E-12	0.00E+00	1.58E-11	3.84E-07	2.75E-06
Br-82	0.00E+00	0.00E+00	5.66E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-83	0.00E+00	0.00E+00	1.28E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	1.48E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	6.84E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	5.36E-05	3.09E-05	0.00E+00	0.00E+00	0.00E+00	2.16E-06
Rb-88	0.00E+00	1.52E-07	9.90E-08	0.00E+00	0.00E+00	0.00E+00	4.66E-09
Rb-89	0.00E+00	9.33E-08	7.83E-08	0.00E+00	0.00E+00	0.00E+00	5.11E-10
Sr-89	1.62E-04	0.00E+00	4.66E-06	0.00E+00	0.00E+00	5.83E-04	4.52E-05
Sr-90	1.04E-02	0.00E+00	2.07E-04	0.00E+00	0.00E+00	3.99E-03	9.28E-05
Sr-91	3.28E-08	0.00E+00	1.24E-09	0.00E+00	0.00E+00	1.44E-05	4.70E-05
Sr-92	3.54E-09	0.00E+00	1.42E-10	0.00E+00	0.00E+00	6.49E-06	6.55E-05
Y-90	1.11E-06	0.00E+00	2.99E-08	0.00E+00	0.00E+00	7.07E-05	7.24E-05
Y-91m	1.37E-10	0.00E+00	4.98E-12	0.00E+00	0.00E+00	7.60E-07	4.64E-07
Y-91	2.47E-04	0.00E+00	6.59E-06	0.00E+00	0.00E+00	7.10E-04	4.97E-05
Y-92	5.50E-09	0.00E+00	1.57E-10	0.00E+00	0.00E+00	6.46E-06	6.46E-05
Y-93	5.04E-08	0.00E+00	1.38E-09	0.00E+00	0.00E+00	2.01E-05	1.05E-04
Zr-95	5.13E-05	1.13E-05	1.00E-05	0.00E+00	1.61E-05	6.03E-04	1.65E-05
Zr-97	5.07E-08	7.34E-09	4.32E-09	0.00E+00	1.05E-08	3.06E-05	9.49E-05
Nb-95	6.35E-06	2.48E-06	1.77E-06	0.00E+00	2.33E-06	1.66E-04	1.00E-05
Mo-99	0.00E+00	4.66E-08	1.15E-08	0.00E+00	1.06E-07	3.66E-05	3.42E-05
Tc-99m	4.81E-13	9.41E-13	1.56E-11	0.00E+00	1.37E-11	2.57E-07	1.30E-06
Tc-101	2.19E-14	2.30E-14	2.91E-13	0.00E+00	3.92E-13	1.58E-07	4.41E-09
Ru-103	7.55E-07	0.00E+00	2.90E-07	0.00E+00	1.90E-06	1.79E-04	1.21E-05
Ru-105	4.13E-10	0.00E+00	1.50E-10	0.00E+00	3.63E-10	4.30E-06	2.69E-05
Ru-106	3.68E-05	0.00E+00	4.57E-06	0.00E+00	4.97E-05	3.87E-03	1.16E-04
Rh-105	3.91E-09	2.10E-09	1.79E-09	0.00E+00	8.39E-09	7.82E-06	1.33E-05
Ag-110m	4.56E-06	3.08E-06	2.47E-06	0.00E+00	5.74E-06	1.48E-03	2.71E-05
Cd-113m	0.00E+00	4.93E-04	2.12E-05	0.00E+00	5.13E-04	6.94E-04	1.63E-05
Sb-124	1.55E-05	2.00E-07	5.41E-06	3.41E-08	0.00E+00	8.76E-04	4.43E-05
Sb-125	2.66E-05	2.05E-07	5.59E-06	2.46E-08	0.00E+00	6.27E-04	1.09E-05
Sb-126	1.72E-06	2.62E-08	6.16E-07	1.00E-08	0.00E+00	2.86E-04	5.67E-05

All values are in (mrem/pCi inhaled). They are obtained from Reference 11 (Table E-9), Reference 30, and Reference 31.

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Table A8-2 (contd) Inhalation Dose Factors for the Child Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Sb-127	1.36E-07	2.09E-09	4.70E-08	1.51E-09	0.00E+00	6.17E-05	3.82E-05
Te-125m	1.82E-06	6.29E-07	2.47E-07	5.20E-07	0.00E+00	1.29E-04	9.13E-06
Te-127m	6.72E-06	2.31E-06	8.16E-07	1.64E-06	1.72E-05	4.00E-04	1.93E-05
Te-127	7.49E-10	2.57E-10	1.65E-10	5.30E-10	1.91E-09	2.71E-06	1.52E-05
Te-129m	5.19E-06	1.85E-06	8.22E-07	1.71E-06	1.36E-05	4.76E-04	4.91E-05
Te-129	2.64E-11	9.45E-12	6.44E-12	1.93E-11	6.94E-11	7.93E-07	6.89E-06
Te-131m	3.63E-08	1.60E-08	1.37E-08	2.64E-08	1.08E-07	5.56E-05	8.32E-05
Te-131	5.87E-12	2.28E-12	1.78E-12	4.59E-12	1.59E-11	5.55E-07	3.60E-07
Te-132	1.30E-07	7.36E-08	7.12E-08	8.58E-08	4.79E-07	1.02E-04	3.72E-05
I-129	1.05E-05	6.40E-06	5.71E-06	4.28E-03	1.08E-05	0.00E+00	2.15E-07
I-130	2.21E-06	4.43E-06	2.28E-06	4.99E-04	6.61E-06	0.00E+00	1.38E-06
I-131	1.30E-05	1.30E-05	7.37E-06	4.39E-03	2.13E-05	0.00E+00	7.68E-07
I-132	5.72E-07	1.10E-06	5.07E-07	5.23E-05	1.69E-06	0.00E+00	8.65E-07
I-133	4.48E-06	5.49E-06	2.08E-06	1.04E-03	9.13E-06	0.00E+00	1.48E-06
I-134	3.17E-07	5.84E-07	2.69E-07	1.37E-05	8.92E-07	0.00E+00	2.58E-07
I-135	1.33E-06	2.36E-06	1.12E-06	2.14E-04	3.62E-06	0.00E+00	1.20E-06
Cs-134	1.76E-04	2.74E-04	6.07E-05	0.00E+00	8.93E-05	3.27E-05	1.04E-06
Cs-135	6.23E-05	4.13E-05	4.45E-06	0.00E+00	1.53E-05	5.22E-06	2.17E-07
Cs-136	1.76E-05	4.62E-05	3.14E-05	0.00E+00	2.58E-05	3.93E-06	1.13E-06
Cs-137	2.45E-04	2.23E-04	3.47E-05	0.00E+00	7.63E-05	2.81E-05	9.78E-07
Cs-138	1.71E-07	2.27E-07	1.50E-07	0.00E+00	1.68E-07	1.84E-08	7.29E-08
Ba-139	4.98E-10	2.66E-13	1.45E-11	0.00E+00	2.33E-13	1.56E-06	1.56E-05
Ba-140	2.00E-05	1.75E-08	1.17E-06	0.00E+00	5.71E-09	4.71E-04	2.75E-05
Ba-141	5.29E-11	2.95E-14	1.72E-12	0.00E+00	2.56E-14	7.89E-07	7.44E-08
Ba-142	1.35E-11	9.73E-15	7.54E-13	0.00E+00	7.87E-15	4.44E-07	7.41E-10
La-140	1.74E-07	6.08E-08	2.04E-08	0.00E+00	0.00E+00	4.94E-05	6.10E-05
La-142	3.50E-10	1.11E-10	3.49E-11	0.00E+00	0.00E+00	2.35E-06	2.05E-05
Ce-141	1.06E-05	5.28E-06	7.83E-07	0.00E+00	2.31E-06	1.47E-04	1.53E-05
Ce-143	9.89E-08	5.37E-08	7.77E-09	0.00E+00	2.26E-08	3.12E-05	3.44E-05
Ce-144	1.83E-03	5.72E-04	9.77E-05	0.00E+00	3.17E-04	3.23E-03	1.05E-04
Pr-143	4.99E-06	1.50E-06	2.47E-07	0.00E+00	8.11E-07	1.17E-04	2.63E-05
Pr-144	1.61E-11	4.99E-12	8.10E-13	0.00E+00	2.64E-12	4.23E-07	5.32E-08
Nd-147	2.92E-06	2.36E-06	1.84E-07	0.00E+00	1.30E-06	8.87E-05	2.22E-05
Eu-152	7.42E-04	1.37E-04	1.61E-04	0.00E+00	5.73E-04	9.00E-04	1.14E-05
W-187	4.41E-09	2.61E-09	1.17E-09	0.00E+00	0.00E+00	1.11E-05	2.46E-05
Np-239	1.26E-07	9.04E-09	6.35E-09	0.00E+00	2.63E-08	1.57E-05	1.73E-05

Table A8-3 Inhalation Dose Factors for the Teenager Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00E+00	9.06E-08	9.06E-08	9.06E-08	9.06E-08	9.06E-08	9.06E-08
C-14	3.25E-06	6.09E-07	6.09E-07	6.09E-07	6.09E-07	6.09E-07	6.09E-07
Na-24	1.72E-06	1.72E-06	1.72E-06	1.72E-06	1.72E-06	1.72E-06	1.72E-06
P-32	2.36E-04	1.37E-05	8.95E-06	0.00E+00	0.00E+00	0.00E+00	1.16E-05
Cr-51	0.00E+00	0.00E+00	1.69E-08	9.37E-09	3.84E-09	2.62E-06	3.75E-07
Mn-54	0.00E+00	6.39E-06	1.05E-06	0.00E+00	1.59E-06	2.48E-04	8.35E-06
Mn-56	0.00E+00	2.12E-10	3.15E-11	0.00E+00	2.24E-10	1.90E-06	7.18E-06
Fe-55	4.18E-06	2.98E-06	6.93E-07	0.00E+00	0.00E+00	1.55E-05	7.99E-07
Fe-59	1.99E-06	4.62E-06	1.79E-06	0.00E+00	0.00E+00	1.91E-04	2.23E-05
Co-57	0.00E+00	1.18E-07	1.15E-07	0.00E+00	0.00E+00	7.33E-05	3.93E-06
Co-58	0.00E+00	2.59E-07	3.47E-07	0.00E+00	0.00E+00	1.68E-04	1.19E-05
Co-60	0.00E+00	1.89E-06	2.48E-06	0.00E+00	0.00E+00	1.09E-03	3.24E-05
Ni-63	7.25E-05	5.43E-06	2.47E-06	0.00E+00	0.00E+00	3.84E-05	1.77E-06
Ni-65	2.73E-10	3.66E-11	1.59E-11	0.00E+00	0.00E+00	1.17E-06	4.59E-06
Cu-64	0.00E+00	2.54E-10	1.06E-10	0.00E+00	8.01E-10	1.39E-06	7.68E-06
Zn-65	4.82E-06	1.67E-05	7.80E-06	0.00E+00	1.08E-05	1.55E-04	5.83E-06
Zn-69m	1.44E-09	3.39E-09	3.11E-10	0.00E+00	2.06E-09	3.92E-06	2.14E-05
Zn-69	6.04E-12	1.15E-11	8.07E-13	0.00E+00	7.53E-12	1.98E-07	3.56E-08
Br-82	0.00E+00	0.00E+00	2.28E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-83	0.00E+00	0.00E+00	4.30E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	5.41E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	2.29E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	2.38E-05	1.05E-05	0.00E+00	0.00E+00	0.00E+00	2.21E-06
Rb-88	0.00E+00	6.82E-08	3.40E-08	0.00E+00	0.00E+00	0.00E+00	3.65E-15
Rb-89	0.00E+00	4.40E-08	2.91E-08	0.00E+00	0.00E+00	0.00E+00	4.22E-17
Sr-89	5.43E-05	0.00E+00	1.56E-06	0.00E+00	0.00E+00	3.02E-04	4.64E-05
Sr-90	4.14E-03	0.00E+00	8.33E-05	0.00E+00	0.00E+00	2.06E-03	9.56E-05
Sr-91	1.10E-08	0.00E+00	4.39E-10	0.00E+00	0.00E+00	7.59E-06	3.24E-05
Sr-92	1.19E-09	0.00E+00	5.08E-11	0.00E+00	0.00E+00	3.43E-06	1.49E-05
Y-90	3.73E-07	0.00E+00	1.00E-08	0.00E+00	0.00E+00	3.66E-05	6.99E-05
Y-91m	4.63E-11	0.00E+00	1.77E-12	0.00E+00	0.00E+00	4.00E-07	3.77E-09
Y-91	8.26E-05	0.00E+00	2.21E-06	0.00E+00	0.00E+00	3.67E-04	5.11E-05
Y-92	1.84E-09	0.00E+00	5.36E-11	0.00E+00	0.00E+00	3.35E-06	2.06E-05
Y-93	1.69E-08	0.00E+00	4.65E-10	0.00E+00	0.00E+00	1.04E-05	7.24E-05
Zr-95	1.82E-05	5.73E-06	3.94E-06	0.00E+00	8.42E-06	3.36E-04	1.86E-05
Zr-97	1.72E-08	3.40E-09	1.57E-09	0.00E+00	5.15E-09	1.62E-05	7.88E-05
Nb-95	2.32E-06	1.29E-06	7.08E-07	0.00E+00	1.25E-06	9.39E-05	1.21E-05
Mo-99	0.00E+00	2.11E-08	4.03E-09	0.00E+00	5.14E-08	1.92E-05	3.36E-05
Tc-99m	1.73E-13	4.83E-13	6.24E-12	0.00E+00	7.20E-12	1.44E-07	7.66E-07
Tc-101	7.40E-15	1.05E-14	1.03E-13	0.00E+00	1.90E-13	8.34E-08	1.09E-16
Ru-103	2.63E-07	0.00E+00	1.12E-07	0.00E+00	9.29E-07	9.79E-05	1.36E-05
Ru-105	1.40E-10	0.00E+00	5.42E-11	0.00E+00	1.76E-10	2.27E-06	1.13E-05
Ru-106	1.23E-05	0.00E+00	1.55E-06	0.00E+00	2.38E-05	2.01E-03	1.20E-04
Rh-105	1.32E-09	9.48E-10	6.24E-10	0.00E+00	4.04E-09	4.09E-06	1.23E-05
Ag-110m	1.73E-06	1.64E-06	9.99E-07	0.00E+00	3.13E-06	8.44E-04	3.41E-05
Cd-113m	0.00E+00	2.17E-04	7.10E-06	0.00E+00	2.43E-04	3.59E-04	1.68E-05
Sb-124	5.38E-06	9.92E-08	2.10E-06	1.22E-08	0.00E+00	4.81E-04	4.98E-05
Sb-125	9.23E-06	1.01E-07	2.15E-06	8.80E-09	0.00E+00	3.42E-04	1.24E-05
Sb-126	0.00E+00	0.00E+00	4.30E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00

All values are in (mrem/pCi inhaled). They are obtained from Reference 11 (Table E-8), Reference 30, and Reference 31.

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Table A8-3 (contd) Inhalation Dose Factors for the Teenager Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Sb-127	4.64E-08	9.92E-10	1.75E-08	5.21E-10	0.00E+00	3.31E-05	3.94E-05
Te-125m	6.10E-07	2.80E-07	8.34E-08	1.75E-07	0.00E+00	6.70E-05	9.38E-06
Te-127m	2.25E-06	1.02E-06	2.73E-07	5.48E-07	8.17E-06	2.07E-04	1.99E-05
Te-127	2.51E-10	1.14E-10	5.52E-11	1.77E-10	9.10E-10	1.40E-06	1.01E-05
Te-129m	1.74E-06	8.23E-07	2.81E-07	5.72E-07	6.49E-06	2.47E-04	5.06E-05
Te-129	8.87E-12	4.22E-12	2.20E-12	6.48E-12	3.32E-11	4.12E-07	2.02E-07
Te-131m	1.23E-08	7.51E-09	5.03E-09	9.06E-09	5.49E-08	2.97E-05	7.76E-05
Te-131	1.97E-12	1.04E-12	6.30E-13	1.55E-12	7.72E-12	2.92E-07	1.89E-09
Te-132	4.50E-08	3.63E-08	2.74E-08	3.07E-08	2.44E-07	5.61E-05	5.79E-05
I-129	3.53E-06	2.94E-06	4.90E-06	3.66E-03	5.26E-06	0.00E+00	2.29E-07
I-130	7.80E-07	2.24E-06	8.96E-07	1.86E-04	3.44E-06	0.00E+00	1.14E-06
I-131	4.43E-06	6.14E-06	3.30E-06	1.83E-03	1.05E-05	0.00E+00	8.11E-07
I-132	1.99E-07	5.47E-07	1.97E-07	1.89E-05	8.65E-07	0.00E+00	1.59E-07
I-133	1.52E-06	2.56E-06	7.78E-07	3.65E-04	4.49E-06	0.00E+00	1.29E-06
I-134	1.11E-07	2.90E-07	1.05E-07	4.94E-06	4.58E-07	0.00E+00	2.55E-09
I-135	4.62E-07	1.18E-06	4.36E-07	7.76E-05	1.86E-06	0.00E+00	8.69E-07
Cs-134	6.28E-05	1.41E-04	6.86E-05	0.00E+00	4.69E-05	1.83E-05	1.22E-06
Cs-135	2.08E-05	1.82E-05	4.47E-06	0.00E+00	7.30E-06	2.70E-06	2.23E-07
Cs-136	6.44E-06	2.42E-05	1.71E-05	0.00E+00	1.38E-05	2.22E-06	1.36E-06
Cs-137	8.38E-05	1.06E-04	3.89E-05	0.00E+00	3.80E-05	1.51E-05	1.06E-06
Cs-138	5.82E-08	1.07E-07	5.58E-08	0.00E+00	8.28E-08	9.84E-09	3.38E-11
Ba-139	1.67E-10	1.18E-13	4.87E-12	0.00E+00	1.11E-13	8.08E-07	8.06E-07
Ba-140	6.84E-06	8.38E-09	4.40E-07	0.00E+00	2.85E-09	2.54E-04	2.86E-05
Ba-141	1.78E-11	1.32E-14	5.93E-13	0.00E+00	1.23E-14	4.11E-07	9.33E-14
Ba-142	4.62E-12	4.63E-15	2.84E-13	0.00E+00	3.92E-15	2.39E-07	5.99E-20
La-140	5.99E-08	2.95E-08	7.82E-09	0.00E+00	0.00E+00	2.68E-05	6.09E-05
La-142	1.20E-10	5.31E-11	1.32E-11	0.00E+00	0.00E+00	1.27E-06	1.50E-06
Ce-141	3.55E-06	2.37E-06	2.71E-07	0.00E+00	1.11E-06	7.67E-05	1.58E-05
Ce-143	3.32E-08	2.42E-08	2.70E-09	0.00E+00	1.08E-08	1.63E-05	3.19E-05
Ce-144	6.11E-04	2.53E-04	3.28E-05	0.00E+00	1.51E-04	1.67E-03	1.08E-04
Pr-143	1.67E-06	6.64E-07	8.28E-08	0.00E+00	3.86E-07	6.04E-05	2.67E-05
Pr-144	5.37E-12	2.20E-12	2.72E-13	0.00E+00	1.26E-12	2.19E-07	2.94E-14
Nd-147	9.83E-07	1.07E-06	6.41E-08	0.00E+00	6.28E-07	4.65E-05	2.28E-05
Eu-152	2.96E-04	7.19E-05	6.30E-05	0.00E+00	3.34E-04	5.01E-04	1.35E-05
W-187	1.50E-09	1.22E-09	4.29E-10	0.00E+00	0.00E+00	5.92E-06	2.21E-05
Np-239	4.23E-08	3.99E-09	2.21E-09	0.00E+00	1.25E-08	8.11E-06	1.65E-05

Table A8-4 Inhalation Dose Factors for the Adult Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00E+00	8.98E-08	8.98E-08	8.98E-08	8.98E-08	8.98E-08	8.98E-08
C-14	2.27E-06	4.26E-07	4.26E-07	4.26E-07	4.26E-07	4.26E-07	4.26E-07
Na-24	1.28E-06	1.28E-06	1.28E-06	1.28E-06	1.28E-06	1.28E-06	1.28E-06
P-32	1.65E-04	9.64E-06	6.26E-06	0.00E+00	0.00E+00	0.00E+00	1.08E-05
Cr-51	0.00E+00	0.00E+00	1.25E-08	7.44E-09	2.85E-09	1.80E-06	4.15E-07
Mn-54	0.00E+00	4.95E-06	7.87E-07	0.00E+00	1.23E-06	1.75E-04	9.67E-06
Mn-56	0.00E+00	1.55E-10	2.29E-11	0.00E+00	1.63E-10	1.18E-06	2.53E-06
Fe-55	3.07E-06	2.12E-06	4.93E-07	0.00E+00	0.00E+00	9.01E-06	7.54E-07
Fe-59	1.47E-06	3.47E-06	1.32E-06	0.00E+00	0.00E+00	1.27E-04	2.35E-05
Co-57	0.00E+00	8.65E-08	8.39E-08	0.00E+00	0.00E+00	4.62E-05	3.93E-06
Co-58	0.00E+00	1.98E-07	2.59E-07	0.00E+00	0.00E+00	1.16E-04	1.33E-05
Co-60	0.00E+00	1.44E-06	1.85E-06	0.00E+00	0.00E+00	7.46E-04	3.56E-05
Ni-63	5.40E-05	3.93E-06	1.81E-06	0.00E+00	0.00E+00	2.23E-05	1.67E-06
Ni-65	1.92E-10	2.62E-11	1.14E-11	0.00E+00	0.00E+00	7.00E-07	1.54E-06
Cu-64	0.00E+00	1.83E-10	7.69E-11	0.00E+00	5.78E-10	8.48E-07	6.12E-06
Zn-65	4.05E-06	1.29E-05	5.82E-06	0.00E+00	8.62E-06	1.08E-04	6.68E-06
Zn-69m	1.02E-09	2.45E-09	2.24E-10	0.00E+00	1.48E-09	2.38E-06	1.71E-05
Zn-69	4.23E-12	8.14E-12	5.65E-13	0.00E+00	5.27E-12	1.15E-07	2.04E-09
Br-82	0.00E+00	0.00E+00	1.69E-06	0.00E+00	0.00E+00	0.00E+00	1.30E-06
Br-83	0.00E+00	0.00E+00	3.01E-08	0.00E+00	0.00E+00	0.00E+00	2.90E-08
Br-84	0.00E+00	0.00E+00	3.91E-08	0.00E+00	0.00E+00	0.00E+00	2.05E-13
Br-85	0.00E+00	0.00E+00	1.60E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	1.69E-05	7.37E-06	0.00E+00	0.00E+00	0.00E+00	2.08E-06
Rb-88	0.00E+00	4.84E-08	2.41E-08	0.00E+00	0.00E+00	0.00E+00	4.18E-19
Rb-89	0.00E+00	3.20E-08	2.12E-08	0.00E+00	0.00E+00	0.00E+00	1.16E-21
Sr-89	3.80E-05	0.00E+00	1.09E-06	0.00E+00	0.00E+00	1.75E-04	4.37E-05
Sr-90	3.59E-03	0.00E+00	7.21E-05	0.00E+00	0.00E+00	1.20E-03	9.02E-05
Sr-91	7.74E-09	0.00E+00	3.13E-10	0.00E+00	0.00E+00	4.56E-06	2.39E-05
Sr-92	8.43E-10	0.00E+00	3.64E-11	0.00E+00	0.00E+00	2.06E-06	5.38E-06
Y-90	2.61E-07	0.00E+00	7.01E-09	0.00E+00	0.00E+00	2.12E-05	6.32E-05
Y-91m	3.26E-11	0.00E+00	1.27E-12	0.00E+00	0.00E+00	2.40E-07	1.66E-10
Y-91	5.78E-05	0.00E+00	1.55E-06	0.00E+00	0.00E+00	2.13E-04	4.81E-05
Y-92	1.29E-09	0.00E+00	3.77E-11	0.00E+00	0.00E+00	1.96E-06	9.19E-06
Y-93	1.18E-08	0.00E+00	3.26E-10	0.00E+00	0.00E+00	6.06E-06	5.27E-05
Zr-95	1.34E-05	4.30E-06	2.91E-06	0.00E+00	6.77E-06	2.21E-04	1.88E-05
Zr-97	1.21E-08	2.45E-09	1.13E-09	0.00E+00	3.71E-09	9.84E-06	6.54E-05
Nb-95	1.76E-06	9.77E-07	5.26E-07	0.00E+00	9.67E-07	6.31E-05	1.30E-05
Mo-99	0.00E+00	1.51E-08	2.87E-09	0.00E+00	3.64E-08	1.14E-05	3.10E-05
Tc-99m	1.29E-13	3.64E-13	4.63E-12	0.00E+00	5.52E-12	9.55E-08	5.20E-07
Tc-101	5.22E-15	7.52E-15	7.38E-14	0.00E+00	1.35E-13	4.99E-08	1.36E-21
Ru-103	1.91E-07	0.00E+00	8.23E-08	0.00E+00	7.29E-07	6.31E-05	1.38E-05
Ru-105	9.88E-11	0.00E+00	3.89E-11	0.00E+00	1.27E-10	1.37E-06	6.02E-06
Ru-106	8.64E-06	0.00E+00	1.09E-06	0.00E+00	1.67E-05	1.17E-03	1.14E-04
Rh-105	9.24E-10	6.73E-10	4.43E-10	0.00E+00	2.86E-09	2.41E-06	1.09E-05
Ag-110m	1.35E-06	1.25E-06	7.43E-07	0.00E+00	2.46E-06	5.79E-04	3.78E-05
Cd-113m	0.00E+00	1.54E-04	4.97E-06	0.00E+00	1.71E-04	2.08E-04	1.59E-05
Sb-124	3.90E-06	7.36E-08	1.55E-06	9.44E-09	0.00E+00	3.10E-04	5.08E-05
Sb-125	6.67E-06	7.44E-08	1.58E-06	6.75E-09	0.00E+00	2.18E-04	1.26E-05
Sb-126	4.50E-07	9.13E-09	1.62E-07	2.75E-09	0.00E+00	9.57E-05	6.01E-05

All values are in (mrem/pCi inhaled). They are obtained from Reference 11 (Table E-7), Reference 30, and Reference 31.

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Table A8-4 (contd) Inhalation Dose Factors for the Adult Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Sb-127	3.30E-08	7.22E-10	1.27E-08	3.97E-10	0.00E+00	2.05E-05	3.77E-05
Te-125m	4.27E-07	1.98E-07	5.84E-08	1.31E-07	1.55E-06	3.92E-05	8.83E-06
Te-127m	1.58E-06	7.21E-07	1.96E-07	4.11E-07	5.72E-06	1.20E-04	1.87E-05
Te-127	1.75E-10	8.03E-11	3.87E-11	1.32E-10	6.37E-10	8.14E-07	7.17E-06
Te-129m	1.22E-06	5.84E-07	1.98E-07	4.30E-07	4.57E-06	1.45E-04	4.79E-05
Te-129	6.22E-12	2.99E-12	1.55E-12	4.87E-12	2.34E-11	2.42E-07	1.96E-08
Te-131m	8.74E-09	5.45E-09	3.63E-09	6.88E-09	3.86E-08	1.82E-05	6.95E-05
Te-131	1.39E-12	7.44E-13	4.49E-13	1.17E-12	5.46E-12	1.74E-07	2.30E-09
Te-132	3.25E-08	2.69E-08	2.02E-08	2.37E-08	1.82E-07	3.60E-05	6.37E-05
I-129	2.48E-06	2.11E-06	6.91E-06	5.54E-03	4.53E-06	0.00E+00	2.22E-07
I-130	5.72E-07	1.68E-06	6.60E-07	1.42E-04	2.61E-06	0.00E+00	9.61E-07
I-131	3.15E-06	4.47E-06	2.56E-06	1.49E-03	7.66E-06	0.00E+00	7.85E-07
I-132	1.45E-07	4.07E-07	1.45E-07	1.43E-05	6.48E-07	0.00E+00	5.08E-08
I-133	1.08E-06	1.85E-06	5.65E-07	2.69E-04	3.23E-06	0.00E+00	1.11E-06
I-134	8.05E-08	2.16E-07	7.69E-08	3.73E-06	3.44E-07	0.00E+00	1.26E-10
I-135	3.35E-07	8.73E-07	3.21E-07	5.60E-05	1.39E-06	0.00E+00	6.56E-07
Cs-134	4.66E-05	1.06E-04	9.10E-05	0.00E+00	3.59E-05	1.22E-05	1.30E-06
Cs-135	1.46E-05	1.29E-05	5.99E-06	0.00E+00	5.11E-06	1.57E-06	2.11E-07
Cs-136	4.88E-06	1.83E-05	1.38E-05	0.00E+00	1.07E-05	1.50E-06	1.46E-06
Cs-137	5.98E-05	7.76E-05	5.35E-05	0.00E+00	2.78E-05	9.40E-06	1.05E-06
Cs-138	4.14E-08	7.76E-08	4.05E-08	0.00E+00	6.00E-08	6.07E-09	2.33E-13
Ba-139	1.17E-10	8.32E-14	3.42E-12	0.00E+00	7.78E-14	4.70E-07	1.12E-07
Ba-140	4.88E-06	6.13E-09	3.21E-07	0.00E+00	2.09E-09	1.59E-04	2.73E-05
Ba-141	1.25E-11	9.41E-15	4.20E-13	0.00E+00	8.75E-15	2.42E-07	1.45E-17
Ba-142	3.29E-12	3.38E-15	2.07E-13	0.00E+00	2.86E-15	1.49E-07	1.96E-26
La-140	4.30E-08	2.17E-08	5.73E-09	0.00E+00	0.00E+00	1.70E-05	5.73E-05
La-142	8.54E-11	3.88E-11	9.65E-12	0.00E+00	0.00E+00	7.91E-07	2.64E-07
Ce-141	2.49E-06	1.69E-06	1.91E-07	0.00E+00	7.83E-07	4.52E-05	1.50E-05
Ce-143	2.33E-08	1.72E-08	1.91E-09	0.00E+00	7.60E-09	9.97E-06	2.83E-05
Ce-144	4.29E-04	1.79E-04	2.30E-05	0.00E+00	1.06E-04	9.72E-04	1.02E-04
Pr-143	1.17E-06	4.69E-07	5.80E-08	0.00E+00	2.70E-07	3.51E-05	2.50E-05
Pr-144	3.76E-12	1.56E-12	1.91E-13	0.00E+00	8.81E-13	1.27E-07	2.69E-18
Nd-147	6.59E-07	7.62E-07	4.56E-08	0.00E+00	4.45E-07	2.76E-05	2.16E-05
Eu-152	2.38E-04	5.41E-05	4.76E-05	0.00E+00	3.35E-04	3.43E-04	1.59E-05
W-187	1.06E-09	8.85E-10	3.10E-10	0.00E+00	0.00E+00	3.63E-06	1.94E-05
Np-239	2.87E-08	2.82E-09	1.55E-09	0.00E+00	8.75E-09	4.70E-06	1.49E-05

Table A8-5 Ingestion Dose Factors for the Infant Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00E+00	1.76E-07	1.76E-07	1.76E-07	1.76E-07	1.76E-07	1.76E-07
C-14	2.37E-05	5.06E-06	5.06E-06	5.06E-06	5.06E-06	5.06E-06	5.06E-06
Na-24	1.01E-05	1.01E-05	1.01E-05	1.01E-05	1.01E-05	1.01E-05	1.01E-05
P-32	1.70E-03	1.00E-04	6.59E-05	0.00E+00	0.00E+00	0.00E+00	2.30E-05
Cr-51	0.00E+00	0.00E+00	1.41E-08	9.20E-09	2.01E-09	1.79E-08	4.11E-07
Mn-54	0.00E+00	1.99E-05	4.51E-06	0.00E+00	4.41E-06	0.00E+00	7.31E-06
Mn-56	0.00E+00	8.18E-07	1.41E-07	0.00E+00	7.03E-07	0.00E+00	7.43E-05
Fe-55	1.39E-05	8.98E-06	2.40E-06	0.00E+00	0.00E+00	4.39E-06	1.14E-06
Fe-59	3.08E-05	5.38E-05	2.12E-05	0.00E+00	0.00E+00	1.59E-05	2.57E-05
Co-57	0.00E+00	1.15E-06	1.87E-06	0.00E+00	0.00E+00	0.00E+00	3.92E-06
Co-58	0.00E+00	3.60E-06	8.98E-06	0.00E+00	0.00E+00	0.00E+00	8.97E-06
Co-60	0.00E+00	1.08E-05	2.55E-05	0.00E+00	0.00E+00	0.00E+00	2.57E-05
Ni-63	6.34E-04	3.92E-05	2.20E-05	0.00E+00	0.00E+00	0.00E+00	1.95E-06
Ni-65	4.70E-06	5.32E-07	2.42E-07	0.00E+00	0.00E+00	0.00E+00	4.05E-05
Cu-64	0.00E+00	6.09E-07	2.82E-07	0.00E+00	1.03E-06	0.00E+00	1.25E-05
Zn-65	1.84E-05	6.31E-05	2.91E-05	0.00E+00	3.06E-05	0.00E+00	5.33E-05
Zn-69m	1.50E-06	3.06E-06	2.79E-07	0.00E+00	1.24E-06	0.00E+00	4.24E-05
Zn-69	9.33E-08	1.68E-07	1.25E-08	0.00E+00	6.98E-08	0.00E+00	1.37E-05
Br-82	0.00E+00	0.00E+00	1.27E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-83	0.00E+00	0.00E+00	3.63E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	3.82E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	1.94E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	1.70E-04	8.40E-05	0.00E+00	0.00E+00	0.00E+00	4.35E-06
Rb-88	0.00E+00	4.98E-07	2.73E-07	0.00E+00	0.00E+00	0.00E+00	4.85E-07
Rb-89	0.00E+00	2.86E-07	1.97E-07	0.00E+00	0.00E+00	0.00E+00	9.74E-08
Sr-89	2.51E-03	0.00E+00	7.20E-05	0.00E+00	0.00E+00	0.00E+00	5.16E-05
Sr-90	2.83E-02	0.00E+00	5.74E-04	0.00E+00	0.00E+00	0.00E+00	2.31E-04
Sr-91	5.00E-05	0.00E+00	1.81E-06	0.00E+00	0.00E+00	0.00E+00	5.92E-05
Sr-92	1.92E-05	0.00E+00	7.13E-07	0.00E+00	0.00E+00	0.00E+00	2.07E-04
Y-90	8.69E-08	0.00E+00	2.33E-09	0.00E+00	0.00E+00	0.00E+00	1.20E-04
Y-91m	8.10E-10	0.00E+00	2.76E-11	0.00E+00	0.00E+00	0.00E+00	2.70E-06
Y-91	1.13E-06	0.00E+00	3.01E-08	0.00E+00	0.00E+00	0.00E+00	8.10E-05
Y-92	7.65E-09	0.00E+00	2.15E-10	0.00E+00	0.00E+00	0.00E+00	1.46E-04
Y-93	2.43E-08	0.00E+00	6.62E-10	0.00E+00	0.00E+00	0.00E+00	1.92E-04
Zr-95	2.06E-07	5.02E-08	3.56E-08	0.00E+00	5.41E-08	0.00E+00	2.50E-05
Zr-97	1.48E-08	2.54E-09	1.16E-09	0.00E+00	2.56E-09	0.00E+00	1.62E-04
Nb-95	4.20E-08	1.73E-08	1.00E-08	0.00E+00	1.24E-08	0.00E+00	1.46E-05
Mo-99	0.00E+00	3.40E-05	6.63E-06	0.00E+00	5.08E-05	0.00E+00	1.12E-05
Tc-99m	1.92E-09	3.96E-09	5.10E-08	0.00E+00	4.26E-08	2.07E-09	1.15E-06
Tc-101	2.27E-09	2.86E-09	2.83E-08	0.00E+00	3.40E-08	1.56E-09	4.86E-07
Ru-103	1.48E-06	0.00E+00	4.95E-07	0.00E+00	3.08E-06	0.00E+00	1.80E-05
Ru-105	1.36E-07	0.00E+00	4.58E-08	0.00E+00	1.00E-06	0.00E+00	5.41E-05
Ru-106	2.41E-05	0.00E+00	3.01E-06	0.00E+00	2.85E-05	0.00E+00	1.83E-04
Rh-105	1.09E-06	7.13E-07	4.79E-07	0.00E+00	1.98E-06	0.00E+00	1.77E-05
Ag-110m	9.96E-07	7.27E-07	4.81E-07	0.00E+00	1.04E-06	0.00E+00	3.77E-05
Cd-113m	0.00E+00	1.77E-05	6.52E-07	0.00E+00	1.34E-05	0.00E+00	2.66E-05
Sb-124	2.14E-05	3.15E-07	6.63E-06	5.68E-08	0.00E+00	1.34E-05	6.60E-05
Sb-125	1.23E-05	1.19E-07	2.53E-06	1.54E-08	0.00E+00	7.12E-06	1.64E-05
Sb-126	8.06E-06	1.58E-07	2.91E-06	6.19E-08	0.00E+00	5.07E-06	8.35E-05

All values are in (mrem/pCi ingested). They are obtained from Reference 11 (Table E-14), Reference 30, and Reference 31.

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Table A8-5 (contd) Ingestion Dose Factors for the Infant Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Sb-127	2.23E-06	3.98E-08	6.90E-07	2.84E-08	0.00E+00	1.15E-06	5.91E-05
Te-125m	2.33E-05	7.79E-06	3.15E-06	7.84E-06	0.00E+00	0.00E+00	1.11E-05
Te-127m	5.85E-05	1.94E-05	7.08E-06	1.69E-05	1.44E-04	0.00E+00	2.36E-05
Te-127	1.00E-06	3.35E-07	2.15E-07	8.14E-07	2.44E-06	0.00E+00	2.10E-05
Te-129m	1.00E-04	3.43E-05	1.54E-05	3.84E-05	2.50E-04	0.00E+00	5.97E-05
Te-129	2.84E-07	9.79E-08	6.63E-08	2.38E-07	7.07E-07	0.00E+00	2.27E-05
Te-131m	1.52E-05	6.12E-06	5.05E-06	1.24E-05	4.21E-05	0.00E+00	1.03E-04
Te-131	1.76E-07	6.50E-08	4.94E-08	1.57E-07	4.50E-07	0.00E+00	7.11E-06
Te-132	2.08E-05	1.03E-05	9.61E-06	1.52E-05	6.44E-05	0.00E+00	3.81E-05
I-129	2.86E-05	2.12E-05	1.55E-05	1.36E-02	2.51E-05	0.00E+00	4.24E-07
I-130	6.00E-06	1.32E-05	5.30E-06	1.48E-03	1.45E-05	0.00E+00	2.83E-06
I-131	3.59E-05	4.23E-05	1.86E-05	1.39E-02	4.94E-05	0.00E+00	1.51E-06
I-132	1.66E-06	3.37E-06	1.20E-06	1.58E-04	3.76E-06	0.00E+00	2.73E-06
I-133	1.25E-05	1.82E-05	5.33E-06	3.31E-03	2.14E-05	0.00E+00	3.08E-06
I-134	8.69E-07	1.78E-06	6.33E-07	4.15E-05	1.99E-06	0.00E+00	1.84E-06
I-135	3.64E-06	7.24E-06	2.64E-06	6.49E-04	8.07E-06	0.00E+00	2.62E-06
Cs-134	3.77E-04	7.03E-04	7.10E-05	0.00E+00	1.81E-04	7.42E-05	1.91E-06
Cs-135	1.33E-04	1.21E-04	6.30E-06	0.00E+00	3.44E-05	1.31E-05	4.37E-07
Cs-136	4.59E-05	1.35E-04	5.04E-05	0.00E+00	5.38E-05	1.10E-05	2.05E-06
Cs-137	5.22E-04	6.11E-04	4.33E-05	0.00E+00	1.64E-04	6.64E-05	1.91E-06
Cs-138	4.81E-07	7.82E-07	3.79E-07	0.00E+00	3.90E-07	6.09E-08	1.25E-06
Ba-139	8.81E-07	5.84E-10	2.55E-08	0.00E+00	3.51E-10	3.54E-10	5.58E-05
Ba-140	1.71E-04	1.71E-07	8.81E-06	0.00E+00	4.06E-08	1.05E-07	4.20E-05
Ba-141	4.25E-07	2.91E-10	1.34E-08	0.00E+00	1.75E-10	1.77E-10	5.19E-06
Ba-142	1.84E-07	1.53E-10	9.06E-09	0.00E+00	8.81E-11	9.26E-11	7.59E-07
La-140	2.11E-08	8.32E-09	2.14E-09	0.00E+00	0.00E+00	0.00E+00	9.77E-05
La-142	1.10E-09	4.04E-10	9.67E-11	0.00E+00	0.00E+00	0.00E+00	6.86E-05
Ce-141	7.87E-08	4.80E-08	5.65E-09	0.00E+00	1.48E-08	0.00E+00	2.48E-05
Ce-143	1.48E-08	9.82E-06	1.12E-09	0.00E+00	2.86E-09	0.00E+00	5.73E-05
Ce-144	2.98E-06	1.22E-06	1.67E-07	0.00E+00	4.93E-07	0.00E+00	1.71E-04
Pr-143	8.13E-08	3.04E-08	4.03E-09	0.00E+00	1.13E-08	0.00E+00	4.29E-05
Pr-144	2.74E-10	1.06E-10	1.38E-11	0.00E+00	3.84E-11	0.00E+00	4.93E-06
Nd-147	5.53E-08	5.68E-08	3.48E-09	0.00E+00	2.19E-08	0.00E+00	3.60E-05
Eu-152	6.74E-07	1.79E-07	1.51E-07	0.00E+00	5.02E-07	0.00E+00	1.59E-05
W-187	9.03E-07	6.28E-07	2.17E-07	0.00E+00	0.00E+00	0.00E+00	3.69E-05
Np-239	1.11E-08	9.93E-10	5.61E-10	0.00E+00	1.98E-09	0.00E+00	2.87E-05

Table A8-6 Ingestion Dose Factors for the Child Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00E+00	1.16E-07	1.16E-07	1.16E-07	1.16E-07	1.16E-07	1.16E-07
C-14	1.21E-05	2.42E-06	2.42E-06	2.42E-06	2.42E-06	2.42E-06	2.42E-06
Na-24	5.80E-06	5.80E-06	5.80E-06	5.80E-06	5.80E-06	5.80E-06	5.80E-06
P-32	8.25E-04	3.86E-05	3.18E-05	0.00E+00	0.00E+00	0.00E+00	2.28E-05
Cr-51	0.00E+00	0.00E+00	8.90E-09	4.94E-09	1.35E-09	9.02E-09	4.72E-07
Mn-54	0.00E+00	1.07E-05	2.85E-06	0.00E+00	3.00E-06	0.00E+00	8.98E-06
Mn-56	0.00E+00	3.34E-07	7.54E-08	0.00E+00	4.04E-07	0.00E+00	4.84E-05
Fe-55	1.15E-05	6.10E-06	1.89E-06	0.00E+00	0.00E+00	3.45E-06	1.13E-06
Fe-59	1.65E-05	2.67E-05	1.33E-05	0.00E+00	0.00E+00	7.74E-06	2.78E-05
Co-57	0.00E+00	4.93E-07	9.98E-07	0.00E+00	0.00E+00	0.00E+00	4.04E-06
Co-58	0.00E+00	1.80E-06	5.51E-06	0.00E+00	0.00E+00	0.00E+00	1.05E-05
Co-60	0.00E+00	5.29E-06	1.56E-05	0.00E+00	0.00E+00	0.00E+00	2.93E-05
Ni-63	5.38E-04	2.88E-05	1.83E-05	0.00E+00	0.00E+00	0.00E+00	1.94E-06
Ni-65	2.22E-06	2.09E-07	1.22E-07	0.00E+00	0.00E+00	0.00E+00	2.56E-05
Cu-64	0.00E+00	2.45E-07	1.48E-07	0.00E+00	5.92E-07	0.00E+00	1.15E-05
Zn-65	1.37E-05	3.65E-05	2.27E-05	0.00E+00	2.30E-05	0.00E+00	6.41E-06
Zn-69m	7.10E-07	1.21E-06	1.43E-07	0.00E+00	7.03E-07	0.00E+00	3.94E-05
Zn-69	4.38E-08	6.33E-08	5.85E-09	0.00E+00	3.84E-08	0.00E+00	3.99E-06
Br-82	0.00E+00	0.00E+00	7.55E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-83	0.00E+00	0.00E+00	1.71E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	1.98E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	9.12E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	6.70E-05	4.12E-05	0.00E+00	0.00E+00	0.00E+00	4.31E-06
Rb-88	0.00E+00	1.90E-07	1.32E-07	0.00E+00	0.00E+00	0.00E+00	9.32E-09
Rb-89	0.00E+00	1.17E-07	1.04E-07	0.00E+00	0.00E+00	0.00E+00	1.02E-09
Sr-89	1.32E-03	0.00E+00	3.77E-05	0.00E+00	0.00E+00	0.00E+00	5.11E-05
Sr-90	2.56E-02	0.00E+00	5.15E-04	0.00E+00	0.00E+00	0.00E+00	2.29E-04
Sr-91	2.40E-05	0.00E+00	9.06E-07	0.00E+00	0.00E+00	0.00E+00	5.30E-05
Sr-92	9.03E-06	0.00E+00	3.62E-07	0.00E+00	0.00E+00	0.00E+00	1.71E-04
Y-90	4.11E-08	0.00E+00	1.10E-09	0.00E+00	0.00E+00	0.00E+00	1.17E-04
Y-91m	3.82E-10	0.00E+00	1.39E-11	0.00E+00	0.00E+00	0.00E+00	7.48E-07
Y-91	6.02E-07	0.00E+00	1.61E-08	0.00E+00	0.00E+00	0.00E+00	8.02E-05
Y-92	3.60E-09	0.00E+00	1.03E-10	0.00E+00	0.00E+00	0.00E+00	1.04E-04
Y-93	1.14E-08	0.00E+00	3.13E-10	0.00E+00	0.00E+00	0.00E+00	1.70E-04
Zr-95	1.16E-07	2.55E-08	2.27E-08	0.00E+00	3.65E-08	0.00E+00	2.66E-05
Zr-97	6.99E-09	1.01E-09	5.96E-10	0.00E+00	1.45E-09	0.00E+00	1.53E-04
Nb-95	2.25E-08	8.76E-09	6.26E-09	0.00E+00	8.23E-09	0.00E+00	1.62E-05
Mo-99	0.00E+00	1.33E-05	3.29E-06	0.00E+00	2.84E-05	0.00E+00	1.10E-05
Tc-99m	9.23E-10	1.81E-09	3.00E-08	0.00E+00	2.63E-08	9.19E-10	1.03E-06
Tc-101	1.07E-09	1.12E-09	1.42E-08	0.00E+00	1.91E-08	5.92E-10	3.56E-09
Ru-103	7.31E-07	0.00E+00	2.81E-07	0.00E+00	1.84E-06	0.00E+00	1.89E-05
Ru-105	6.45E-08	0.00E+00	2.34E-08	0.00E+00	5.67E-07	0.00E+00	4.21E-05
Ru-106	1.17E-05	0.00E+00	1.46E-06	0.00E+00	1.58E-05	0.00E+00	1.82E-04
Rh-105	5.14E-07	2.76E-07	2.36E-07	0.00E+00	1.10E-06	0.00E+00	1.71E-05
Ag-110m	5.39E-07	3.64E-07	2.91E-07	0.00E+00	6.78E-07	0.00E+00	4.33E-05
Cd-113m	0.00E+00	1.02E-05	4.34E-07	0.00E+00	1.05E-05	0.00E+00	2.63E-05
Sb-124	1.11E-05	1.44E-07	3.89E-06	2.45E-08	0.00E+00	6.16E-06	6.94E-05
Sb-125	7.16E-06	5.52E-08	1.50E-06	6.63E-09	0.00E+00	3.99E-06	1.71E-05
Sb-126	4.40E-06	6.73E-08	1.58E-06	2.58E-08	0.00E+00	2.10E-06	8.87E-05

All values are in (mrem/pCi ingested). They are obtained from Reference 11 (Table E-13), Reference 30, and Reference 31.

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Table A8-6 (contd) Ingestion Dose Factors for the Child Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Sb-127	1.06E-06	1.64E-08	3.68E-07	1.18E-08	0.00E+00	4.60E-07	5.97E-05
Te-125m	1.14E-05	3.09E-06	1.52E-06	3.20E-06	0.00E+00	0.00E+00	1.10E-05
Te-127m	2.89E-05	7.78E-06	3.43E-06	6.91E-06	8.24E-05	0.00E+00	2.34E-05
Te-127	4.71E-07	1.27E-07	1.01E-07	3.26E-07	1.34E-06	0.00E+00	1.84E-05
Te-129m	4.87E-05	1.36E-05	7.56E-06	1.57E-05	1.43E-04	0.00E+00	5.94E-05
Te-129	1.34E-07	3.74E-08	3.18E-08	9.56E-08	3.92E-07	0.00E+00	8.34E-06
Te-131m	7.20E-06	2.49E-06	2.65E-06	5.12E-06	2.41E-05	0.00E+00	1.01E-04
Te-131	8.30E-08	2.53E-08	2.47E-08	6.35E-08	2.51E-07	0.00E+00	4.36E-07
Te-132	1.01E-05	4.47E-06	5.40E-06	6.51E-06	4.15E-05	0.00E+00	4.50E-05
I-129	1.39E-05	8.53E-06	7.62E-06	5.58E-03	1.44E-05	0.00E+00	4.29E-07
I-130	2.92E-06	5.90E-06	3.04E-06	6.50E-04	8.82E-06	0.00E+00	2.76E-06
I-131	1.72E-05	1.73E-05	9.83E-06	5.72E-03	2.84E-05	0.00E+00	1.54E-06
I-132	8.00E-07	1.47E-06	6.76E-07	6.82E-05	2.25E-06	0.00E+00	1.73E-06
I-133	5.92E-06	7.32E-06	2.77E-06	1.36E-03	1.22E-05	0.00E+00	2.95E-06
I-134	4.19E-07	7.78E-07	3.58E-07	1.79E-05	1.19E-06	0.00E+00	5.16E-07
I-135	1.75E-06	3.15E-06	1.49E-06	2.79E-04	4.83E-06	0.00E+00	2.40E-06
Cs-134	2.34E-04	3.84E-04	8.10E-05	0.00E+00	1.19E-04	4.27E-05	2.07E-06
Cs-135	8.30E-05	5.78E-05	5.93E-06	0.00E+00	2.04E-05	6.81E-06	4.33E-07
Cs-136	2.35E-05	6.46E-05	4.18E-05	0.00E+00	3.44E-05	5.13E-06	2.27E-06
Cs-137	3.27E-04	3.13E-04	4.62E-05	0.00E+00	1.02E-04	3.67E-05	1.96E-06
Cs-138	2.28E-07	3.17E-07	2.01E-07	0.00E+00	2.23E-07	2.40E-08	1.46E-07
Ba-139	4.14E-07	2.21E-10	1.20E-08	0.00E+00	1.93E-10	1.30E-10	2.39E-05
Ba-140	8.31E-05	7.28E-08	4.85E-06	0.00E+00	2.37E-08	4.34E-08	4.21E-05
Ba-141	2.00E-07	1.12E-10	6.51E-09	0.00E+00	9.69E-11	6.58E-10	1.14E-07
Ba-142	8.74E-08	6.29E-11	4.88E-09	0.00E+00	5.09E-11	3.70E-11	1.14E-09
La-140	1.01E-08	3.53E-09	1.19E-09	0.00E+00	0.00E+00	0.00E+00	9.84E-05
La-142	5.24E-10	1.67E-10	5.23E-11	0.00E+00	0.00E+00	0.00E+00	3.31E-05
Ce-141	3.97E-08	1.98E-08	2.94E-09	0.00E+00	8.68E-09	0.00E+00	2.47E-05
Ce-143	6.99E-09	3.79E-06	5.49E-10	0.00E+00	1.59E-09	0.00E+00	5.55E-05
Ce-144	2.08E-06	6.52E-07	1.11E-07	0.00E+00	3.61E-07	0.00E+00	1.70E-04
Pr-143	3.93E-08	1.18E-08	1.95E-09	0.00E+00	6.39E-09	0.00E+00	4.24E-05
Pr-144	1.29E-10	3.99E-11	6.49E-12	0.00E+00	2.11E-11	0.00E+00	8.59E-08
Nd-147	2.79E-08	2.26E-08	1.75E-09	0.00E+00	1.24E-08	0.00E+00	3.58E-05
Eu-152	6.15E-07	1.12E-07	1.33E-07	0.00E+00	4.73E-07	0.00E+00	1.84E-05
W-187	4.29E-07	2.54E-07	1.14E-07	0.00E+00	0.00E+00	0.00E+00	3.57E-05
Np-239	5.25E-09	3.77E-10	2.65E-10	0.00E+00	1.09E-09	0.00E+00	2.79E-05

Table A8-7 Ingestion Dose Factors for the Teenager Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00E+00	6.04E-08	6.04E-08	6.04E-08	6.04E-08	6.04E-08	6.04E-08
C-14	4.06E-06	8.12E-07	8.12E-07	8.12E-07	8.12E-07	8.12E-07	8.12E-07
Na-24	2.30E-06	2.30E-06	2.30E-06	2.30E-06	2.30E-06	2.30E-06	2.30E-06
P-32	2.76E-04	1.71E-05	1.07E-05	0.00E+00	0.00E+00	0.00E+00	2.32E-05
Cr-51	0.00E+00	0.00E+00	3.60E-09	2.00E-09	7.89E-10	5.14E-09	6.05E-07
Mn-54	0.00E+00	5.90E-06	1.17E-06	0.00E+00	1.76E-06	0.00E+00	1.21E-05
Mn-56	0.00E+00	1.58E-07	2.81E-08	0.00E+00	2.00E-07	0.00E+00	1.04E-05
Fe-55	3.78E-06	2.68E-06	6.25E-07	0.00E+00	0.00E+00	1.70E-06	1.16E-06
Fe-59	5.87E-06	1.37E-05	5.29E-06	0.00E+00	0.00E+00	4.32E-06	3.24E-05
Co-57	0.00E+00	2.38E-07	3.99E-07	0.00E+00	0.00E+00	0.00E+00	4.44E-06
Co-58	0.00E+00	9.72E-07	2.24E-06	0.00E+00	0.00E+00	0.00E+00	1.34E-05
Co-60	0.00E+00	2.81E-06	6.33E-06	0.00E+00	0.00E+00	0.00E+00	3.66E-05
Ni-63	1.77E-04	1.25E-05	6.00E-06	0.00E+00	0.00E+00	0.00E+00	1.99E-06
Ni-65	7.49E-07	9.57E-08	4.36E-08	0.00E+00	0.00E+00	0.00E+00	5.19E-06
Cu-64	0.00E+00	1.15E-07	5.41E-08	0.00E+00	2.91E-07	0.00E+00	8.92E-06
Zn-65	5.76E-06	2.00E-05	9.33E-06	0.00E+00	1.28E-05	0.00E+00	8.47E-06
Zn-69m	2.40E-07	5.66E-07	5.19E-08	0.00E+00	3.44E-07	0.00E+00	3.11E-05
Zn-69	1.47E-08	2.80E-08	1.96E-09	0.00E+00	1.83E-08	0.00E+00	5.16E-08
Br-82	0.00E+00	0.00E+00	3.04E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-83	0.00E+00	0.00E+00	5.74E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	7.22E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	3.05E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	2.98E-05	1.40E-05	0.00E+00	0.00E+00	0.00E+00	4.41E-06
Rb-88	0.00E+00	8.52E-08	4.54E-08	0.00E+00	0.00E+00	0.00E+00	7.30E-15
Rb-89	0.00E+00	5.50E-08	3.89E-08	0.00E+00	0.00E+00	0.00E+00	8.43E-17
Sr-89	4.40E-04	0.00E+00	1.26E-05	0.00E+00	0.00E+00	0.00E+00	5.24E-05
Sr-90	1.02E-02	0.00E+00	2.04E-04	0.00E+00	0.00E+00	0.00E+00	2.33E-04
Sr-91	8.07E-06	0.00E+00	3.21E-07	0.00E+00	0.00E+00	0.00E+00	3.66E-05
Sr-92	3.05E-06	0.00E+00	1.30E-07	0.00E+00	0.00E+00	0.00E+00	7.77E-05
Y-90	1.37E-08	0.00E+00	3.69E-10	0.00E+00	0.00E+00	0.00E+00	1.13E-04
Y-91m	1.29E-10	0.00E+00	4.93E-12	0.00E+00	0.00E+00	0.00E+00	6.09E-09
Y-91	2.01E-07	0.00E+00	5.39E-09	0.00E+00	0.00E+00	0.00E+00	8.24E-05
Y-92	1.21E-09	0.00E+00	3.50E-11	0.00E+00	0.00E+00	0.00E+00	3.32E-05
Y-93	3.83E-09	0.00E+00	1.05E-10	0.00E+00	0.00E+00	0.00E+00	1.17E-04
Zr-95	4.12E-08	1.30E-08	8.94E-09	0.00E+00	1.91E-08	0.00E+00	3.00E-05
Zr-97	2.37E-09	4.69E-10	2.16E-10	0.00E+00	7.11E-10	0.00E+00	1.27E-04
Nb-95	8.22E-09	4.56E-09	2.51E-09	0.00E+00	4.42E-09	0.00E+00	1.95E-05
Mo-99	0.00E+00	6.03E-06	1.15E-06	0.00E+00	1.38E-05	0.00E+00	1.08E-05
Tc-99m	3.32E-10	9.26E-10	1.20E-08	0.00E+00	1.38E-08	5.14E-10	6.08E-07
Tc-101	3.60E-10	5.12E-10	5.03E-09	0.00E+00	9.26E-09	3.12E-10	8.75E-17
Ru-103	2.55E-07	0.00E+00	1.09E-07	0.00E+00	8.99E-07	0.00E+00	2.13E-05
Ru-105	2.18E-08	0.00E+00	8.46E-09	0.00E+00	2.75E-07	0.00E+00	1.76E-05
Ru-106	3.92E-06	0.00E+00	4.94E-07	0.00E+00	7.56E-06	0.00E+00	1.88E-04
Rh-105	1.73E-07	1.25E-07	8.20E-08	0.00E+00	5.31E-07	0.00E+00	1.59E-05
Ag-110m	2.05E-07	1.94E-07	1.18E-07	0.00E+00	3.70E-07	0.00E+00	5.45E-05
Cd-113m	0.00E+00	4.51E-06	1.45E-07	0.00E+00	4.99E-06	0.00E+00	2.71E-05
Sb-124	3.87E-06	7.13E-08	1.51E-06	8.78E-09	0.00E+00	3.38E-06	7.80E-05
Sb-125	2.48E-06	2.71E-08	5.80E-07	2.37E-09	0.00E+00	2.18E-06	1.93E-05
Sb-126	1.59E-06	3.25E-08	5.71E-07	8.99E-09	0.00E+00	1.14E-06	9.41E-05

All values are in (mrem/pCi ingested). They are obtained from Reference 11 (Table E-12), Reference 30, and Reference 31.

Table A8-7 (contd) Ingestion Dose Factors for the Teenager Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Sb-127	3.63E-07	7.76E-09	1.37E-07	4.08E-09	0.00E+00	2.47E-07	6.16E-05
Te-125m	3.83E-06	1.38E-06	5.12E-07	1.07E-06	0.00E+00	0.00E+00	1.13E-05
Te-127m	9.67E-06	3.43E-06	1.15E-06	2.30E-06	3.92E-05	0.00E+00	2.41E-05
Te-127	1.58E-07	5.60E-08	3.40E-08	1.09E-07	6.40E-07	0.00E+00	1.22E-05
Te-129m	1.63E-05	6.05E-06	2.58E-06	5.26E-06	6.82E-05	0.00E+00	6.12E-05
Te-129	4.48E-08	1.67E-08	1.09E-08	3.20E-08	1.88E-07	0.00E+00	2.45E-07
Te-131m	2.44E-06	1.17E-06	9.76E-07	1.76E-06	1.22E-05	0.00E+00	9.39E-05
Te-131	2.79E-08	1.15E-08	8.72E-09	2.15E-08	1.22E-07	0.00E+00	2.29E-09
Te-132	3.49E-06	2.21E-06	2.08E-06	2.33E-06	2.12E-05	0.00E+00	7.00E-05
I-129	4.66E-06	3.92E-06	6.54E-06	4.77E-03	7.01E-06	0.00E+00	4.57E-07
I-130	1.03E-06	2.98E-06	1.19E-06	2.43E-04	4.59E-06	0.00E+00	2.29E-06
I-131	5.85E-06	8.19E-06	4.40E-06	2.39E-03	1.41E-05	0.00E+00	1.62E-06
I-132	2.79E-07	7.30E-07	2.62E-07	2.46E-05	1.15E-06	0.00E+00	3.18E-07
I-133	2.01E-06	3.41E-06	1.04E-06	4.76E-04	5.98E-06	0.00E+00	2.58E-06
I-134	1.46E-07	3.87E-07	1.39E-07	6.45E-06	6.10E-07	0.00E+00	5.10E-09
I-135	6.10E-07	1.57E-06	5.82E-07	1.01E-04	2.48E-06	0.00E+00	1.74E-06
Cs-134	8.37E-05	1.97E-04	9.14E-05	0.00E+00	6.26E-05	2.39E-05	2.45E-06
Cs-135	2.78E-05	2.55E-05	5.96E-06	0.00E+00	9.73E-06	3.52E-06	4.46E-07
Cs-136	8.59E-06	3.38E-05	2.27E-05	0.00E+00	1.84E-05	2.90E-06	2.72E-06
Cs-137	1.12E-04	1.49E-04	5.19E-05	0.00E+00	5.07E-05	1.97E-05	2.12E-06
Cs-138	7.76E-08	1.49E-07	7.45E-08	0.00E+00	1.10E-07	1.28E-08	6.76E-11
Ba-139	1.39E-07	9.78E-11	4.05E-09	0.00E+00	9.22E-11	6.74E-11	1.24E-06
Ba-140	2.84E-05	3.48E-08	1.83E-06	0.00E+00	1.18E-08	2.34E-08	4.38E-05
Ba-141	6.71E-08	5.01E-11	2.24E-09	0.00E+00	4.65E-11	3.43E-11	1.43E-13
Ba-142	2.99E-08	2.99E-11	1.84E-09	0.00E+00	2.53E-11	1.99E-11	9.18E-20
La-140	3.48E-09	1.71E-09	4.55E-10	0.00E+00	0.00E+00	0.00E+00	9.82E-05
La-142	1.79E-10	7.95E-11	1.98E-11	0.00E+00	0.00E+00	0.00E+00	2.42E-06
Ce-141	1.33E-08	8.88E-09	1.02E-09	0.00E+00	4.18E-09	0.00E+00	2.54E-05
Ce-143	2.35E-09	1.71E-06	1.91E-10	0.00E+00	7.67E-10	0.00E+00	5.14E-05
Ce-144	6.96E-07	2.88E-07	3.74E-08	0.00E+00	1.72E-07	0.00E+00	1.75E-04
Pr-143	1.31E-08	5.23E-09	6.52E-10	0.00E+00	3.04E-09	0.00E+00	4.31E-05
Pr-144	4.30E-11	1.76E-11	2.18E-12	0.00E+00	1.01E-11	0.00E+00	4.74E-14
Nd-147	9.38E-09	1.02E-08	6.11E-10	0.00E+00	5.99E-09	0.00E+00	3.68E-05
Eu-152	2.45E-07	5.90E-08	5.20E-08	0.00E+00	2.74E-07	0.00E+00	2.17E-05
W-187	1.46E-07	1.19E-07	4.17E-08	0.00E+00	0.00E+00	0.00E+00	3.22E-05
Np-239	1.76E-09	1.66E-10	9.22E-11	0.00E+00	5.21E-10	0.00E+00	2.67E-05

Table A8-8 Ingestion Dose Factors for the Adult Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00E+00	5.99E-08	5.99E-08	5.99E-08	5.99E-08	5.99E-08	5.99E-08
C-14	2.84E-06	5.68E-07	5.68E-07	5.68E-07	5.68E-07	5.68E-07	5.68E-07
Na-24	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06
P-32	1.93E-04	1.20E-05	7.46E-06	0.00E+00	0.00E+00	0.00E+00	2.17E-05
Cr-51	0.00E+00	0.00E+00	2.66E-09	1.59E-09	5.86E-10	3.53E-09	6.69E-07
Mn-54	0.00E+00	4.57E-06	8.72E-07	0.00E+00	1.36E-06	0.00E+00	1.40E-05
Mn-56	0.00E+00	1.15E-07	2.04E-08	0.00E+00	1.46E-07	0.00E+00	3.67E-06
Fe-55	2.75E-06	1.90E-06	4.43E-07	0.00E+00	0.00E+00	1.06E-06	1.09E-06
Fe-59	4.34E-06	1.02E-05	3.91E-06	0.00E+00	0.00E+00	2.85E-06	3.40E-05
Co-57	0.00E+00	1.75E-07	2.91E-07	0.00E+00	0.00E+00	0.00E+00	4.44E-06
Co-58	0.00E+00	7.45E-07	1.67E-06	0.00E+00	0.00E+00	0.00E+00	1.51E-05
Co-60	0.00E+00	2.14E-06	4.72E-06	0.00E+00	0.00E+00	0.00E+00	4.02E-05
Ni-63	1.30E-04	9.01E-06	4.36E-06	0.00E+00	0.00E+00	0.00E+00	1.88E-06
Ni-65	5.28E-07	6.86E-08	3.13E-08	0.00E+00	0.00E+00	0.00E+00	1.74E-06
Cu-64	0.00E+00	8.33E-08	3.91E-08	0.00E+00	2.10E-07	0.00E+00	7.10E-06
Zn-65	4.84E-06	1.54E-05	6.96E-06	0.00E+00	1.03E-05	0.00E+00	9.70E-06
Zn-69m	1.70E-07	4.08E-07	3.73E-08	0.00E+00	2.47E-07	0.00E+00	2.49E-05
Zn-69	1.03E-08	1.97E-08	1.37E-09	0.00E+00	1.28E-08	0.00E+00	2.96E-09
Br-82	0.00E+00	0.00E+00	2.26E-06	0.00E+00	0.00E+00	0.00E+00	2.59E-06
Br-83	0.00E+00	0.00E+00	4.02E-08	0.00E+00	0.00E+00	0.00E+00	5.79E-08
Br-84	0.00E+00	0.00E+00	5.21E-08	0.00E+00	0.00E+00	0.00E+00	4.09E-13
Br-85	0.00E+00	0.00E+00	2.14E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	2.11E-05	9.83E-06	0.00E+00	0.00E+00	0.00E+00	4.16E-06
Rb-88	0.00E+00	6.05E-08	3.21E-08	0.00E+00	0.00E+00	0.00E+00	8.36E-19
Rb-89	0.00E+00	4.01E-08	2.82E-08	0.00E+00	0.00E+00	0.00E+00	2.33E-21
Sr-89	3.08E-04	0.00E+00	8.84E-06	0.00E+00	0.00E+00	0.00E+00	4.94E-05
Sr-90	8.71E-03	0.00E+00	1.75E-04	0.00E+00	0.00E+00	0.00E+00	2.19E-04
Sr-91	5.67E-06	0.00E+00	2.29E-07	0.00E+00	0.00E+00	0.00E+00	2.70E-05
Sr-92	2.15E-06	0.00E+00	9.30E-08	0.00E+00	0.00E+00	0.00E+00	4.26E-05
Y-90	9.62E-09	0.00E+00	2.58E-10	0.00E+00	0.00E+00	0.00E+00	1.02E-04
Y-91m	9.09E-11	0.00E+00	3.52E-12	0.00E+00	0.00E+00	0.00E+00	2.67E-10
Y-91	1.41E-07	0.00E+00	3.77E-09	0.00E+00	0.00E+00	0.00E+00	7.76E-05
Y-92	8.45E-10	0.00E+00	2.47E-11	0.00E+00	0.00E+00	0.00E+00	1.48E-05
Y-93	2.68E-09	0.00E+00	7.40E-11	0.00E+00	0.00E+00	0.00E+00	8.50E-05
Zr-95	3.04E-08	9.75E-09	6.60E-09	0.00E+00	1.53E-08	0.00E+00	3.09E-05
Zr-97	1.68E-09	3.39E-10	1.55E-10	0.00E+00	5.12E-10	0.00E+00	1.05E-04
Nb-95	6.22E-09	3.46E-09	1.86E-09	0.00E+00	3.42E-09	0.00E+00	2.10E-05
Mo-99	0.00E+00	4.31E-06	8.20E-07	0.00E+00	9.76E-06	0.00E+00	9.99E-06
Tc-99m	2.47E-10	6.98E-10	8.89E-09	0.00E+00	1.06E-08	3.42E-10	4.13E-07
Tc-101	2.54E-10	3.66E-10	3.59E-09	0.00E+00	6.59E-09	1.87E-10	1.10E-21
Ru-103	1.85E-07	0.00E+00	7.97E-08	0.00E+00	7.06E-07	0.00E+00	2.16E-05
Ru-105	1.54E-08	0.00E+00	6.08E-09	0.00E+00	1.99E-07	0.00E+00	9.42E-06
Ru-106	2.75E-06	0.00E+00	3.48E-07	0.00E+00	5.31E-06	0.00E+00	1.78E-04
Rh-105	1.21E-07	8.85E-08	5.83E-08	0.00E+00	3.76E-07	0.00E+00	1.41E-05
Ag-110m	1.60E-07	1.48E-07	8.79E-08	0.00E+00	2.91E-07	0.00E+00	6.04E-05
Cd-113m	0.00E+00	3.18E-06	1.02E-07	0.00E+00	3.50E-06	0.00E+00	2.56E-05
Sb-124	2.80E-06	5.29E-08	1.11E-06	6.79E-09	0.00E+00	2.18E-06	7.95E-05
Sb-125	1.79E-06	2.00E-08	4.26E-07	1.82E-09	0.00E+00	1.38E-06	1.97E-05
Sb-126	1.15E-06	2.34E-08	4.15E-07	7.04E-09	0.00E+00	7.05E-07	9.40E-05

All values are in (mrem/pCi ingested). They are obtained from Reference 11 (Table E–11), Reference 30, and Reference 31.

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Table A8-8 (contd) Ingestion Dose Factors for the Adult Age Group

Nuclide	Bone	Liver	T.Body	Thyroid	Kidney	Lung	GI-LLI
Sb-127	2.58E-07	5.65E-09	9.90E-08	3.10E-09	0.00E+00	1.53E-07	5.90E-05
Te-125m	2.68E-06	9.71E-07	3.59E-07	8.06E-07	1.09E-05	0.00E+00	1.07E-05
Te-127m	6.77E-06	2.42E-06	8.25E-07	1.73E-06	2.75E-05	0.00E+00	2.27E-05
Te-127	1.10E-07	3.95E-08	2.38E-08	8.15E-08	4.48E-07	0.00E+00	8.68E-06
Te-129m	1.15E-05	4.29E-06	1.82E-06	3.95E-06	4.80E-05	0.00E+00	5.79E-05
Te-129	3.14E-08	1.18E-08	7.65E-09	2.41E-08	1.32E-07	0.00E+00	2.37E-08
Te-131m	1.73E-06	8.46E-07	7.05E-07	1.34E-06	8.57E-06	0.00E+00	8.40E-05
Te-131	1.97E-08	8.23E-09	6.22E-09	1.62E-08	8.63E-08	0.00E+00	2.79E-09
Te-132	2.52E-06	1.63E-06	1.53E-06	1.80E-06	1.57E-05	0.00E+00	7.71E-05
I-129	3.27E-06	2.81E-06	9.21E-06	7.23E-03	6.04E-06	0.00E+00	4.44E-07
I-130	7.56E-07	2.23E-06	8.80E-07	1.89E-04	3.48E-06	0.00E+00	1.92E-06
I-131	4.16E-06	5.95E-06	3.41E-06	1.95E-03	1.02E-05	0.00E+00	1.57E-06
I-132	2.03E-07	5.43E-07	1.90E-07	1.90E-05	8.65E-07	0.00E+00	1.02E-07
I-133	1.42E-06	2.47E-06	7.53E-07	3.63E-04	4.31E-06	0.00E+00	2.22E-06
I-134	1.06E-07	2.88E-07	1.03E-07	4.99E-06	4.58E-07	0.00E+00	2.51E-10
I-135	4.43E-07	1.16E-06	4.28E-07	7.65E-05	1.86E-06	0.00E+00	1.31E-06
Cs-134	6.22E-05	1.48E-04	1.21E-04	0.00E+00	4.79E-05	1.59E-05	2.59E-06
Cs-135	1.95E-05	1.80E-05	7.99E-06	0.00E+00	6.81E-06	2.04E-06	4.21E-07
Cs-136	6.51E-06	2.57E-05	1.85E-05	0.00E+00	1.43E-05	1.96E-06	2.92E-06
Cs-137	7.97E-05	1.09E-04	7.14E-05	0.00E+00	3.70E-05	1.23E-05	2.11E-06
Cs-138	5.52E-08	1.09E-07	5.40E-08	0.00E+00	8.01E-08	7.91E-09	4.65E-13
Ba-139	9.70E-08	6.91E-11	2.84E-09	0.00E+00	6.46E-11	3.92E-11	1.72E-07
Ba-140	2.03E-05	2.55E-08	1.33E-06	0.00E+00	8.67E-09	1.46E-08	4.18E-05
Ba-141	4.71E-08	3.56E-11	1.59E-09	0.00E+00	3.31E-11	2.02E-11	2.22E-17
Ba-142	2.13E-08	2.19E-11	1.34E-09	0.00E+00	1.85E-11	1.24E-11	3.00E-26
La-140	2.50E-09	1.26E-09	3.33E-10	0.00E+00	0.00E+00	0.00E+00	9.25E-05
La-142	1.28E-10	5.82E-11	1.45E-11	0.00E+00	0.00E+00	0.00E+00	4.25E-07
Ce-141	9.36E-09	6.33E-09	7.18E-10	0.00E+00	2.94E-09	0.00E+00	2.42E-05
Ce-143	1.65E-09	1.22E-06	1.35E-10	0.00E+00	5.37E-10	0.00E+00	4.56E-05
Ce-144	4.88E-07	2.04E-07	2.62E-08	0.00E+00	1.21E-07	0.00E+00	1.65E-04
Pr-143	9.20E-09	3.69E-09	4.56E-10	0.00E+00	2.13E-09	0.00E+00	4.03E-05
Pr-144	3.01E-11	1.25E-11	1.53E-12	0.00E+00	7.05E-12	0.00E+00	4.33E-18
Nd-147	6.29E-09	7.27E-09	4.35E-10	0.00E+00	4.25E-09	0.00E+00	3.49E-05
Eu-152	1.95E-07	4.44E-08	3.90E-08	0.00E+00	2.75E-07	0.00E+00	2.56E-05
W-187	1.03E-07	8.61E-08	3.01E-08	0.00E+00	0.00E+00	0.00E+00	2.82E-05
Np-239	1.19E-09	1.17E-10	6.45E-11	0.00E+00	3.65E-10	0.00E+00	2.40E-05

Table A8-9 External Dose Factors for Standing on Contaminated Ground

Nuclide	T. Body	Skin
H-3	0.00E+00	0.00E+00
C-14	0.00E+00	0.00E+00
Na-24	2.50E-08	2.90E-08
P-32	0.00E+00	0.00E+00
Cr-51	2.20E-10	2.60E-10
Mn-54	5.80E-09	6.80E-09
Mn-56	1.10E-08	1.30E-08
Fe-55	0.00E+00	0.00E+00
Fe-59	8.00E-09	9.40E-09
Co-57	9.10E-10	1.00E-09
Co-58	7.00E-09	8.20E-09
Co-60	1.70E-08	2.00E-08
Ni-63	0.00E+00	0.00E+00
Ni-65	3.70E-09	4.30E-09
Cu-64	1.50E-09	1.70E-09
Zn-65	4.00E-09	4.60E-09
Zn-69m	2.90E-09	3.40E-09
Zn-69	0.00E+00	0.00E+00
Br-82	1.90E-08	2.20E-08
Br-83	6.40E-11	9.30E-11
Br-84	1.20E-08	1.40E-08
Br-85	0.00E+00	0.00E+00
Rb-86	6.30E-10	7.20E-10
Rb-88	3.50E-09	4.00E-09
Rb-89	1.50E-08	1.80E-08
Sr-89	5.60E-13	6.50E-13
Sr-90	0.00E+00	0.00E+00
Sr-91	7.10E-09	8.30E-09

Nuclide	T. Body	Skin
Sr-92	9.00E-09	1.00E-08
Y-90	2.20E-12	2.60E-12
Y-91m	3.80E-09	4.40E-09
Y-91	2.40E-11	2.70E-11
Y-92	1.60E-09	1.90E-09
Y-93	5.70E-10	7.80E-10
Zr-95	5.00E-09	5.80E-09
Zr-97	5.50E-09	6.40E-09
Nb-95	5.10E-09	6.00E-09
Mo-99	1.90E-09	2.20E-09
Tc-99m	9.60E-10	1.10E-09
Tc-101	2.70E-09	3.00E-09
Ru-103	3.60E-09	4.20E-09
Ru-105	4.50E-09	5.10E-09
Sr-92	9.00E-09	1.00E-08
Ru-106	1.50E-09	1.80E-09
Rh-105	6.60E-10	7.70E-10
Ag-110m	1.80E-08	2.10E-08
Cd-113m	2.30E-12	2.60E-12
Sb-124	1.30E-08	1.50E-08
Sb-125	3.10E-09	3.50E-09
Sb-126	8.90E-09	1.00E-08
Sb-127	5.70E-09	6.60E-09
Te-125m	3.50E-11	4.80E-11
Te-127m	1.10E-12	1.30E-12
Te-127	1.00E-11	1.10E-11
Te-129m	7.70E-10	9.00E-10
Te-129	7.10E-10	8.40E-10

All values are in (mrem/h) per (pCi/m^2). They are obtained from Reference 11 (Table E-6), Reference 30, and Reference 31.

Table A8-9 (contd) External Dose Factors for Standing on Contaminated Ground

Nuclide	T.Body	Skin
Te-131m	8.40E-09	9.90E-09
Te-131	2.20E-09	2.60E-06
Te-132	1.70E-09	2.00E-09
I-129	4.50E-10	7.50E-10
I-130	1.40E-08	1.70E-08
I-131	2.80E-09	3.40E-09
I-132	1.70E-08	2.00E-08
I-133	3.70E-09	4.50E-09
I-134	1.60E-08	1.90E-08
I-135	1.20E-08	1.40E-08
Cs-134	1.20E-08	1.40E-08
Cs-135	0.00E+00	0.00E+00
Cs-136	1.50E-08	1.70E-08
Cs-137	4.20E-09	4.90E-09
Cs-138	2.10E-08	2.40E-08
Ba-139	2.40E-09	2.70E-09
Ba-140	2.10E-09	2.40E-09
Ba-141	4.30E-09	4.90E-09
Ba-142	7.90E-09	9.00E-09
La-140	1.50E-08	1.70E-08
La-142	1.50E-08	1.80E-08
Ce-141	5.50E-10	6.20E-10
Ce-143	2.20E-09	2.50E-09
Ce-144	3.20E-10	3.70E-10
Pr-143	0.00E+00	0.00E+00
Pr-144	2.00E-10	2.30E-10
Nd-147	1.00E-09	1.20E-09
Eu-152	7.37E-09	8.53E-09
W-187	3.10E-09	3.60E-09
Np-239	9.50E-10	1.10E-09

Table A8-10 Bioaccumulation Factors

Element	Freshwater Fish BFi*	Freshwater Invertebrate BFi*
H	9.0 E-01	9.0 E-01
C	4.6 E+03	9.1 E+03
Na	1.0 E+02	2.0 E+02
P	3.0 E+03	2.0 E+04
Cr	2.0 E+02	2.0 E+03
Mn	4.0 E+02	9.0 E+04
Fe	1.0 E+02	3.2 E+03
Co	5.0 E+01	2.0 E+02
Ni	1.0 E+02	1.0 E+02
Cu	5.0 E+01	4.0 E+02
Zn	2.0 E+03	1.0 E+04
Br	4.2 E+02	3.3 E+02
Rb	2.0 E+03	1.0 E+03
Sr	3.0 E+01	1.0 E+02
Y	2.5 E+01	1.0 E+03
Zr	3.3 E+00	6.7 E+00
Nb	5.5 E+02	1.0 E+02
Mo	1.0 E+01	1.0 E+01
Tc	1.5 E+01	5.0 E+00
Ru	1.0 E+01	3.0 E+02
Rh	1.0 E+01	3.0 E+02
Ag	2.3 E+00	7.7 E+02
Sb	2.0 E+02	1.0 E+01
Te	4.0 E+02	6.1 E+03
I	1.5 E+01	5.0 E+00
Cs	2.0 E+03	1.0 E+03
Ba	4.0 E+00	2.0 E+02
La	2.5 E+01	1.0 E+03
Ce	1.0 E+00	1.0 E+03
Pr	2.5 E+01	1.0 E+03
Nd	2.5 E+01	1.0 E+03
W	1.2 E+03	1.0 E+01
Np	1.0 E+01	4.0 E+02

* - Bioaccumulation Factors for freshwater fish and freshwater invertebrate, in (pCi/kg)/(pCi/L). They are obtained from Reference 11 (Table A-1), except as follows: Reference 41 for P; Reference 10 (Table A-8) for Ag; and Reference 49 for Nb and Sb.

Table A8-11 Decay Constants

Nuclide	Decay Constant sec^{-1}	Decay Constant hr^{-1}	Decay Constant $days^{-1}$	$T_{1/2}$ days
H-3	1.79E-09	6.44E-06	1.55E-04	4.49E+03
C-14	3.83E-12	1.38E-08	3.31E-07	2.09E+06
Na-24	1.28E-05	4.62E-02	1.11E+00	6.25E-01
P-32	5.61E-07	2.02E-03	4.85E-02	1.43E+01
Cr-51	2.90E-07	1.04E-03	2.50E-02	2.77E+01
Mn-54	2.57E-08	9.24E-05	2.22E-03	3.13E+02
Mn-56	7.47E-05	2.69E-01	6.45E+00	1.07E-01
Fe-55	8.14E-09	2.93E-05	7.03E-04	9.86E+02
Fe-59	1.80E-07	6.47E-04	1.55E-02	4.46E+01
Co-58	1.13E-07	4.08E-04	9.79E-03	7.08E+01
Co-60	4.17E-09	1.50E-05	3.60E-04	1.93E+03
Ni-63	2.19E-10	7.90E-07	1.90E-05	3.66E+04
Ni-65	7.64E-05	2.75E-01	6.60E+00	1.05E-01
Cu-64	1.52E-05	5.46E-02	1.31E+00	5.29E-01
Zn-65	3.28E-08	1.18E-04	2.84E-03	2.44E+02
Zn-69	2.08E-04	7.48E-01	1.80E+01	3.86E-02
Br-83	8.06E-05	2.90E-01	6.96E+00	9.96E-02
Br-84	3.63E-04	1.31E+00	3.14E+01	2.21E-02
Br-85	4.03E-03	1.45E+01	3.48E+02	1.99E-03
Rb-86	4.30E-07	1.55E-03	3.71E-02	1.87E+01
Rb-88	6.49E-04	2.34E+00	5.61E+01	1.24E-02
Rb-89	7.48E-04	2.69E+00	6.46E+01	1.07E-02
Sr-89	1.59E-07	5.71E-04	1.37E-02	5.06E+01
Sr-90	7.68E-10	2.76E-06	6.64E-05	1.04E+04
Sr-91	2.03E-05	7.30E-02	1.75E+00	3.96E-01
Sr-92	7.10E-05	2.56E-01	6.14E+00	1.13E-01
Y-90	3.00E-06	1.08E-02	2.60E-01	2.67E+00
Y-91m	2.32E-04	8.37E-01	2.01E+01	3.45E-02
Y-91	1.37E-07	4.94E-04	1.18E-02	5.85E+01
Y-92	5.44E-05	1.96E-01	4.70E+00	1.48E-01
Y-93	1.91E-05	6.86E-02	1.65E+00	4.21E-01
Zr-95	1.25E-07	4.51E-04	1.08E-02	6.40E+01
Zr-97	1.14E-05	4.10E-02	9.84E-01	7.04E-01
Nb-95	2.29E-07	8.24E-04	1.98E-02	3.51E+01
Mo-99	2.92E-06	1.05E-02	2.52E-01	2.75E+00
Tc-99m	3.20E-05	1.15E-01	2.76E+00	2.51E-01
Tc-101	8.14E-04	2.93E+00	7.03E+01	9.86E-03

Decay constants are from Reference 46.

Table A8-11 Decay Constants

Nuclide	Decay Constant sec^{-1}	Decay Constant hr^{-1}	Decay Constant $days^{-1}$	$T_{1/2}$ days
Ru-103	2.04E-07	7.34E-04	1.76E-02	3.94E+01
Ru-106	2.18E-08	7.84E-05	1.88E-03	3.68E+02
Rh-105	5.45E-06	1.96E-02	4.70E-01	1.47E+00
Ag-110m	3.21E-08	1.16E-04	2.77E-03	2.50E+02
Sb-124	1.33E-07	4.80E-04	1.15E-02	6.02E+01
Sb-125	7.93E-09	2.85E-05	6.85E-04	1.01E+03
Te-125m	1.38E-07	4.98E-04	1.20E-02	5.80E+01
Te-127m	7.36E-08	2.65E-04	6.36E-03	1.09E+02
Te-127	2.06E-05	7.41E-02	1.78E+00	3.90E-01
Te-129	1.66E-04	5.98E-01	1.43E+01	4.83E-02
Te-131m	6.42E-06	2.31E-02	5.55E-01	1.25E+00
Te-131	4.62E-04	1.66E+00	3.99E+01	1.74E-02
Te-132	2.46E-06	8.86E-03	2.13E-01	3.26E+00
I-130	1.56E-05	5.61E-02	1.35E+00	5.15E-01
I-131	9.98E-07	3.59E-03	8.62E-02	8.04E+00
I-132	8.37E-05	3.01E-01	7.23E+00	9.58E-02
I-133	9.26E-06	3.33E-02	8.00E-01	8.67E-01
I-134	2.20E-04	7.91E-01	1.90E+01	3.65E-02
I-135	2.91E-05	1.05E-01	2.52E+00	2.75E-01
Cs-134	1.07E-08	3.83E-05	9.20E-04	7.53E+02
Cs-136	6.10E-07	2.19E-03	5.27E-02	1.32E+01
Cs-137	7.28E-10	2.62E-06	6.29E-05	1.10E+04
Cs-138	3.59E-04	1.29E+00	3.10E+01	2.24E-02
Ba-139	1.39E-04	5.00E-01	1.20E+01	5.77E-02
Ba-140	6.27E-07	2.26E-03	5.42E-02	1.28E+01
Ba-141	6.32E-04	2.28E+00	5.46E+01	1.27E-02
Ba-142	1.08E-03	3.89E+00	9.33E+01	7.43E-03
La-140	4.79E-06	1.72E-02	4.14E-01	1.68E+00
La-142	1.21E-04	4.36E-01	1.05E+01	6.63E-02
Ce-141	2.47E-07	8.89E-04	2.13E-02	3.25E+01
Ce-143	5.83E-06	2.10E-02	5.04E-01	1.38E+00
Ce-144	2.82E-08	1.02E-04	2.44E-03	2.84E+02
Pr-143	5.92E-07	2.13E-03	5.11E-02	1.36E+01
Pr-144	6.69E-04	2.41E+00	5.78E+01	1.20E-02
Nd-147	7.31E-07	2.63E-03	6.31E-02	1.10E+01
W-187	8.08E-06	2.91E-02	6.98E-01	9.93E-01
Np-239	3.41E-06	1.23E-02	2.94E-01	2.36E+00

Table A8-12 Stable Element Transfer Data

Element	Veg/Soil B_{iv}*	Cow Milk F_m (d/L)*	Goat Milk F_m (d/L)+	Meat F_f (d/kg)*
H	4.8 E+00	1.0 E-02	1.7 E-01	1.2 E-02
C	5.5 E+00	1.2 E-02	1.0 E-01	3.1 E-02
Na	5.2 E-02	4.0 E-02	4.0 E-02	3.0 E-02
P	1.1 E+00	2.5 E-02	2.5 E-01	4.6 E-02
Cr	2.5 E-04	2.2 E-03	2.2 E-03	2.4 E-03
Mn	2.9 E-02	2.5 E-04	2.5 E-04	8.0 E-04
Fe	6.6 E-04	1.2 E-03	1.3 E-04	4.0 E-02
Co	9.4 E-03	1.0 E-03	1.0 E-03	1.3 E-02
Ni	1.9 E-02	6.7 E-03	6.7 E-03	5.3 E-02
Cu	1.2 E-01	1.4 E-02	1.3 E-02	8.0 E-03
Zn	4.0 E-01	3.9 E-02	3.9 E-02	3.0 E-02
Br	7.6 E-01	5.0 E-02	5.0 E-02	2.6 E-02
Rb	1.3 E-01	3.0 E-02	3.0 E-02	3.1 E-02
Sr	1.7 E-02	8.0 E-04	1.4 E-02	6.0 E-04
Y	2.6 E-03	1.0 E-05	1.0 E-05	4.6 E-03
Zr	1.7 E-04	5.0 E-06	5.0 E-06	3.4 E-02
Nb	9.4 E-03	2.5 E-03	2.5 E-03	2.8 E-01
Mo	1.2 E-01	7.5 E-03	7.5 E-03	8.0 E-03
Tc	2.5 E-01	2.5 E-02	2.5 E-02	4.0 E-01
Ru	5.0 E-02	1.0 E-06	1.0 E-06	4.0 E-01
Rh	1.3 E+01	1.0 E-02	1.0 E-02	1.5 E-03
Ag	1.5 E-01	5.0 E-02	5.0 E-02	1.7 E-02
Sb	1.1 E-02	1.5 E-03	1.5 E-03	4.0 E-03
Te	1.3 E+00	1.0 E-03	1.0 E-03	7.7 E-02
I	2.0 E-02	6.0 E-03	6.0 E-02	2.9 E-03
Cs	1.0 E-02	1.2 E-02	3.0 E-01	4.0 E-03
Ba	5.0 E-03	4.0 E-04	4.0 E-04	3.2 E-03
La	2.5 E-03	5.0 E-06	5.0 E-06	2.0 E-04
Ce	2.5 E-03	1.0 E-04	1.0 E-04	1.2 E-03
Pr	2.5 E-03	5.0 E-06	5.0 E-06	4.7 E-03
Nd	2.4 E-03	5.0 E-06	5.0 E-06	3.3 E-03
W	1.8 E-02	5.0 E-04	5.0 E-04	1.3 E-03
Np	2.5 E-03	5.0 E-06	5.0 E-06	2.0 E-04

* - Values from Reference 31 (Page 2.40)
\+ - Values from Reference 31 (Page 2.41) for H, C, P, Fe, Cu, Sr, I, and Cs in goat milk, and Reference 31 (Page 2.40) for all other elements in cow milk.

ATTACHMENT 9: RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM (page 1 of 5)

Exposure Pathway and/or Sample	Number of Samples and Sample Location[a]	Collection FREQUENCY	Type and FREQUENCY of Analysis
1. DIRECT RADIATION			
Direct Radiation[b]	No less than forty (40) routine monitoring stations, either with two or more dosimeters or with one instrument for measuring and recording dose rate continuously, to be placed as follows: 1) an inner ring of stations, one in each emergency meteorological sector in the general area of the SITE BOUNDARY 2) an outer ring of stations, one in each emergency meteorological sector within 4 to 5 miles range from the site. 3) the balance of the stations to be placed in special interest areas such as population centers, nearby residences, schools, and in 1 or 2 areas to serve as control stations	Quarterly	Gamma dose quarterly

ATTACHMENT 9 (continued page 2 of 5)

Exposure Pathway and/or Sample	**Number of Samples and Sample Location**[a]	**Collection FREQUENCY**	**Type and FREQUENCY of Analysis**
2. AIRBORNE			
Radioiodines and Particulates	Samples from 5 locations: 1) 3 samples from different sectors close to the SITE BOUNDARY having the highest calculated historical average ground level D/Q 2) 1 sample from the vicinity of a community having the highest calculated annual average ground level D/Q 3) 1 sample from a control location 10 to 20 miles distant and in the least prevalent wind direction	Continuous sampler operation with sample collection weekly or more frequently if needed because of dust loading	Radioiodine Canister: I-131 analysis, weekly Particulate Sampler: gross beta radioactivity analysis following filter change[c] Gamma isotopic analysis of composite (by location) quarterly[d]

ATTACHMENT 9 (continued page 3 of 5)

Exposure Pathway and/or Sample	**Number of Samples and Sample Location[a]**	**Collection FREQUENCY**	**Type and FREQUENCY of Analysis**
3. WATERBORNE			
a) Surface[e]	Samples from 2 locations: 1) 1 sample upstream of discharge point for Units 1/2/3/4 2) 1 sample downstream of discharge point for Units 1/2/3/4	COMPOSITE SAMPLE over 1-month period[f]	Gamma isotopic analysis monthly[d] Composite for tritium analysis quarterly
b) Groundwater	Ground water sampling is not included within this ODCM. It is covered by the Radiological Groundwater Protection Program and site procedures.	See Radiological Groundwater Protection Program	See Radiological Groundwater Protection Program
c) Sediment from Shoreline	1 sample from downstream area with existing or potential recreational value	Semi-Annually	Gamma isotopic analysis[d] semi-annually
d) Drinking	2 samples at each of the one to three nearest water treatment plants that could be affected by discharges from the facility. Two samples at a control location.	COMPOSITE SAMPLE of river water near intake at each water treatment plant over 2-week period when I-131 analysis is performed, monthly composite otherwise; and grab sample of finished water at each water treatment plant every 2 weeks or monthly, as appropriate[f].	I-131 analysis on each sample when the dose calculated for the consumption of the water is greater than 1 mrem per year[g]. Composite for gross beta and gamma isotopic analyses monthly. Composite for tritium analysis quarterly[d].

ATTACHMENT 9 (continued, page 4 of 5)

Exposure Pathway and/or Sample	**Number of Samples and Sample Location[b]**	**Collection FREQUENCY**	**Type and FREQUENCY of Analysis**
4. INGESTION			
Milk[i]	Samples from milking animals in 3 locations within 3 miles that have the highest dose potential. If there are none, then 1 sample from milking animals in each of 3 areas between 3 to 5 miles where doses are calculated to be greater than 1 mrem per yr[g] 1 sample from milking animals at a control location about 10 miles or beyond in the least prevalent wind direction	Semimonthly when animals are on pasture; Monthly at other times	Gamma isotopic[d] and I-131 analysis[h] semi-monthly when animals are on pasture; monthly at other times
Fish and Invertebrates	1 sample of commercially and recreationally important species (bass, sunfish, catfish) in vicinity of plant discharge area 1 sample of same species in areas not influenced by plant discharge At least one sample of any anadromous species in vicinity of plant discharge	Semiannually or when in season During spring spawning season	Gamma isotopic analysis[d] on edible portions
Food Products[j]	Sample 3 different kinds of broad leaf vegetation grown nearest each of 2 different offsite locations of highest predicted historical annual average ground level D/Q if milk sampling is not performed: 1 sample of broad leaf vegetation grown 10 to 20 miles in the least prevalent wind direction if milk sampling is not performed 1 sample of food products from any area that is irrigated by water in which plant liquid effluents have impacted.	Monthly if available, or at harvest	Gamma isotopic[d] and I-131 analysis[h].

ATTACHMENT 9 (continued page 5 of 5)

NOTES

a. For each sample location in this table, specific parameters of distance and direction sector from a point midway between the center of the two reactors, and additional description where pertinent, are provided in Attachment 10.

b. One or more instruments, such as a pressurized ion chamber, for measuring and recording dose rate continuously, may be used in place of or in addition to integrating dosimeters. For the purpose of this table, an optically stimulated luminescent dosimeter (OSLD) is considered to be one phosphor; two or more phosphors in a packet are considered as two or more dosimeters. Film badges shall not be used as dosimeters for measuring direct radiation.

c. Airborne particulate sample filters shall be analyzed for gross beta radioactivity 24 hours or more after sampling to allow for radon and thoron daughter decay. If gross beta activity in air particulate samples is greater than 10 times the yearly mean of control samples, gamma isotopic analysis shall be performed on the individual samples.

d. Gamma isotopic analysis means the identification and quantification of gamma-emitting radionuclides that may be attributable to the effluents from the facility.

e. The upstream sample shall be taken at a distance beyond significant influence of the discharge. The downstream sample shall be taken in an area beyond but near the mixing zone.

f. COMPOSITE SAMPLE aliquots shall be collected at time intervals that are very short (e.g., hourly) relative to the compositing period (e.g., monthly) in order to assure obtaining a representative sample.

g. The dose shall be calculated for the maximum organ and age group, using the methodology and parameters in Section 6.2.3.

h. If gamma isotopic analysis is not sensitive enough to meet the required MDC for I-131, a separate analysis for I-131 will be performed. See Attachment 11 for MDC equation.

i. If milk sampling cannot be performed, use samples for food products (Attachment 9).

j. If edible broadleaf vegetation is unavailable, non-edible vegetation of similar leaf characteristics may be substituted.

ATTACHMENT 10: ENVIRONMENTAL SAMPLING LOCATIONS FROM THE CENTERPOINT OF UNITS 3 AND 4 (page 1 of 3)

Location Number	Descriptive Location	Direction	Distance (miles)	Sample Type[a]
1	River Bank	NNE	1.2	D
2	River Bank	NNE	1.2	D
3*	Discharge Area	NE	0.9	A
3*	River Bank	ENE	1.1	D
4	River Bank	ENE	1.3	D
5	River Bank	E	1.4	D
6	Plant Wilson	E	1.5	D
7	Simulator Building	ESE	2.0	D,V,A
8	River Road	SE	1.4	D
9	River Road	SSE	1.1	D
10*	Met Tower	S	0.8	A
10*	River Road	S	1.0	D
11	River Road	SSW	0.9	D
12	River Road	WSW	0.7	D,A
13	River Road	W	0.9	D
14	River Road	WNW	1.8	D
15	Hancock Landing Road	NW	1.5	D,V
16	Hancock Landing Road	NNW	1.4	D,A
17	Savannah River Site, River Road	N	5.5	D
18	Savannah River Site, D Area	N	5.5	D
19	Savannah River Site, Road A.13	NE	5.0	D
20	Savannah River Site, Road A.13.1	ENE	4.8	D
21	Savannah River Site, Road A.17	E	5.1	D
22	River Bank Downstream of Buxton Landing	ESE	5.6	D
23	River Road	SE	4.8	D

* = Two locations in the same sector and shown as a single sample station in Figure 6.6.1-2.

ATTACHMENT 10: ENVIRONMENTAL SAMPLING LOCATIONS FROM THE CENTERPOINT OF UNITS 3 AND 4 (page 2 of 3)

Location Number	Descriptive Location	Direction	Distance (miles)	Sample Type[a]
24	Chance Road	SSE	5.2	D
25	Chance Road near Highway 23	S	5.1	D
26	Highway 23 and Ebenezer Church Rd.	SSW	4.5	D
27	Highway 23, opposite Boll Weevil Road	SSW	4.1	D
28	Thomas Road	WSW	4.6	D
29	Claxton-Lively Road	W	4.5	D
30	Nathaniel Howard Road	WNW	4.6	D
31	River Road at Allen's Chapel Fork	NW	4.8	D
32	River Bank	NNW	4.7	D
35	Girard	SSE	6.6	D,A
36	GPC Waynesboro Operating Headquarters	WSW	13.5	D,A
37	Substation; Waynesboro, GA	WSW	16.7	D,V
43	Employees Recreation Area	SSW	2.0	D
47	Oak Grove Church	E	1.2	D
48	McBean Cemetery	NW	10.0	D
51	SGA School; Sardis, GA	S	10.9	D
52	Oglethorp Substation; Alexander, GA	SW	10.3	D
80	Augusta Water Treatment Plant	NNW	29.2	W(b)
81	Savannah River	NE	1.1	F(c),S(d)
82	Savannah River (RM 151.2)	ENE	1.3	R
83	Savannah River (RM 150.4)	ENE	1.3	R,S(d)
84	Savannah River (RM 149.5)	E	2.1	R
85	Savannah River	ESE	4.3	F(c)

RM = river mile

ATTACHMENT 10: ENVIRONMENTAL SAMPLING LOCATIONS FROM THE CENTERPOINT OF UNITS 3 AND 4. (page 3 of 3)

Location Number	Descriptive Location	Direction	Distance (miles)	Sample Type[a]
87	Beaufort - Jasper Water Treatment Plant; Beaufort, SC	SE	74.9	W[(e)] SEE NOTE e
88	Cherokee Hill Water Treatment Plant; Port Wentworth, GA	SSE	70.0	W[(f)]
89	Purrysburg Water Treatment Plant; Purrysburg, SC	SSE	66.0	W[(7)]
101	Girard Dairy	S	5.9	M
102	Seven Oaks Dairy/Milky Way Dairy	W	7.5/16.0	M
111	Near Plant Wilson	E	1.2	V
112	Near River Intake	NE	1.0	D
113	River Road	SW	0.8	D
114	River Road	WNW	1.2	D
115	Handcock Landing Road	N	1.4	D
116	Shell Bluff Landing Road	NNW	6.3	D
117	Highway 23, near Jack Delaigle Road	SW	4.6	D
118	Near Plant Wilson	E	1.2	A
119	Near Vogtle 1&2 Cooling Tower	NE	1.0	A

a. Sample Types:

A -	Airborne Radioactivity	R -	River Water
D -	Direct Radiation	S -	River Shoreline Sediment
F -	Fish	W -	Drinking Water (at water treatment plant)
M -	Milk	V -	Vegetation

Sample FREQUENCY: See Attachment 9

b. The intake for the Augusta Water Treatment Plant is located on the Augusta Canal. The entrance to this canal is at river mile (RM) 207 on the Savannah River. The canal effectively parallels the river. The intake to the pumping station is about 4 miles down the canal and only 0.1 mile from the river (across land).

c. About a 5-mile stretch of the river is generally needed to obtain adequate fish samples. Samples are normally gathered between RM 153 and 158 for upriver collections and between RMs 144 and 149.4 for downriver collections.

d. Sediment is collected at locations with existing or potential recreational value. High water shifting of the river bottom or other reasons could cause a suitable location for sediment collection to become unavailable or unsuitable. Thus, a stretch of river between RM 148.5 and 150.5 is designated for downriver sediment collections, while a stretch between RM 153 and 154 is designated for upriver collections. In practice, collections are normally made at RM 150.2 for downriver collections and at RM 153.3 for upriver collections.

e. DELETED THIS SAMPLE LOCATION IN 2014 (Reference 51). Two additional indicator stations are available. Historical: The intake for the Beaufort-Jasper Water Treatment Plant is located at the end of a canal which begins at RM 39.3 on the Savannah River. This intake is about 16 miles by line of sight down the canal from its beginning on the Savannah River.

f. The intake for the Cherokee Hill Water Treatment Plant is located on Abercorn Creek, which is about one and a quarter creek miles from its mouth on the Savannah River at RM 29.

g. The intake for the Purrysburg Water Treatment Plant is located on the same canal as the Beaufort–Jasper Water Treatment Plant. The Purrysburg intake is nearer to the Savannah River at the beginning of the canal.

ATTACHMENT 11: VALUES FOR THE MINIMUM DETECTABLE CONCENTRATION (MDC)

Analysis[a]	Water (pCi/l)	Airborne Particulate or Gases (pCi/m^3)	Fish (pCi/kg) (wet)	Milk (pCi/l)	Food Products (pCi/kg) (wet)	Sediment (pCi/kg) (dry)
gross beta	4 E+0	1 E-2				
H-3	2 E+3 [(b)]					
Mn-54	1.5 E+1		1.3 E+2			
Fe-59	3 E+1		2.6 E+2			
Co-58, Co-60	1.5 E+1		1.3 E+2			
Zn-65	3 E+1		2.6 E+2			
Zr-95	3 E+1					
Nb-95	1.5 E+1					
I-131	1 E+0[c]	7 E-2		1 E+0	6 E+1	
Cs-134	1.5 E+1	5 E-2	1.3 E+2	1.5 E+1	6 E+1	1.5 E+2
Cs-137	1.8 E+1	6 E-2	1.5 E+2	1.8 E+1	8 E+1	1.8 E+2
Ba-140	6 E+1			6 E+1		
La-140	1.5 E+1			1.5 E+1		

a. Other peaks which are measurable and identifiable as plant effluents, together with the radionuclides in this table, shall be analyzed and reported in accordance with Section 6.7.1.
b. If no drinking water pathway exists, a value of 3 x 10^{+3} pCi/L may be used.
c. If no drinking water pathway exists, a value of 1.5 x 10^{+1} pCi/L may be used.
d. MDC is defined as follows, consistent with NUREG/CR-4007 (Reference 28).

$$MDC = \frac{\frac{2.71}{t_s} + 3.29\sqrt{R_b\left(\frac{1}{t_s} + \frac{1}{t_b}\right)}}{E \cdot V \cdot 2.22E6 \cdot Y \cdot e^{-\lambda \Delta t}}$$ Eqn A11-1

where

MDC	=	the *a priori* MINIMUM DETECTABLE CONCENTRATION as defined above as µCi per unit mass or volume.
t_s	=	t the length of the sample counting period (minutes)
t_b	=	the length of the background counting period (minutes)
R_b	=	background count rate in cpm
E	=	the counting efficiency, as counts per disintegration
V	=	the sample size in units of mass or volume
2.22E6	=	the number of disintegrations per minute per µCi
Y	=	the fractional radiochemical yield, when applicable
λ	=	the radioactive decay constant for the particular radionuclide. Values of λ used in effluent calculations should be based on decay data from a recognized and current source, such as Reference 46.
Δt	=	for effluent samples, the elapsed time between the midpoint of sample collection and the time of counting (h); for environmental samples, the elapsed time between the end of sample collection and the time of counting (h).

ATTACHMENT 12: REPORTING LEVELS FOR RADIOACTIVITY CONCENTRATIONS IN ENVIRONMENTAL SAMPLES

Analysis	Water (pCi/L)	Airborne Particulate or Gases (pCi/m^3)	Fish (pCi/kg, wet)	Milk (pCi/l)	Food Products (pCi/kg, wet)
H-3	2 E+04 [(a)]				
Mn-54	1 E+03		3 E+04		
Fe-59	4 E+02		1 E+04		
Co-58	1 E+03		3 E+04		
Co-60	3 E+02		1 E+04		
Zn-65	3 E+02		2 E+04		
Zr-Nb-95	4 E+02				
I-131	2 E+00 [(b)]	9 E-01		3 E+00	1 E+02
Cs-134	3 E+01	1 E+01	1 E+03	6 E+01	1 E+03
Cs-137	5 E+01	2 E+01	2 E+03	7 E+01	2 E+03
Ba-La-140	1 E+02			3 E+02	

a. This is the 40 CFR 141 maximum contaminant level for drinking water. If no drinking water pathway exists, a value of 3E+04 pCi/L may be used.

b. If no drinking water pathway exists, a value of 2E+01 pCi/L may be used.

ATTACHMENT 13: METEROLOGICAL, LIQUID AND GASEOUS PATHWAY ANALYSIS

1.0 METEOROLOGICAL ANALYSIS

1.1 Purpose

The purpose of the meteorological analysis is to determine the annual average X/Q and D/Q values at critical locations around the site for each mode of release. The annual average X/Q and D/Q values were used to perform a dose pathway analysis to determine both the MAXIMUM EXPOSED INDIVIDUAL at SITE BOUNDARY and a MEMBER OF THE PUBLIC inside the SITE BOUNDARY.

1.2 Meteorological Data, Parameters, and Methodology

The annual summaries of onsite meteorological data used to calculate dispersion (X/Q) and deposition (D/Q) factors in Table A13.1.3-1 were calculated based on site meteorological data. The VEGP 3&4 values were based on hourly-averaged measurements from instrumentation mounted on the Vogtle site primary tower taken over the 5-year period of record from 1998 through 2002. These data were used to determine the wind roses and joint frequency distributions of wind speed and wind direction by atmospheric stability class presented and discussed in the Site Safety Analysis Report prepared for Vogtle Units 3 and 4 Early Site Permit Application (Reference 38).

The X/Q's and D/Q's were calculated using the NRC computer code "XOQDOQ - Program for the Meteorological Evaluation of Routine Effluent Releases at Nuclear Power Stations," (Reference 37). The code is based upon a straight line airflow model implementing the assumptions outlined in Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors" (Reference 13).

Because the Plant Vent for Units 3/4 discharges at the level of the shield building roof (near the bottom of the passive containment system water storage tank), it is below the height of adjacent solid structures. This makes the Plant Vent a ground-level release according to Reg Guide 1.111 (Reference 13). The Plant Vent is the highest planned effluent release pathway. Therefore, all other releases are considered ground-level releases.

The exclusion area boundary (EAB) is conservatively used to represent the SITE BOUNDARY. According to Reference 38, the site exclusion area boundary (EAB) is bounded by River Road, Hancock Landing Road, and 1.7 miles of the Savannah River (River Miles 150.0 to 151.7). The EAB is the same as the exclusion area boundary for the existing VEGP units. The nearest point to the exclusion area boundary (EAB) is located approximately 3,400 ft southwest of the VEGP Units 3 and 4 power block area. The distance to the nearest residence (i.e., 0.67 mi) was conservatively used in all the directional sectors for all types of sensitive receptors (meat animal, vegetable garden, and residence). Based on the Land Use Census three critical receptors were identified (i.e., Resident, Cow Meat, and Vegetation Garden) The distances to these receptors and the dose pathways assigned are shown in shown in Table A13.1.3-1.

The models presented in this chapter are those which were used to compute the specific values of meteorology-related parameters that are referenced throughout this ODCM. These models should also be used whenever it is necessary to calculate values of these parameters for new locations of interest.

1.3 Results

Table A13.1.3-1 Attributes of Critical Receptor Locations Onsite and Offsite for Vogtle 3&4

Location	Sector	Distance Meters	Distance Miles	X/Q	D/Q	Occupancy Factor	Pathways
Visitor Center	ESE	605	0.38	9.66E-06	2.57E-08	0.24	Inhalation Ground Plane
Unit 4 Construction	NE	402	0.25	1.83E-05	4.90E-08	0.24	Inhalation Ground Plane
Site Boundary	NE	800	0.5	5.44E-06	1.70E-08	1	Inhalation Ground Plane
Resident	N	2253	1.4	8.53E-07	2.27E-09	1	Inhalation Ground Plane
Beef	NW	2897	1.8	5.17E-07	1.19E-09	1	Inhalation Ground Plane Cow Meat
Vegetation	W	6898	4.1	2.07E-07	3.61E-10	1	Inhalation Ground Plane Vegetation

1.3.1 Atmospheric Dispersion

Atmospheric dispersion may be calculated using the appropriate form of the sector-averaged Gaussian model. Gaseous release elevations may be considered to be at ground-level. Facility release model for each gaseous release point are as indicated on Table 6.3.2-1.

a. Ground-Level Releases
Relative concentration calculations for ground-level releases, shall be made as follows:

$$(X/Q)_G = \frac{2.032\,\delta\, K_r}{N\ r} \sum_{jk} \left[\frac{n_{jk}}{u_j \sum_{zk}} \right] \qquad \text{Eqn A13.1.3.1-1}$$

where:

$\left({}^{X}/_{Q}\right)_G$ = the ground-level sector-averaged relative concentration for a given wind direction (sector) and distance (s/m^3).

2.032 = $(2/\pi)^{1/2}$ divided by the width in radians of a 22.5° sector, which is 0.3927 radians.

δ = the plume depletion factor for all radionuclides other than noble gases at a distance r shown in Figure A13-3. For noble gases, the depletion factor is unity. If an undepleted relative concentration is desired, the depletion factor is unity. Only depletion by deposition is considered since depletion by radioactive decay would be of little significance at the distances considered.

K_r = the terrain recirculation factor corresponding to a distance r, adapted from Reference 55.

n_{jk} = the number of hours that wind of wind speed class j is directed into the given sector during the time atmospheric stability category k existed.

N = the total hours of valid meteorological data recorded throughout the period of interest for all sectors, wind speed classes, and stability categories.

u_j = the wind speed (mid-point of wind speed class j) at ground level (m/s).

r = the distance from release point to location of interest (m).

$\sum_{zk}$ = the vertical standard deviation of the plume concentration distribution considering the initial dispersion within the building wake, calculated as follows:

$$\sum_{zk} = the\ \ lesser\ \ of \begin{cases} \left(\sigma_{zk}^2 + \dfrac{b^2}{2\pi} \right)^{1/2} \\ OR \\ \sqrt{3}(\sigma_{zk}) \end{cases} \qquad \text{Eqn A13.1.3.1-2}$$

σ_{zk}	=	the vertical standard deviation of the plume concentration distribution (m) for a given distance and stability category k as shown in Figure A13-2. The stability category is determined by the vertical temperature gradient $\Delta T/\Delta z$ (°C/100 m).
b	=	the maximum height of adjacent plant structure.

1.3.2 Relative Deposition

Plume depletion may be calculated using the appropriate form of the sector-averaged Gaussian model. Gaseous release elevations may be considered to be ground-level. Facility release mode for each gaseous release points are as indicated in Table 6.3.2-1.

a. Ground-Level Releases

Relative deposition calculations for ground-level releases shall be made as follows:

$$(D/Q)_G = \frac{2.55 D_g \; K_r}{N \; r} \sum_k n_k \qquad \text{Eqn A13.1.3.2-3}$$

where:

$\left(D/Q\right)_G$ = the ground-level sector-averaged relative deposition for a given wind direction (sector) and distance (s/m^3).

2.55 = the inverse of the number of radians in a 22.5° sector [= $(2\pi/16)^{-1}$].

D_g = the deposition rate at distance r, taken from Figure A13-7 for ground-level releases (m^{-1}).

n_k = the number of hours in which the wind is directed into the sector of interest, and during which stability category k exists.

All other symbols are as previously defined in Attachment 13 Section 1.3.1.

Figure A13-1 Terrain Elevation Profiles Within 50 Miles of the VEGP Site (1 of 4)

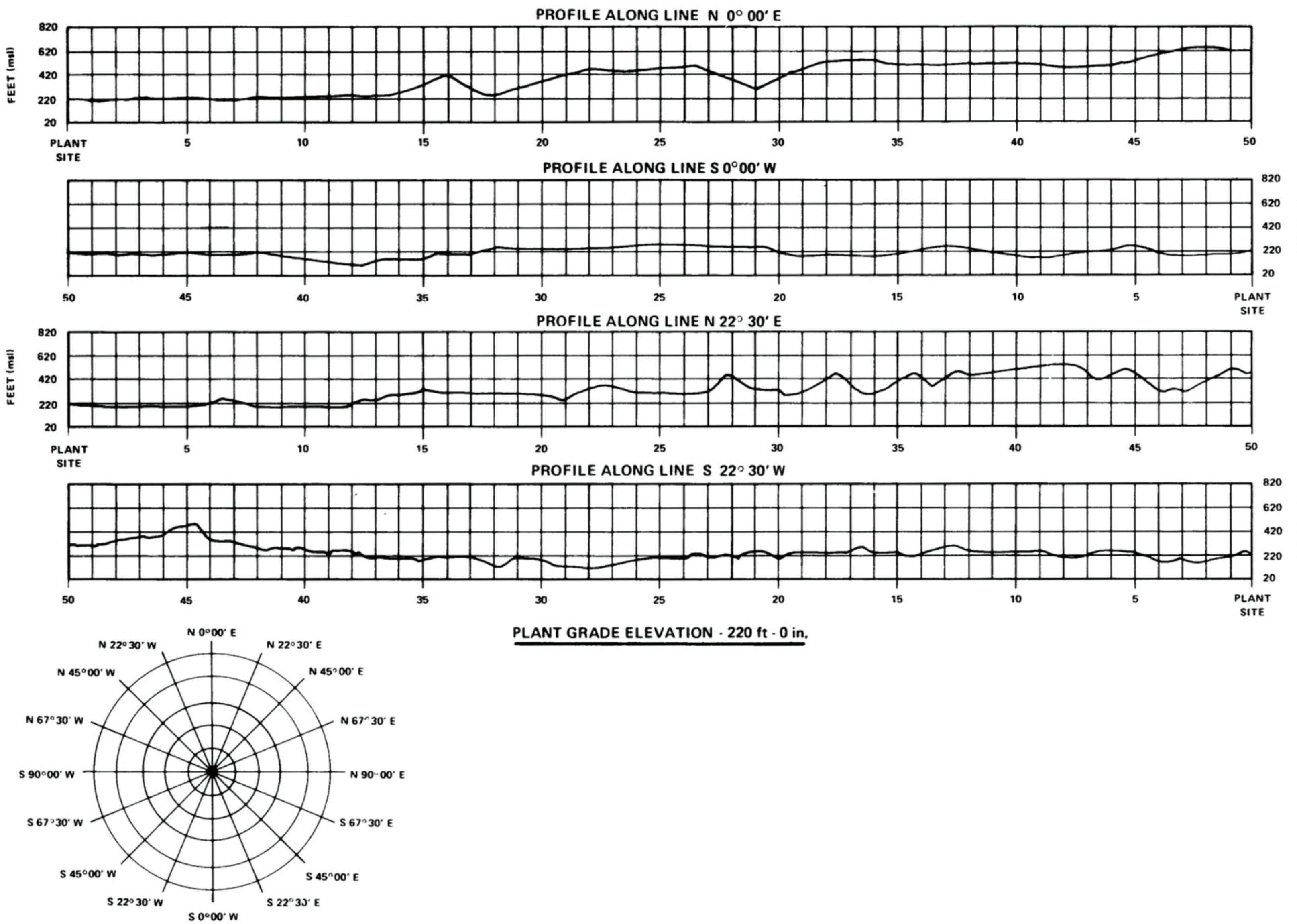


Figure A13-1 Terrain Elevation Profiles Within 50 Miles of the VEGP Site (2 of 4)

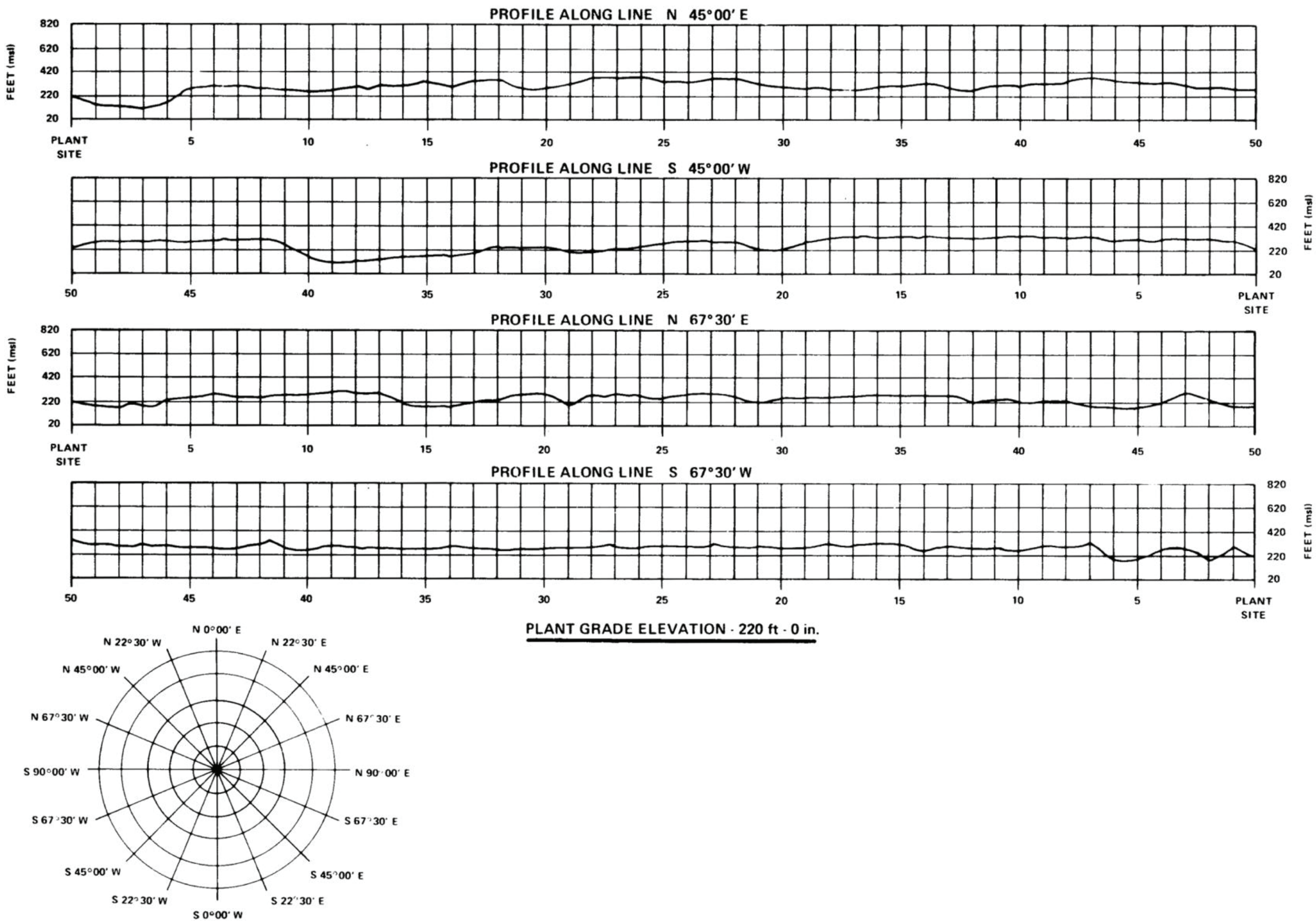


Figure A13-1 Terrain Elevation Profiles Within 50 Miles of the VEGP Site (3 of 4)

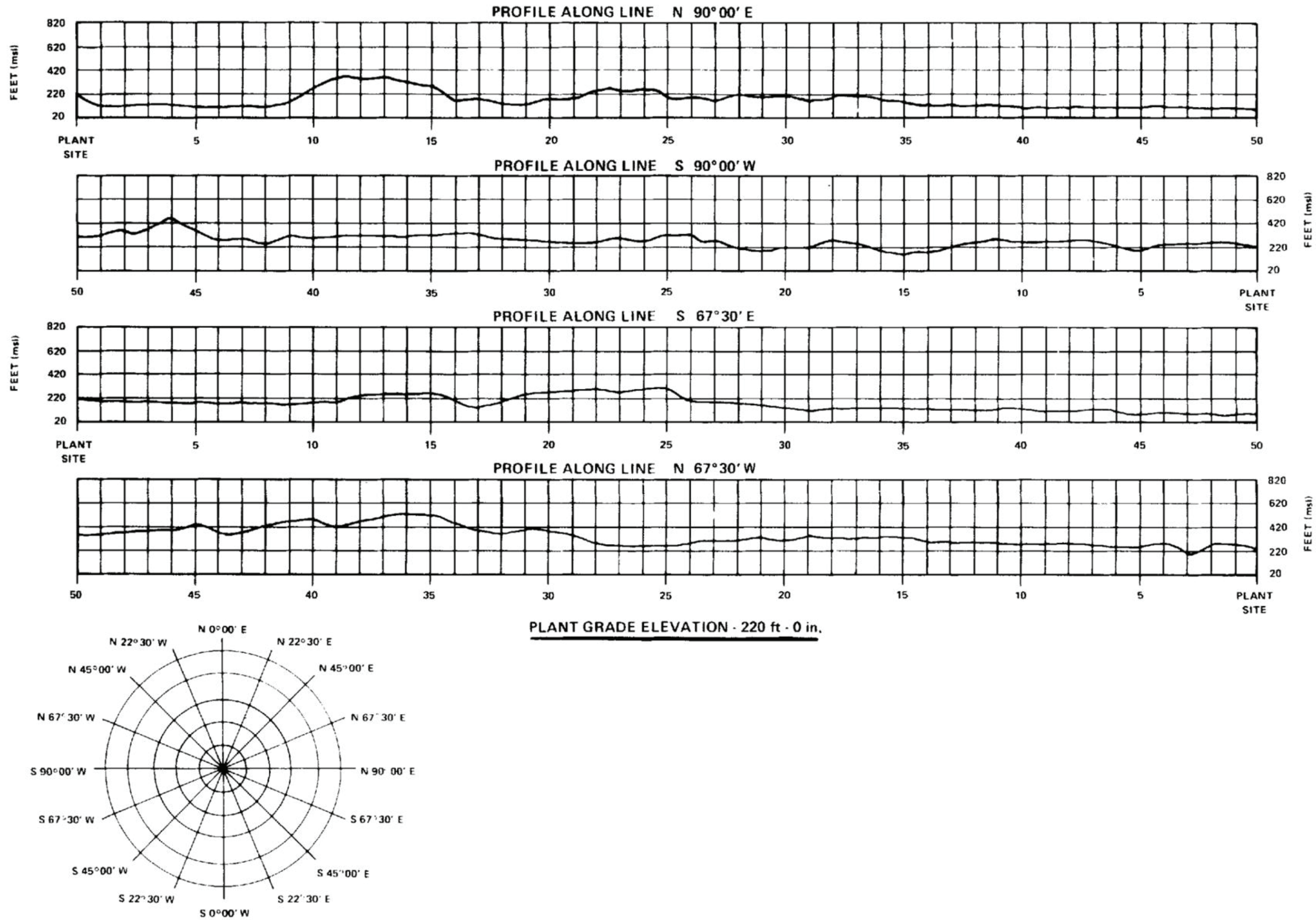


Figure A13-1 Terrain Elevation Profiles Within 50 Miles of the VEGP Site (4 of 4)

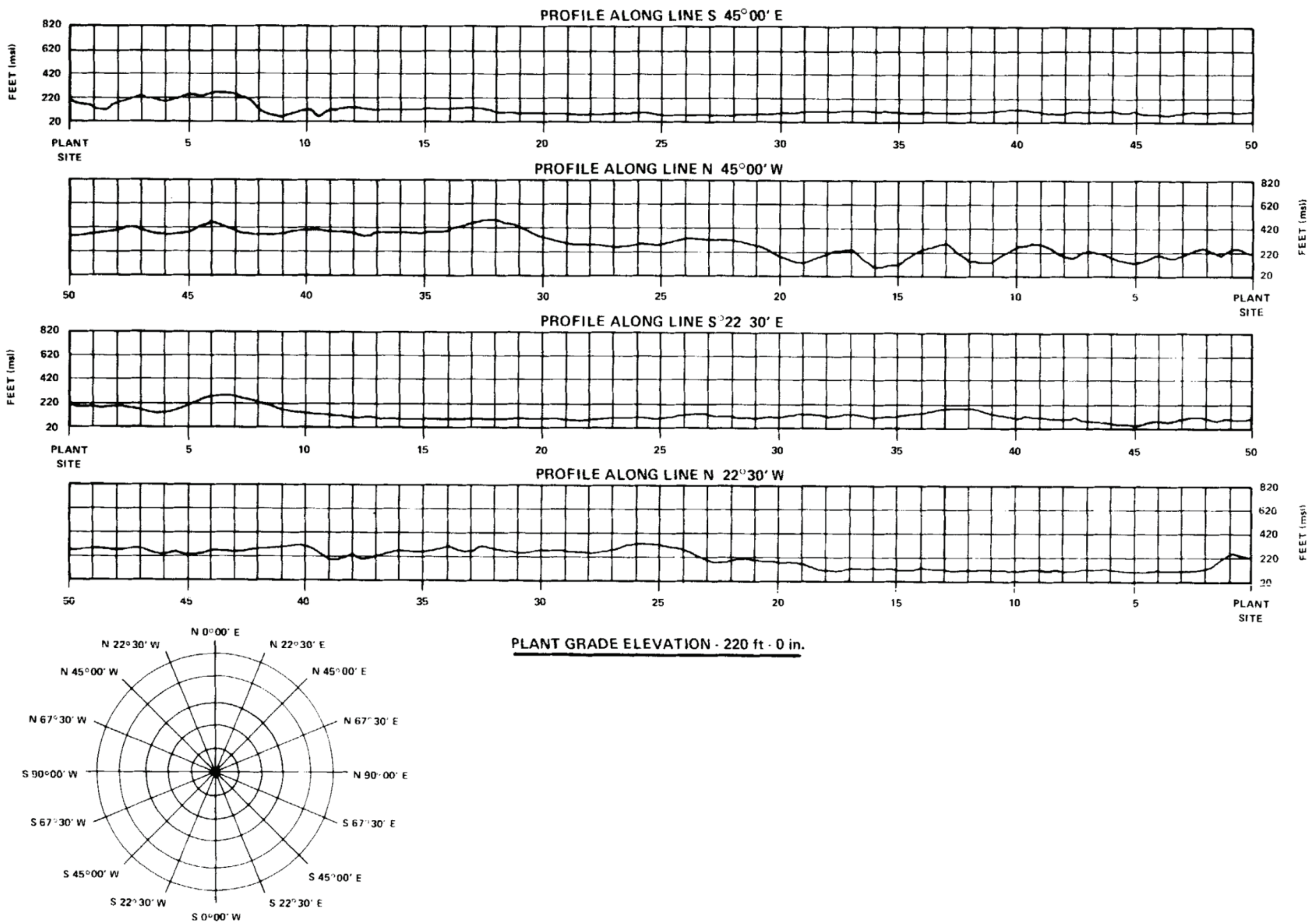
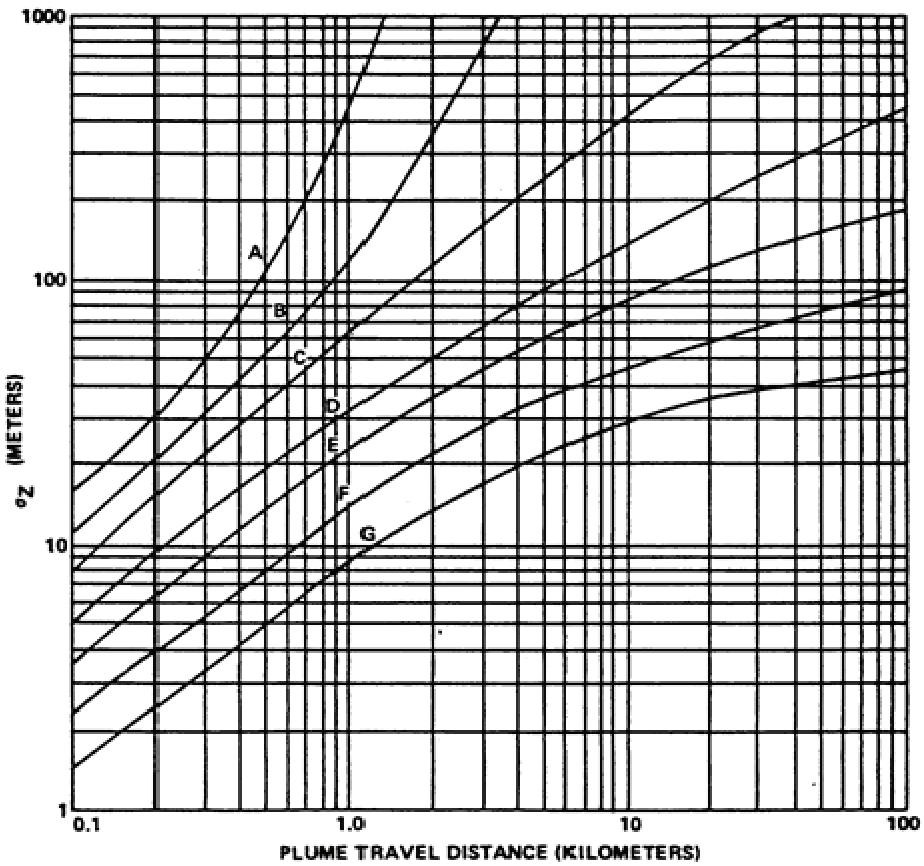


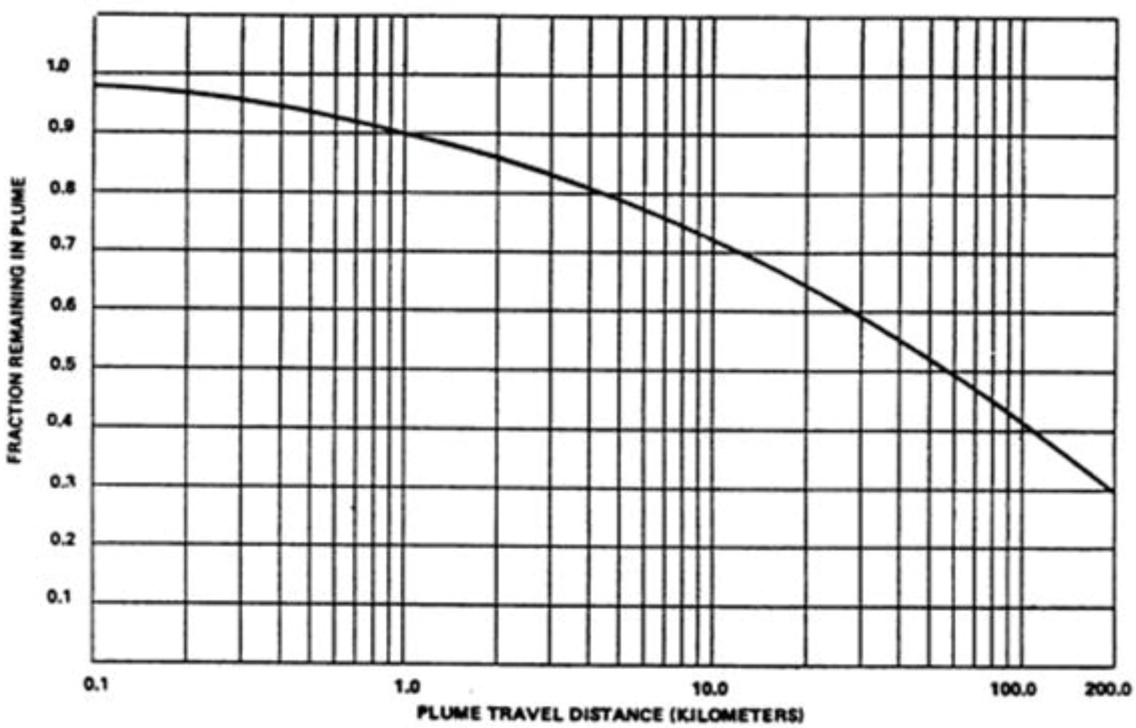
Figure A13-2 Vertical Standard Deviation of Material in a Plume (σ_z)



Category	Range of Vertical Temperature Gradient (°C/100 m)	Range of Vertical Temperature Gradient (°F/100 ft)
A	$\Delta T/\Delta Z < -1.9$	$\Delta T/\Delta Z < -1.0$
B	$-1.9 \leq \Delta T/\Delta Z < -1.7$	$-1.0 \leq \Delta T/\Delta Z < -0.9$
C	$-1.7 \leq \Delta T/\Delta Z < -1.5$	$-0.9 \leq \Delta T/\Delta Z < -0.8$
D	$-1.5 \leq \Delta T/\Delta Z < -0.5$	$-0.8 \leq \Delta T/\Delta Z < -0.3$
E	$-0.5 \leq \Delta T/\Delta Z < 1.5$	$-0.3 \leq \Delta T/\Delta Z < 0.8$
F	$1.5 \leq \Delta T/\Delta Z < 4.0$	$0.8 \leq \Delta T/\Delta Z < 2.2$
G	$4.0 \leq \Delta T/\Delta Z$	$2.2 \leq \Delta T/\Delta Z$

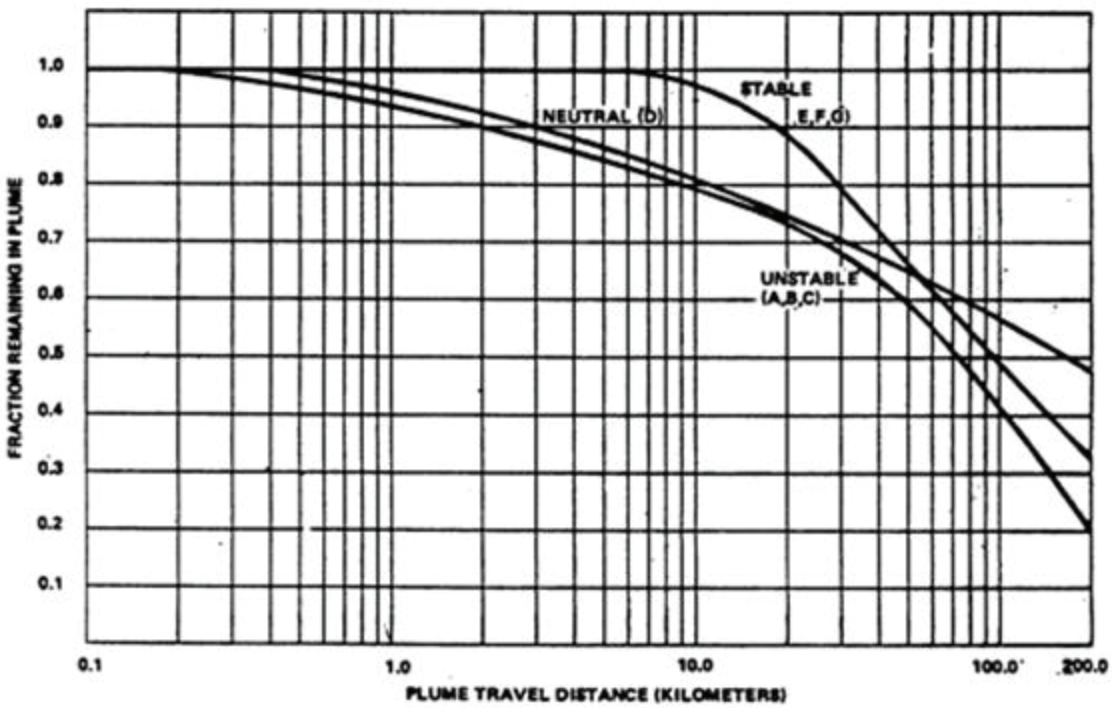
This graph is reproduced from Reference 13 (Figure 1)

Figure A13-3 Plume Depletion Effect for Ground Level Releases



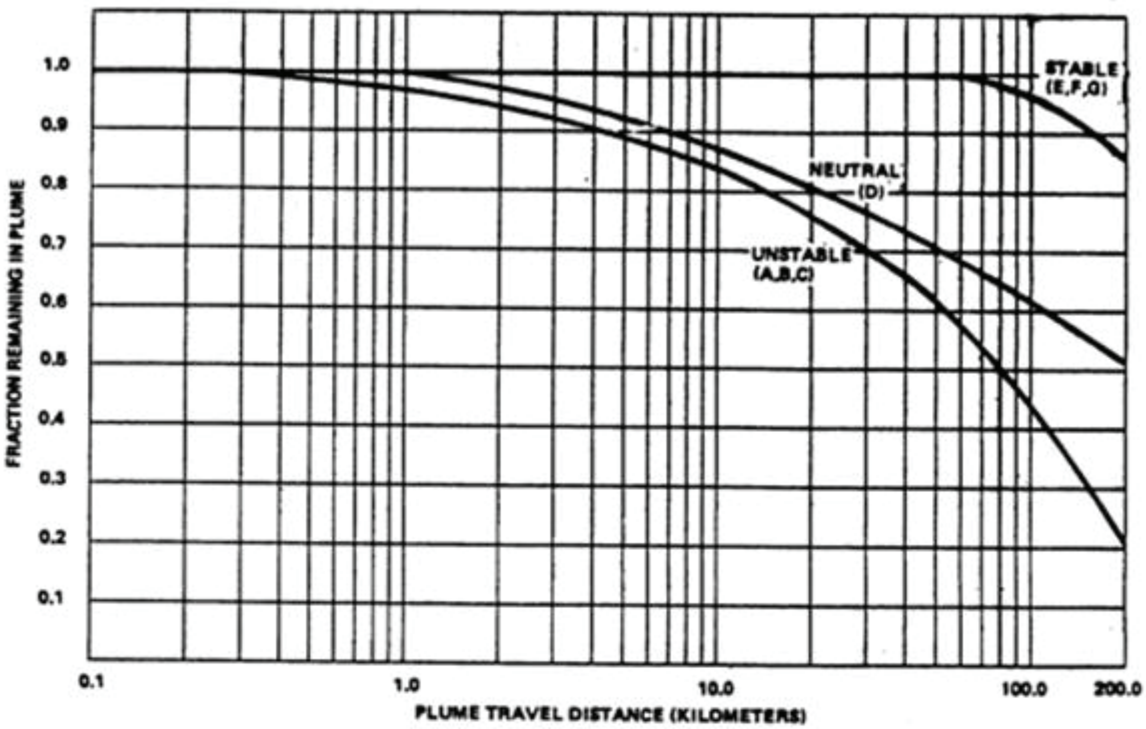
This graph is reproduced from Reference 13 (Figure 2)

Figure A13-4 Plume Depletion Effect for 30-Meter Releases



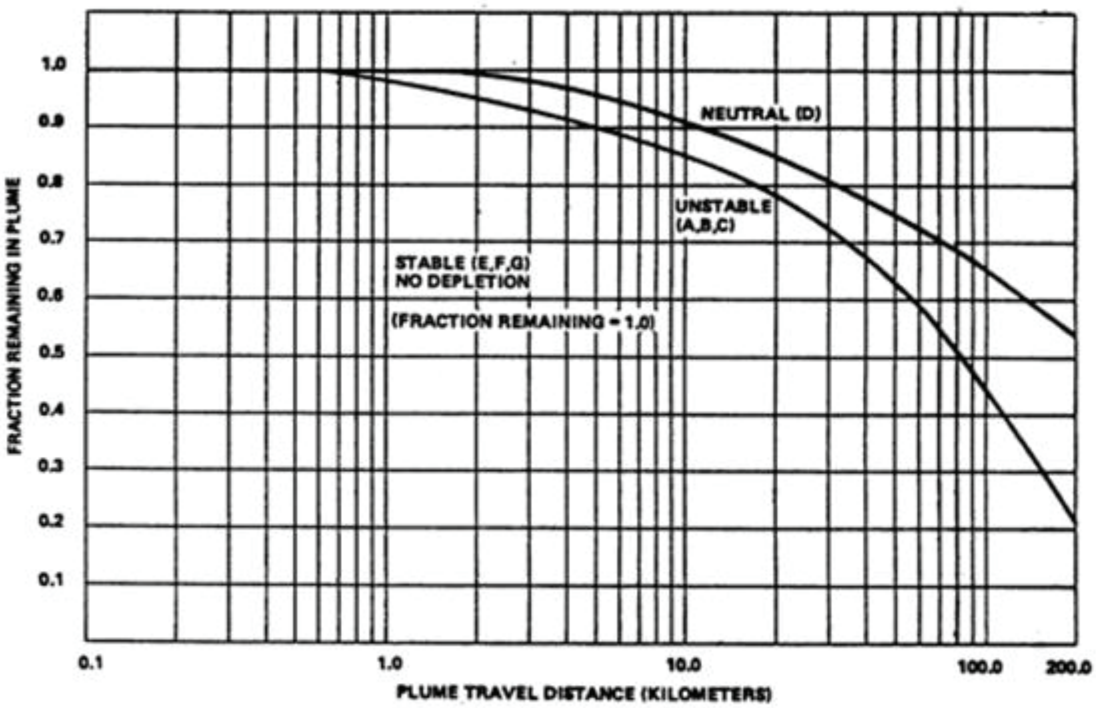
This graph is reproduced from Reference 13 (Figure 3)

Figure A13-5 Plume Depletion Effect for 60-Meter Releases



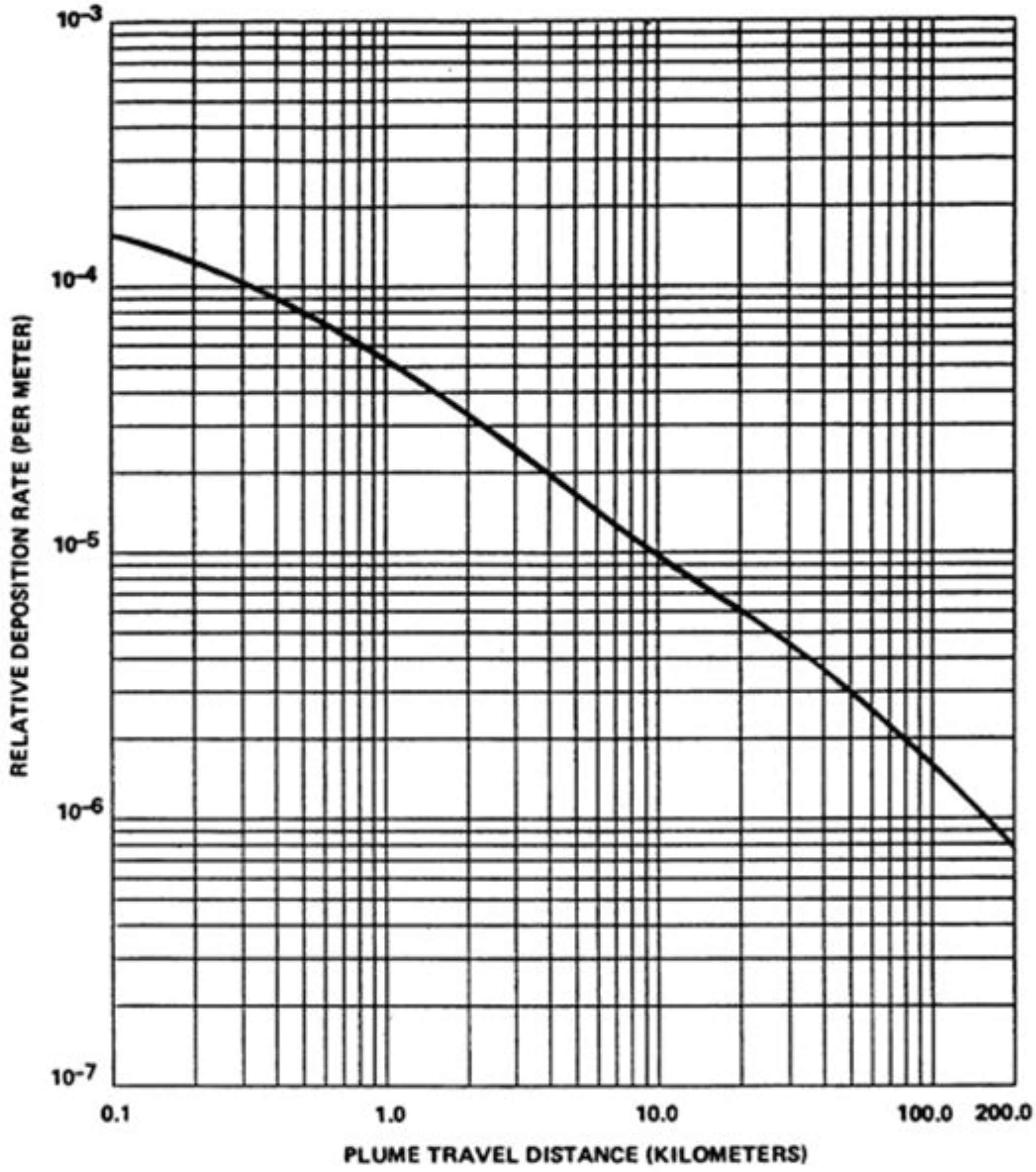
This graph is reproduced from Reference 13 (Figure 4)

Figure A13-6 Plume Depletion Effect for 100-Meter Releases



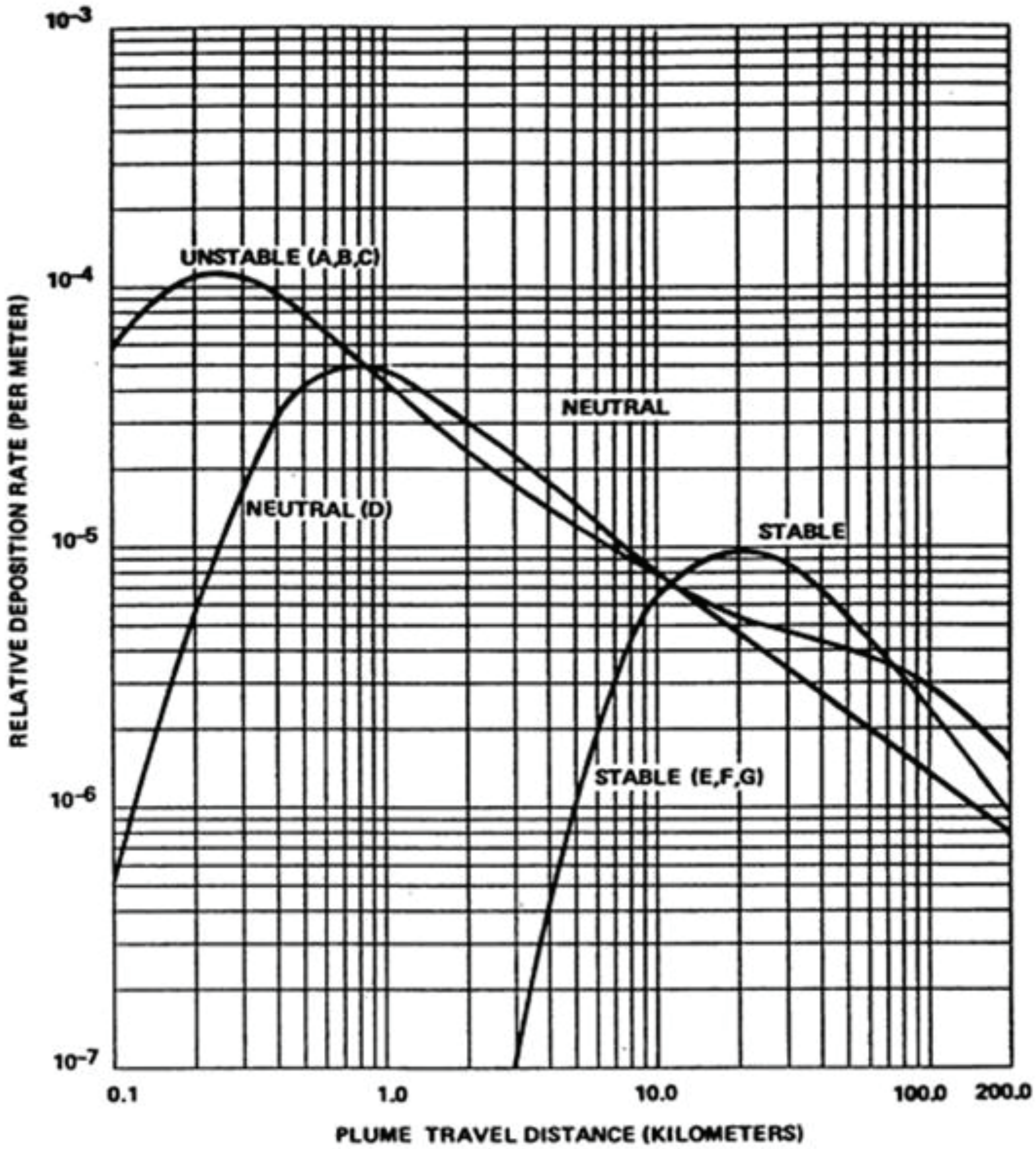
This graph is reproduced from Reference 13 (Figure 5)

Figure A13-7 Relative Deposition for Ground-Level Releases



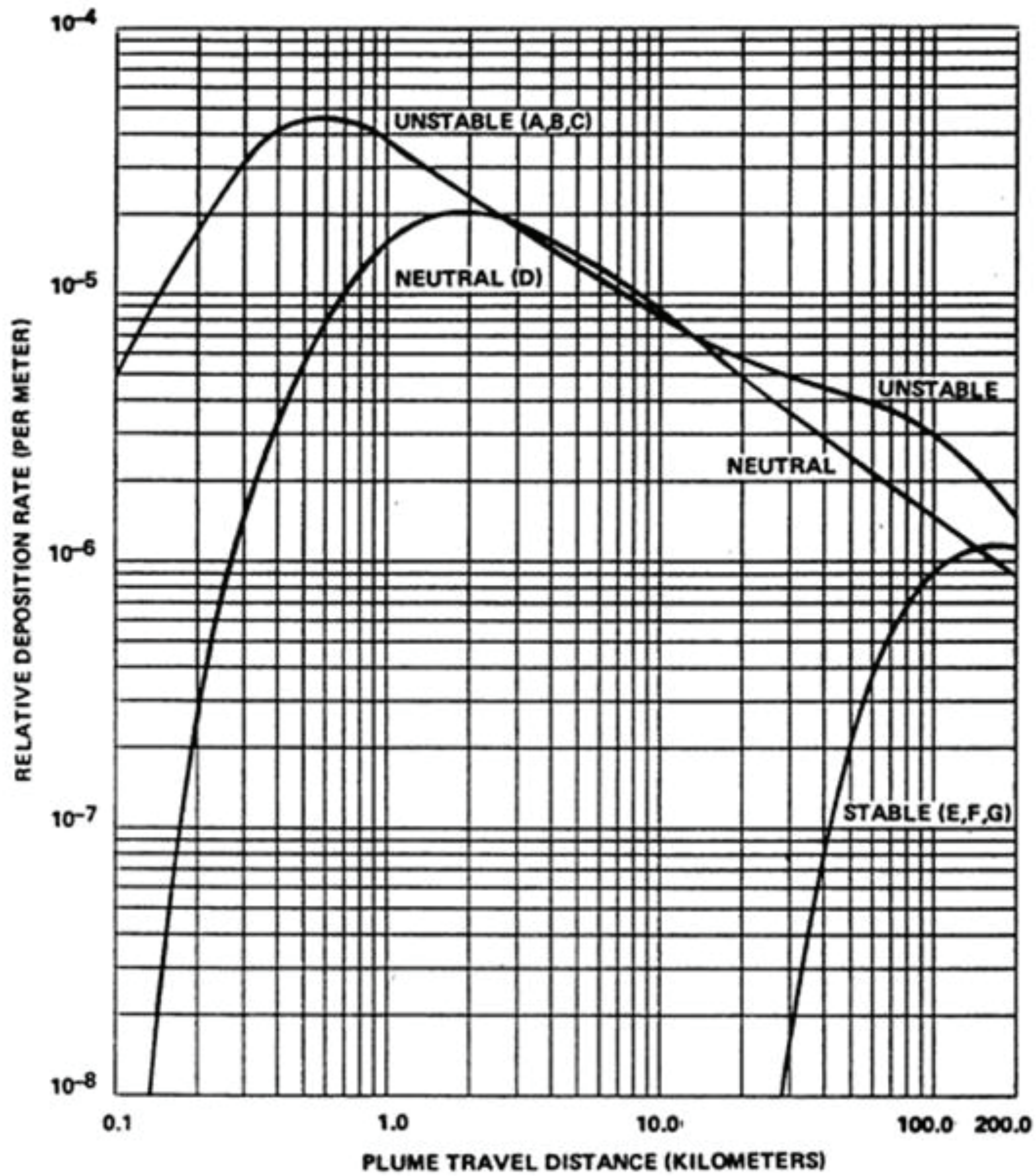
This graph is reproduced from Reference 13 (Figure 6)

Figure A13-8 Relative Deposition for 30-Meter Releases



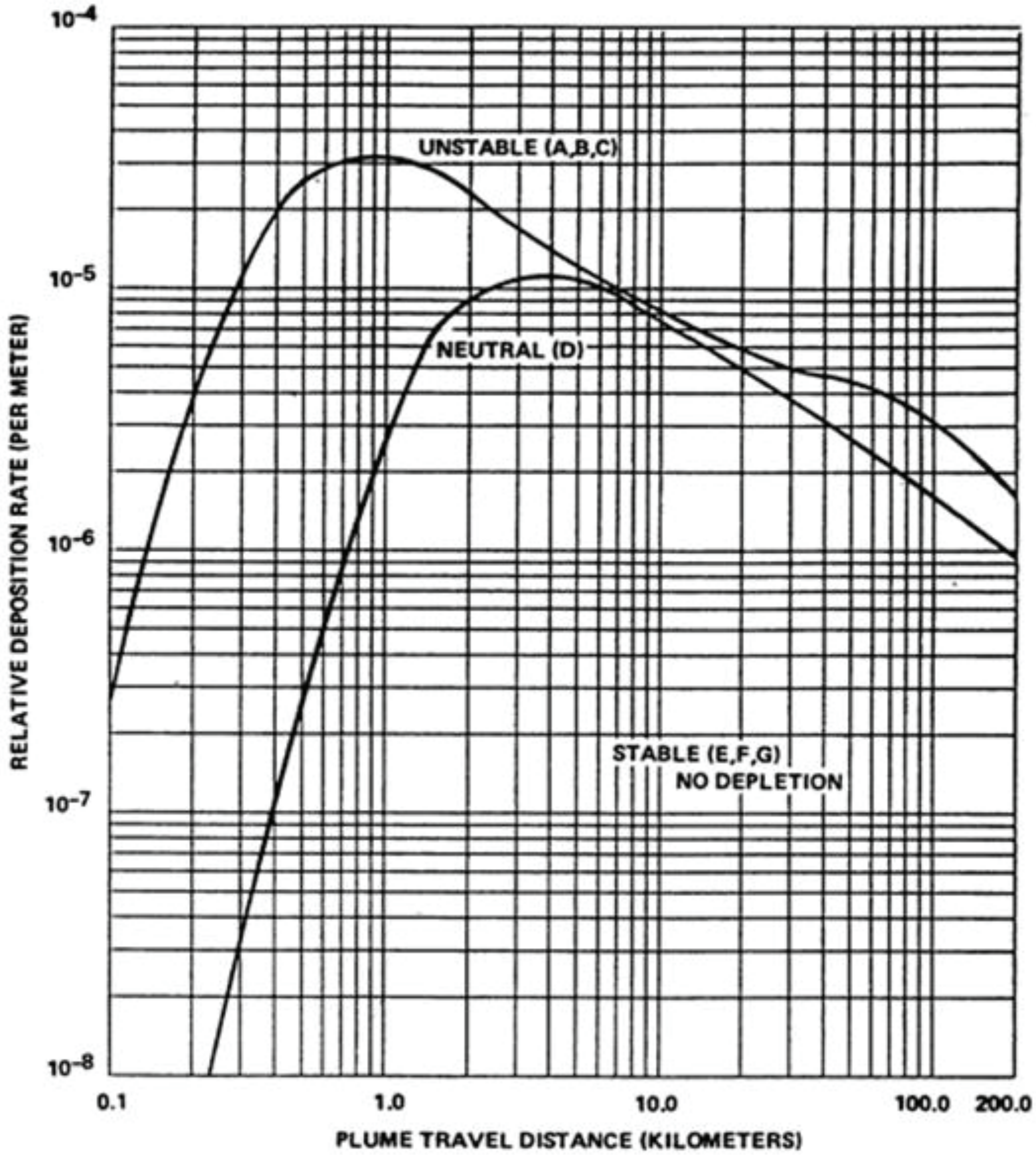
This graph is reproduced from Reference 13 (Figure 7)

Figure A13-9 Relative Deposition for 60-Meter Releases



This graph is reproduced from Reference 13 (Figure 8)

Figure A13-10 Relative Deposition for 100-Meter (or Greater) Releases



This graph is reproduced from Reference 13 (Figure 9)

2.0 LIQUID PATHWAY ANALYSIS

2.1 Purpose

The purpose of the liquid pathway analysis is to determine the maximum exposed MEMBER OF THE PUBLIC in UNRESTRICTED AREAS as a result of radioactive liquid effluent releases. The analysis includes a determination of most restrictive liquid pathway, most restrictive age group, and CRITICAL ORGAN. This analysis is required per Section 6.2.

2.2 Data, Parameters, and Methodology

Evaluation of liquid pathway dose calculations in the VEGP 3&4 UFSAR Section 12.4.1.9.3.3 (Reference 44) indicates that the adult liver dose is limiting when compared to the dose limitations of ODCM Section 6.2.3. However, the $A_{i\tau}$ values in Equation 6.2.3-1, calculated for all age groups. The fish consumption location and shoreline exposure location are in the vicinity of the discharge point. The drinking water location is 111.7 river miles downstream at Beaufort, South Carolina. There is currently no irrigated garden.

The calculation of the $A_{i\tau}$ values are determined by the following formulas based on References 11 and 24.

Drinking Water

$$A_{i\tau} = k_0(U_w/D_w)DF_i e^{(-\lambda_i t_p^D)} \qquad \text{Eqn A13.2.2-1}$$

Fish Ingestion

$$A_{i\tau} = k_0(U_F BF_i)DF_i e^{(-\lambda_i t_p^A)} \qquad \text{Eqn A13.2.2-2}$$

Shoreline Exposure

$$A_{i\tau} = k_0 U_s W T_i DFG_i \left(e^{-\lambda_i t_p^S}\right)\left(1 - e^{-\lambda_i T_b}\right) \qquad \text{Eqn A13.2.2-3}$$

Where:

$A_{i\tau}$ = The dose parameter for the total body or organ for each age group for nuclide (i) for the appropriate pathway, (mrem/hr per uCi/ml)

k_0 = 1.14E+05 - units conversion factor (1.0 E6 pCi/µCi x 1000 ml/liter)/ 8760 hr/yr)

U_W = Usage Factor Drinking Water Ref. 11

U_F = Usage Factor Fish Ingestion Ref. 11

U_S = Usage Factor Shoreline Exposure Ref. 11

Table A13.2.2 Usage Factors for Liquid Pathways

Age Group	Drinking Water U_W Liters/yr.	Fish Ingestion U_F Kilograms/yr.	Shoreline Exposure U_S Hours/yr.
Adult	730	21	12
Teenager	510	16	67
Child	510	6.9	14
Infant	330	0	0

D_W	=	8 – Dilution factor from the near field area within one-quarter mile of the release point to the potable water intake	Ref. 47
BF_i	=	Bioaccumulation factor for nuclide, i, in freshwater fish	Ref. Table A8-10
λ_i	=	Radioactive Decay Constant for nuclide (i). For Drinking Water and Fish λ_i is per hour. For Shoreline Exposure λ_i is per day	Ref. Table A8-11
T_i	=	Radiological half-life of nuclide (i) in days	Ref. Table A8-11
W	=	2 - Shoreline shore-width factor	Ref. 11 Table A-2
t_p^D	=	16 - The average transient time required for nuclides to reach the point of exposure for the potable water pathway (hours)	Ref. 44 Table 11.2-201
t_p^A	=	24 - The average transient time required for nuclides to reach the point of exposure for the aquatic food pathway (hours)	Ref. 44 Table 11.2-201
t_p^S	=	16 - The average transient time required for nuclides to reach the point of exposure for shoreline deposit pathway (hours)	Ref. 44 Table 11.2-201
T_b	=	15 - Approximate midpoint of facility operating life (years)	Ref 11
DF_i	=	Ingestion Dose Factor by age group	Ref. Tables A8-5 to A8-8
DFG_i	=	External Dose Factor for standing on Contaminated Ground	Ref. Table A8-9

Table A13.2.2-1 Site-Related $A_{i\tau}$ Ingestion Dose Factors for Drinking Water, Adult Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00E+00	6.24E-01	6.24E-01	6.24E-01	6.24E-01	6.24E-01	6.24E-01
C-14	2.96E+01	5.92E+00	5.92E+00	5.92E+00	5.92E+00	5.92E+00	5.92E+00
Na-24	1.93E+00	1.93E+00	1.93E+00	1.93E+00	1.93E+00	1.93E+00	1.93E+00
P-32	1.82E+03	1.13E+02	7.05E+01	0.00E+00	0.00E+00	0.00E+00	2.05E+02
Cr-51	0.00E+00	0.00E+00	2.64E-02	1.58E-02	5.81E-03	3.50E-02	6.63E+00
Mn-54	0.00E+00	4.74E+01	9.04E+00	0.00E+00	1.41E+01	0.00E+00	1.45E+02
Mn-56	0.00E+00	2.98E-06	5.29E-07	0.00E+00	3.79E-06	0.00E+00	9.52E-05
Fe-55	2.86E+01	1.98E+01	4.61E+00	0.00E+00	0.00E+00	1.10E+01	1.13E+01
Fe-59	4.38E+01	1.03E+02	3.95E+01	0.00E+00	0.00E+00	2.88E+01	3.43E+02
Co-57	0.00E+00	1.81E+00	3.02E+00	0.00E+00	0.00E+00	0.00E+00	4.60E+01
Co-58	0.00E+00	7.61E+00	1.71E+01	0.00E+00	0.00E+00	0.00E+00	1.54E+02
Co-60	0.00E+00	2.23E+01	4.91E+01	0.00E+00	0.00E+00	0.00E+00	4.18E+02
Ni-63	1.35E+03	9.39E+01	4.54E+01	0.00E+00	0.00E+00	0.00E+00	1.96E+01
Ni-65	1.01E-05	1.32E-06	6.02E-07	0.00E+00	0.00E+00	0.00E+00	3.34E-05
Cu-64	0.00E+00	6.32E-02	2.97E-02	0.00E+00	1.59E-01	0.00E+00	5.39E+00
Zn-65	5.01E+01	1.60E+02	7.21E+01	0.00E+00	1.07E+02	0.00E+00	1.00E+02
Zn-69m	1.58E-01	3.78E-01	3.46E-02	0.00E+00	2.29E-01	0.00E+00	2.31E+01
Zn-69	2.74E-17	5.24E-17	3.64E-18	0.00E+00	3.40E-17	0.00E+00	7.87E-18
Br-82	0.00E+00	0.00E+00	9.17E+00	0.00E+00	0.00E+00	0.00E+00	1.05E+01
Br-83	0.00E+00	0.00E+00	3.77E-07	0.00E+00	0.00E+00	0.00E+00	5.43E-07
Br-84	0.00E+00	0.00E+00	2.96E-28	0.00E+00	0.00E+00	0.00E+00	2.32E-33
Br-85	0.00E+00	0.00E+00	8.28E-305	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	2.04E+02	9.51E+01	0.00E+00	0.00E+00	0.00E+00	4.02E+01
Rb-88	0.00E+00	1.24E-49	6.58E-50	0.00E+00	0.00E+00	0.00E+00	1.71E-60
Rb-89	0.00E+00	2.95E-57	2.08E-57	0.00E+00	0.00E+00	0.00E+00	1.72E-70
Sr-89	3.12E+03	0.00E+00	8.96E+01	0.00E+00	0.00E+00	0.00E+00	5.01E+02
Sr-90	9.07E+04	0.00E+00	1.82E+03	0.00E+00	0.00E+00	0.00E+00	2.28E+03
Sr-91	1.78E+00	0.00E+00	7.19E-02	0.00E+00	0.00E+00	0.00E+00	8.47E+00
Sr-92	1.04E-04	0.00E+00	4.51E-06	0.00E+00	0.00E+00	0.00E+00	2.07E-03
Y-90	5.96E-02	0.00E+00	1.60E-03	0.00E+00	0.00E+00	0.00E+00	6.32E+02
Y-91m	3.43E-21	0.00E+00	1.33E-22	0.00E+00	0.00E+00	0.00E+00	1.01E-20
Y-91	1.43E+00	0.00E+00	3.84E-02	0.00E+00	0.00E+00	0.00E+00	7.89E+02
Y-92	7.29E-07	0.00E+00	2.13E-08	0.00E+00	0.00E+00	0.00E+00	1.28E-02
Y-93	1.04E-03	0.00E+00	2.86E-05	0.00E+00	0.00E+00	0.00E+00	3.28E+01
Zr-95	3.10E-01	9.94E-02	6.73E-02	0.00E+00	1.56E-01	0.00E+00	3.15E+02
Zr-97	2.44E-03	4.93E-04	2.25E-04	0.00E+00	7.45E-04	0.00E+00	1.53E+02
Nb-95	6.23E-02	3.46E-02	1.86E-02	0.00E+00	3.42E-02	0.00E+00	2.10E+02
Nb-97	5.14E-16	1.30E-16	4.75E-17	0.00E+00	1.52E-16	0.00E+00	4.79E-13
Mo-99	0.00E+00	2.71E+01	5.16E+00	0.00E+00	6.14E+01	0.00E+00	6.29E+01
Tc-99m	1.02E-05	2.89E-05	3.68E-04	0.00E+00	4.39E-04	1.42E-05	1.71E-02
Tc-101	2.34E-64	3.37E-64	3.30E-63	0.00E+00	6.06E-63	1.72E-64	1.01E-75
Ru-103	1.86E+00	0.00E+00	8.01E-01	0.00E+00	7.10E+00	0.00E+00	2.17E+02
Ru-105	8.93E-05	0.00E+00	3.53E-05	0.00E+00	1.15E-03	0.00E+00	5.46E-02

All values are in (mrem·mL)/(h·μCi).

Table A13.2.2-1 (cont.) Site-Related $A_{i\tau}$ Ingestion Dose Factors for Drinking Water, Adult Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ru-106	2.85E+01	0.00E+00	3.61E+00	0.00E+00	5.51E+01	0.00E+00	1.85E+03
Rh-105	4.92E-01	3.60E-01	2.37E-01	0.00E+00	1.53E+00	0.00E+00	5.73E+01
Ag-110m	1.66E+00	1.53E+00	9.11E-01	0.00E+00	3.01E+00	0.00E+00	6.26E+02
Cd-113m	0.00E+00	3.31E+01	1.06E+00	0.00E+00	3.64E+01	0.00E+00	2.67E+02
Sb-124	2.85E+01	5.38E-01	1.13E+01	6.91E-02	0.00E+00	2.22E+01	8.09E+02
Sb-125	1.86E+01	2.08E-01	4.43E+00	1.89E-02	0.00E+00	1.44E+01	2.05E+02
Sb-126	1.07E+01	2.18E-01	3.87E+00	6.56E-02	0.00E+00	6.57E+00	8.76E+02
Sb-127	1.87E+00	4.11E-02	7.19E-01	2.25E-02	0.00E+00	1.11E+00	4.29E+02
Te-125m	2.73E+01	9.88E+00	3.65E+00	8.20E+00	1.11E+02	0.00E+00	1.09E+02
Te-127m	6.96E+01	2.49E+01	8.49E+00	1.78E+01	2.83E+02	0.00E+00	2.33E+02
Te-127	3.26E-02	1.17E-02	7.06E-03	2.42E-02	1.33E-01	0.00E+00	2.58E+00
Te-129m	1.15E+02	4.29E+01	1.82E+01	3.95E+01	4.80E+02	0.00E+00	5.79E+02
Te-129	1.14E-13	4.30E-14	2.79E-14	8.78E-14	4.81E-13	0.00E+00	8.63E-14
Te-131m	5.94E+00	2.91E+00	2.42E+00	4.60E+00	2.94E+01	0.00E+00	2.89E+02
Te-131	4.30E-36	1.80E-36	1.36E-36	3.54E-36	1.88E-35	0.00E+00	6.09E-37
Te-132	1.72E+01	1.11E+01	1.04E+01	1.23E+01	1.07E+02	0.00E+00	5.25E+02
I-129	3.41E+01	2.93E+01	9.59E+01	7.53E+04	6.29E+01	0.00E+00	4.63E+00
I-130	5.34E-01	1.57E+00	6.21E-01	1.33E+02	2.46E+00	0.00E+00	1.36E+00
I-131	3.65E+01	5.22E+01	2.99E+01	1.71E+04	8.94E+01	0.00E+00	1.38E+01
I-132	1.10E-06	2.95E-06	1.03E-06	1.03E-04	4.70E-06	0.00E+00	5.55E-07
I-133	2.99E+00	5.20E+00	1.58E+00	7.64E+02	9.07E+00	0.00E+00	4.67E+00
I-134	3.64E-17	9.88E-17	3.53E-17	1.71E-15	1.57E-16	0.00E+00	8.61E-20
I-135	3.01E-02	7.87E-02	2.91E-02	5.19E+00	1.26E-01	0.00E+00	8.89E-02
Cs-134	6.47E+02	1.54E+03	1.26E+03	0.00E+00	4.98E+02	1.65E+02	2.69E+01
Cs-135	2.03E+02	1.88E+02	8.32E+01	0.00E+00	7.09E+01	2.13E+01	4.39E+00
Cs-136	6.10E+01	2.41E+02	1.73E+02	0.00E+00	1.34E+02	1.84E+01	2.74E+01
Cs-137	8.30E+02	1.14E+03	7.44E+02	0.00E+00	3.85E+02	1.28E+02	2.20E+01
Cs-138	6.84E-28	1.35E-27	6.69E-28	0.00E+00	9.93E-28	9.81E-29	5.76E-33
Ba-139	3.73E-11	2.66E-14	1.09E-12	0.00E+00	2.48E-14	1.51E-14	6.61E-11
Ba-140	1.90E+02	2.38E-01	1.24E+01	0.00E+00	8.10E-02	1.36E-01	3.91E+02
Ba-141	1.73E-48	1.31E-51	5.84E-50	0.00E+00	1.21E-51	7.41E-52	8.15E-58
Ba-142	2.10E-82	2.15E-85	1.32E-83	0.00E+00	1.82E-85	1.22E-85	2.95E-100
La-140	1.14E-02	5.74E-03	1.52E-03	0.00E+00	0.00E+00	0.00E+00	4.21E+02
La-142	1.09E-12	4.95E-13	1.23E-13	0.00E+00	0.00E+00	0.00E+00	3.62E-09
Ce-141	9.34E-02	6.32E-02	7.17E-03	0.00E+00	2.93E-02	0.00E+00	2.42E+02
Ce-143	6.27E-03	4.64E+00	5.13E-04	0.00E+00	2.04E-03	0.00E+00	1.73E+02
Ce-144	5.06E+00	2.11E+00	2.72E-01	0.00E+00	1.25E+00	0.00E+00	1.71E+03
Pr-143	8.65E-02	3.47E-02	4.29E-03	0.00E+00	2.00E-02	0.00E+00	3.79E+02
Pr-144	2.11E-54	8.77E-55	1.07E-55	0.00E+00	4.95E-55	0.00E+00	3.04E-61
Nd-147	5.77E-02	6.67E-02	3.99E-03	0.00E+00	3.90E-02	0.00E+00	3.20E+02
Eu-152	2.03E+00	4.62E-01	4.06E-01	0.00E+00	2.86E+00	0.00E+00	2.67E+02
W-187	2.66E-01	2.22E-01	7.76E-02	0.00E+00	0.00E+00	0.00E+00	7.27E+01
Np-239	6.88E-03	6.76E-04	3.73E-04	0.00E+00	2.11E-03	0.00E+00	1.39E+02

Table A13.2.2-2 Site-Related $A_{i\tau}$ Ingestion Dose Factors for Drinking Water, Teenager Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00E+00	4.39E-01	4.39E-01	4.39E-01	4.39E-01	4.39E-01	4.39E-01
C-14	2.95E+01	5.91E+00	5.91E+00	5.91E+00	5.91E+00	5.91E+00	5.91E+00
Na-24	1.82E+00	1.82E+00	1.82E+00	1.82E+00	1.82E+00	1.82E+00	1.82E+00
P-32	1.82E+03	1.13E+02	7.07E+01	0.00E+00	0.00E+00	0.00E+00	1.53E+02
Cr-51	0.00E+00	0.00E+00	2.49E-02	1.38E-02	5.46E-03	3.56E-02	4.19E+00
Mn-54	0.00E+00	4.27E+01	8.48E+00	0.00E+00	1.28E+01	0.00E+00	8.77E+01
Mn-56	0.00E+00	2.86E-06	5.09E-07	0.00E+00	3.62E-06	0.00E+00	1.88E-04
Fe-55	2.75E+01	1.95E+01	4.54E+00	0.00E+00	0.00E+00	1.24E+01	8.43E+00
Fe-59	4.14E+01	9.67E+01	3.73E+01	0.00E+00	0.00E+00	3.05E+01	2.29E+02
Co-57	0.00E+00	1.72E+00	2.89E+00	0.00E+00	0.00E+00	0.00E+00	3.21E+01
Co-58	0.00E+00	6.94E+00	1.60E+01	0.00E+00	0.00E+00	0.00E+00	9.56E+01
Co-60	0.00E+00	2.04E+01	4.60E+01	0.00E+00	0.00E+00	0.00E+00	2.66E+02
Ni-63	1.29E+03	9.10E+01	4.37E+01	0.00E+00	0.00E+00	0.00E+00	1.45E+01
Ni-65	1.01E-05	1.29E-06	5.86E-07	0.00E+00	0.00E+00	0.00E+00	6.97E-05
Cu-64	0.00E+00	6.10E-02	2.87E-02	0.00E+00	1.54E-01	0.00E+00	4.73E+00
Zn-65	4.17E+01	1.45E+02	6.75E+01	0.00E+00	9.26E+01	0.00E+00	6.13E+01
Zn-69m	1.56E-01	3.67E-01	3.36E-02	0.00E+00	2.23E-01	0.00E+00	2.02E+01
Zn-69	2.73E-17	5.20E-17	3.64E-18	0.00E+00	3.40E-17	0.00E+00	9.59E-17
Br-82	0.00E+00	0.00E+00	8.62E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-83	0.00E+00	0.00E+00	3.76E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	2.87E-28	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	8.24E-305	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	2.01E+02	9.46E+01	0.00E+00	0.00E+00	0.00E+00	2.98E+01
Rb-88	0.00E+00	1.22E-49	6.50E-50	0.00E+00	0.00E+00	0.00E+00	1.05E-56
Rb-89	0.00E+00	2.83E-57	2.00E-57	0.00E+00	0.00E+00	0.00E+00	4.34E-66
Sr-89	3.12E+03	0.00E+00	8.92E+01	0.00E+00	0.00E+00	0.00E+00	3.71E+02
Sr-90	7.42E+04	0.00E+00	1.48E+03	0.00E+00	0.00E+00	0.00E+00	1.70E+03
Sr-91	1.77E+00	0.00E+00	7.04E-02	0.00E+00	0.00E+00	0.00E+00	8.03E+00
Sr-92	1.03E-04	0.00E+00	4.41E-06	0.00E+00	0.00E+00	0.00E+00	2.63E-03
Y-90	5.93E-02	0.00E+00	1.60E-03	0.00E+00	0.00E+00	0.00E+00	4.89E+02
Y-91m	3.40E-21	0.00E+00	1.30E-22	0.00E+00	0.00E+00	0.00E+00	1.61E-19
Y-91	1.43E+00	0.00E+00	3.83E-02	0.00E+00	0.00E+00	0.00E+00	5.86E+02
Y-92	7.29E-07	0.00E+00	2.11E-08	0.00E+00	0.00E+00	0.00E+00	2.00E-02
Y-93	1.03E-03	0.00E+00	2.83E-05	0.00E+00	0.00E+00	0.00E+00	3.16E+01
Zr-95	2.93E-01	9.26E-02	6.37E-02	0.00E+00	1.36E-01	0.00E+00	2.14E+02
Zr-97	2.41E-03	4.77E-04	2.19E-04	0.00E+00	7.23E-04	0.00E+00	1.29E+02
Nb-95	5.75E-02	3.19E-02	1.76E-02	0.00E+00	3.09E-02	0.00E+00	1.36E+02
Nb-97	5.07E-16	1.26E-16	4.59E-17	0.00E+00	1.47E-16	0.00E+00	3.01E-12
Mo-99	0.00E+00	2.65E+01	5.06E+00	0.00E+00	6.07E+01	0.00E+00	4.75E+01
Tc-99m	9.61E-06	2.68E-05	3.47E-04	0.00E+00	4.00E-04	1.49E-05	1.76E-02
Tc-101	2.31E-64	3.29E-64	3.23E-63	0.00E+00	5.95E-63	2.01E-64	5.62E-71
Ru-103	1.79E+00	0.00E+00	7.66E-01	0.00E+00	6.32E+00	0.00E+00	1.50E+02
Ru-105	8.83E-05	0.00E+00	3.43E-05	0.00E+00	1.11E-03	0.00E+00	7.13E-02

All values are in (mrem·mL)/(h·μCi).

Table A13.2.2-2 (cont.) Site-Related $A_{i\tau}$ Ingestion Dose Factors for Drinking Water, Teenager Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ru-106	2.84E+01	0.00E+00	3.58E+00	0.00E+00	5.48E+01	0.00E+00	1.36E+03
Rh-105	4.91E-01	3.55E-01	2.33E-01	0.00E+00	1.51E+00	0.00E+00	4.52E+01
Ag-110m	1.48E+00	1.40E+00	8.54E-01	0.00E+00	2.68E+00	0.00E+00	3.94E+02
Cd-113m	0.00E+00	3.28E+01	1.05E+00	0.00E+00	3.63E+01	0.00E+00	1.97E+02
Sb-124	2.75E+01	5.07E-01	1.07E+01	6.24E-02	0.00E+00	2.40E+01	5.55E+02
Sb-125	1.80E+01	1.97E-01	4.22E+00	1.72E-02	0.00E+00	1.58E+01	1.40E+02
Sb-126	1.03E+01	2.11E-01	3.72E+00	5.85E-02	0.00E+00	7.42E+00	6.12E+02
Sb-127	1.84E+00	3.94E-02	6.96E-01	2.07E-02	0.00E+00	1.25E+00	3.13E+02
Te-125m	2.72E+01	9.81E+00	3.64E+00	7.60E+00	0.00E+00	0.00E+00	8.03E+01
Te-127m	6.95E+01	2.46E+01	8.26E+00	1.65E+01	2.82E+02	0.00E+00	1.73E+02
Te-127	3.28E-02	1.16E-02	7.05E-03	2.26E-02	1.33E-01	0.00E+00	2.53E+00
Te-129m	1.14E+02	4.22E+01	1.80E+01	3.67E+01	4.76E+02	0.00E+00	4.27E+02
Te-129	1.14E-13	4.25E-14	2.77E-14	8.14E-14	4.78E-13	0.00E+00	6.23E-13
Te-131m	5.86E+00	2.81E+00	2.34E+00	4.23E+00	2.93E+01	0.00E+00	2.25E+02
Te-131	4.26E-36	1.75E-36	1.33E-36	3.28E-36	1.86E-35	0.00E+00	3.49E-37
Te-132	1.66E+01	1.05E+01	9.89E+00	1.11E+01	1.01E+02	0.00E+00	3.33E+02
I-129	3.39E+01	2.85E+01	4.76E+01	3.47E+04	5.10E+01	0.00E+00	3.33E+00
I-130	5.08E-01	1.47E+00	5.87E-01	1.20E+02	2.26E+00	0.00E+00	1.13E+00
I-131	3.58E+01	5.02E+01	2.69E+01	1.46E+04	8.64E+01	0.00E+00	9.92E+00
I-132	1.06E-06	2.77E-06	9.95E-07	9.34E-05	4.37E-06	0.00E+00	1.21E-06
I-133	2.95E+00	5.01E+00	1.53E+00	7.00E+02	8.79E+00	0.00E+00	3.79E+00
I-134	3.50E-17	9.28E-17	3.33E-17	1.55E-15	1.46E-16	0.00E+00	1.22E-18
I-135	2.89E-02	7.45E-02	2.76E-02	4.79E+00	1.18E-01	0.00E+00	8.25E-02
Cs-134	6.08E+02	1.43E+03	6.64E+02	0.00E+00	4.55E+02	1.74E+02	1.78E+01
Cs-135	2.02E+02	1.86E+02	4.34E+01	0.00E+00	7.08E+01	2.56E+01	3.25E+00
Cs-136	5.63E+01	2.21E+02	1.49E+02	0.00E+00	1.21E+02	1.90E+01	1.78E+01
Cs-137	8.15E+02	1.08E+03	3.78E+02	0.00E+00	3.69E+02	1.43E+02	1.54E+01
Cs-138	6.72E-28	1.29E-27	6.45E-28	0.00E+00	9.53E-28	1.11E-28	5.85E-31
Ba-139	3.73E-11	2.63E-14	1.09E-12	0.00E+00	2.48E-14	1.81E-14	3.33E-10
Ba-140	1.85E+02	2.27E-01	1.19E+01	0.00E+00	7.71E-02	1.53E-01	2.86E+02
Ba-141	1.72E-48	1.28E-51	5.74E-50	0.00E+00	1.19E-51	8.80E-52	3.67E-54
Ba-142	2.05E-82	2.05E-85	1.26E-83	0.00E+00	1.74E-85	1.37E-85	6.31E-94
La-140	1.11E-02	5.44E-03	1.45E-03	0.00E+00	0.00E+00	0.00E+00	3.12E+02
La-142	1.06E-12	4.73E-13	1.18E-13	0.00E+00	0.00E+00	0.00E+00	1.44E-08
Ce-141	9.27E-02	6.19E-02	7.11E-03	0.00E+00	2.91E-02	0.00E+00	1.77E+02
Ce-143	6.24E-03	4.54E+00	5.07E-04	0.00E+00	2.04E-03	0.00E+00	1.36E+02
Ce-144	5.04E+00	2.09E+00	2.71E-01	0.00E+00	1.25E+00	0.00E+00	1.27E+03
Pr-143	8.61E-02	3.44E-02	4.28E-03	0.00E+00	2.00E-02	0.00E+00	2.83E+02
Pr-144	2.11E-54	8.63E-55	1.07E-55	0.00E+00	4.95E-55	0.00E+00	2.32E-57
Nd-147	6.02E-02	6.54E-02	3.92E-03	0.00E+00	3.84E-02	0.00E+00	2.36E+02
Eu-152	1.78E+00	4.29E-01	3.78E-01	0.00E+00	1.99E+00	0.00E+00	1.58E+02
W-187	2.63E-01	2.14E-01	7.51E-02	0.00E+00	0.00E+00	0.00E+00	5.80E+01
Np-239	7.11E-03	6.71E-04	3.72E-04	0.00E+00	2.10E-03	0.00E+00	1.08E+02

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Table A13.2.2-3 Site-Related $A_{i\tau}$ Ingestion Dose Factors for Drinking Water, Child Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00E+00	8.44E-01	8.44E-01	8.44E-01	8.44E-01	8.44E-01	8.44E-01
C-14	8.81E+01	1.76E+01	1.76E+01	1.76E+01	1.76E+01	1.76E+01	1.76E+01
Na-24	4.59E+00	4.59E+00	4.59E+00	4.59E+00	4.59E+00	4.59E+00	4.59E+00
P-32	5.45E+03	2.55E+02	2.10E+02	0.00E+00	0.00E+00	0.00E+00	1.51E+02
Cr-51	0.00E+00	0.00E+00	6.16E-02	3.42E-02	9.34E-03	6.24E-02	3.27E+00
Mn-54	0.00E+00	7.75E+01	2.06E+01	0.00E+00	2.17E+01	0.00E+00	6.51E+01
Mn-56	0.00E+00	6.05E-06	1.37E-06	0.00E+00	7.32E-06	0.00E+00	8.77E-04
Fe-55	8.36E+01	4.43E+01	1.37E+01	0.00E+00	0.00E+00	2.51E+01	8.21E+00
Fe-59	1.16E+02	1.88E+02	9.38E+01	0.00E+00	0.00E+00	5.46E+01	1.96E+02
Co-57	0.00E+00	3.57E+00	7.23E+00	0.00E+00	0.00E+00	0.00E+00	2.93E+01
Co-58	0.00E+00	1.28E+01	3.93E+01	0.00E+00	0.00E+00	0.00E+00	7.49E+01
Co-60	0.00E+00	3.85E+01	1.13E+02	0.00E+00	0.00E+00	0.00E+00	2.13E+02
Ni-63	3.92E+03	2.10E+02	1.33E+02	0.00E+00	0.00E+00	0.00E+00	1.41E+01
Ni-65	2.98E-05	2.81E-06	1.64E-06	0.00E+00	0.00E+00	0.00E+00	3.44E-04
Cu-64	0.00E+00	1.30E-01	7.84E-02	0.00E+00	3.14E-01	0.00E+00	6.10E+00
Zn-65	9.91E+01	2.64E+02	1.64E+02	0.00E+00	1.66E+02	0.00E+00	4.64E+01
Zn-69m	4.60E-01	7.84E-01	9.27E-02	0.00E+00	4.56E-01	0.00E+00	2.55E+01
Zn-69	8.14E-17	1.18E-16	1.09E-17	0.00E+00	7.13E-17	0.00E+00	7.41E-15
Br-82	0.00E+00	0.00E+00	2.14E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-83	0.00E+00	0.00E+00	1.12E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	7.86E-28	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	2.47E-304	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	4.53E+02	2.78E+02	0.00E+00	0.00E+00	0.00E+00	2.91E+01
Rb-88	0.00E+00	2.72E-49	1.89E-49	0.00E+00	0.00E+00	0.00E+00	1.33E-50
Rb-89	0.00E+00	6.02E-57	5.35E-57	0.00E+00	0.00E+00	0.00E+00	5.25E-59
Sr-89	9.35E+03	0.00E+00	2.67E+02	0.00E+00	0.00E+00	0.00E+00	3.62E+02
Sr-90	1.86E+05	0.00E+00	3.75E+03	0.00E+00	0.00E+00	0.00E+00	1.67E+03
Sr-91	5.26E+00	0.00E+00	1.99E-01	0.00E+00	0.00E+00	0.00E+00	1.16E+01
Sr-92	3.06E-04	0.00E+00	1.23E-05	0.00E+00	0.00E+00	0.00E+00	5.80E-03
Y-90	1.78E-01	0.00E+00	4.76E-03	0.00E+00	0.00E+00	0.00E+00	5.07E+02
Y-91m	1.01E-20	0.00E+00	3.67E-22	0.00E+00	0.00E+00	0.00E+00	1.97E-17
Y-91	4.28E+00	0.00E+00	1.14E-01	0.00E+00	0.00E+00	0.00E+00	5.70E+02
Y-92	2.17E-06	0.00E+00	6.21E-08	0.00E+00	0.00E+00	0.00E+00	6.27E-02
Y-93	3.08E-03	0.00E+00	8.45E-05	0.00E+00	0.00E+00	0.00E+00	4.59E+01
Zr-95	8.26E-01	1.82E-01	1.62E-01	0.00E+00	2.60E-01	0.00E+00	1.89E+02
Zr-97	7.10E-03	1.03E-03	6.06E-04	0.00E+00	1.47E-03	0.00E+00	1.55E+02
Nb-95	1.57E-01	6.13E-02	4.38E-02	0.00E+00	5.76E-02	0.00E+00	1.13E+02
Nb-97	1.49E-15	2.70E-16	1.26E-16	0.00E+00	2.99E-16	0.00E+00	8.32E-11
Mo-99	0.00E+00	5.85E+01	1.45E+01	0.00E+00	1.25E+02	0.00E+00	4.84E+01
Tc-99m	2.67E-05	5.24E-05	8.69E-04	0.00E+00	7.62E-04	2.66E-05	2.98E-02
Tc-101	6.88E-64	7.20E-64	9.13E-63	0.00E+00	1.23E-62	3.80E-64	2.29E-63
Ru-103	5.14E+00	0.00E+00	1.97E+00	0.00E+00	1.29E+01	0.00E+00	1.33E+02
Ru-105	2.61E-04	0.00E+00	9.48E-05	0.00E+00	2.30E-03	0.00E+00	1.71E-01

All values are in (mrem·mL)/(h·μCi).

Table A13.2.2-3 (cont.) Site-Related $A_{i\tau}$ Ingestion Dose Factors for Drinking Water, Child Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ru-106	8.48E+01	0.00E+00	1.06E+01	0.00E+00	1.15E+02	0.00E+00	1.32E+03
Rh-105	1.46E+00	7.84E-01	6.70E-01	0.00E+00	3.12E+00	0.00E+00	4.86E+01
Ag-110m	3.90E+00	2.63E+00	2.11E+00	0.00E+00	4.91E+00	0.00E+00	3.13E+02
Cd-113m	0.00E+00	7.42E+01	3.16E+00	0.00E+00	7.64E+01	0.00E+00	1.91E+02
Sb-124	7.89E+01	1.02E+00	2.77E+01	1.74E-01	0.00E+00	4.38E+01	4.94E+02
Sb-125	5.20E+01	4.01E-01	1.09E+01	4.82E-02	0.00E+00	2.90E+01	1.24E+02
Sb-126	2.86E+01	4.38E-01	1.03E+01	1.68E-01	0.00E+00	1.37E+01	5.77E+02
Sb-127	5.38E+00	8.33E-02	1.87E+00	5.99E-02	0.00E+00	2.34E+00	3.03E+02
Te-125m	8.10E+01	2.20E+01	1.08E+01	2.27E+01	0.00E+00	0.00E+00	7.82E+01
Te-127m	2.08E+02	5.59E+01	2.46E+01	4.97E+01	5.92E+02	0.00E+00	1.68E+02
Te-127	9.76E-02	2.63E-02	2.09E-02	6.76E-02	2.78E-01	0.00E+00	3.81E+00
Te-129m	3.40E+02	9.50E+01	5.28E+01	1.10E+02	9.99E+02	0.00E+00	4.15E+02
Te-129	3.41E-13	9.52E-14	8.09E-14	2.43E-13	9.97E-13	0.00E+00	2.12E-11
Te-131m	1.73E+01	5.98E+00	6.36E+00	1.23E+01	5.79E+01	0.00E+00	2.42E+02
Te-131	1.27E-35	3.86E-36	3.77E-36	9.68E-36	3.83E-35	0.00E+00	6.65E-35
Te-132	4.80E+01	2.13E+01	2.57E+01	3.10E+01	1.97E+02	0.00E+00	2.14E+02
I-129	1.01E+02	6.21E+01	5.55E+01	4.06E+04	1.05E+02	0.00E+00	3.12E+00
I-130	1.44E+00	2.91E+00	1.50E+00	3.21E+02	4.35E+00	0.00E+00	1.36E+00
I-131	1.05E+02	1.06E+02	6.02E+01	3.50E+04	1.74E+02	0.00E+00	9.43E+00
I-132	3.04E-06	5.58E-06	2.57E-06	2.59E-04	8.55E-06	0.00E+00	6.57E-06
I-133	8.70E+00	1.08E+01	4.07E+00	2.00E+03	1.79E+01	0.00E+00	4.34E+00
I-134	1.00E-16	1.87E-16	8.58E-17	4.29E-15	2.85E-16	0.00E+00	1.24E-16
I-135	8.30E-02	1.49E-01	7.07E-02	1.32E+01	2.29E-01	0.00E+00	1.14E-01
Cs-134	1.70E+03	2.79E+03	5.88E+02	0.00E+00	8.64E+02	3.10E+02	1.50E+01
Cs-135	6.04E+02	4.21E+02	4.32E+01	0.00E+00	1.48E+02	4.96E+01	3.15E+00
Cs-136	1.54E+02	4.23E+02	2.74E+02	0.00E+00	2.25E+02	3.36E+01	1.49E+01
Cs-137	2.38E+03	2.28E+03	3.36E+02	0.00E+00	7.42E+02	2.67E+02	1.43E+01
Cs-138	1.97E-27	2.75E-27	1.74E-27	0.00E+00	1.93E-27	2.08E-28	1.26E-27
Ba-139	1.11E-10	5.94E-14	3.22E-12	0.00E+00	5.18E-14	3.49E-14	6.42E-09
Ba-140	5.43E+02	4.75E-01	3.17E+01	0.00E+00	1.55E-01	2.83E-01	2.75E+02
Ba-141	5.13E-48	2.87E-51	1.67E-49	0.00E+00	2.48E-51	1.69E-50	2.92E-48
Ba-142	6.01E-82	4.32E-85	3.35E-83	0.00E+00	3.50E-85	2.54E-85	7.83E-84
La-140	3.21E-02	1.12E-02	3.79E-03	0.00E+00	0.00E+00	0.00E+00	3.13E+02
La-142	3.12E-12	9.93E-13	3.11E-13	0.00E+00	0.00E+00	0.00E+00	1.97E-07
Ce-141	2.77E-01	1.38E-01	2.05E-02	0.00E+00	6.05E-02	0.00E+00	1.72E+02
Ce-143	1.86E-02	1.01E+01	1.46E-03	0.00E+00	4.22E-03	0.00E+00	1.47E+02
Ce-144	1.51E+01	4.72E+00	8.04E-01	0.00E+00	2.61E+00	0.00E+00	1.23E+03
Pr-143	2.58E-01	7.75E-02	1.28E-02	0.00E+00	4.20E-02	0.00E+00	2.79E+02
Pr-144	6.32E-54	1.96E-54	3.18E-55	0.00E+00	1.03E-54	0.00E+00	4.21E-51
Nd-147	1.79E-01	1.45E-01	1.12E-02	0.00E+00	7.95E-02	0.00E+00	2.30E+02
Eu-152	4.47E+00	8.15E-01	9.68E-01	0.00E+00	3.44E+00	0.00E+00	1.34E+02
W-187	7.73E-01	4.58E-01	2.05E-01	0.00E+00	0.00E+00	0.00E+00	6.43E+01
Np-239	2.12E-02	1.52E-03	1.07E-03	0.00E+00	4.40E-03	0.00E+00	1.13E+02

Table A13.2.2-4 Site-Related $A_{i\tau}$ Ingestion Dose Factors for Drinking Water, Infant Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00E+00	8.29E-01	8.29E-01	8.29E-01	8.29E-01	8.29E-01	8.29E-01
C-14	1.12E+02	2.38E+01	2.38E+01	2.38E+01	2.38E+01	2.38E+01	2.38E+01
Na-24	5.18E+00	5.18E+00	5.18E+00	5.18E+00	5.18E+00	5.18E+00	5.18E+00
P-32	7.27E+03	4.27E+02	2.82E+02	0.00E+00	0.00E+00	0.00E+00	9.83E+01
Cr-51	0.00E+00	0.00E+00	6.32E-02	4.12E-02	9.00E-03	8.02E-02	1.84E+00
Mn-54	0.00E+00	9.33E+01	2.11E+01	0.00E+00	2.07E+01	0.00E+00	3.43E+01
Mn-56	0.00E+00	9.59E-06	1.65E-06	0.00E+00	8.24E-06	0.00E+00	8.71E-04
Fe-55	6.54E+01	4.22E+01	1.13E+01	0.00E+00	0.00E+00	2.06E+01	5.36E+00
Fe-59	1.41E+02	2.46E+02	9.68E+01	0.00E+00	0.00E+00	7.26E+01	1.17E+02
Co-57	0.00E+00	5.39E+00	8.76E+00	0.00E+00	0.00E+00	0.00E+00	1.84E+01
Co-58	0.00E+00	1.66E+01	4.15E+01	0.00E+00	0.00E+00	0.00E+00	4.14E+01
Co-60	0.00E+00	5.08E+01	1.20E+02	0.00E+00	0.00E+00	0.00E+00	1.21E+02
Ni-63	2.99E+03	1.85E+02	1.04E+02	0.00E+00	0.00E+00	0.00E+00	9.18E+00
Ni-65	4.08E-05	4.62E-06	2.10E-06	0.00E+00	0.00E+00	0.00E+00	3.52E-04
Cu-64	0.00E+00	2.09E-01	9.67E-02	0.00E+00	3.53E-01	0.00E+00	4.29E+00
Zn-65	8.62E+01	2.95E+02	1.36E+02	0.00E+00	1.43E+02	0.00E+00	2.50E+02
Zn-69m	6.29E-01	1.28E+00	1.17E-01	0.00E+00	5.20E-01	0.00E+00	1.78E+01
Zn-69	1.12E-16	2.02E-16	1.50E-17	0.00E+00	8.39E-17	0.00E+00	1.65E-14
Br-82	0.00E+00	0.00E+00	2.33E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-83	0.00E+00	0.00E+00	1.54E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	9.81E-28	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	3.39E-304	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	7.43E+02	3.67E+02	0.00E+00	0.00E+00	0.00E+00	1.90E+01
Rb-88	0.00E+00	4.62E-49	2.53E-49	0.00E+00	0.00E+00	0.00E+00	4.49E-49
Rb-89	0.00E+00	9.52E-57	6.56E-57	0.00E+00	0.00E+00	0.00E+00	3.24E-57
Sr-89	1.15E+04	0.00E+00	3.30E+02	0.00E+00	0.00E+00	0.00E+00	2.36E+02
Sr-90	1.33E+05	0.00E+00	2.70E+03	0.00E+00	0.00E+00	0.00E+00	1.09E+03
Sr-91	7.09E+00	0.00E+00	2.57E-01	0.00E+00	0.00E+00	0.00E+00	8.40E+00
Sr-92	4.21E-04	0.00E+00	1.56E-05	0.00E+00	0.00E+00	0.00E+00	4.54E-03
Y-90	2.44E-01	0.00E+00	6.53E-03	0.00E+00	0.00E+00	0.00E+00	3.36E+02
Y-91m	1.38E-20	0.00E+00	4.71E-22	0.00E+00	0.00E+00	0.00E+00	4.61E-17
Y-91	5.20E+00	0.00E+00	1.38E-01	0.00E+00	0.00E+00	0.00E+00	3.72E+02
Y-92	2.98E-06	0.00E+00	8.39E-08	0.00E+00	0.00E+00	0.00E+00	5.70E-02
Y-93	4.25E-03	0.00E+00	1.16E-04	0.00E+00	0.00E+00	0.00E+00	3.35E+01
Zr-95	9.49E-01	2.31E-01	1.64E-01	0.00E+00	2.49E-01	0.00E+00	1.15E+02
Zr-97	9.73E-03	1.67E-03	7.63E-04	0.00E+00	1.68E-03	0.00E+00	1.07E+02
Nb-95	1.90E-01	7.83E-02	4.53E-02	0.00E+00	5.61E-02	0.00E+00	6.61E+01
Nb-97	2.04E-15	4.36E-16	1.57E-16	0.00E+00	3.40E-16	0.00E+00	1.38E-10
Mo-99	0.00E+00	9.67E+01	1.89E+01	0.00E+00	1.45E+02	0.00E+00	3.19E+01
Tc-99m	3.60E-05	7.42E-05	9.56E-04	0.00E+00	7.98E-04	3.88E-05	2.15E-02
Tc-101	9.44E-64	1.19E-63	1.18E-62	0.00E+00	1.41E-62	6.49E-64	2.02E-61
Ru-103	6.73E+00	0.00E+00	2.25E+00	0.00E+00	1.40E+01	0.00E+00	8.18E+01
Ru-105	3.57E-04	0.00E+00	1.20E-04	0.00E+00	2.62E-03	0.00E+00	1.42E-01

All values are in (mrem·mL)/(h·μCi).

Table A13.2.2-4 (cont.) Site-Related $A_{i\tau}$ Ingestion Dose Factors for Drinking Water, Infant Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ru-106	1.13E+02	0.00E+00	1.41E+01	0.00E+00	1.34E+02	0.00E+00	8.58E+02
Rh-105	2.00E+00	1.31E+00	8.80E-01	0.00E+00	3.64E+00	0.00E+00	3.25E+01
Ag-110m	4.66E+00	3.40E+00	2.25E+00	0.00E+00	4.87E+00	0.00E+00	1.77E+02
Cd-113m	0.00E+00	8.33E+01	3.07E+00	0.00E+00	6.31E+01	0.00E+00	1.25E+02
Sb-124	9.85E+01	1.45E+00	3.05E+01	2.61E-01	0.00E+00	6.17E+01	3.04E+02
Sb-125	5.78E+01	5.60E-01	1.19E+01	7.24E-02	0.00E+00	3.35E+01	7.71E+01
Sb-126	3.39E+01	6.65E-01	1.23E+01	2.61E-01	0.00E+00	2.13E+01	3.52E+02
Sb-127	7.33E+00	1.31E-01	2.27E+00	9.33E-02	0.00E+00	3.78E+00	1.94E+02
Te-125m	1.07E+02	3.58E+01	1.45E+01	3.60E+01	0.00E+00	0.00E+00	5.10E+01
Te-127m	2.72E+02	9.02E+01	3.29E+01	7.86E+01	6.70E+02	0.00E+00	1.10E+02
Te-127	1.34E-01	4.49E-02	2.88E-02	1.09E-01	3.27E-01	0.00E+00	2.82E+00
Te-129m	4.52E+02	1.55E+02	6.96E+01	1.74E+02	1.13E+03	0.00E+00	2.70E+02
Te-129	4.68E-13	1.61E-13	1.09E-13	3.92E-13	1.16E-12	0.00E+00	3.74E-11
Te-131m	2.36E+01	9.51E+00	7.84E+00	1.93E+01	6.54E+01	0.00E+00	1.60E+02
Te-131	1.74E-35	6.41E-36	4.88E-36	1.55E-35	4.44E-35	0.00E+00	7.02E-34
Te-132	6.40E+01	3.17E+01	2.96E+01	4.68E+01	1.98E+02	0.00E+00	1.17E+02
I-129	1.35E+02	9.98E+01	7.30E+01	6.40E+04	1.18E+02	0.00E+00	2.00E+00
I-130	1.91E+00	4.21E+00	1.69E+00	4.72E+02	4.63E+00	0.00E+00	9.03E-01
I-131	1.42E+02	1.68E+02	7.37E+01	5.51E+04	1.96E+02	0.00E+00	5.98E+00
I-132	4.08E-06	8.28E-06	2.95E-06	3.88E-04	9.24E-06	0.00E+00	6.71E-06
I-133	1.19E+01	1.73E+01	5.07E+00	3.15E+03	2.04E+01	0.00E+00	2.93E+00
I-134	1.35E-16	2.76E-16	9.82E-17	6.44E-15	3.09E-16	0.00E+00	2.85E-16
I-135	1.12E-01	2.22E-01	8.10E-02	1.99E+01	2.48E-01	0.00E+00	8.04E-02
Cs-134	1.77E+03	3.30E+03	3.34E+02	0.00E+00	8.51E+02	3.49E+02	8.98E+00
Cs-135	6.26E+02	5.70E+02	2.97E+01	0.00E+00	1.62E+02	6.17E+01	2.06E+00
Cs-136	1.95E+02	5.72E+02	2.14E+02	0.00E+00	2.28E+02	4.66E+01	8.69E+00
Cs-137	2.46E+03	2.88E+03	2.04E+02	0.00E+00	7.72E+02	3.13E+02	8.99E+00
Cs-138	2.70E-27	4.38E-27	2.12E-27	0.00E+00	2.19E-27	3.41E-28	7.00E-27
Ba-139	1.53E-10	1.02E-13	4.43E-12	0.00E+00	6.10E-14	6.15E-14	9.70E-09
Ba-140	7.23E+02	7.23E-01	3.72E+01	0.00E+00	1.72E-01	4.44E-01	1.77E+02
Ba-141	7.05E-48	4.83E-51	2.22E-49	0.00E+00	2.90E-51	2.94E-51	8.61E-47
Ba-142	8.18E-82	6.80E-85	4.03E-83	0.00E+00	3.92E-85	4.12E-85	3.37E-81
La-140	4.34E-02	1.71E-02	4.41E-03	0.00E+00	0.00E+00	0.00E+00	2.01E+02
La-142	4.23E-12	1.55E-12	3.72E-13	0.00E+00	0.00E+00	0.00E+00	2.64E-07
Ce-141	3.55E-01	2.17E-01	2.55E-02	0.00E+00	6.68E-02	0.00E+00	1.12E+02
Ce-143	2.54E-02	1.69E+01	1.92E-03	0.00E+00	4.91E-03	0.00E+00	9.84E+01
Ce-144	1.40E+01	5.72E+00	7.83E-01	0.00E+00	2.31E+00	0.00E+00	8.01E+02
Pr-143	3.46E-01	1.29E-01	1.71E-02	0.00E+00	4.80E-02	0.00E+00	1.82E+02
Pr-144	8.69E-54	3.36E-54	4.38E-55	0.00E+00	1.22E-54	0.00E+00	1.56E-49
Nd-147	2.30E-01	2.36E-01	1.44E-02	0.00E+00	9.09E-02	0.00E+00	1.49E+02
Eu-152	3.17E+00	8.43E-01	7.11E-01	0.00E+00	2.36E+00	0.00E+00	7.49E+01
W-187	1.05E+00	7.32E-01	2.53E-01	0.00E+00	0.00E+00	0.00E+00	4.30E+01
Np-239	2.90E-02	2.60E-03	1.47E-03	0.00E+00	5.18E-03	0.00E+00	7.50E+01

Table A13.2.2-5 Site-Related $A_{i\tau}$ Ingestion Dose Factors for Fish, Adult Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00E+00	1.29E-01	1.29E-01	1.29E-01	1.29E-01	1.29E-01	1.29E-01
C-14	3.13E+04	6.26E+03	6.26E+03	6.26E+03	6.26E+03	6.26E+03	6.26E+03
Na-24	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02
P-32	1.32E+06	8.22E+04	5.11E+04	0.00E+00	0.00E+00	0.00E+00	1.49E+05
Cr-51	0.00E+00	0.00E+00	1.24E+00	7.43E-01	2.74E-01	1.65E+00	3.13E+02
Mn-54	0.00E+00	4.37E+03	8.34E+02	0.00E+00	1.30E+03	0.00E+00	1.34E+04
Mn-56	0.00E+00	1.74E-01	3.09E-02	0.00E+00	2.21E-01	0.00E+00	5.55E+00
Fe-55	6.59E+02	4.55E+02	1.06E+02	0.00E+00	0.00E+00	2.54E+02	2.61E+02
Fe-59	1.02E+03	2.41E+03	9.23E+02	0.00E+00	0.00E+00	6.73E+02	8.03E+03
Co-57	0.00E+00	2.09E+01	3.48E+01	0.00E+00	0.00E+00	0.00E+00	5.31E+02
Co-58	0.00E+00	8.84E+01	1.98E+02	0.00E+00	0.00E+00	0.00E+00	1.79E+03
Co-60	0.00E+00	2.56E+02	5.66E+02	0.00E+00	0.00E+00	0.00E+00	4.82E+03
Ni-63	3.12E+04	2.16E+03	1.05E+03	0.00E+00	0.00E+00	0.00E+00	4.51E+02
Ni-65	1.72E-01	2.23E-02	1.02E-02	0.00E+00	0.00E+00	0.00E+00	5.67E-01
Cu-64	0.00E+00	2.69E+00	1.26E+00	0.00E+00	6.79E+00	0.00E+00	2.30E+02
Zn-65	2.31E+04	7.36E+04	3.33E+04	0.00E+00	4.92E+04	0.00E+00	4.64E+04
Zn-69m	2.43E+02	5.84E+02	5.34E+01	0.00E+00	3.53E+02	0.00E+00	3.56E+04
Zn-69	7.89E-07	1.51E-06	1.05E-07	0.00E+00	9.81E-07	0.00E+00	2.27E-07
Br-82	0.00E+00	0.00E+00	1.42E+03	0.00E+00	0.00E+00	0.00E+00	1.63E+03
Br-83	0.00E+00	0.00E+00	3.84E-02	0.00E+00	0.00E+00	0.00E+00	5.53E-02
Br-84	0.00E+00	0.00E+00	1.23E-12	0.00E+00	0.00E+00	0.00E+00	9.62E-18
Br-85	0.00E+00	0.00E+00	1.31E-151	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	9.75E+04	4.54E+04	0.00E+00	0.00E+00	0.00E+00	1.92E+04
Rb-88	0.00E+00	1.29E-22	6.83E-23	0.00E+00	0.00E+00	0.00E+00	1.78E-33
Rb-89	0.00E+00	1.62E-26	1.14E-26	0.00E+00	0.00E+00	0.00E+00	9.39E-40
Sr-89	2.18E+04	0.00E+00	6.27E+02	0.00E+00	0.00E+00	0.00E+00	3.50E+03
Sr-90	6.26E+05	0.00E+00	1.26E+04	0.00E+00	0.00E+00	0.00E+00	1.57E+04
Sr-91	7.08E+01	0.00E+00	2.86E+00	0.00E+00	0.00E+00	0.00E+00	3.37E+02
Sr-92	3.34E-01	0.00E+00	1.44E-02	0.00E+00	0.00E+00	0.00E+00	6.61E+00
Y-90	4.45E-01	0.00E+00	1.19E-02	0.00E+00	0.00E+00	0.00E+00	4.72E+03
Y-91m	1.04E-11	0.00E+00	4.02E-13	0.00E+00	0.00E+00	0.00E+00	3.05E-11
Y-91	8.35E+00	0.00E+00	2.23E-01	0.00E+00	0.00E+00	0.00E+00	4.60E+03
Y-92	4.61E-04	0.00E+00	1.35E-05	0.00E+00	0.00E+00	0.00E+00	8.07E+00
Y-93	3.09E-02	0.00E+00	8.54E-04	0.00E+00	0.00E+00	0.00E+00	9.81E+02
Zr-95	2.38E-01	7.63E-02	5.17E-02	0.00E+00	1.20E-01	0.00E+00	2.42E+02
Zr-97	4.97E-03	1.00E-03	4.58E-04	0.00E+00	1.51E-03	0.00E+00	3.10E+02
Nb-95	8.04E+00	4.47E+00	2.40E+00	0.00E+00	4.42E+00	0.00E+00	2.71E+04
Nb-97	6.69E-08	1.69E-08	6.18E-09	0.00E+00	1.97E-08	0.00E+00	6.24E-05
Mo-99	0.00E+00	8.03E+01	1.53E+01	0.00E+00	1.82E+02	0.00E+00	1.86E+02
Tc-99m	5.60E-04	1.58E-03	2.02E-02	0.00E+00	2.40E-02	7.76E-04	9.37E-01
Tc-101	2.71E-33	3.91E-33	3.84E-32	0.00E+00	7.04E-32	2.00E-33	1.18E-44
Ru-103	4.36E+00	0.00E+00	1.88E+00	0.00E+00	1.66E+01	0.00E+00	5.09E+02
Ru-105	8.71E-03	0.00E+00	3.44E-03	0.00E+00	1.13E-01	0.00E+00	5.33E+00
Ru-106	6.58E+01	0.00E+00	8.33E+00	0.00E+00	1.27E+02	0.00E+00	4.26E+03

All values are in (mrem·mL)/(h·µCi).

Table A13.2.2-5 (cont.) Site-Related $A_{i\tau}$ Ingestion Dose Factors for Fish, Adult Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Rh-105	1.81E+00	1.33E+00	8.73E-01	0.00E+00	5.63E+00	0.00E+00	2.11E+02
Ag-110m	8.80E-01	8.14E-01	4.83E-01	0.00E+00	1.60E+00	0.00E+00	3.32E+02
Cd-113m	0.00E+00	1.52E+03	4.89E+01	0.00E+00	1.68E+03	0.00E+00	1.23E+04
Sb-124	1.33E+03	2.51E+01	5.26E+02	3.22E+00	0.00E+00	1.03E+03	3.77E+04
Sb-125	8.58E+02	9.58E+00	2.04E+02	8.72E-01	0.00E+00	6.61E+02	9.44E+03
Sb-126	5.21E+02	1.06E+01	1.88E+02	3.19E+00	0.00E+00	3.20E+02	4.26E+04
Sb-127	1.03E+02	2.26E+00	3.96E+01	1.24E+00	0.00E+00	6.13E+01	2.36E+04
Te-125m	2.54E+03	9.20E+02	3.40E+02	7.64E+02	1.03E+04	0.00E+00	1.01E+04
Te-127m	6.45E+03	2.31E+03	7.86E+02	1.65E+03	2.62E+04	0.00E+00	2.16E+04
Te-127	1.78E+01	6.39E+00	3.85E+00	1.32E+01	7.25E+01	0.00E+00	1.40E+03
Te-129m	1.08E+04	4.03E+03	1.71E+03	3.71E+03	4.51E+04	0.00E+00	5.44E+04
Te-129	1.78E-05	6.69E-06	4.34E-06	1.37E-05	7.48E-05	0.00E+00	1.34E-05
Te-131m	9.53E+02	4.66E+02	3.88E+02	7.38E+02	4.72E+03	0.00E+00	4.63E+04
Te-131	8.65E-17	3.61E-17	2.73E-17	7.11E-17	3.79E-16	0.00E+00	1.22E-17
Te-132	1.95E+03	1.26E+03	1.19E+03	1.40E+03	1.22E+04	0.00E+00	5.98E+04
I-129	1.18E+02	1.01E+02	3.31E+02	2.60E+05	2.17E+02	0.00E+00	1.60E+01
I-130	7.08E+00	2.09E+01	8.24E+00	1.77E+03	3.26E+01	0.00E+00	1.80E+01
I-131	1.37E+02	1.96E+02	1.12E+02	6.43E+04	3.36E+02	0.00E+00	5.18E+01
I-132	5.27E-03	1.41E-02	4.94E-03	4.94E-01	2.25E-02	0.00E+00	2.65E-03
I-133	2.29E+01	3.99E+01	1.22E+01	5.87E+03	6.97E+01	0.00E+00	3.59E+01
I-134	2.19E-08	5.94E-08	2.13E-08	1.03E-06	9.45E-08	0.00E+00	5.18E-11
I-135	1.29E+00	3.37E+00	1.24E+00	2.22E+02	5.40E+00	0.00E+00	3.80E+00
Cs-134	2.98E+05	7.09E+05	5.80E+05	0.00E+00	2.29E+05	7.62E+04	1.24E+04
Cs-135	9.35E+04	8.63E+04	3.83E+04	0.00E+00	3.27E+04	9.78E+03	2.02E+03
Cs-136	2.96E+04	1.17E+05	8.41E+04	0.00E+00	6.50E+04	8.92E+03	1.33E+04
Cs-137	3.82E+05	5.23E+05	3.42E+05	0.00E+00	1.77E+05	5.90E+04	1.01E+04
Cs-138	9.13E-12	1.80E-11	8.93E-12	0.00E+00	1.32E-11	1.31E-12	7.69E-17
Ba-139	5.65E-06	4.03E-09	1.65E-07	0.00E+00	3.76E-09	2.28E-09	1.00E-05
Ba-140	1.84E+02	2.32E-01	1.21E+01	0.00E+00	7.88E-02	1.33E-01	3.80E+02
Ba-141	8.48E-25	6.41E-28	2.86E-26	0.00E+00	5.96E-28	3.64E-28	4.00E-34
Ba-142	6.28E-42	6.45E-45	3.95E-43	0.00E+00	5.45E-45	3.65E-45	8.84E-60
La-140	9.91E-02	4.99E-02	1.32E-02	0.00E+00	0.00E+00	0.00E+00	3.67E+03
La-142	2.19E-07	9.97E-08	2.48E-08	0.00E+00	0.00E+00	0.00E+00	7.28E-04
Ce-141	2.20E-02	1.49E-02	1.68E-03	0.00E+00	6.90E-03	0.00E+00	5.68E+01
Ce-143	2.39E-03	1.77E+00	1.95E-04	0.00E+00	7.78E-04	0.00E+00	6.60E+01
Ce-144	1.17E+00	4.88E-01	6.27E-02	0.00E+00	2.89E-01	0.00E+00	3.95E+02
Pr-143	5.24E-01	2.10E-01	2.60E-02	0.00E+00	1.21E-01	0.00E+00	2.29E+03
Pr-144	1.48E-28	6.15E-29	7.53E-30	0.00E+00	3.47E-29	0.00E+00	2.13E-35
Nd-147	3.54E-01	4.09E-01	2.45E-02	0.00E+00	2.39E-01	0.00E+00	1.96E+03
Eu-152	1.17E+01	2.66E+00	2.34E+00	0.00E+00	1.65E+01	0.00E+00	1.53E+03
W-187	1.47E+02	1.23E+02	4.31E+01	0.00E+00	0.00E+00	0.00E+00	4.04E+04
Np-239	2.13E-02	2.09E-03	1.15E-03	0.00E+00	6.52E-03	0.00E+00	4.29E+02

Table A13.2.2-6 Site-Related $A_{i\tau}$ Ingestion Dose Factors for Fish, Teenager Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00E+00	9.93E-02	9.93E-02	9.93E-02	9.93E-02	9.93E-02	9.93E-02
C-14	3.41E+04	6.82E+03	6.82E+03	6.82E+03	6.82E+03	6.82E+03	6.82E+03
Na-24	1.39E+02	1.39E+02	1.39E+02	1.39E+02	1.39E+02	1.39E+02	1.39E+02
P-32	1.44E+06	8.93E+04	5.59E+04	0.00E+00	0.00E+00	0.00E+00	1.21E+05
Cr-51	0.00E+00	0.00E+00	1.28E+00	7.13E-01	2.81E-01	1.83E+00	2.16E+02
Mn-54	0.00E+00	4.30E+03	8.53E+02	0.00E+00	1.28E+03	0.00E+00	8.82E+03
Mn-56	0.00E+00	1.82E-01	3.24E-02	0.00E+00	2.31E-01	0.00E+00	1.20E+01
Fe-55	6.90E+02	4.89E+02	1.14E+02	0.00E+00	0.00E+00	3.10E+02	2.12E+02
Fe-59	1.06E+03	2.46E+03	9.51E+02	0.00E+00	0.00E+00	7.77E+02	5.83E+03
Co-57	0.00E+00	2.17E+01	3.63E+01	0.00E+00	0.00E+00	0.00E+00	4.04E+02
Co-58	0.00E+00	8.79E+01	2.03E+02	0.00E+00	0.00E+00	0.00E+00	1.21E+03
Co-60	0.00E+00	2.57E+02	5.78E+02	0.00E+00	0.00E+00	0.00E+00	3.34E+03
Ni-63	3.23E+04	2.28E+03	1.10E+03	0.00E+00	0.00E+00	0.00E+00	3.63E+02
Ni-65	1.86E-01	2.37E-02	1.08E-02	0.00E+00	0.00E+00	0.00E+00	1.29E+00
Cu-64	0.00E+00	2.83E+00	1.33E+00	0.00E+00	7.17E+00	0.00E+00	2.20E+02
Zn-65	2.10E+04	7.29E+04	3.40E+04	0.00E+00	4.66E+04	0.00E+00	3.09E+04
Zn-69m	2.62E+02	6.17E+02	5.66E+01	0.00E+00	3.75E+02	0.00E+00	3.39E+04
Zn-69	8.58E-07	1.63E-06	1.14E-07	0.00E+00	1.07E-06	0.00E+00	3.01E-06
Br-82	0.00E+00	0.00E+00	1.46E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-83	0.00E+00	0.00E+00	4.18E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	1.29E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	1.43E-151	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	1.05E+05	4.93E+04	0.00E+00	0.00E+00	0.00E+00	1.55E+04
Rb-88	0.00E+00	1.38E-22	7.36E-23	0.00E+00	0.00E+00	0.00E+00	1.18E-29
Rb-89	0.00E+00	1.69E-26	1.19E-26	0.00E+00	0.00E+00	0.00E+00	2.59E-35
Sr-89	2.38E+04	0.00E+00	6.81E+02	0.00E+00	0.00E+00	0.00E+00	2.83E+03
Sr-90	5.59E+05	0.00E+00	1.12E+04	0.00E+00	0.00E+00	0.00E+00	1.28E+04
Sr-91	7.68E+01	0.00E+00	3.05E+00	0.00E+00	0.00E+00	0.00E+00	3.48E+02
Sr-92	3.61E-01	0.00E+00	1.54E-02	0.00E+00	0.00E+00	0.00E+00	9.19E+00
Y-90	4.83E-01	0.00E+00	1.30E-02	0.00E+00	0.00E+00	0.00E+00	3.98E+03
Y-91m	1.12E-11	0.00E+00	4.29E-13	0.00E+00	0.00E+00	0.00E+00	5.30E-10
Y-91	9.07E+00	0.00E+00	2.43E-01	0.00E+00	0.00E+00	0.00E+00	3.72E+03
Y-92	5.03E-04	0.00E+00	1.45E-05	0.00E+00	0.00E+00	0.00E+00	1.38E+01
Y-93	3.37E-02	0.00E+00	9.23E-04	0.00E+00	0.00E+00	0.00E+00	1.03E+03
Zr-95	2.46E-01	7.75E-02	5.33E-02	0.00E+00	1.14E-01	0.00E+00	1.79E+02
Zr-97	5.34E-03	1.06E-03	4.87E-04	0.00E+00	1.60E-03	0.00E+00	2.86E+02
Nb-95	8.10E+00	4.49E+00	2.47E+00	0.00E+00	4.35E+00	0.00E+00	1.92E+04
Nb-97	7.20E-08	1.79E-08	6.52E-09	0.00E+00	2.09E-08	0.00E+00	4.27E-04
Mo-99	0.00E+00	8.56E+01	1.63E+01	0.00E+00	1.96E+02	0.00E+00	1.53E+02
Tc-99m	5.74E-04	1.60E-03	2.07E-02	0.00E+00	2.38E-02	8.88E-04	1.05E+00
Tc-101	2.93E-33	4.17E-33	4.10E-32	0.00E+00	7.54E-32	2.54E-33	7.12E-40
Ru-103	4.58E+00	0.00E+00	1.96E+00	0.00E+00	1.61E+01	0.00E+00	3.82E+02
Ru-105	9.39E-03	0.00E+00	3.65E-03	0.00E+00	1.19E-01	0.00E+00	7.58E+00

All values are in (mrem·mL)/(h·μCi).

Table A13.2.2-6 (cont.) Site-Related $A_{i\tau}$ Ingestion Dose Factors for Fish, Teenager Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ru-106	7.15E+01	0.00E+00	9.01E+00	0.00E+00	1.38E+02	0.00E+00	3.43E+03
Rh-105	1.97E+00	1.43E+00	9.36E-01	0.00E+00	6.06E+00	0.00E+00	1.81E+02
Ag-110m	8.59E-01	8.13E-01	4.94E-01	0.00E+00	1.55E+00	0.00E+00	2.28E+02
Cd-113m	0.00E+00	1.65E+03	5.30E+01	0.00E+00	1.82E+03	0.00E+00	9.90E+03
Sb-124	1.40E+03	2.57E+01	5.45E+02	3.17E+00	0.00E+00	1.22E+03	2.82E+04
Sb-125	9.05E+02	9.89E+00	2.12E+02	8.65E-01	0.00E+00	7.96E+02	7.05E+03
Sb-126	5.49E+02	1.12E+01	1.97E+02	3.11E+00	0.00E+00	3.94E+02	3.25E+04
Sb-127	1.11E+02	2.37E+00	4.18E+01	1.24E+00	0.00E+00	7.54E+01	1.88E+04
Te-125m	2.76E+03	9.96E+02	3.70E+02	7.72E+02	0.00E+00	0.00E+00	8.16E+03
Te-127m	7.02E+03	2.49E+03	8.35E+02	1.67E+03	2.85E+04	0.00E+00	1.75E+04
Te-127	1.95E+01	6.91E+00	4.19E+00	1.34E+01	7.89E+01	0.00E+00	1.50E+03
Te-129m	1.17E+04	4.33E+03	1.85E+03	3.76E+03	4.88E+04	0.00E+00	4.38E+04
Te-129	1.94E-05	7.21E-06	4.71E-06	1.38E-05	8.12E-05	0.00E+00	1.06E-04
Te-131m	1.02E+03	4.91E+02	4.10E+02	7.39E+02	5.12E+03	0.00E+00	3.94E+04
Te-131	9.33E-17	3.85E-17	2.92E-17	7.19E-17	4.08E-16	0.00E+00	7.66E-18
Te-132	2.06E+03	1.31E+03	1.23E+03	1.38E+03	1.25E+04	0.00E+00	4.13E+04
I-129	1.28E+02	1.07E+02	1.79E+02	1.31E+05	1.92E+02	0.00E+00	1.25E+01
I-130	7.35E+00	2.13E+01	8.49E+00	1.73E+03	3.27E+01	0.00E+00	1.63E+01
I-131	1.47E+02	2.06E+02	1.11E+02	6.01E+04	3.54E+02	0.00E+00	4.07E+01
I-132	5.52E-03	1.44E-02	5.19E-03	4.87E-01	2.28E-02	0.00E+00	6.29E-03
I-133	2.47E+01	4.20E+01	1.28E+01	5.86E+03	7.36E+01	0.00E+00	3.18E+01
I-134	2.30E-08	6.09E-08	2.19E-08	1.01E-06	9.59E-08	0.00E+00	8.02E-10
I-135	1.35E+00	3.47E+00	1.29E+00	2.23E+02	5.48E+00	0.00E+00	3.85E+00
Cs-134	3.05E+05	7.19E+05	3.34E+05	0.00E+00	2.28E+05	8.72E+04	8.94E+03
Cs-135	1.02E+05	9.32E+04	2.18E+04	0.00E+00	3.55E+04	1.29E+04	1.63E+03
Cs-136	2.98E+04	1.17E+05	7.87E+04	0.00E+00	6.38E+04	1.01E+04	9.43E+03
Cs-137	4.09E+05	5.44E+05	1.90E+05	0.00E+00	1.85E+05	7.20E+04	7.74E+03
Cs-138	9.78E-12	1.88E-11	9.39E-12	0.00E+00	1.39E-11	1.61E-12	8.52E-15
Ba-139	6.17E-06	4.34E-09	1.80E-07	0.00E+00	4.09E-09	2.99E-09	5.50E-05
Ba-140	1.97E+02	2.41E-01	1.27E+01	0.00E+00	8.17E-02	1.62E-01	3.03E+02
Ba-141	9.20E-25	6.87E-28	3.07E-26	0.00E+00	6.38E-28	4.70E-28	1.96E-30
Ba-142	6.71E-42	6.71E-45	4.13E-43	0.00E+00	5.68E-45	4.47E-45	2.06E-53
La-140	1.05E-01	5.16E-02	1.37E-02	0.00E+00	0.00E+00	0.00E+00	2.97E+03
La-142	2.34E-07	1.04E-07	2.58E-08	0.00E+00	0.00E+00	0.00E+00	3.16E-03
Ce-141	2.38E-02	1.59E-02	1.82E-03	0.00E+00	7.47E-03	0.00E+00	4.54E+01
Ce-143	2.59E-03	1.89E+00	2.11E-04	0.00E+00	8.46E-04	0.00E+00	5.67E+01
Ce-144	1.27E+00	5.25E-01	6.81E-02	0.00E+00	3.13E-01	0.00E+00	3.19E+02
Pr-143	5.68E-01	2.27E-01	2.83E-02	0.00E+00	1.32E-01	0.00E+00	1.87E+03
Pr-144	1.61E-28	6.60E-29	8.17E-30	0.00E+00	3.78E-29	0.00E+00	1.78E-31
Nd-147	4.02E-01	4.37E-01	2.62E-02	0.00E+00	2.57E-01	0.00E+00	1.58E+03
Eu-152	1.12E+01	2.69E+00	2.37E+00	0.00E+00	1.25E+01	0.00E+00	9.91E+02
W-187	1.59E+02	1.30E+02	4.55E+01	0.00E+00	0.00E+00	0.00E+00	3.51E+04
Np-239	2.39E-02	2.26E-03	1.25E-03	0.00E+00	7.09E-03	0.00E+00	3.63E+02

Table A13.2.2-7 Site-Related $A_{i\tau}$ Ingestion Dose Factors for Fish, Child Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00E+00	8.22E-02	8.22E-02	8.22E-02	8.22E-02	8.22E-02	8.22E-02
C-14	4.38E+04	8.77E+03	8.77E+03	8.77E+03	8.77E+03	8.77E+03	8.77E+03
Na-24	1.51E+02	1.51E+02	1.51E+02	1.51E+02	1.51E+02	1.51E+02	1.51E+02
P-32	1.86E+06	8.69E+04	7.16E+04	0.00E+00	0.00E+00	0.00E+00	5.13E+04
Cr-51	0.00E+00	0.00E+00	1.37E+00	7.59E-01	2.07E-01	1.39E+00	7.25E+01
Mn-54	0.00E+00	3.36E+03	8.96E+02	0.00E+00	9.43E+02	0.00E+00	2.82E+03
Mn-56	0.00E+00	1.66E-01	3.75E-02	0.00E+00	2.01E-01	0.00E+00	2.41E+01
Fe-55	9.05E+02	4.80E+02	1.49E+02	0.00E+00	0.00E+00	2.72E+02	8.89E+01
Fe-59	1.28E+03	2.07E+03	1.03E+03	0.00E+00	0.00E+00	6.00E+02	2.16E+03
Co-57	0.00E+00	1.94E+01	3.92E+01	0.00E+00	0.00E+00	0.00E+00	1.59E+02
Co-58	0.00E+00	7.02E+01	2.15E+02	0.00E+00	0.00E+00	0.00E+00	4.09E+02
Co-60	0.00E+00	2.08E+02	6.14E+02	0.00E+00	0.00E+00	0.00E+00	1.15E+03
Ni-63	4.24E+04	2.27E+03	1.44E+03	0.00E+00	0.00E+00	0.00E+00	1.53E+02
Ni-65	2.38E-01	2.24E-02	1.31E-02	0.00E+00	0.00E+00	0.00E+00	2.74E+00
Cu-64	0.00E+00	2.60E+00	1.57E+00	0.00E+00	6.29E+00	0.00E+00	1.22E+02
Zn-65	2.15E+04	5.73E+04	3.57E+04	0.00E+00	3.61E+04	0.00E+00	1.01E+04
Zn-69m	3.34E+02	5.69E+02	6.72E+01	0.00E+00	3.30E+02	0.00E+00	1.85E+04
Zn-69	1.10E-06	1.59E-06	1.47E-07	0.00E+00	9.67E-07	0.00E+00	1.00E-04
Br-82	0.00E+00	0.00E+00	1.56E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-83	0.00E+00	0.00E+00	5.37E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	1.53E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	1.84E-151	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	1.02E+05	6.25E+04	0.00E+00	0.00E+00	0.00E+00	6.54E+03
Rb-88	0.00E+00	1.33E-22	9.22E-23	0.00E+00	0.00E+00	0.00E+00	6.51E-24
Rb-89	0.00E+00	1.55E-26	1.38E-26	0.00E+00	0.00E+00	0.00E+00	1.35E-28
Sr-89	3.08E+04	0.00E+00	8.79E+02	0.00E+00	0.00E+00	0.00E+00	1.19E+03
Sr-90	6.05E+05	0.00E+00	1.22E+04	0.00E+00	0.00E+00	0.00E+00	5.41E+03
Sr-91	9.84E+01	0.00E+00	3.72E+00	0.00E+00	0.00E+00	0.00E+00	2.17E+02
Sr-92	4.60E-01	0.00E+00	1.85E-02	0.00E+00	0.00E+00	0.00E+00	8.72E+00
Y-90	6.24E-01	0.00E+00	1.67E-02	0.00E+00	0.00E+00	0.00E+00	1.78E+03
Y-91m	1.43E-11	0.00E+00	5.21E-13	0.00E+00	0.00E+00	0.00E+00	2.81E-08
Y-91	1.17E+01	0.00E+00	3.13E-01	0.00E+00	0.00E+00	0.00E+00	1.56E+03
Y-92	6.45E-04	0.00E+00	1.85E-05	0.00E+00	0.00E+00	0.00E+00	1.86E+01
Y-93	4.32E-02	0.00E+00	1.19E-03	0.00E+00	0.00E+00	0.00E+00	6.45E+02
Zr-95	2.98E-01	6.56E-02	5.84E-02	0.00E+00	9.39E-02	0.00E+00	6.84E+01
Zr-97	6.79E-03	9.81E-04	5.79E-04	0.00E+00	1.41E-03	0.00E+00	1.49E+02
Nb-95	9.56E+00	3.72E+00	2.66E+00	0.00E+00	3.50E+00	0.00E+00	6.88E+03
Nb-97	9.14E-08	1.65E-08	7.71E-09	0.00E+00	1.83E-08	0.00E+00	5.10E-03
Mo-99	0.00E+00	8.14E+01	2.01E+01	0.00E+00	1.74E+02	0.00E+00	6.73E+01
Tc-99m	6.88E-04	1.35E-03	2.24E-02	0.00E+00	1.96E-02	6.85E-04	7.68E-01
Tc-101	3.76E-33	3.93E-33	4.99E-32	0.00E+00	6.71E-32	2.08E-33	1.25E-32
Ru-103	5.66E+00	0.00E+00	2.17E+00	0.00E+00	1.42E+01	0.00E+00	1.46E+02
Ru-105	1.20E-02	0.00E+00	4.35E-03	0.00E+00	1.05E-01	0.00E+00	7.82E+00

All values are in (mrem·mL)/(h·μCi).

Table A13.2.2-7 (cont.) Site-Related $A_{i\tau}$ Ingestion Dose Factors for Fish, Child Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ru-106	9.20E+01	0.00E+00	1.15E+01	0.00E+00	1.24E+02	0.00E+00	1.43E+03
Rh-105	2.53E+00	1.36E+00	1.16E+00	0.00E+00	5.41E+00	0.00E+00	8.41E+01
Ag-110m	9.74E-01	6.58E-01	5.26E-01	0.00E+00	1.22E+00	0.00E+00	7.82E+01
Cd-113m	0.00E+00	1.61E+03	6.84E+01	0.00E+00	1.65E+03	0.00E+00	4.14E+03
Sb-124	1.73E+03	2.24E+01	6.06E+02	3.82E+00	0.00E+00	9.59E+02	1.08E+04
Sb-125	1.13E+03	8.69E+00	2.36E+02	1.04E+00	0.00E+00	6.28E+02	2.69E+03
Sb-126	6.55E+02	1.00E+01	2.35E+02	3.84E+00	0.00E+00	3.13E+02	1.32E+04
Sb-127	1.39E+02	2.16E+00	4.84E+01	1.55E+00	0.00E+00	6.05E+01	7.86E+03
Te-125m	3.55E+03	9.62E+02	4.73E+02	9.96E+02	0.00E+00	0.00E+00	3.42E+03
Te-127m	9.05E+03	2.44E+03	1.07E+03	2.16E+03	2.58E+04	0.00E+00	7.33E+03
Te-127	2.50E+01	6.75E+00	5.37E+00	1.73E+01	7.13E+01	0.00E+00	9.78E+02
Te-129m	1.50E+04	4.20E+03	2.33E+03	4.85E+03	4.41E+04	0.00E+00	1.83E+04
Te-129	2.50E-05	6.97E-06	5.92E-06	1.78E-05	7.30E-05	0.00E+00	1.55E-03
Te-131m	1.30E+03	4.51E+02	4.80E+02	9.27E+02	4.36E+03	0.00E+00	1.83E+04
Te-131	1.20E-16	3.65E-17	3.56E-17	9.16E-17	3.62E-16	0.00E+00	6.29E-16
Te-132	2.57E+03	1.14E+03	1.38E+03	1.66E+03	1.06E+04	0.00E+00	1.15E+04
I-129	1.64E+02	1.01E+02	9.00E+01	6.59E+04	1.70E+02	0.00E+00	5.07E+00
I-130	8.98E+00	1.81E+01	9.35E+00	2.00E+03	2.71E+01	0.00E+00	8.49E+00
I-131	1.86E+02	1.88E+02	1.07E+02	6.20E+04	3.08E+02	0.00E+00	1.67E+01
I-132	6.83E-03	1.25E-02	5.77E-03	5.82E-01	1.92E-02	0.00E+00	1.48E-02
I-133	3.14E+01	3.89E+01	1.47E+01	7.22E+03	6.48E+01	0.00E+00	1.57E+01
I-134	2.84E-08	5.28E-08	2.43E-08	1.21E-06	8.07E-08	0.00E+00	3.50E-08
I-135	1.67E+00	3.00E+00	1.42E+00	2.66E+02	4.61E+00	0.00E+00	2.29E+00
Cs-134	3.68E+05	6.04E+05	1.27E+05	0.00E+00	1.87E+05	6.72E+04	3.26E+03
Cs-135	1.31E+05	9.11E+04	9.34E+03	0.00E+00	3.21E+04	1.07E+04	6.82E+02
Cs-136	3.51E+04	9.65E+04	6.25E+04	0.00E+00	5.14E+04	7.67E+03	3.39E+03
Cs-137	5.15E+05	4.93E+05	7.28E+04	0.00E+00	1.61E+05	5.78E+04	3.09E+03
Cs-138	1.24E-11	1.72E-11	1.09E-11	0.00E+00	1.21E-11	1.30E-12	7.93E-12
Ba-139	7.93E-06	4.23E-09	2.30E-07	0.00E+00	3.69E-09	2.49E-09	4.58E-04
Ba-140	2.48E+02	2.17E-01	1.45E+01	0.00E+00	7.07E-02	1.30E-01	1.26E+02
Ba-141	1.18E-24	6.62E-28	3.85E-26	0.00E+00	5.73E-28	3.89E-27	6.74E-25
Ba-142	8.46E-42	6.09E-45	4.72E-43	0.00E+00	4.93E-45	3.58E-45	1.10E-43
La-140	1.32E-01	4.60E-02	1.55E-02	0.00E+00	0.00E+00	0.00E+00	1.28E+03
La-142	2.95E-07	9.40E-08	2.94E-08	0.00E+00	0.00E+00	0.00E+00	1.86E-02
Ce-141	3.06E-02	1.53E-02	2.27E-03	0.00E+00	6.69E-03	0.00E+00	1.90E+01
Ce-143	3.33E-03	1.80E+00	2.61E-04	0.00E+00	7.57E-04	0.00E+00	2.64E+01
Ce-144	1.63E+00	5.12E-01	8.72E-02	0.00E+00	2.84E-01	0.00E+00	1.34E+02
Pr-143	7.35E-01	2.21E-01	3.65E-02	0.00E+00	1.20E-01	0.00E+00	7.93E+02
Pr-144	2.08E-28	6.45E-29	1.05E-29	0.00E+00	3.41E-29	0.00E+00	1.39E-25
Nd-147	5.16E-01	4.18E-01	3.24E-02	0.00E+00	2.29E-01	0.00E+00	6.62E+02
Eu-152	1.21E+01	2.21E+00	2.62E+00	0.00E+00	9.31E+00	0.00E+00	3.62E+02
W-187	2.02E+02	1.19E+02	5.36E+01	0.00E+00	0.00E+00	0.00E+00	1.68E+04
Np-239	3.08E-02	2.21E-03	1.56E-03	0.00E+00	6.40E-03	0.00E+00	1.64E+02

Table A13.2.2-8 Site-Related $A_{i\tau}$ Shoreline Dose Factors, Adult Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI	Skin
H-3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C-14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Na-24	4.28E-01	4.28E-01	4.28E-01	4.28E-01	4.28E-01	4.28E-01	4.28E-01	4.97E-01
P-32	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cr-51	1.67E-01	1.67E-01	1.67E-01	1.67E-01	1.67E-01	1.67E-01	1.67E-01	1.97E-01
Mn-54	4.97E+01	4.97E+01	4.97E+01	4.97E+01	4.97E+01	4.97E+01	4.97E+01	5.83E+01
Mn-56	3.24E-02	3.24E-02	3.24E-02	3.24E-02	3.24E-02	3.24E-02	3.24E-02	3.83E-02
Fe-55	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Fe-59	9.78E+00	9.78E+00	9.78E+00	9.78E+00	9.78E+00	9.78E+00	9.78E+00	1.15E+01
Co-57	6.75E+00	6.75E+00	6.75E+00	6.75E+00	6.75E+00	6.75E+00	6.75E+00	7.42E+00
Co-58	1.36E+01	1.36E+01	1.36E+01	1.36E+01	1.36E+01	1.36E+01	1.36E+01	1.59E+01
Co-60	7.72E+02	7.72E+02	7.72E+02	7.72E+02	7.72E+02	7.72E+02	7.72E+02	9.08E+02
Ni-63	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ni-65	1.06E-02	1.06E-02	1.06E-02	1.06E-02	1.06E-02	1.06E-02	1.06E-02	1.24E-02
Cu-64	2.17E-02	2.17E-02	2.17E-02	2.17E-02	2.17E-02	2.17E-02	2.17E-02	2.46E-02
Zn-65	2.68E+01	2.68E+01	2.68E+01	2.68E+01	2.68E+01	2.68E+01	2.68E+01	3.08E+01
Zn-69m	4.55E-02	4.55E-02	4.55E-02	4.55E-02	4.55E-02	4.55E-02	4.55E-02	5.34E-02
Zn-69	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-82	7.66E-01	7.66E-01	7.66E-01	7.66E-01	7.66E-01	7.66E-01	7.66E-01	8.87E-01
Br-83	1.75E-04	1.75E-04	1.75E-04	1.75E-04	1.75E-04	1.75E-04	1.75E-04	2.54E-04
Br-84	7.26E-03	7.26E-03	7.26E-03	7.26E-03	7.26E-03	7.26E-03	7.26E-03	8.47E-03
Br-85	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	3.22E-01	3.22E-01	3.22E-01	3.22E-01	3.22E-01	3.22E-01	3.22E-01	3.68E-01
Rb-88	1.19E-03	1.19E-03	1.19E-03	1.19E-03	1.19E-03	1.19E-03	1.19E-03	1.35E-03
Rb-89	4.41E-03	4.41E-03	4.41E-03	4.41E-03	4.41E-03	4.41E-03	4.41E-03	5.29E-03
Sr-89	7.76E-04	7.76E-04	7.76E-04	7.76E-04	7.76E-04	7.76E-04	7.76E-04	9.00E-04
Sr-90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr-91	7.70E-02	7.70E-02	7.70E-02	7.70E-02	7.70E-02	7.70E-02	7.70E-02	9.00E-02
Sr-92	2.78E-02	2.78E-02	2.78E-02	2.78E-02	2.78E-02	2.78E-02	2.78E-02	3.09E-02
Y-90	1.61E-04	1.61E-04	1.61E-04	1.61E-04	1.61E-04	1.61E-04	1.61E-04	1.90E-04
Y-91m	3.59E-03	3.59E-03	3.59E-03	3.59E-03	3.59E-03	3.59E-03	3.59E-03	4.16E-03
Y-91	3.85E-02	3.85E-02	3.85E-02	3.85E-02	3.85E-02	3.85E-02	3.85E-02	4.33E-02
Y-92	6.47E-03	6.47E-03	6.47E-03	6.47E-03	6.47E-03	6.47E-03	6.47E-03	7.68E-03
Y-93	6.57E-03	6.57E-03	6.57E-03	6.57E-03	6.57E-03	6.57E-03	6.57E-03	8.99E-03
Zr-95	8.77E+00	8.77E+00	8.77E+00	8.77E+00	8.77E+00	8.77E+00	8.77E+00	1.02E+01
Zr-97	1.06E-01	1.06E-01	1.06E-01	1.06E-01	1.06E-01	1.06E-01	1.06E-01	1.23E-01
Nb-95	4.90E+00	4.90E+00	4.90E+00	4.90E+00	4.90E+00	4.90E+00	4.90E+00	5.76E+00
Nb-97	6.31E-03	6.31E-03	6.31E-03	6.31E-03	6.31E-03	6.31E-03	6.31E-03	7.41E-03
Mo-99	1.43E-01	1.43E-01	1.43E-01	1.43E-01	1.43E-01	1.43E-01	1.43E-01	1.66E-01
Tc-99m	6.60E-03	6.60E-03	6.60E-03	6.60E-03	6.60E-03	6.60E-03	6.60E-03	7.56E-03
Tc-101	7.29E-04	7.29E-04	7.29E-04	7.29E-04	7.29E-04	7.29E-04	7.29E-04	8.11E-04
Ru-103	3.88E+00	3.88E+00	3.88E+00	3.88E+00	3.88E+00	3.88E+00	3.88E+00	4.53E+00
Ru-105	2.28E-02	2.28E-02	2.28E-02	2.28E-02	2.28E-02	2.28E-02	2.28E-02	2.58E-02

All values are in (mrem·mL)/(h·μCi).

Table A13.2.2-8 (cont.) Site-Related $A_{i\tau}$ Shoreline Dose Factors, Adult Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI	Skin
Ru-106	1.51E+01	1.51E+01	1.51E+01	1.51E+01	1.51E+01	1.51E+01	1.51E+01	1.82E+01
Rh-105	2.66E-02	2.66E-02	2.66E-02	2.66E-02	2.66E-02	2.66E-02	2.66E-02	3.11E-02
Ag-110m	1.23E+02	1.23E+02	1.23E+02	1.23E+02	1.23E+02	1.23E+02	1.23E+02	1.44E+02
Cd-113m	1.68E-01	1.68E-01	1.68E-01	1.68E-01	1.68E-01	1.68E-01	1.68E-01	1.90E-01
Sb-124	2.14E+01	2.14E+01	2.14E+01	2.14E+01	2.14E+01	2.14E+01	2.14E+01	2.47E+01
Sb-125	8.39E+01	8.39E+01	8.39E+01	8.39E+01	8.39E+01	8.39E+01	8.39E+01	9.47E+01
Sb-126	3.02E+00	3.02E+00	3.02E+00	3.02E+00	3.02E+00	3.02E+00	3.02E+00	3.40E+00
Sb-127	6.01E-01	6.01E-01	6.01E-01	6.01E-01	6.01E-01	6.01E-01	6.01E-01	6.96E-01
Te-125m	5.56E-02	5.56E-02	5.56E-02	5.56E-02	5.56E-02	5.56E-02	5.56E-02	7.63E-02
Te-127m	3.28E-03	3.28E-03	3.28E-03	3.28E-03	3.28E-03	3.28E-03	3.28E-03	3.88E-03
Te-127	1.07E-04	1.07E-04	1.07E-04	1.07E-04	1.07E-04	1.07E-04	1.07E-04	1.17E-04
Te-129m	7.09E-01	7.09E-01	7.09E-01	7.09E-01	7.09E-01	7.09E-01	7.09E-01	8.28E-01
Te-129	9.40E-04	9.40E-04	9.40E-04	9.40E-04	9.40E-04	9.40E-04	9.40E-04	1.11E-03
Te-131m	2.88E-01	2.88E-01	2.88E-01	2.88E-01	2.88E-01	2.88E-01	2.88E-01	3.39E-01
Te-131	1.05E-03	1.05E-03	1.05E-03	1.05E-03	1.05E-03	1.05E-03	1.05E-03	1.24E+00
Te-132	1.52E-01	1.52E-01	1.52E-01	1.52E-01	1.52E-01	1.52E-01	1.52E-01	1.79E-01
I-129	4.68E+01	4.68E+01	4.68E+01	4.68E+01	4.68E+01	4.68E+01	4.68E+01	7.80E+01
I-130	1.98E-01	1.98E-01	1.98E-01	1.98E-01	1.98E-01	1.98E-01	1.98E-01	2.40E-01
I-131	6.17E-01	6.17E-01	6.17E-01	6.17E-01	6.17E-01	6.17E-01	6.17E-01	7.49E-01
I-132	4.46E-02	4.46E-02	4.46E-02	4.46E-02	4.46E-02	4.46E-02	4.46E-02	5.25E-02
I-133	8.79E-02	8.79E-02	8.79E-02	8.79E-02	8.79E-02	8.79E-02	8.79E-02	1.07E-01
I-134	1.60E-02	1.60E-02	1.60E-02	1.60E-02	1.60E-02	1.60E-02	1.60E-02	1.90E-02
I-135	9.05E-02	9.05E-02	9.05E-02	9.05E-02	9.05E-02	9.05E-02	9.05E-02	1.06E-01
Cs-134	2.46E+02	2.46E+02	2.46E+02	2.46E+02	2.46E+02	2.46E+02	2.46E+02	2.87E+02
Cs-135	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cs-136	5.41E+00	5.41E+00	5.41E+00	5.41E+00	5.41E+00	5.41E+00	5.41E+00	6.13E+00
Cs-137	3.70E+02	3.70E+02	3.70E+02	3.70E+02	3.70E+02	3.70E+02	3.70E+02	4.31E+02
Cs-138	1.29E-02	1.29E-02	1.29E-02	1.29E-02	1.29E-02	1.29E-02	1.29E-02	1.47E-02
Ba-139	3.79E-03	3.79E-03	3.79E-03	3.79E-03	3.79E-03	3.79E-03	3.79E-03	4.27E-03
Ba-140	7.36E-01	7.36E-01	7.36E-01	7.36E-01	7.36E-01	7.36E-01	7.36E-01	8.41E-01
Ba-141	1.49E-03	1.49E-03	1.49E-03	1.49E-03	1.49E-03	1.49E-03	1.49E-03	1.70E-03
Ba-142	1.61E-03	1.61E-03	1.61E-03	1.61E-03	1.61E-03	1.61E-03	1.61E-03	1.83E-03
La-140	6.89E-01	6.89E-01	6.89E-01	6.89E-01	6.89E-01	6.89E-01	6.89E-01	7.81E-01
La-142	2.72E-02	2.72E-02	2.72E-02	2.72E-02	2.72E-02	2.72E-02	2.72E-02	3.27E-02
Ce-141	4.90E-01	4.90E-01	4.90E-01	4.90E-01	4.90E-01	4.90E-01	4.90E-01	5.52E-01
Ce-143	8.29E-02	8.29E-02	8.29E-02	8.29E-02	8.29E-02	8.29E-02	8.29E-02	9.42E-02
Ce-144	2.49E+00	2.49E+00	2.49E+00	2.49E+00	2.49E+00	2.49E+00	2.49E+00	2.88E+00
Pr-143	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pr-144	6.58E-05	6.58E-05	6.58E-05	6.58E-05	6.58E-05	6.58E-05	6.58E-05	7.56E-05
Nd-147	3.01E-01	3.01E-01	3.01E-01	3.01E-01	3.01E-01	3.01E-01	3.01E-01	3.61E-01
Eu-152	5.36E+02	5.36E+02	5.36E+02	5.36E+02	5.36E+02	5.36E+02	5.36E+02	6.20E+02
W-187	8.43E-02	8.43E-02	8.43E-02	8.43E-02	8.43E-02	8.43E-02	8.43E-02	9.79E-02
Np-239	6.13E-02	6.13E-02	6.13E-02	6.13E-02	6.13E-02	6.13E-02	6.13E-02	7.10E-02

Table A13.2.2-9 Site-Related $A_{i\tau}$ Shoreline Dose Factors, Teenager Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI	Skin
H-3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C-14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Na-24	2.39E+00	2.39E+00	2.39E+00	2.39E+00	2.39E+00	2.39E+00	2.39E+00	2.77E+00
P-32	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cr-51	9.32E-01	9.32E-01	9.32E-01	9.32E-01	9.32E-01	9.32E-01	9.32E-01	1.10E+00
Mn-54	2.77E+02	2.77E+02	2.77E+02	2.77E+02	2.77E+02	2.77E+02	2.77E+02	3.25E+02
Mn-56	1.81E-01	1.81E-01	1.81E-01	1.81E-01	1.81E-01	1.81E-01	1.81E-01	2.14E-01
Fe-55	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Fe-59	5.46E+01	5.46E+01	5.46E+01	5.46E+01	5.46E+01	5.46E+01	5.46E+01	6.42E+01
Co-57	3.77E+01	3.77E+01	3.77E+01	3.77E+01	3.77E+01	3.77E+01	3.77E+01	4.14E+01
Co-58	7.58E+01	7.58E+01	7.58E+01	7.58E+01	7.58E+01	7.58E+01	7.58E+01	8.88E+01
Co-60	4.31E+03	4.31E+03	4.31E+03	4.31E+03	4.31E+03	4.31E+03	4.31E+03	5.07E+03
Ni-63	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ni-65	5.94E-02	5.94E-02	5.94E-02	5.94E-02	5.94E-02	5.94E-02	5.94E-02	6.91E-02
Cu-64	1.21E-01	1.21E-01	1.21E-01	1.21E-01	1.21E-01	1.21E-01	1.21E-01	1.38E-01
Zn-65	1.50E+02	1.50E+02	1.50E+02	1.50E+02	1.50E+02	1.50E+02	1.50E+02	1.72E+02
Zn-69m	2.54E-01	2.54E-01	2.54E-01	2.54E-01	2.54E-01	2.54E-01	2.54E-01	2.98E-01
Zn-69	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-82	4.27E+00	4.27E+00	4.27E+00	4.27E+00	4.27E+00	4.27E+00	4.27E+00	4.95E+00
Br-83	9.75E-04	9.75E-04	9.75E-04	9.75E-04	9.75E-04	9.75E-04	9.75E-04	1.42E-03
Br-84	4.05E-02	4.05E-02	4.05E-02	4.05E-02	4.05E-02	4.05E-02	4.05E-02	4.73E-02
Br-85	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	1.80E+00	1.80E+00	1.80E+00	1.80E+00	1.80E+00	1.80E+00	1.80E+00	2.06E+00
Rb-88	6.62E-03	6.62E-03	6.62E-03	6.62E-03	6.62E-03	6.62E-03	6.62E-03	7.56E-03
Rb-89	2.46E-02	2.46E-02	2.46E-02	2.46E-02	2.46E-02	2.46E-02	2.46E-02	2.95E-02
Sr-89	4.33E-03	4.33E-03	4.33E-03	4.33E-03	4.33E-03	4.33E-03	4.33E-03	5.03E-03
Sr-90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr-91	4.30E-01	4.30E-01	4.30E-01	4.30E-01	4.30E-01	4.30E-01	4.30E-01	5.03E-01
Sr-92	1.55E-01	1.55E-01	1.55E-01	1.55E-01	1.55E-01	1.55E-01	1.55E-01	1.73E-01
Y-90	8.99E-04	8.99E-04	8.99E-04	8.99E-04	8.99E-04	8.99E-04	8.99E-04	1.06E-03
Y-91m	2.01E-02	2.01E-02	2.01E-02	2.01E-02	2.01E-02	2.01E-02	2.01E-02	2.32E-02
Y-91	2.15E-01	2.15E-01	2.15E-01	2.15E-01	2.15E-01	2.15E-01	2.15E-01	2.42E-01
Y-92	3.61E-02	3.61E-02	3.61E-02	3.61E-02	3.61E-02	3.61E-02	3.61E-02	4.29E-02
Y-93	3.67E-02	3.67E-02	3.67E-02	3.67E-02	3.67E-02	3.67E-02	3.67E-02	5.02E-02
Zr-95	4.90E+01	4.90E+01	4.90E+01	4.90E+01	4.90E+01	4.90E+01	4.90E+01	5.68E+01
Zr-97	5.92E-01	5.92E-01	5.92E-01	5.92E-01	5.92E-01	5.92E-01	5.92E-01	6.89E-01
Nb-95	2.74E+01	2.74E+01	2.74E+01	2.74E+01	2.74E+01	2.74E+01	2.74E+01	3.22E+01
Nb-97	3.52E-02	3.52E-02	3.52E-02	3.52E-02	3.52E-02	3.52E-02	3.52E-02	4.14E-02
Mo-99	8.00E-01	8.00E-01	8.00E-01	8.00E-01	8.00E-01	8.00E-01	8.00E-01	9.26E-01
Tc-99m	3.68E-02	3.68E-02	3.68E-02	3.68E-02	3.68E-02	3.68E-02	3.68E-02	4.22E-02
Tc-101	4.07E-03	4.07E-03	4.07E-03	4.07E-03	4.07E-03	4.07E-03	4.07E-03	4.53E-03
Ru-103	2.17E+01	2.17E+01	2.17E+01	2.17E+01	2.17E+01	2.17E+01	2.17E+01	2.53E+01
Ru-105	1.27E-01	1.27E-01	1.27E-01	1.27E-01	1.27E-01	1.27E-01	1.27E-01	1.44E-01

All values are in (mrem·mL)/(h·μCi).

Table A13.2.2-9 (cont.) Site-Related $A_{i\tau}$ Shoreline Dose Factors, Teenager Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI	Skin
Ru-106	8.45E+01	8.45E+01	8.45E+01	8.45E+01	8.45E+01	8.45E+01	8.45E+01	1.01E+02
Rh-105	1.49E-01	1.49E-01	1.49E-01	1.49E-01	1.49E-01	1.49E-01	1.49E-01	1.74E-01
Ag-110m	6.88E+02	6.88E+02	6.88E+02	6.88E+02	6.88E+02	6.88E+02	6.88E+02	8.03E+02
Cd-113m	9.36E-01	9.36E-01	9.36E-01	9.36E-01	9.36E-01	9.36E-01	9.36E-01	1.06E+00
Sb-124	1.20E+02	1.20E+02	1.20E+02	1.20E+02	1.20E+02	1.20E+02	1.20E+02	1.38E+02
Sb-125	4.69E+02	4.69E+02	4.69E+02	4.69E+02	4.69E+02	4.69E+02	4.69E+02	5.29E+02
Sb-126	1.69E+01	1.69E+01	1.69E+01	1.69E+01	1.69E+01	1.69E+01	1.69E+01	1.90E+01
Sb-127	3.36E+00	3.36E+00	3.36E+00	3.36E+00	3.36E+00	3.36E+00	3.36E+00	3.89E+00
Te-125m	3.11E-01	3.11E-01	3.11E-01	3.11E-01	3.11E-01	3.11E-01	3.11E-01	4.26E-01
Te-127m	1.83E-02	1.83E-02	1.83E-02	1.83E-02	1.83E-02	1.83E-02	1.83E-02	2.17E-02
Te-127	5.96E-04	5.96E-04	5.96E-04	5.96E-04	5.96E-04	5.96E-04	5.96E-04	6.56E-04
Te-129m	3.96E+00	3.96E+00	3.96E+00	3.96E+00	3.96E+00	3.96E+00	3.96E+00	4.63E+00
Te-129	5.25E-03	5.25E-03	5.25E-03	5.25E-03	5.25E-03	5.25E-03	5.25E-03	6.21E-03
Te-131m	1.61E+00	1.61E+00	1.61E+00	1.61E+00	1.61E+00	1.61E+00	1.61E+00	1.89E+00
Te-131	5.84E-03	5.84E-03	5.84E-03	5.84E-03	5.84E-03	5.84E-03	5.84E-03	6.90E+00
Te-132	8.47E-01	8.47E-01	8.47E-01	8.47E-01	8.47E-01	8.47E-01	8.47E-01	9.97E-01
I-129	2.61E+02	2.61E+02	2.61E+02	2.61E+02	2.61E+02	2.61E+02	2.61E+02	4.36E+02
I-130	1.10E+00	1.10E+00	1.10E+00	1.10E+00	1.10E+00	1.10E+00	1.10E+00	1.34E+00
I-131	3.44E+00	3.44E+00	3.44E+00	3.44E+00	3.44E+00	3.44E+00	3.44E+00	4.18E+00
I-132	2.49E-01	2.49E-01	2.49E-01	2.49E-01	2.49E-01	2.49E-01	2.49E-01	2.93E-01
I-133	4.91E-01	4.91E-01	4.91E-01	4.91E-01	4.91E-01	4.91E-01	4.91E-01	5.97E-01
I-134	8.94E-02	8.94E-02	8.94E-02	8.94E-02	8.94E-02	8.94E-02	8.94E-02	1.06E-01
I-135	5.06E-01	5.06E-01	5.06E-01	5.06E-01	5.06E-01	5.06E-01	5.06E-01	5.90E-01
Cs-134	1.37E+03	1.37E+03	1.37E+03	1.37E+03	1.37E+03	1.37E+03	1.37E+03	1.60E+03
Cs-135	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cs-136	3.02E+01	3.02E+01	3.02E+01	3.02E+01	3.02E+01	3.02E+01	3.02E+01	3.42E+01
Cs-137	2.06E+03	2.06E+03	2.06E+03	2.06E+03	2.06E+03	2.06E+03	2.06E+03	2.41E+03
Cs-138	7.18E-02	7.18E-02	7.18E-02	7.18E-02	7.18E-02	7.18E-02	7.18E-02	8.21E-02
Ba-139	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.38E-02
Ba-140	4.11E+00	4.11E+00	4.11E+00	4.11E+00	4.11E+00	4.11E+00	4.11E+00	4.70E+00
Ba-141	8.35E-03	8.35E-03	8.35E-03	8.35E-03	8.35E-03	8.35E-03	8.35E-03	9.51E-03
Ba-142	8.98E-03	8.98E-03	8.98E-03	8.98E-03	8.98E-03	8.98E-03	8.98E-03	1.02E-02
La-140	3.85E+00	3.85E+00	3.85E+00	3.85E+00	3.85E+00	3.85E+00	3.85E+00	4.36E+00
La-142	1.52E-01	1.52E-01	1.52E-01	1.52E-01	1.52E-01	1.52E-01	1.52E-01	1.82E-01
Ce-141	2.73E+00	2.73E+00	2.73E+00	2.73E+00	2.73E+00	2.73E+00	2.73E+00	3.08E+00
Ce-143	4.63E-01	4.63E-01	4.63E-01	4.63E-01	4.63E-01	4.63E-01	4.63E-01	5.26E-01
Ce-144	1.39E+01	1.39E+01	1.39E+01	1.39E+01	1.39E+01	1.39E+01	1.39E+01	1.61E+01
Pr-143	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pr-144	3.67E-04	3.67E-04	3.67E-04	3.67E-04	3.67E-04	3.67E-04	3.67E-04	4.22E-04
Nd-147	1.68E+00	1.68E+00	1.68E+00	1.68E+00	1.68E+00	1.68E+00	1.68E+00	2.02E+00
Eu-152	2.99E+03	2.99E+03	2.99E+03	2.99E+03	2.99E+03	2.99E+03	2.99E+03	3.46E+03
W-187	4.71E-01	4.71E-01	4.71E-01	4.71E-01	4.71E-01	4.71E-01	4.71E-01	5.47E-01
Np-239	3.42E-01	3.42E-01	3.42E-01	3.42E-01	3.42E-01	3.42E-01	3.42E-01	3.96E-01

Table A13.2.2-10 Site-Related $A_{i\tau}$ Shoreline Dose Factors, Child Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI	Skin
H-3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C-14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Na-24	4.99E-01	4.99E-01	4.99E-01	4.99E-01	4.99E-01	4.99E-01	4.99E-01	5.79E-01
P-32	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cr-51	1.95E-01	1.95E-01	1.95E-01	1.95E-01	1.95E-01	1.95E-01	1.95E-01	2.30E-01
Mn-54	5.80E+01	5.80E+01	5.80E+01	5.80E+01	5.80E+01	5.80E+01	5.80E+01	6.80E+01
Mn-56	3.78E-02	3.78E-02	3.78E-02	3.78E-02	3.78E-02	3.78E-02	3.78E-02	4.46E-02
Fe-55	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Fe-59	1.14E+01	1.14E+01	1.14E+01	1.14E+01	1.14E+01	1.14E+01	1.14E+01	1.34E+01
Co-57	7.88E+00	7.88E+00	7.88E+00	7.88E+00	7.88E+00	7.88E+00	7.88E+00	8.66E+00
Co-58	1.58E+01	1.58E+01	1.58E+01	1.58E+01	1.58E+01	1.58E+01	1.58E+01	1.86E+01
Co-60	9.01E+02	9.01E+02	9.01E+02	9.01E+02	9.01E+02	9.01E+02	9.01E+02	1.06E+03
Ni-63	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ni-65	1.24E-02	1.24E-02	1.24E-02	1.24E-02	1.24E-02	1.24E-02	1.24E-02	1.44E-02
Cu-64	2.54E-02	2.54E-02	2.54E-02	2.54E-02	2.54E-02	2.54E-02	2.54E-02	2.88E-02
Zn-65	3.12E+01	3.12E+01	3.12E+01	3.12E+01	3.12E+01	3.12E+01	3.12E+01	3.59E+01
Zn-69m	5.31E-02	5.31E-02	5.31E-02	5.31E-02	5.31E-02	5.31E-02	5.31E-02	6.23E-02
Zn-69	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-82	8.93E-01	8.93E-01	8.93E-01	8.93E-01	8.93E-01	8.93E-01	8.93E-01	1.03E+00
Br-83	2.04E-04	2.04E-04	2.04E-04	2.04E-04	2.04E-04	2.04E-04	2.04E-04	2.96E-04
Br-84	8.47E-03	8.47E-03	8.47E-03	8.47E-03	8.47E-03	8.47E-03	8.47E-03	9.88E-03
Br-85	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	3.76E-01	3.76E-01	3.76E-01	3.76E-01	3.76E-01	3.76E-01	3.76E-01	4.29E-01
Rb-88	1.38E-03	1.38E-03	1.38E-03	1.38E-03	1.38E-03	1.38E-03	1.38E-03	1.58E-03
Rb-89	5.14E-03	5.14E-03	5.14E-03	5.14E-03	5.14E-03	5.14E-03	5.14E-03	6.17E-03
Sr-89	9.05E-04	9.05E-04	9.05E-04	9.05E-04	9.05E-04	9.05E-04	9.05E-04	1.05E-03
Sr-90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr-91	8.98E-02	8.98E-02	8.98E-02	8.98E-02	8.98E-02	8.98E-02	8.98E-02	1.05E-01
Sr-92	3.25E-02	3.25E-02	3.25E-02	3.25E-02	3.25E-02	3.25E-02	3.25E-02	3.61E-02
Y-90	1.88E-04	1.88E-04	1.88E-04	1.88E-04	1.88E-04	1.88E-04	1.88E-04	2.22E-04
Y-91m	4.19E-03	4.19E-03	4.19E-03	4.19E-03	4.19E-03	4.19E-03	4.19E-03	4.85E-03
Y-91	4.49E-02	4.49E-02	4.49E-02	4.49E-02	4.49E-02	4.49E-02	4.49E-02	5.05E-02
Y-92	7.54E-03	7.54E-03	7.54E-03	7.54E-03	7.54E-03	7.54E-03	7.54E-03	8.96E-03
Y-93	7.67E-03	7.67E-03	7.67E-03	7.67E-03	7.67E-03	7.67E-03	7.67E-03	1.05E-02
Zr-95	1.02E+01	1.02E+01	1.02E+01	1.02E+01	1.02E+01	1.02E+01	1.02E+01	1.19E+01
Zr-97	1.24E-01	1.24E-01	1.24E-01	1.24E-01	1.24E-01	1.24E-01	1.24E-01	1.44E-01
Nb-95	5.72E+00	5.72E+00	5.72E+00	5.72E+00	5.72E+00	5.72E+00	5.72E+00	6.72E+00
Nb-97	7.36E-03	7.36E-03	7.36E-03	7.36E-03	7.36E-03	7.36E-03	7.36E-03	8.64E-03
Mo-99	1.67E-01	1.67E-01	1.67E-01	1.67E-01	1.67E-01	1.67E-01	1.67E-01	1.93E-01
Tc-99m	7.70E-03	7.70E-03	7.70E-03	7.70E-03	7.70E-03	7.70E-03	7.70E-03	8.82E-03
Tc-101	8.51E-04	8.51E-04	8.51E-04	8.51E-04	8.51E-04	8.51E-04	8.51E-04	9.46E-04
Ru-103	4.53E+00	4.53E+00	4.53E+00	4.53E+00	4.53E+00	4.53E+00	4.53E+00	5.28E+00
Ru-105	2.66E-02	2.66E-02	2.66E-02	2.66E-02	2.66E-02	2.66E-02	2.66E-02	3.02E-02

All values are in (mrem·mL)/(h·μCi).

Table A13.2.2-10 (cont.) Site-Related $A_{i\tau}$ Shoreline Dose Factors, Child Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI	Skin
Ru-106	1.77E+01	1.77E+01	1.77E+01	1.77E+01	1.77E+01	1.77E+01	1.77E+01	2.12E+01
Rh-105	3.11E-02	3.11E-02	3.11E-02	3.11E-02	3.11E-02	3.11E-02	3.11E-02	3.63E-02
Ag-110m	1.44E+02	1.44E+02	1.44E+02	1.44E+02	1.44E+02	1.44E+02	1.44E+02	1.68E+02
Cd-113m	1.96E-01	1.96E-01	1.96E-01	1.96E-01	1.96E-01	1.96E-01	1.96E-01	2.21E-01
Sb-124	2.50E+01	2.50E+01	2.50E+01	2.50E+01	2.50E+01	2.50E+01	2.50E+01	2.89E+01
Sb-125	9.79E+01	9.79E+01	9.79E+01	9.79E+01	9.79E+01	9.79E+01	9.79E+01	1.11E+02
Sb-126	3.53E+00	3.53E+00	3.53E+00	3.53E+00	3.53E+00	3.53E+00	3.53E+00	3.96E+00
Sb-127	7.01E-01	7.01E-01	7.01E-01	7.01E-01	7.01E-01	7.01E-01	7.01E-01	8.12E-01
Te-125m	6.49E-02	6.49E-02	6.49E-02	6.49E-02	6.49E-02	6.49E-02	6.49E-02	8.90E-02
Te-127m	3.83E-03	3.83E-03	3.83E-03	3.83E-03	3.83E-03	3.83E-03	3.83E-03	4.53E-03
Te-127	1.25E-04	1.25E-04	1.25E-04	1.25E-04	1.25E-04	1.25E-04	1.25E-04	1.37E-04
Te-129m	8.27E-01	8.27E-01	8.27E-01	8.27E-01	8.27E-01	8.27E-01	8.27E-01	9.67E-01
Te-129	1.10E-03	1.10E-03	1.10E-03	1.10E-03	1.10E-03	1.10E-03	1.10E-03	1.30E-03
Te-131m	3.36E-01	3.36E-01	3.36E-01	3.36E-01	3.36E-01	3.36E-01	3.36E-01	3.96E-01
Te-131	1.22E-03	1.22E-03	1.22E-03	1.22E-03	1.22E-03	1.22E-03	1.22E-03	1.44E+00
Te-132	1.77E-01	1.77E-01	1.77E-01	1.77E-01	1.77E-01	1.77E-01	1.77E-01	2.08E-01
I-129	5.46E+01	5.46E+01	5.46E+01	5.46E+01	5.46E+01	5.46E+01	5.46E+01	9.10E+01
I-130	2.30E-01	2.30E-01	2.30E-01	2.30E-01	2.30E-01	2.30E-01	2.30E-01	2.80E-01
I-131	7.20E-01	7.20E-01	7.20E-01	7.20E-01	7.20E-01	7.20E-01	7.20E-01	8.74E-01
I-132	5.21E-02	5.21E-02	5.21E-02	5.21E-02	5.21E-02	5.21E-02	5.21E-02	6.13E-02
I-133	1.02E-01	1.02E-01	1.02E-01	1.02E-01	1.02E-01	1.02E-01	1.02E-01	1.25E-01
I-134	1.87E-02	1.87E-02	1.87E-02	1.87E-02	1.87E-02	1.87E-02	1.87E-02	2.22E-02
I-135	1.06E-01	1.06E-01	1.06E-01	1.06E-01	1.06E-01	1.06E-01	1.06E-01	1.23E-01
Cs-134	2.87E+02	2.87E+02	2.87E+02	2.87E+02	2.87E+02	2.87E+02	2.87E+02	3.35E+02
Cs-135	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cs-136	6.31E+00	6.31E+00	6.31E+00	6.31E+00	6.31E+00	6.31E+00	6.31E+00	7.15E+00
Cs-137	4.31E+02	4.31E+02	4.31E+02	4.31E+02	4.31E+02	4.31E+02	4.31E+02	5.03E+02
Cs-138	1.50E-02	1.50E-02	1.50E-02	1.50E-02	1.50E-02	1.50E-02	1.50E-02	1.72E-02
Ba-139	4.43E-03	4.43E-03	4.43E-03	4.43E-03	4.43E-03	4.43E-03	4.43E-03	4.98E-03
Ba-140	8.58E-01	8.58E-01	8.58E-01	8.58E-01	8.58E-01	8.58E-01	8.58E-01	9.81E-01
Ba-141	1.74E-03	1.74E-03	1.74E-03	1.74E-03	1.74E-03	1.74E-03	1.74E-03	1.99E-03
Ba-142	1.88E-03	1.88E-03	1.88E-03	1.88E-03	1.88E-03	1.88E-03	1.88E-03	2.14E-03
La-140	8.03E-01	8.03E-01	8.03E-01	8.03E-01	8.03E-01	8.03E-01	8.03E-01	9.11E-01
La-142	3.18E-02	3.18E-02	3.18E-02	3.18E-02	3.18E-02	3.18E-02	3.18E-02	3.81E-02
Ce-141	5.71E-01	5.71E-01	5.71E-01	5.71E-01	5.71E-01	5.71E-01	5.71E-01	6.44E-01
Ce-143	9.67E-02	9.67E-02	9.67E-02	9.67E-02	9.67E-02	9.67E-02	9.67E-02	1.10E-01
Ce-144	2.91E+00	2.91E+00	2.91E+00	2.91E+00	2.91E+00	2.91E+00	2.91E+00	3.36E+00
Pr-143	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pr-144	7.67E-05	7.67E-05	7.67E-05	7.67E-05	7.67E-05	7.67E-05	7.67E-05	8.82E-05
Nd-147	3.51E-01	3.51E-01	3.51E-01	3.51E-01	3.51E-01	3.51E-01	3.51E-01	4.21E-01
Eu-152	6.25E+02	6.25E+02	6.25E+02	6.25E+02	6.25E+02	6.25E+02	6.25E+02	7.24E+02
W-187	9.84E-02	9.84E-02	9.84E-02	9.84E-02	9.84E-02	9.84E-02	9.84E-02	1.14E-01
Np-239	7.15E-02	7.15E-02	7.15E-02	7.15E-02	7.15E-02	7.15E-02	7.15E-02	8.28E-02

3.0 GASEOUS PATHWAY ANALYSIS

3.1 Purpose

A gaseous effluent pathway analysis is performed to determine the location for each of the following:

3.1.1 The location that would result in the maximum doses due to noble gases for use in demonstrating compliance with Section 6.3.3.a

3.1.2 The location, critical pathway, and age group of a maximum exposed individual through the inhalation pathway from I-131, I-133, tritium, and particulates with half-lives greater than 8 days to demonstrate compliance with Section 6.3.1.a.2.

3.1.3 Critical pathway, the location of a maximally exposed MEMBER OF THE PUBLIC, and the CRITICAL ORGAN for the maximum dose due to I-131, I-133, tritium, and for all radionuclides in particulate form with half-lives greater than 8 days for use in demonstrating compliance with requirements in Section 6.3.4.a.1.

3.2 Data, Parameters, and Methodology

3.2.1 Annual average X/Q values, for both the Plant Vent (ground release) and the turbine island vent (ground release) were calculated, as described in Section 1.0 of this attachment, for each directional sector at various distances. The maximum dose rates to total body and skin (Section 6.3.1.a.1) and air doses for gamma and beta radiation due to noble gases (Section 6.3.3.a) would be at the maximum X/Q locations.

3.2.2 Section 6.3.1.a.2 dose rates ensure that the dose at any time at and beyond the SITE BOUNDARY from gaseous effluents from Vogtle 1,2,3 and 4 on the site will be within the annual dose limits of 10 CFR Part 20 to UNRESTRICTED AREAS. The annual dose limits are the doses associated with the concentrations of 10 CFR Part 20, Appendix B, Table 2, Column I. These limits provide reasonable assurance that radioactive material discharged in gaseous effluents will not result in the exposure of a MEMBER OF THE PUBLIC in an UNRESTRICTED AREAS, either within or outside the SITE BOUNDARY, to annual average concentrations exceeding the limits specified in Appendix B, Table 2 of 10 CFR Part 20 (10 CFR Part 20.1301). The ability to meet this requirement for VEGP units 3 and 4 is shown in the VEGP 3&4 UFSAR, Subsection 11.3.3 (Reference 44).

3.2.3 Section 6.3.4.a. requires that the organ dose to the maximum exposed MEMBER OF THE PUBLIC from I-131, I-133, tritium, and from all radionuclides in particulate form with half-lives greater than 8 days be less than or equal to the specified limits. As demonstrated in the Site Safety Analysis Report for Units 3 and 4 (Reference 38), the organ is the child's thyroid. Dose calculations in support of Section 6.3.4 should be performed for the following locations:

- an exposed MEMBER OF THE PUBLIC at the SITE BOUNDARY with the highest X/Q
- the nearest residence
- the nearest garden
- the nearest meat animal

as identified in the land use census, using the following pathways, as appropriate:

- inhalation
- ground plane
- cow meat
- garden vegetation.

Both historically and currently, there have been no milk cows within 5 miles of the plant.

Attachment 8 contains factors for calculating dose to satisfy Section 6.3.4.a, for the child and currently used pathways identified above. Although the child's thyroid is the CRITICAL ORGAN, factors of R_{aipo} for all the relevant organs and age groups are provided. Should the CRITICAL RECEPTOR, CRITICAL ORGAN, or pathway change over time, the factors can be recalculated using equations provided as follows:

Inhalation	NUREG-0133 Section 5.3.1.1
Ground plane	NUREG-0133 Section 5.3.1.2
Grass-cow-milk	NUREG-0133 Section 5.3.1.3
Grass-goat-milk	NUREG-0133 Section 5.3.1.3
Grass-cow-meat	NUREG-0133 Section 5.3.1.4
Garden vegetation	NUREG-0133 Section 5.3.1.5

Parameters are available in NUREG-0133 (Reference 24), Reg Guide 1.109 Revision 0 (Reference 10), and Reg Guide 1.109 Revision 1 (Reference 11).

3.3 Development of Site Specific R_{aipj} Dose Values

Table A13.3.3-1 Individual Usage Factors

Usage Factor	Receptor Age Group			
	Infant	Child	Teenager	Adult
Milk Consumption Rate, U_{ap} (L/y)	330	330	400	310
Meat Consumption Rate, U_{ap} (kg/y)	0	41	65	110
Fresh Leafy Garden Vegetation Consumption Rate, U_{aL} (kg/y)	0	26	42	64
Stored Garden Vegetation Consumption Rate, U_{aS} (kg/y)	0	520	630	520
Breathing Rate, $(BR)_a$ (m^3/y)	1400	3700	8000	8000

All values are from Reference 11, Table E-5.

3.3.1 INHALATION PATHWAY FACTOR

For the inhalation pathway, R_{aipj} in (mrem/y) per (μCi/m^3) is calculated as follows (Reference 24, Section 5.3.1.1):

Eqn A13.3.3.1-1

$$R_{aipj} = K_1 \times (BR)_a \times (DFA)_{aij}$$

where:

K_1 = the units conversion factor: 10^6 pCi/μCi.

$(BR)_a$ = the breathing rate of receptor age group a, in m^3/y, from Table A13.3.3-1.

$(DFA)_{aij}$ = the inhalation dose factor for receptor age group a, radionuclide i, and organ j, in mrem/pCi, from Table A8-1 through Table A8-4.

Table A13.3.3.1-1 Site-Related Inhalation R_{aipj} Dose Factors, Adult Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00E+00	7.18E+02	7.18E+02	7.18E+02	7.18E+02	7.18E+02	7.18E+02
C-14	1.82E+04	3.41E+03	3.41E+03	3.41E+03	3.41E+03	3.41E+03	3.41E+03
Na-24	1.02E+04	1.02E+04	1.02E+04	1.02E+04	1.02E+04	1.02E+04	1.02E+04
P-32	1.32E+06	7.71E+04	5.01E+04	0.00E+00	0.00E+00	0.00E+00	8.64E+04
Cr-51	0.00E+00	0.00E+00	1.00E+02	5.95E+01	2.28E+01	1.44E+04	3.32E+03
Mn-54	0.00E+00	3.96E+04	6.30E+03	0.00E+00	9.84E+03	1.40E+06	7.74E+04
Mn-56	0.00E+00	1.24E+00	1.83E-01	0.00E+00	1.30E+00	9.44E+03	2.02E+04
Fe-55	2.46E+04	1.70E+04	3.94E+03	0.00E+00	0.00E+00	7.21E+04	6.03E+03
Fe-59	1.18E+04	2.78E+04	1.06E+04	0.00E+00	0.00E+00	1.02E+06	1.88E+05
Co-57	0.00E+00	6.92E+02	6.71E+02	0.00E+00	0.00E+00	3.70E+05	3.14E+04
Co-58	0.00E+00	1.58E+03	2.07E+03	0.00E+00	0.00E+00	9.28E+05	1.06E+05
Co-60	0.00E+00	1.15E+04	1.48E+04	0.00E+00	0.00E+00	5.97E+06	2.85E+05
Ni-63	4.32E+05	3.14E+04	1.45E+04	0.00E+00	0.00E+00	1.78E+05	1.34E+04
Ni-65	1.54E+00	2.10E-01	9.12E-02	0.00E+00	0.00E+00	5.60E+03	1.23E+04
Cu-64	0.00E+00	1.46E+00	6.15E-01	0.00E+00	4.62E+00	6.78E+03	4.90E+04
Zn-65	3.24E+04	1.03E+05	4.66E+04	0.00E+00	6.90E+04	8.64E+05	5.34E+04
Zn-69m	8.16E+00	1.96E+01	1.79E+00	0.00E+00	1.18E+01	1.90E+04	1.37E+05
Zn-69	3.38E-02	6.51E-02	4.52E-03	0.00E+00	4.22E-02	9.20E+02	1.63E+01
Br-82	0.00E+00	0.00E+00	1.35E+04	0.00E+00	0.00E+00	0.00E+00	1.04E+04
Br-83	0.00E+00	0.00E+00	2.41E+02	0.00E+00	0.00E+00	0.00E+00	2.32E+02
Br-84	0.00E+00	0.00E+00	3.13E+02	0.00E+00	0.00E+00	0.00E+00	1.64E-03
Br-85	0.00E+00	0.00E+00	1.28E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	1.35E+05	5.90E+04	0.00E+00	0.00E+00	0.00E+00	1.66E+04
Rb-88	0.00E+00	3.87E+02	1.93E+02	0.00E+00	0.00E+00	0.00E+00	3.34E-09
Rb-89	0.00E+00	2.56E+02	1.70E+02	0.00E+00	0.00E+00	0.00E+00	9.28E-12
Sr-89	3.04E+05	0.00E+00	8.72E+03	0.00E+00	0.00E+00	1.40E+06	3.50E+05
Sr-90	2.87E+07	0.00E+00	5.77E+05	0.00E+00	0.00E+00	9.60E+06	7.22E+05
Sr-91	6.19E+01	0.00E+00	2.50E+00	0.00E+00	0.00E+00	3.65E+04	1.91E+05
Sr-92	6.74E+00	0.00E+00	2.91E-01	0.00E+00	0.00E+00	1.65E+04	4.30E+04
Y-90	2.09E+03	0.00E+00	5.61E+01	0.00E+00	0.00E+00	1.70E+05	5.06E+05
Y-91m	2.61E-01	0.00E+00	1.02E-02	0.00E+00	0.00E+00	1.92E+03	1.33E+00
Y-91	4.62E+05	0.00E+00	1.24E+04	0.00E+00	0.00E+00	1.70E+06	3.85E+05
Y-92	1.03E+01	0.00E+00	3.02E-01	0.00E+00	0.00E+00	1.57E+04	7.35E+04
Y-93	9.44E+01	0.00E+00	2.61E+00	0.00E+00	0.00E+00	4.85E+04	4.22E+05
Zr-95	1.07E+05	3.44E+04	2.33E+04	0.00E+00	5.42E+04	1.77E+06	1.50E+05
Zr-97	9.68E+01	1.96E+01	9.04E+00	0.00E+00	2.97E+01	7.87E+04	5.23E+05
Nb-95	1.41E+04	7.82E+03	4.21E+03	0.00E+00	7.74E+03	5.05E+05	1.04E+05
Nb-97	2.22E-01	5.62E-02	2.05E-02	0.00E+00	6.54E-02	2.40E+03	2.42E+02
Mo-99	0.00E+00	1.21E+02	2.30E+01	0.00E+00	2.91E+02	9.12E+04	2.48E+05
Tc-99m	1.03E-03	2.91E-03	3.70E-02	0.00E+00	4.42E-02	7.64E+02	4.16E+03
Tc-101	4.18E-05	6.02E-05	5.90E-04	0.00E+00	1.08E-03	3.99E+02	1.09E-11
Ru-103	1.53E+03	0.00E+00	6.58E+02	0.00E+00	5.83E+03	5.05E+05	1.10E+05
Ru-105	7.90E-01	0.00E+00	3.11E-01	0.00E+00	1.02E+00	1.10E+04	4.82E+04

All values are in (mrem·mL)/(h·μCi).

Table A13.3.3.1-1 (cont.) Site-Related Inhalation R_{aipj} Dose Factors, Adult Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ru-106	6.91E+04	0.00E+00	8.72E+03	0.00E+00	1.34E+05	9.36E+06	9.12E+05
Rh-105	7.39E+00	5.38E+00	3.54E+00	0.00E+00	2.29E+01	1.93E+04	8.72E+04
Ag-110m	1.08E+04	1.00E+04	5.94E+03	0.00E+00	1.97E+04	4.63E+06	3.02E+05
Cd-113m	0.00E+00	1.23E+06	3.98E+04	0.00E+00	1.37E+06	1.66E+06	1.27E+05
Sb-124	3.12E+04	5.89E+02	1.24E+04	7.55E+01	0.00E+00	2.48E+06	4.06E+05
Sb-125	5.34E+04	5.95E+02	1.26E+04	5.40E+01	0.00E+00	1.74E+06	1.01E+05
Sb-126	3.60E+03	7.30E+01	1.30E+03	2.20E+01	0.00E+00	7.66E+05	4.81E+05
Sb-127	2.64E+02	5.78E+00	1.02E+02	3.18E+00	0.00E+00	1.64E+05	3.02E+05
Te-125m	3.42E+03	1.58E+03	4.67E+02	1.05E+03	1.24E+04	3.14E+05	7.06E+04
Te-127m	1.26E+04	5.77E+03	1.57E+03	3.29E+03	4.58E+04	9.60E+05	1.50E+05
Te-127	1.40E+00	6.42E-01	3.10E-01	1.06E+00	5.10E+00	6.51E+03	5.74E+04
Te-129m	9.76E+03	4.67E+03	1.58E+03	3.44E+03	3.66E+04	1.16E+06	3.83E+05
Te-129	4.98E-02	2.39E-02	1.24E-02	3.90E-02	1.87E-01	1.94E+03	1.57E+02
Te-131m	6.99E+01	4.36E+01	2.90E+01	5.50E+01	3.09E+02	1.46E+05	5.56E+05
Te-131	1.11E-02	5.95E-03	3.59E-03	9.36E-03	4.37E-02	1.39E+03	1.84E+01
Te-132	2.60E+02	2.15E+02	1.62E+02	1.90E+02	1.46E+03	2.88E+05	5.10E+05
I-129	1.98E+04	1.69E+04	5.53E+04	4.43E+07	3.62E+04	0.00E+00	1.78E+03
I-130	4.58E+03	1.34E+04	5.28E+03	1.14E+06	2.09E+04	0.00E+00	7.69E+03
I-131	2.52E+04	3.58E+04	2.05E+04	1.19E+07	6.13E+04	0.00E+00	6.28E+03
I-132	1.16E+03	3.26E+03	1.16E+03	1.14E+05	5.18E+03	0.00E+00	4.06E+02
I-133	8.64E+03	1.48E+04	4.52E+03	2.15E+06	2.58E+04	0.00E+00	8.88E+03
I-134	6.44E+02	1.73E+03	6.15E+02	2.98E+04	2.75E+03	0.00E+00	1.01E+00
I-135	2.68E+03	6.98E+03	2.57E+03	4.48E+05	1.11E+04	0.00E+00	5.25E+03
Cs-134	3.73E+05	8.48E+05	7.28E+05	0.00E+00	2.87E+05	9.76E+04	1.04E+04
Cs-135	1.17E+05	1.03E+05	4.79E+04	0.00E+00	4.09E+04	1.26E+04	1.69E+03
Cs-136	3.90E+04	1.46E+05	1.10E+05	0.00E+00	8.56E+04	1.20E+04	1.17E+04
Cs-137	4.78E+05	6.21E+05	4.28E+05	0.00E+00	2.22E+05	7.52E+04	8.40E+03
Cs-138	3.31E+02	6.21E+02	3.24E+02	0.00E+00	4.80E+02	4.86E+01	1.86E-03
Ba-139	9.36E-01	6.66E-04	2.74E-02	0.00E+00	6.22E-04	3.76E+03	8.96E+02
Ba-140	3.90E+04	4.90E+01	2.57E+03	0.00E+00	1.67E+01	1.27E+06	2.18E+05
Ba-141	1.00E-01	7.53E-05	3.36E-03	0.00E+00	7.00E-05	1.94E+03	1.16E-07
Ba-142	2.63E-02	2.70E-05	1.66E-03	0.00E+00	2.29E-05	1.19E+03	1.57E-16
La-140	3.44E+02	1.74E+02	4.58E+01	0.00E+00	0.00E+00	1.36E+05	4.58E+05
La-142	6.83E-01	3.10E-01	7.72E-02	0.00E+00	0.00E+00	6.33E+03	2.11E+03
Ce-141	1.99E+04	1.35E+04	1.53E+03	0.00E+00	6.26E+03	3.62E+05	1.20E+05
Ce-143	1.86E+02	1.38E+02	1.53E+01	0.00E+00	6.08E+01	7.98E+04	2.26E+05
Ce-144	3.43E+06	1.43E+06	1.84E+05	0.00E+00	8.48E+05	7.78E+06	8.16E+05
Pr-143	9.36E+03	3.75E+03	4.64E+02	0.00E+00	2.16E+03	2.81E+05	2.00E+05
Pr-144	3.01E-02	1.25E-02	1.53E-03	0.00E+00	7.05E-03	1.02E+03	2.15E-08
Nd-147	5.27E+03	6.10E+03	3.65E+02	0.00E+00	3.56E+03	2.21E+05	1.73E+05
Eu-152	1.90E+06	4.33E+05	3.81E+05	0.00E+00	2.68E+06	2.74E+06	1.27E+05
W-187	8.48E+00	7.08E+00	2.48E+00	0.00E+00	0.00E+00	2.90E+04	1.55E+05
Np-239	2.30E+02	2.26E+01	1.24E+01	0.00E+00	7.00E+01	3.76E+04	1.19E+05

Table A13.3.3.1-2 Site-Related Inhalation R_{aipj} Dose Factors, Teenager Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00E+00	7.25E+02	7.25E+02	7.25E+02	7.25E+02	7.25E+02	7.25E+02
C-14	2.60E+04	4.87E+03	4.87E+03	4.87E+03	4.87E+03	4.87E+03	4.87E+03
Na-24	1.38E+04	1.38E+04	1.38E+04	1.38E+04	1.38E+04	1.38E+04	1.38E+04
P-32	1.89E+06	1.10E+05	7.16E+04	0.00E+00	0.00E+00	0.00E+00	9.28E+04
Cr-51	0.00E+00	0.00E+00	1.35E+02	7.50E+01	3.07E+01	2.10E+04	3.00E+03
Mn-54	0.00E+00	5.11E+04	8.40E+03	0.00E+00	1.27E+04	1.98E+06	6.68E+04
Mn-56	0.00E+00	1.70E+00	2.52E-01	0.00E+00	1.79E+00	1.52E+04	5.74E+04
Fe-55	3.34E+04	2.38E+04	5.54E+03	0.00E+00	0.00E+00	1.24E+05	6.39E+03
Fe-59	1.59E+04	3.70E+04	1.43E+04	0.00E+00	0.00E+00	1.53E+06	1.78E+05
Co-57	0.00E+00	9.44E+02	9.20E+02	0.00E+00	0.00E+00	5.86E+05	3.14E+04
Co-58	0.00E+00	2.07E+03	2.78E+03	0.00E+00	0.00E+00	1.34E+06	9.52E+04
Co-60	0.00E+00	1.51E+04	1.98E+04	0.00E+00	0.00E+00	8.72E+06	2.59E+05
Ni-63	5.80E+05	4.34E+04	1.98E+04	0.00E+00	0.00E+00	3.07E+05	1.42E+04
Ni-65	2.18E+00	2.93E-01	1.27E-01	0.00E+00	0.00E+00	9.36E+03	3.67E+04
Cu-64	0.00E+00	2.03E+00	8.48E-01	0.00E+00	6.41E+00	1.11E+04	6.14E+04
Zn-65	3.86E+04	1.34E+05	6.24E+04	0.00E+00	8.64E+04	1.24E+06	4.66E+04
Zn-69m	1.15E+01	2.71E+01	2.49E+00	0.00E+00	1.65E+01	3.14E+04	1.71E+05
Zn-69	4.83E-02	9.20E-02	6.46E-03	0.00E+00	6.02E-02	1.58E+03	2.85E+02
Br-82	0.00E+00	0.00E+00	1.82E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-83	0.00E+00	0.00E+00	3.44E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	4.33E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	1.83E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	1.90E+05	8.40E+04	0.00E+00	0.00E+00	0.00E+00	1.77E+04
Rb-88	0.00E+00	5.46E+02	2.72E+02	0.00E+00	0.00E+00	0.00E+00	2.92E-05
Rb-89	0.00E+00	3.52E+02	2.33E+02	0.00E+00	0.00E+00	0.00E+00	3.38E-07
Sr-89	4.34E+05	0.00E+00	1.25E+04	0.00E+00	0.00E+00	2.42E+06	3.71E+05
Sr-90	3.31E+07	0.00E+00	6.66E+05	0.00E+00	0.00E+00	1.65E+07	7.65E+05
Sr-91	8.80E+01	0.00E+00	3.51E+00	0.00E+00	0.00E+00	6.07E+04	2.59E+05
Sr-92	9.52E+00	0.00E+00	4.06E-01	0.00E+00	0.00E+00	2.74E+04	1.19E+05
Y-90	2.98E+03	0.00E+00	8.00E+01	0.00E+00	0.00E+00	2.93E+05	5.59E+05
Y-91m	3.70E-01	0.00E+00	1.42E-02	0.00E+00	0.00E+00	3.20E+03	3.02E+01
Y-91	6.61E+05	0.00E+00	1.77E+04	0.00E+00	0.00E+00	2.94E+06	4.09E+05
Y-92	1.47E+01	0.00E+00	4.29E-01	0.00E+00	0.00E+00	2.68E+04	1.65E+05
Y-93	1.35E+02	0.00E+00	3.72E+00	0.00E+00	0.00E+00	8.32E+04	5.79E+05
Zr-95	1.46E+05	4.58E+04	3.15E+04	0.00E+00	6.74E+04	2.69E+06	1.49E+05
Zr-97	1.38E+02	2.72E+01	1.26E+01	0.00E+00	4.12E+01	1.30E+05	6.30E+05
Nb-95	1.86E+04	1.03E+04	5.66E+03	0.00E+00	1.00E+04	7.51E+05	9.68E+04
Nb-97	3.14E-01	7.78E-02	2.84E-02	0.00E+00	9.12E-02	3.93E+03	2.17E+03
Mo-99	0.00E+00	1.69E+02	3.22E+01	0.00E+00	4.11E+02	1.54E+05	2.69E+05
Tc-99m	1.38E-03	3.86E-03	4.99E-02	0.00E+00	5.76E-02	1.15E+03	6.13E+03
Tc-101	5.92E-05	8.40E-05	8.24E-04	0.00E+00	1.52E-03	6.67E+02	8.72E-07
Ru-103	2.10E+03	0.00E+00	8.96E+02	0.00E+00	7.43E+03	7.83E+05	1.09E+05
Ru-105	1.12E+00	0.00E+00	4.34E-01	0.00E+00	1.41E+00	1.82E+04	9.04E+04

All values are in (mrem·mL)/(h·μCi).

Table A13.3.3.1-2 (cont.) Site-Related Inhalation R_{aipj} Dose Factors, Teenager Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ru-106	9.84E+04	0.00E+00	1.24E+04	0.00E+00	1.90E+05	1.61E+07	9.60E+05
Rh-105	1.06E+01	7.58E+00	4.99E+00	0.00E+00	3.23E+01	3.27E+04	9.84E+04
Ag-110m	1.38E+04	1.31E+04	7.99E+03	0.00E+00	2.50E+04	6.75E+06	2.73E+05
Cd-113m	0.00E+00	1.74E+06	5.68E+04	0.00E+00	1.94E+06	2.87E+06	1.34E+05
Sb-124	4.30E+04	7.94E+02	1.68E+04	9.76E+01	0.00E+00	3.85E+06	3.98E+05
Sb-125	7.38E+04	8.08E+02	1.72E+04	7.04E+01	0.00E+00	2.74E+06	9.92E+04
Sb-126	4.95E+03	1.02E+02	1.78E+03	2.80E+01	0.00E+00	1.24E+06	4.81E+05
Sb-127	3.71E+02	7.94E+00	1.40E+02	4.17E+00	0.00E+00	2.65E+05	3.15E+05
Te-125m	4.88E+03	2.24E+03	6.67E+02	1.40E+03	0.00E+00	5.36E+05	7.50E+04
Te-127m	1.80E+04	8.16E+03	2.18E+03	4.38E+03	6.54E+04	1.66E+06	1.59E+05
Te-127	2.01E+00	9.12E-01	4.42E-01	1.42E+00	7.28E+00	1.12E+04	8.08E+04
Te-129m	1.39E+04	6.58E+03	2.25E+03	4.58E+03	5.19E+04	1.98E+06	4.05E+05
Te-129	7.10E-02	3.38E-02	1.76E-02	5.18E-02	2.66E-01	3.30E+03	1.62E+03
Te-131m	9.84E+01	6.01E+01	4.02E+01	7.25E+01	4.39E+02	2.38E+05	6.21E+05
Te-131	1.58E-02	8.32E-03	5.04E-03	1.24E-02	6.18E-02	2.34E+03	1.51E+01
Te-132	3.60E+02	2.90E+02	2.19E+02	2.46E+02	1.95E+03	4.49E+05	4.63E+05
I-129	2.82E+04	2.35E+04	3.92E+04	2.93E+07	4.21E+04	0.00E+00	1.83E+03
I-130	6.24E+03	1.79E+04	7.17E+03	1.49E+06	2.75E+04	0.00E+00	9.12E+03
I-131	3.54E+04	4.91E+04	2.64E+04	1.46E+07	8.40E+04	0.00E+00	6.49E+03
I-132	1.59E+03	4.38E+03	1.58E+03	1.51E+05	6.92E+03	0.00E+00	1.27E+03
I-133	1.22E+04	2.05E+04	6.22E+03	2.92E+06	3.59E+04	0.00E+00	1.03E+04
I-134	8.88E+02	2.32E+03	8.40E+02	3.95E+04	3.66E+03	0.00E+00	2.04E+01
I-135	3.70E+03	9.44E+03	3.49E+03	6.21E+05	1.49E+04	0.00E+00	6.95E+03
Cs-134	5.02E+05	1.13E+06	5.49E+05	0.00E+00	3.75E+05	1.46E+05	9.76E+03
Cs-135	1.66E+05	1.46E+05	3.58E+04	0.00E+00	5.84E+04	2.16E+04	1.78E+03
Cs-136	5.15E+04	1.94E+05	1.37E+05	0.00E+00	1.10E+05	1.78E+04	1.09E+04
Cs-137	6.70E+05	8.48E+05	3.11E+05	0.00E+00	3.04E+05	1.21E+05	8.48E+03
Cs-138	4.66E+02	8.56E+02	4.46E+02	0.00E+00	6.62E+02	7.87E+01	2.70E-01
Ba-139	1.34E+00	9.44E-04	3.90E-02	0.00E+00	8.88E-04	6.46E+03	6.45E+03
Ba-140	5.47E+04	6.70E+01	3.52E+03	0.00E+00	2.28E+01	2.03E+06	2.29E+05
Ba-141	1.42E-01	1.06E-04	4.74E-03	0.00E+00	9.84E-05	3.29E+03	7.46E-04
Ba-142	3.70E-02	3.70E-05	2.27E-03	0.00E+00	3.14E-05	1.91E+03	4.79E-10
La-140	4.79E+02	2.36E+02	6.26E+01	0.00E+00	0.00E+00	2.14E+05	4.87E+05
La-142	9.60E-01	4.25E-01	1.06E-01	0.00E+00	0.00E+00	1.02E+04	1.20E+04
Ce-141	2.84E+04	1.90E+04	2.17E+03	0.00E+00	8.88E+03	6.14E+05	1.26E+05
Ce-143	2.66E+02	1.94E+02	2.16E+01	0.00E+00	8.64E+01	1.30E+05	2.55E+05
Ce-144	4.89E+06	2.02E+06	2.62E+05	0.00E+00	1.21E+06	1.34E+07	8.64E+05
Pr-143	1.34E+04	5.31E+03	6.62E+02	0.00E+00	3.09E+03	4.83E+05	2.14E+05
Pr-144	4.30E-02	1.76E-02	2.18E-03	0.00E+00	1.01E-02	1.75E+03	2.35E-04
Nd-147	7.86E+03	8.56E+03	5.13E+02	0.00E+00	5.02E+03	3.72E+05	1.82E+05
Eu-152	2.37E+06	5.75E+05	5.04E+05	0.00E+00	2.67E+06	4.01E+06	1.08E+05
W-187	1.20E+01	9.76E+00	3.43E+00	0.00E+00	0.00E+00	4.74E+04	1.77E+05
Np-239	3.38E+02	3.19E+01	1.77E+01	0.00E+00	1.00E+02	6.49E+04	1.32E+05

Table A13.3.3.1-3 Site-Related Inhalation R_{aipj} Dose Factors, Child Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00E+00	6.40E+02	6.40E+02	6.40E+02	6.40E+02	6.40E+02	6.40E+02
C-14	3.59E+04	6.73E+03	6.73E+03	6.73E+03	6.73E+03	6.73E+03	6.73E+03
Na-24	1.61E+04	1.61E+04	1.61E+04	1.61E+04	1.61E+04	1.61E+04	1.61E+04
P-32	2.60E+06	1.14E+05	9.88E+04	0.00E+00	0.00E+00	0.00E+00	4.22E+04
Cr-51	0.00E+00	0.00E+00	1.54E+02	8.55E+01	2.43E+01	1.70E+04	1.08E+03
Mn-54	0.00E+00	4.29E+04	9.51E+03	0.00E+00	1.00E+04	1.58E+06	2.29E+04
Mn-56	0.00E+00	1.66E+00	3.12E-01	0.00E+00	1.67E+00	1.31E+04	1.23E+05
Fe-55	4.74E+04	2.52E+04	7.77E+03	0.00E+00	0.00E+00	1.11E+05	2.87E+03
Fe-59	2.07E+04	3.34E+04	1.67E+04	0.00E+00	0.00E+00	1.27E+06	7.07E+04
Co-57	0.00E+00	9.03E+02	1.07E+03	0.00E+00	0.00E+00	5.07E+05	1.32E+04
Co-58	0.00E+00	1.77E+03	3.16E+03	0.00E+00	0.00E+00	1.11E+06	3.44E+04
Co-60	0.00E+00	1.31E+04	2.26E+04	0.00E+00	0.00E+00	7.07E+06	9.62E+04
Ni-63	8.21E+05	4.63E+04	2.80E+04	0.00E+00	0.00E+00	2.75E+05	6.33E+03
Ni-65	2.99E+00	2.96E-01	1.64E-01	0.00E+00	0.00E+00	8.18E+03	8.40E+04
Cu-64	0.00E+00	1.99E+00	1.07E+00	0.00E+00	6.03E+00	9.58E+03	3.67E+04
Zn-65	4.26E+04	1.13E+05	7.03E+04	0.00E+00	7.14E+04	9.95E+05	1.63E+04
Zn-69m	1.58E+01	2.69E+01	3.18E+00	0.00E+00	1.56E+01	2.72E+04	1.00E+05
Zn-69	6.70E-02	9.66E-02	8.92E-03	0.00E+00	5.85E-02	1.42E+03	1.02E+04
Br-82	0.00E+00	0.00E+00	2.09E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-83	0.00E+00	0.00E+00	4.74E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	5.48E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	2.53E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	1.98E+05	1.14E+05	0.00E+00	0.00E+00	0.00E+00	7.99E+03
Rb-88	0.00E+00	5.62E+02	3.66E+02	0.00E+00	0.00E+00	0.00E+00	1.72E+01
Rb-89	0.00E+00	3.45E+02	2.90E+02	0.00E+00	0.00E+00	0.00E+00	1.89E+00
Sr-89	5.99E+05	0.00E+00	1.72E+04	0.00E+00	0.00E+00	2.16E+06	1.67E+05
Sr-90	3.85E+07	0.00E+00	7.66E+05	0.00E+00	0.00E+00	1.48E+07	3.43E+05
Sr-91	1.21E+02	0.00E+00	4.59E+00	0.00E+00	0.00E+00	5.33E+04	1.74E+05
Sr-92	1.31E+01	0.00E+00	5.25E-01	0.00E+00	0.00E+00	2.40E+04	2.42E+05
Y-90	4.11E+03	0.00E+00	1.11E+02	0.00E+00	0.00E+00	2.62E+05	2.68E+05
Y-91m	5.07E-01	0.00E+00	1.84E-02	0.00E+00	0.00E+00	2.81E+03	1.72E+03
Y-91	9.14E+05	0.00E+00	2.44E+04	0.00E+00	0.00E+00	2.63E+06	1.84E+05
Y-92	2.04E+01	0.00E+00	5.81E-01	0.00E+00	0.00E+00	2.39E+04	2.39E+05
Y-93	1.86E+02	0.00E+00	5.11E+00	0.00E+00	0.00E+00	7.44E+04	3.89E+05
Zr-95	1.90E+05	4.18E+04	3.70E+04	0.00E+00	5.96E+04	2.23E+06	6.11E+04
Zr-97	1.88E+02	2.72E+01	1.60E+01	0.00E+00	3.89E+01	1.13E+05	3.51E+05
Nb-95	2.35E+04	9.18E+03	6.55E+03	0.00E+00	8.62E+03	6.14E+05	3.70E+04
Nb-97	4.29E-01	7.70E-02	3.60E-02	0.00E+00	8.55E-02	3.42E+03	2.78E+04
Mo-99	0.00E+00	1.72E+02	4.26E+01	0.00E+00	3.92E+02	1.35E+05	1.27E+05
Tc-99m	1.78E-03	3.48E-03	5.77E-02	0.00E+00	5.07E-02	9.51E+02	4.81E+03
Tc-101	8.10E-05	8.51E-05	1.08E-03	0.00E+00	1.45E-03	5.85E+02	1.63E+01
Ru-103	2.79E+03	0.00E+00	1.07E+03	0.00E+00	7.03E+03	6.62E+05	4.48E+04
Ru-105	1.53E+00	0.00E+00	5.55E-01	0.00E+00	1.34E+00	1.59E+04	9.95E+04

All values are in (mrem·mL)/(h·μCi).

Table A13.3.3.1-3 (cont.) Site-Related Inhalation R_{aipj} Dose Factors, Child Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ru-106	1.36E+05	0.00E+00	1.69E+04	0.00E+00	1.84E+05	1.43E+07	4.29E+05
Rh-105	1.45E+01	7.77E+00	6.62E+00	0.00E+00	3.10E+01	2.89E+04	4.92E+04
Ag-110m	1.69E+04	1.14E+04	9.14E+03	0.00E+00	2.12E+04	5.48E+06	1.00E+05
Cd-113m	0.00E+00	1.82E+06	7.84E+04	0.00E+00	1.90E+06	2.57E+06	6.03E+04
Sb-124	5.74E+04	7.40E+02	2.00E+04	1.26E+02	0.00E+00	3.24E+06	1.64E+05
Sb-125	9.84E+04	7.59E+02	2.07E+04	9.10E+01	0.00E+00	2.32E+06	4.03E+04
Sb-126	6.36E+03	9.69E+01	2.28E+03	3.70E+01	0.00E+00	1.06E+06	2.10E+05
Sb-127	5.03E+02	7.73E+00	1.74E+02	5.59E+00	0.00E+00	2.28E+05	1.41E+05
Te-125m	6.73E+03	2.33E+03	9.14E+02	1.92E+03	0.00E+00	4.77E+05	3.38E+04
Te-127m	2.49E+04	8.55E+03	3.02E+03	6.07E+03	6.36E+04	1.48E+06	7.14E+04
Te-127	2.77E+00	9.51E-01	6.11E-01	1.96E+00	7.07E+00	1.00E+04	5.62E+04
Te-129m	1.92E+04	6.85E+03	3.04E+03	6.33E+03	5.03E+04	1.76E+06	1.82E+05
Te-129	9.77E-02	3.50E-02	2.38E-02	7.14E-02	2.57E-01	2.93E+03	2.55E+04
Te-131m	1.34E+02	5.92E+01	5.07E+01	9.77E+01	4.00E+02	2.06E+05	3.08E+05
Te-131	2.17E-02	8.44E-03	6.59E-03	1.70E-02	5.88E-02	2.05E+03	1.33E+03
Te-132	4.81E+02	2.72E+02	2.63E+02	3.17E+02	1.77E+03	3.77E+05	1.38E+05
I-129	3.89E+04	2.37E+04	2.11E+04	1.58E+07	4.00E+04	0.00E+00	7.96E+02
I-130	8.18E+03	1.64E+04	8.44E+03	1.85E+06	2.45E+04	0.00E+00	5.11E+03
I-131	4.81E+04	4.81E+04	2.73E+04	1.62E+07	7.88E+04	0.00E+00	2.84E+03
I-132	2.12E+03	4.07E+03	1.88E+03	1.94E+05	6.25E+03	0.00E+00	3.20E+03
I-133	1.66E+04	2.03E+04	7.70E+03	3.85E+06	3.38E+04	0.00E+00	5.48E+03
I-134	1.17E+03	2.16E+03	9.95E+02	5.07E+04	3.30E+03	0.00E+00	9.55E+02
I-135	4.92E+03	8.73E+03	4.14E+03	7.92E+05	1.34E+04	0.00E+00	4.44E+03
Cs-134	6.51E+05	1.01E+06	2.25E+05	0.00E+00	3.30E+05	1.21E+05	3.85E+03
Cs-135	2.31E+05	1.53E+05	1.65E+04	0.00E+00	5.66E+04	1.93E+04	8.03E+02
Cs-136	6.51E+04	1.71E+05	1.16E+05	0.00E+00	9.55E+04	1.45E+04	4.18E+03
Cs-137	9.07E+05	8.25E+05	1.28E+05	0.00E+00	2.82E+05	1.04E+05	3.62E+03
Cs-138	6.33E+02	8.40E+02	5.55E+02	0.00E+00	6.22E+02	6.81E+01	2.70E+02
Ba-139	1.84E+00	9.84E-04	5.37E-02	0.00E+00	8.62E-04	5.77E+03	5.77E+04
Ba-140	7.40E+04	6.48E+01	4.33E+03	0.00E+00	2.11E+01	1.74E+06	1.02E+05
Ba-141	1.96E-01	1.09E-04	6.36E-03	0.00E+00	9.47E-05	2.92E+03	2.75E+02
Ba-142	5.00E-02	3.60E-05	2.79E-03	0.00E+00	2.91E-05	1.64E+03	2.74E+00
La-140	6.44E+02	2.25E+02	7.55E+01	0.00E+00	0.00E+00	1.83E+05	2.26E+05
La-142	1.30E+00	4.11E-01	1.29E-01	0.00E+00	0.00E+00	8.70E+03	7.59E+04
Ce-141	3.92E+04	1.95E+04	2.90E+03	0.00E+00	8.55E+03	5.44E+05	5.66E+04
Ce-143	3.66E+02	1.99E+02	2.87E+01	0.00E+00	8.36E+01	1.15E+05	1.27E+05
Ce-144	6.77E+06	2.12E+06	3.61E+05	0.00E+00	1.17E+06	1.20E+07	3.89E+05
Pr-143	1.85E+04	5.55E+03	9.14E+02	0.00E+00	3.00E+03	4.33E+05	9.73E+04
Pr-144	5.96E-02	1.85E-02	3.00E-03	0.00E+00	9.77E-03	1.57E+03	1.97E+02
Nd-147	1.08E+04	8.73E+03	6.81E+02	0.00E+00	4.81E+03	3.28E+05	8.21E+04
Eu-152	2.75E+06	5.07E+05	5.96E+05	0.00E+00	2.12E+06	3.33E+06	4.22E+04
W-187	1.63E+01	9.66E+00	4.33E+00	0.00E+00	0.00E+00	4.11E+04	9.10E+04
Np-239	4.66E+02	3.34E+01	2.35E+01	0.00E+00	9.73E+01	5.81E+04	6.40E+04

Table A13.3.3.1-4 Site-Related Inhalation R_{aipj} Dose Factors, Infant Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	0.00E+00	3.68E+02	3.68E+02	3.68E+02	3.68E+02	3.68E+02	3.68E+02
C-14	2.65E+04	5.31E+03	5.31E+03	5.31E+03	5.31E+03	5.31E+03	5.31E+03
Na-24	1.06E+04	1.06E+04	1.06E+04	1.06E+04	1.06E+04	1.06E+04	1.06E+04
P-32	2.03E+06	1.12E+05	7.74E+04	0.00E+00	0.00E+00	0.00E+00	1.61E+04
Cr-51	0.00E+00	0.00E+00	8.95E+01	5.75E+01	1.32E+01	1.28E+04	3.57E+02
Mn-54	0.00E+00	2.53E+04	4.98E+03	0.00E+00	4.98E+03	1.00E+06	7.06E+03
Mn-56	0.00E+00	1.54E+00	2.21E-01	0.00E+00	1.10E+00	1.25E+04	7.17E+04
Fe-55	1.97E+04	1.17E+04	3.33E+03	0.00E+00	0.00E+00	8.69E+04	1.09E+03
Fe-59	1.36E+04	2.35E+04	9.48E+03	0.00E+00	0.00E+00	1.02E+06	2.48E+04
Co-57	0.00E+00	6.51E+02	6.41E+02	0.00E+00	0.00E+00	3.79E+05	4.86E+03
Co-58	0.00E+00	1.22E+03	1.82E+03	0.00E+00	0.00E+00	7.77E+05	1.11E+04
Co-60	0.00E+00	8.02E+03	1.18E+04	0.00E+00	0.00E+00	4.51E+06	3.19E+04
Ni-63	3.39E+05	2.04E+04	1.16E+04	0.00E+00	0.00E+00	2.09E+05	2.42E+03
Ni-65	2.39E+00	2.84E-01	1.23E-01	0.00E+00	0.00E+00	8.12E+03	5.01E+04
Cu-64	0.00E+00	1.88E+00	7.74E-01	0.00E+00	3.98E+00	9.30E+03	1.50E+04
Zn-65	1.93E+04	6.26E+04	3.11E+04	0.00E+00	3.25E+04	6.47E+05	5.14E+04
Zn-69m	1.26E+01	2.58E+01	2.34E+00	0.00E+00	1.04E+01	2.67E+04	4.09E+04
Zn-69	5.39E-02	9.67E-02	7.18E-03	0.00E+00	4.02E-02	1.47E+03	1.32E+04
Br-82	0.00E+00	0.00E+00	1.33E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-83	0.00E+00	0.00E+00	3.81E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	4.00E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	2.04E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	1.90E+05	8.82E+04	0.00E+00	0.00E+00	0.00E+00	3.04E+03
Rb-88	0.00E+00	5.57E+02	2.87E+02	0.00E+00	0.00E+00	0.00E+00	3.39E+02
Rb-89	0.00E+00	3.21E+02	2.06E+02	0.00E+00	0.00E+00	0.00E+00	6.82E+01
Sr-89	3.98E+05	0.00E+00	1.14E+04	0.00E+00	0.00E+00	2.03E+06	6.40E+04
Sr-90	1.55E+07	0.00E+00	3.12E+05	0.00E+00	0.00E+00	1.12E+07	1.31E+05
Sr-91	9.56E+01	0.00E+00	3.46E+00	0.00E+00	0.00E+00	5.26E+04	7.34E+04
Sr-92	1.05E+01	0.00E+00	3.91E-01	0.00E+00	0.00E+00	2.38E+04	1.40E+05
Y-90	3.29E+03	0.00E+00	8.82E+01	0.00E+00	0.00E+00	2.69E+05	1.04E+05
Y-91m	4.07E-01	0.00E+00	1.39E-02	0.00E+00	0.00E+00	2.79E+03	2.35E+03
Y-91	5.88E+05	0.00E+00	1.57E+04	0.00E+00	0.00E+00	2.45E+06	7.03E+04
Y-92	1.64E+01	0.00E+00	4.61E-01	0.00E+00	0.00E+00	2.45E+04	1.27E+05
Y-93	1.50E+02	0.00E+00	4.07E+00	0.00E+00	0.00E+00	7.64E+04	1.67E+05
Zr-95	1.15E+05	2.79E+04	2.03E+04	0.00E+00	3.11E+04	1.75E+06	2.17E+04
Zr-97	1.50E+02	2.56E+01	1.17E+01	0.00E+00	2.59E+01	1.10E+05	1.40E+05
Nb-95	1.57E+04	6.43E+03	3.78E+03	0.00E+00	4.72E+03	4.79E+05	1.27E+04
Nb-97	3.42E-01	7.29E-02	2.63E-02	0.00E+00	5.70E-02	3.32E+03	2.69E+04
Mo-99	0.00E+00	1.65E+02	3.23E+01	0.00E+00	2.65E+02	1.35E+05	4.87E+04
Tc-99m	1.40E-03	2.88E-03	3.72E-02	0.00E+00	3.11E-02	8.11E+02	2.03E+03
Tc-101	6.51E-05	8.23E-05	8.12E-04	0.00E+00	9.79E-04	5.84E+02	8.44E+02
Ru-103	2.02E+03	0.00E+00	6.79E+02	0.00E+00	4.24E+03	5.52E+05	1.61E+04
Ru-105	1.22E+00	0.00E+00	4.10E-01	0.00E+00	8.99E-01	1.57E+04	4.84E+04

All values are in (mrem·mL)/(h·μCi).

Table A13.3.3.1-4 (cont.) Site-Related Inhalation R_{aipj} Dose Factors, Infant Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ru-106	8.68E+04	0.00E+00	1.09E+04	0.00E+00	1.07E+05	1.16E+07	1.64E+05
Rh-105	1.16E+01	7.57E+00	5.08E+00	0.00E+00	2.10E+01	2.91E+04	1.92E+04
Ag-110m	9.98E+03	7.22E+03	5.00E+03	0.00E+00	1.09E+04	3.67E+06	3.30E+04
Cd-113m	0.00E+00	9.34E+05	3.70E+04	0.00E+00	8.12E+05	1.96E+06	2.31E+04
Sb-124	3.79E+04	5.56E+02	1.20E+04	1.01E+02	0.00E+00	2.65E+06	5.91E+04
Sb-125	5.17E+04	4.77E+02	1.09E+04	6.23E+01	0.00E+00	1.64E+06	1.47E+04
Sb-126	4.31E+03	8.41E+01	1.55E+03	3.29E+01	0.00E+00	9.63E+05	7.46E+04
Sb-127	3.95E+02	7.06E+00	1.23E+02	5.04E+00	0.00E+00	2.16E+05	5.29E+04
Te-125m	4.76E+03	1.99E+03	6.58E+02	1.62E+03	0.00E+00	4.47E+05	1.29E+04
Te-127m	1.67E+04	6.90E+03	2.07E+03	4.87E+03	3.75E+04	1.31E+06	2.73E+04
Te-127	2.23E+00	9.53E-01	4.89E-01	1.85E+00	4.86E+00	1.03E+04	2.44E+04
Te-129m	1.41E+04	6.09E+03	2.23E+03	5.47E+03	3.18E+04	1.68E+06	6.90E+04
Te-129	7.88E-02	3.47E-02	1.88E-02	6.75E-02	1.75E-01	3.00E+03	2.63E+04
Te-131m	1.07E+02	5.50E+01	3.63E+01	8.93E+01	2.65E+02	1.99E+05	1.19E+05
Te-131	1.74E-02	8.22E-03	5.00E-03	1.58E-02	3.99E-02	2.06E+03	8.22E+03
Te-132	3.72E+02	2.37E+02	1.76E+02	2.79E+02	1.03E+03	3.40E+05	4.41E+04
I-129	3.02E+04	2.23E+04	1.62E+04	1.46E+07	2.63E+04	0.00E+00	2.97E+02
I-130	6.36E+03	1.39E+04	5.57E+03	1.60E+06	1.53E+04	0.00E+00	1.99E+03
I-131	3.79E+04	4.44E+04	1.96E+04	1.48E+07	5.18E+04	0.00E+00	1.06E+03
I-132	1.69E+03	3.54E+03	1.26E+03	1.69E+05	3.95E+03	0.00E+00	1.90E+03
I-133	1.32E+04	1.92E+04	5.60E+03	3.56E+06	2.24E+04	0.00E+00	2.16E+03
I-134	9.21E+02	1.88E+03	6.65E+02	4.45E+04	2.09E+03	0.00E+00	1.29E+03
I-135	3.86E+03	7.60E+03	2.77E+03	6.96E+05	8.47E+03	0.00E+00	1.83E+03
Cs-134	3.96E+05	7.03E+05	7.45E+04	0.00E+00	1.90E+05	7.97E+04	1.33E+03
Cs-135	1.40E+05	1.21E+05	6.62E+03	0.00E+00	3.61E+04	1.41E+04	3.05E+02
Cs-136	4.83E+04	1.35E+05	5.29E+04	0.00E+00	5.64E+04	1.18E+04	1.43E+03
Cs-137	5.49E+05	6.12E+05	4.55E+04	0.00E+00	1.72E+05	7.13E+04	1.33E+03
Cs-138	5.05E+02	7.81E+02	3.98E+02	0.00E+00	4.10E+02	6.54E+01	8.76E+02
Ba-139	1.48E+00	9.84E-04	4.30E-02	0.00E+00	5.92E-04	5.95E+03	5.10E+04
Ba-140	5.60E+04	5.60E+01	2.90E+03	0.00E+00	1.34E+01	1.60E+06	3.84E+04
Ba-141	1.57E-01	1.08E-04	4.97E-03	0.00E+00	6.50E-05	2.97E+03	4.75E+03
Ba-142	3.98E-02	3.30E-05	1.96E-03	0.00E+00	1.90E-05	1.55E+03	6.93E+02
La-140	5.05E+02	2.00E+02	5.15E+01	0.00E+00	0.00E+00	1.68E+05	8.48E+04
La-142	1.03E+00	3.77E-01	9.04E-02	0.00E+00	0.00E+00	8.22E+03	5.95E+04
Ce-141	2.77E+04	1.67E+04	1.99E+03	0.00E+00	5.25E+03	5.17E+05	2.16E+04
Ce-143	2.93E+02	1.93E+02	2.21E+01	0.00E+00	5.64E+01	1.16E+05	4.97E+04
Ce-144	3.19E+06	1.21E+06	1.76E+05	0.00E+00	5.38E+05	9.84E+06	1.48E+05
Pr-143	1.40E+04	5.24E+03	6.99E+02	0.00E+00	1.97E+03	4.33E+05	3.72E+04
Pr-144	4.79E-02	1.85E-02	2.41E-03	0.00E+00	6.72E-03	1.61E+03	4.28E+03
Nd-147	7.94E+03	8.13E+03	5.00E+02	0.00E+00	3.15E+03	3.22E+05	3.12E+04
Eu-152	1.10E+06	2.48E+05	2.41E+05	0.00E+00	8.32E+05	2.07E+06	1.38E+04
W-187	1.30E+01	9.02E+00	3.12E+00	0.00E+00	0.00E+00	3.96E+04	3.56E+04
Np-239	3.71E+02	3.32E+01	1.88E+01	0.00E+00	6.62E+01	5.95E+04	2.49E+04

3.3.2 GROUND PLANE PATHWAY FACTOR

For the ground plane external exposure pathway, R_{aipj} in (m^2·mrem/y) per (µCi/s) is calculated as follows (Reference 24, Section 5.3.1.2):

Eqn A13.3.3.2-1

$$R_{aipj} = K_1 \times K_2 \times (SHF) \times (DFG)_{ij} \times \left(\frac{1 - e^{-\lambda_i t}}{\lambda_i} \right)$$

where:

K_1	=	the units conversion factor: 10^6 pCi/µCi.
K_2	=	the units conversion factor: 8760 h/y.
(SHF)	=	the shielding factor due to structure (dimensionless). The value used for (SHF) is 0.7, from (Reference 11, Table E–15).
$(DFG)_{ij}$	=	the ground plane dose factor for radionuclide i and organ j, in (mrem/h) per (pCi/m^2), from Table A8-9. Dose factors are the same for all age groups, and those for the total body also apply to all organs other than skin.
λ_i	=	the radioactive decay constant for radionuclide i, in s^{-1}. Values of λ_i used in effluent calculations should be based on decay data from a recognized and current source, such as Reference 46.
t	=	the exposure time, in s. The value used for t is 4.73 x 10^8 s (= 15 y), from (Reference 24, Section 5.3.1.2).

Table A13.3.3.2-1 Site-Related Ground Plane R_{aipj} Dose Factors for All Age Groups

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI	Skin
H-3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
C-14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Na-24	1.19E+07	1.19E+07	1.19E+07	1.19E+07	1.19E+07	1.19E+07	1.19E+07	1.39E+07
P-32	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cr-51	4.66E+06	4.66E+06	4.66E+06	4.66E+06	4.66E+06	4.66E+06	4.66E+06	5.51E+06
Mn-54	1.39E+09	1.39E+09	1.39E+09	1.39E+09	1.39E+09	1.39E+09	1.39E+09	1.63E+09
Mn-56	9.03E+05	9.03E+05	9.03E+05	9.03E+05	9.03E+05	9.03E+05	9.03E+05	1.07E+06
Fe-55	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Fe-59	2.73E+08	2.73E+08	2.73E+08	2.73E+08	2.73E+08	2.73E+08	2.73E+08	3.21E+08
Co-57	1.88E+08	1.88E+08	1.88E+08	1.88E+08	1.88E+08	1.88E+08	1.88E+08	2.07E+08
Co-58	3.79E+08	3.79E+08	3.79E+08	3.79E+08	3.79E+08	3.79E+08	3.79E+08	4.44E+08
Co-60	2.15E+10	2.15E+10	2.15E+10	2.15E+10	2.15E+10	2.15E+10	2.15E+10	2.53E+10
Ni-63	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ni-65	2.97E+05	2.97E+05	2.97E+05	2.97E+05	2.97E+05	2.97E+05	2.97E+05	3.45E+05
Cu-64	6.07E+05	6.07E+05	6.07E+05	6.07E+05	6.07E+05	6.07E+05	6.07E+05	6.88E+05
Zn-65	7.47E+08	7.47E+08	7.47E+08	7.47E+08	7.47E+08	7.47E+08	7.47E+08	8.59E+08
Zn-69m	1.27E+06	1.27E+06	1.27E+06	1.27E+06	1.27E+06	1.27E+06	1.27E+06	1.49E+06
Zn-69	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-82	2.14E+07	2.14E+07	2.14E+07	2.14E+07	2.14E+07	2.14E+07	2.14E+07	2.47E+07
Br-83	4.87E+03	4.87E+03	4.87E+03	4.87E+03	4.87E+03	4.87E+03	4.87E+03	7.08E+03
Br-84	2.03E+05	2.03E+05	2.03E+05	2.03E+05	2.03E+05	2.03E+05	2.03E+05	2.36E+05
Br-85	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	8.99E+06	8.99E+06	8.99E+06	8.99E+06	8.99E+06	8.99E+06	8.99E+06	1.03E+07
Rb-88	3.31E+04	3.31E+04	3.31E+04	3.31E+04	3.31E+04	3.31E+04	3.31E+04	3.78E+04
Rb-89	1.23E+05	1.23E+05	1.23E+05	1.23E+05	1.23E+05	1.23E+05	1.23E+05	1.48E+05
Sr-89	2.16E+04	2.16E+04	2.16E+04	2.16E+04	2.16E+04	2.16E+04	2.16E+04	2.51E+04
Sr-90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr-91	2.15E+06	2.15E+06	2.15E+06	2.15E+06	2.15E+06	2.15E+06	2.15E+06	2.51E+06
Sr-92	7.77E+05	7.77E+05	7.77E+05	7.77E+05	7.77E+05	7.77E+05	7.77E+05	8.63E+05
Y-90	4.49E+03	4.49E+03	4.49E+03	4.49E+03	4.49E+03	4.49E+03	4.49E+03	5.31E+03
Y-91m	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.16E+05
Y-91	1.07E+06	1.07E+06	1.07E+06	1.07E+06	1.07E+06	1.07E+06	1.07E+06	1.21E+06
Y-92	1.80E+05	1.80E+05	1.80E+05	1.80E+05	1.80E+05	1.80E+05	1.80E+05	2.14E+05
Y-93	1.83E+05	1.83E+05	1.83E+05	1.83E+05	1.83E+05	1.83E+05	1.83E+05	2.51E+05
Zr-95	2.45E+08	2.45E+08	2.45E+08	2.45E+08	2.45E+08	2.45E+08	2.45E+08	2.84E+08
Zr-97	2.96E+06	2.96E+06	2.96E+06	2.96E+06	2.96E+06	2.96E+06	2.96E+06	3.44E+06
Nb-95	1.37E+08	1.37E+08	1.37E+08	1.37E+08	1.37E+08	1.37E+08	1.37E+08	1.61E+08
Nb-97	1.76E+05	1.76E+05	1.76E+05	1.76E+05	1.76E+05	1.76E+05	1.76E+05	2.07E+05
Mo-99	3.99E+06	3.99E+06	3.99E+06	3.99E+06	3.99E+06	3.99E+06	3.99E+06	4.63E+06
Tc-99m	1.84E+05	1.84E+05	1.84E+05	1.84E+05	1.84E+05	1.84E+05	1.84E+05	2.11E+05
Tc-101	2.04E+04	2.04E+04	2.04E+04	2.04E+04	2.04E+04	2.04E+04	2.04E+04	2.26E+04
Ru-103	1.08E+08	1.08E+08	1.08E+08	1.08E+08	1.08E+08	1.08E+08	1.08E+08	1.26E+08
Ru-105	6.36E+05	6.36E+05	6.36E+05	6.36E+05	6.36E+05	6.36E+05	6.36E+05	7.21E+05

All values are in (mrem·mL)/(h·μCi).

Table A13.3.3.2-1 (cont.) Site-Related Ground Plane R_{aipj} Dose Factors for All Age Groups

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI	Skin
Ru-106	4.22E+08	4.22E+08	4.22E+08	4.22E+08	4.22E+08	4.22E+08	4.22E+08	5.07E+08
Rh-105	7.43E+05	7.43E+05	7.43E+05	7.43E+05	7.43E+05	7.43E+05	7.43E+05	8.67E+05
Ag-110m	3.44E+09	3.44E+09	3.44E+09	3.44E+09	3.44E+09	3.44E+09	3.44E+09	4.01E+09
Cd-113m	4.68E+06	4.68E+06	4.68E+06	4.68E+06	4.68E+06	4.68E+06	4.68E+06	5.29E+06
Sb-124	5.98E+08	5.98E+08	5.98E+08	5.98E+08	5.98E+08	5.98E+08	5.98E+08	6.90E+08
Sb-125	2.34E+09	2.34E+09	2.34E+09	2.34E+09	2.34E+09	2.34E+09	2.34E+09	2.64E+09
Sb-126	8.44E+07	8.44E+07	8.44E+07	8.44E+07	8.44E+07	8.44E+07	8.44E+07	9.48E+07
Sb-127	1.68E+07	1.68E+07	1.68E+07	1.68E+07	1.68E+07	1.68E+07	1.68E+07	1.94E+07
Te-125m	1.55E+06	1.55E+06	1.55E+06	1.55E+06	1.55E+06	1.55E+06	1.55E+06	2.13E+06
Te-127m	9.16E+04	9.16E+04	9.16E+04	9.16E+04	9.16E+04	9.16E+04	9.16E+04	1.08E+05
Te-127	2.98E+03	2.98E+03	2.98E+03	2.98E+03	2.98E+03	2.98E+03	2.98E+03	3.28E+03
Te-129m	1.98E+07	1.98E+07	1.98E+07	1.98E+07	1.98E+07	1.98E+07	1.98E+07	2.31E+07
Te-129	2.62E+04	2.62E+04	2.62E+04	2.62E+04	2.62E+04	2.62E+04	2.62E+04	3.10E+04
Te-131m	8.03E+06	8.03E+06	8.03E+06	8.03E+06	8.03E+06	8.03E+06	8.03E+06	9.46E+06
Te-131	2.92E+04	2.92E+04	2.92E+04	2.92E+04	2.92E+04	2.92E+04	2.92E+04	3.45E+07
Te-132	4.23E+06	4.23E+06	4.23E+06	4.23E+06	4.23E+06	4.23E+06	4.23E+06	4.98E+06
I-129	1.31E+09	1.31E+09	1.31E+09	1.31E+09	1.31E+09	1.31E+09	1.31E+09	2.18E+09
I-130	5.51E+06	5.51E+06	5.51E+06	5.51E+06	5.51E+06	5.51E+06	5.51E+06	6.69E+06
I-131	1.72E+07	1.72E+07	1.72E+07	1.72E+07	1.72E+07	1.72E+07	1.72E+07	2.09E+07
I-132	1.25E+06	1.25E+06	1.25E+06	1.25E+06	1.25E+06	1.25E+06	1.25E+06	1.46E+06
I-133	2.45E+06	2.45E+06	2.45E+06	2.45E+06	2.45E+06	2.45E+06	2.45E+06	2.98E+06
I-134	4.47E+05	4.47E+05	4.47E+05	4.47E+05	4.47E+05	4.47E+05	4.47E+05	5.30E+05
I-135	2.53E+06	2.53E+06	2.53E+06	2.53E+06	2.53E+06	2.53E+06	2.53E+06	2.95E+06
Cs-134	6.86E+09	6.86E+09	6.86E+09	6.86E+09	6.86E+09	6.86E+09	6.86E+09	8.01E+09
Cs-135	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cs-136	1.51E+08	1.51E+08	1.51E+08	1.51E+08	1.51E+08	1.51E+08	1.51E+08	1.71E+08
Cs-137	1.03E+10	1.03E+10	1.03E+10	1.03E+10	1.03E+10	1.03E+10	1.03E+10	1.20E+10
Cs-138	3.59E+05	3.59E+05	3.59E+05	3.59E+05	3.59E+05	3.59E+05	3.59E+05	4.10E+05
Ba-139	1.06E+05	1.06E+05	1.06E+05	1.06E+05	1.06E+05	1.06E+05	1.06E+05	1.19E+05
Ba-140	2.05E+07	2.05E+07	2.05E+07	2.05E+07	2.05E+07	2.05E+07	2.05E+07	2.35E+07
Ba-141	4.17E+04	4.17E+04	4.17E+04	4.17E+04	4.17E+04	4.17E+04	4.17E+04	4.75E+04
Ba-142	4.49E+04	4.49E+04	4.49E+04	4.49E+04	4.49E+04	4.49E+04	4.49E+04	5.11E+04
La-140	1.92E+07	1.92E+07	1.92E+07	1.92E+07	1.92E+07	1.92E+07	1.92E+07	2.18E+07
La-142	7.60E+05	7.60E+05	7.60E+05	7.60E+05	7.60E+05	7.60E+05	7.60E+05	9.11E+05
Ce-141	1.37E+07	1.37E+07	1.37E+07	1.37E+07	1.37E+07	1.37E+07	1.37E+07	1.54E+07
Ce-143	2.31E+06	2.31E+06	2.31E+06	2.31E+06	2.31E+06	2.31E+06	2.31E+06	2.63E+06
Ce-144	6.95E+07	6.95E+07	6.95E+07	6.95E+07	6.95E+07	6.95E+07	6.95E+07	8.04E+07
Pr-143	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pr-144	1.83E+03	1.83E+03	1.83E+03	1.83E+03	1.83E+03	1.83E+03	1.83E+03	2.11E+03
Nd-147	8.39E+06	8.39E+06	8.39E+06	8.39E+06	8.39E+06	8.39E+06	8.39E+06	1.01E+07
Eu-152	1.49E+10	1.49E+10	1.49E+10	1.49E+10	1.49E+10	1.49E+10	1.49E+10	1.73E+10
W-187	2.35E+06	2.35E+06	2.35E+06	2.35E+06	2.35E+06	2.35E+06	2.35E+06	2.73E+06
Np-239	1.71E+06	1.71E+06	1.71E+06	1.71E+06	1.71E+06	1.71E+06	1.71E+06	1.98E+06

3.3.3 GARDEN VEGETATION PATHWAY FACTOR

For radionuclides other than tritium in the garden vegetation consumption pathway, R_{aipj} in ($m^2 \cdot$mrem/y) per (μCi/s) is calculated as follows (Reference 24, Section 5.3.1.5):

Eqn A13.3.3.3-1

$$R_{aipj} = K_1 \times \frac{r}{Y_v(\lambda_i + \lambda_w)} \times (DFL)_{aij} \times \left(U_{aL} f_L e^{-\lambda_i t_L} + U_{aS} f_g e^{-\lambda_i t_{hv}}\right)$$

where:

K_1 = the units conversion factor: 10^6 pCi/μCi.

r = the fraction of deposited activity retained on the edible parts of garden vegetation (dimensionless). The value used for r is 1.0 for radioiodines and 0.2 for particulates, from (Reference 11, Table E–1).

Y_v = the areal density (agricultural productivity) of growing leafy garden vegetation, in kg/m^2, from Table A13.3.3.3-1.

λ_i = the radioactive decay constant for radionuclide i, in s^{-1}. Values of λ_i used in effluent calculations should be based on decay data from a recognized and current source, such as Reference 46.

λ_w = the rate constant for removal of activity on leaf and plant surfaces by weathering, in s^{-1}, from Table A13.3.3.3-1.

$(DFL)_{aij}$ = the ingestion dose factor for receptor age group a, radionuclide i, and organ j, in mrem/pCi, from Table A8-5 through Table A8-8.

U_{aL} = the consumption rate of fresh leafy garden vegetation by a receptor in age group a, in kg/y, from Table A13.3.3.6-2.

U_{aS} = the consumption rate of stored garden vegetation by a receptor in age group a, in kg/y, from Table A13.3.3.6-2.

f_L = the fraction of the annual intake of fresh leafy garden vegetation that is grown locally (dimensionless), from Table A13.3.3.3-1.

f_g = the fraction of the annual intake of stored garden vegetation that is grown locally (dimensionless), from Table A13.3.3.3-1.

t_L = the average time between harvest of fresh leafy garden vegetation and its consumption, in s, from Table A13.3.3.3-1.

t_{hv} = the average time between harvest of stored garden vegetation and its consumption, in s, from Table A13.3.3.3-1.

For tritium in the garden vegetation consumption pathway, R_{aipj} in (mrem/y) per (μCi/m^3) is calculated as follows (Reference 24, Section 5.3.1.5), based on the concentration in air rather than deposition onto the ground:

Eqn A13.3.3.3-2

$$R_{aipj} = K_1 \times K_3 \times (DFL)_{aij} \times \left(U_{aL} f_L + U_{aS} f_g\right) \times 0.75 \times \left(\frac{0.5}{H}\right)$$

where:

K_3 =	=	the units conversion factor: 10^3 g/kg.
H =	=	the absolute humidity of atmospheric air, in g/m^3, from Table A13.3.3.3-1.
0.75 =	=	the fraction of the mass of total garden vegetation that is water (dimensionless).
0.5 =	=	the ratio of the specific activity of tritium in garden vegetation water to that in atmospheric water (dimensionless).

Other parameters are as defined above.

For carbon-14 in the garden vegetation consumption pathway, R_{aipj} in (mrem/y) per (μCi/m^3) is calculated from the modified formula as follows (Reference 11, Eqn C-8), based on the concentration in air rather than deposition onto the ground:

$$R_{aipj} = K_1 \; x \; K_3 \; x \; (DFL)_{aij} \; x \; \left(U_{aL} f_L + U_{aS} f_g\right) \; x \; (p) \; x \; \left(\frac{0.11}{0.16}\right) \qquad \text{Eqn A13.3.3.3-3}$$

where:

p	=	The ratio of the total annual release time (for C-14) atmospheric releases) to the total annual time during photosynthesis occurs (taken to be 4400 hrs), under the condition that the value of p should never exceed unity. For continuous C-14 releases, p is taken to be unity.
0.11	=	The fraction of total plant mass that is natural carbon, dimensionless.
0.16	=	The concentration of natural carbon in the atmosphere, in g/m^3.

Other parameters are as defined above.

Table A13.3.3.3-1 Miscellaneous Parameters for the Garden Vegetation Pathway

The following parameter values are for use in calculating R_{aipj} for the garden vegetation pathway only.

Parameter	Value	Reference
Y_v	2.0 kg/m^2	Ref. 11, Table E-15
λw	5.73 x 10^{-7} s^{-1} (14-day half-life)	Ref. 24, page 33
f_L	1.0	Ref. 24, page 36
f_g	0.76	Ref. 24, page 33
t_L	8.6 x 10^4 s (1 day)	Ref. 11, Table E-15
t_{hv}	5.18 x 10^6 s (60 days)	Ref. 11, Table E-15
H	8 g/m^3	Ref. 11

Table A13.3.3.3-2 Site-Related Garden Vegetation R_{aipj} Dose Factors, Adult Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3*	0.00E+00	1.21E+03	1.21E+03	1.21E+03	1.21E+03	1.21E+03	1.21E+03
C-14*	8.44E+05	1.69E+05	1.69E+05	1.69E+05	1.69E+05	1.69E+05	1.69E+05
Na-24	1.55E+05	1.55E+05	1.55E+05	1.55E+05	1.55E+05	1.55E+05	1.55E+05
P-32	9.69E+08	6.02E+07	3.74E+07	0.00E+00	0.00E+00	0.00E+00	1.09E+08
Cr-51	0.00E+00	0.00E+00	3.84E+04	2.29E+04	8.45E+03	5.09E+04	9.65E+06
Mn-54	0.00E+00	2.92E+08	5.58E+07	0.00E+00	8.70E+07	0.00E+00	8.96E+08
Mn-56	0.00E+00	8.95E+00	1.59E+00	0.00E+00	1.14E+01	0.00E+00	2.86E+02
Fe-55	1.97E+08	1.36E+08	3.17E+07	0.00E+00	0.00E+00	7.59E+07	7.80E+07
Fe-59	1.11E+08	2.61E+08	9.99E+07	0.00E+00	0.00E+00	7.28E+07	8.69E+08
Co-57	0.00E+00	1.09E+07	1.82E+07	0.00E+00	0.00E+00	0.00E+00	2.77E+08
Co-58	0.00E+00	2.78E+07	6.24E+07	0.00E+00	0.00E+00	0.00E+00	5.64E+08
Co-60	0.00E+00	1.57E+08	3.47E+08	0.00E+00	0.00E+00	0.00E+00	2.95E+09
Ni-63	9.79E+09	6.79E+08	3.28E+08	0.00E+00	0.00E+00	0.00E+00	1.42E+08
Ni-65	3.46E+01	4.49E+00	2.05E+00	0.00E+00	0.00E+00	0.00E+00	1.14E+02
Cu-64	0.00E+00	5.30E+03	2.49E+03	0.00E+00	1.34E+04	0.00E+00	4.52E+05
Zn-65	2.96E+08	9.42E+08	4.26E+08	0.00E+00	6.30E+08	0.00E+00	5.93E+08
Zn-69m	1.29E+04	3.10E+04	2.84E+03	0.00E+00	1.88E+04	0.00E+00	1.89E+06
Zn-69	2.93E-06	5.61E-06	3.90E-07	0.00E+00	3.64E-06	0.00E+00	8.43E-07
Br-82	0.00E+00	0.00E+00	8.69E+05	0.00E+00	0.00E+00	0.00E+00	9.96E+05
Br-83	0.00E+00	0.00E+00	1.74E+00	0.00E+00	0.00E+00	0.00E+00	2.51E+00
Br-84	0.00E+00	0.00E+00	1.24E-11	0.00E+00	0.00E+00	0.00E+00	9.75E-17
Br-85	0.00E+00	0.00E+00	1.20E-151	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	1.65E+08	7.68E+07	0.00E+00	0.00E+00	0.00E+00	3.25E+07
Rb-88	0.00E+00	1.53E-22	8.14E-23	0.00E+00	0.00E+00	0.00E+00	2.12E-33
Rb-89	0.00E+00	1.67E-26	1.18E-26	0.00E+00	0.00E+00	0.00E+00	9.71E-40
Sr-89	8.85E+09	0.00E+00	2.54E+08	0.00E+00	0.00E+00	0.00E+00	1.42E+09
Sr-90	6.54E+11	0.00E+00	1.31E+10	0.00E+00	0.00E+00	0.00E+00	1.64E+10
Sr-91	1.75E+05	0.00E+00	7.08E+03	0.00E+00	0.00E+00	0.00E+00	8.35E+05
Sr-92	2.40E+02	0.00E+00	1.04E+01	0.00E+00	0.00E+00	0.00E+00	4.76E+03
Y-90	7.70E+03	0.00E+00	2.07E+02	0.00E+00	0.00E+00	0.00E+00	8.17E+07
Y-91m	2.76E-09	0.00E+00	1.07E-10	0.00E+00	0.00E+00	0.00E+00	8.10E-09
Y-91	4.59E+06	0.00E+00	1.23E+05	0.00E+00	0.00E+00	0.00E+00	2.52E+09
Y-92	5.19E-01	0.00E+00	1.52E-02	0.00E+00	0.00E+00	0.00E+00	9.10E+03
Y-93	9.76E+01	0.00E+00	2.69E+00	0.00E+00	0.00E+00	0.00E+00	3.09E+06
Zr-95	1.06E+06	3.40E+05	2.30E+05	0.00E+00	5.33E+05	0.00E+00	1.08E+09
Zr-97	1.95E+02	3.93E+01	1.80E+01	0.00E+00	5.94E+01	0.00E+00	1.22E+07
Nb-95	1.22E+05	6.78E+04	3.65E+04	0.00E+00	6.70E+04	0.00E+00	4.12E+08
Nb-97	1.17E-06	2.96E-07	1.08E-07	0.00E+00	3.46E-07	0.00E+00	1.09E-03
Mo-99	0.00E+00	3.56E+06	6.78E+05	0.00E+00	8.07E+06	0.00E+00	8.26E+06
Tc-99m	1.78E+00	5.02E+00	6.39E+01	0.00E+00	7.62E+01	2.46E+00	2.97E+03
Tc-101	3.44E-31	4.96E-31	4.86E-30	0.00E+00	8.93E-30	2.53E-31	1.49E-42
Ru-103	4.14E+06	0.00E+00	1.78E+06	0.00E+00	1.58E+07	0.00E+00	4.84E+08
Ru-105	3.07E+01	0.00E+00	1.21E+01	0.00E+00	3.97E+02	0.00E+00	1.88E+04

Units are in ($m^2 \cdot$mrem/y) per (μCi/s)
*H-3 and C-14 are in units of (mrem/y) per ($\mu Ci/m^3$).

Table A13.3.3.3-2 (cont.) Site-Related Garden Vegetation R_{aipj} Dose Factors, Adult Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ru-106	1.80E+08	0.00E+00	2.28E+07	0.00E+00	3.48E+08	0.00E+00	1.17E+10
Rh-105	4.66E+04	3.41E+04	2.25E+04	0.00E+00	1.45E+05	0.00E+00	5.43E+06
Ag-110m	9.83E+06	9.09E+06	5.40E+06	0.00E+00	1.79E+07	0.00E+00	3.71E+09
Cd-113m	0.00E+00	2.37E+08	7.62E+06	0.00E+00	2.61E+08	0.00E+00	1.91E+09
Sb-124	9.31E+07	1.76E+06	3.69E+07	2.26E+05	0.00E+00	7.25E+07	2.64E+09
Sb-125	1.28E+08	1.43E+06	3.05E+07	1.30E+05	0.00E+00	9.89E+07	1.41E+09
Sb-126	4.61E+06	9.39E+04	1.67E+06	2.82E+04	0.00E+00	2.83E+06	3.77E+08
Sb-127	3.01E+05	6.60E+03	1.16E+05	3.62E+03	0.00E+00	1.79E+05	6.89E+07
Te-125m	8.65E+07	3.14E+07	1.16E+07	2.60E+07	3.52E+08	0.00E+00	3.46E+08
Te-127m	3.21E+08	1.15E+08	3.91E+07	8.21E+07	1.30E+09	0.00E+00	1.08E+09
Te-127	3.26E+03	1.17E+03	7.04E+02	2.41E+03	1.33E+04	0.00E+00	2.57E+05
Te-129m	2.14E+08	7.98E+07	3.39E+07	7.35E+07	8.93E+08	0.00E+00	1.08E+09
Te-129	4.14E-04	1.55E-04	1.01E-04	3.18E-04	1.74E-03	0.00E+00	3.12E-04
Te-131m	5.28E+05	2.58E+05	2.15E+05	4.09E+05	2.61E+06	0.00E+00	2.56E+07
Te-131	7.24E-16	3.02E-16	2.28E-16	5.95E-16	3.17E-15	0.00E+00	1.02E-16
Te-132	2.49E+06	1.61E+06	1.51E+06	1.78E+06	1.55E+07	0.00E+00	7.62E+07
I-129	1.23E+09	1.06E+09	3.47E+09	2.73E+12	2.28E+09	0.00E+00	1.67E+08
I-130	2.26E+05	6.67E+05	2.63E+05	5.65E+07	1.04E+06	0.00E+00	5.74E+05
I-131	4.81E+07	6.88E+07	3.94E+07	2.25E+10	1.18E+08	0.00E+00	1.81E+07
I-132	3.23E+01	8.64E+01	3.02E+01	3.02E+03	1.38E+02	0.00E+00	1.62E+01
I-133	1.20E+06	2.10E+06	6.39E+05	3.08E+08	3.66E+06	0.00E+00	1.88E+06
I-134	5.13E-05	1.39E-04	4.98E-05	2.41E-03	2.22E-04	0.00E+00	1.21E-07
I-135	2.23E+04	5.85E+04	2.16E+04	3.86E+06	9.38E+04	0.00E+00	6.61E+04
Cs-134	4.38E+09	1.04E+10	8.52E+09	0.00E+00	3.37E+09	1.12E+09	1.82E+08
Cs-135	1.47E+09	1.36E+09	6.03E+08	0.00E+00	5.14E+08	1.54E+08	3.18E+07
Cs-136	2.86E+07	1.13E+08	8.14E+07	0.00E+00	6.29E+07	8.62E+06	1.28E+07
Cs-137	5.98E+09	8.19E+09	5.36E+09	0.00E+00	2.78E+09	9.24E+08	1.58E+08
Cs-138	1.97E-11	3.88E-11	1.92E-11	0.00E+00	2.85E-11	2.82E-12	1.66E-16
Ba-139	1.57E-02	1.12E-05	4.59E-04	0.00E+00	1.04E-05	6.33E-06	2.78E-02
Ba-140	8.54E+07	1.07E+05	5.60E+06	0.00E+00	3.65E+04	6.14E+04	1.76E+08
Ba-141	5.19E-22	3.92E-25	1.75E-23	0.00E+00	3.64E-25	2.22E-25	2.44E-31
Ba-142	2.25E-39	2.31E-42	1.41E-40	0.00E+00	1.95E-42	1.31E-42	3.17E-57
La-140	1.14E+03	5.77E+02	1.52E+02	0.00E+00	0.00E+00	0.00E+00	4.24E+07
La-142	1.12E-04	5.08E-05	1.26E-05	0.00E+00	0.00E+00	0.00E+00	3.71E-01
Ce-141	1.67E+05	1.13E+05	1.28E+04	0.00E+00	5.25E+04	0.00E+00	4.32E+08
Ce-143	5.77E+02	4.27E+05	4.72E+01	0.00E+00	1.88E+02	0.00E+00	1.60E+07
Ce-144	3.07E+07	1.28E+07	1.65E+06	0.00E+00	7.62E+06	0.00E+00	1.04E+10
Pr-143	4.24E+04	1.70E+04	2.10E+03	0.00E+00	9.82E+03	0.00E+00	1.86E+08
Pr-144	1.37E-26	5.69E-27	6.97E-28	0.00E+00	3.21E-27	0.00E+00	1.97E-33
Nd-147	2.11E+04	2.44E+04	1.46E+03	0.00E+00	1.43E+04	0.00E+00	1.17E+08
Eu-152	1.46E+07	3.32E+06	2.91E+06	0.00E+00	2.05E+07	0.00E+00	1.91E+09
W-187	2.20E+04	1.84E+04	6.42E+03	0.00E+00	0.00E+00	0.00E+00	6.02E+06
Np-239	8.27E+02	8.13E+01	4.48E+01	0.00E+00	2.54E+02	0.00E+00	1.67E+07

Table A13.3.3.3-3 Site-Related Garden Vegetation R_{aipj} Dose Factors, Teenager Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3*	0.00E+00	1.42E+03	1.42E+03	1.42E+03	1.42E+03	1.42E+03	1.42E+03
C-14*	1.40E+06	2.81E+05	2.81E+05	2.81E+05	2.81E+05	2.81E+05	2.81E+05
Na-24	1.38E+05	1.38E+05	1.38E+05	1.38E+05	1.38E+05	1.38E+05	1.38E+05
P-32	1.20E+09	7.44E+07	4.65E+07	0.00E+00	0.00E+00	0.00E+00	1.01E+08
Cr-51	0.00E+00	0.00E+00	5.45E+04	3.03E+04	1.19E+04	7.78E+04	9.16E+06
Mn-54	0.00E+00	4.37E+08	8.67E+07	0.00E+00	1.30E+08	0.00E+00	8.96E+08
Mn-56	0.00E+00	8.07E+00	1.44E+00	0.00E+00	1.02E+01	0.00E+00	5.31E+02
Fe-55	3.14E+08	2.23E+08	5.20E+07	0.00E+00	0.00E+00	1.41E+08	9.65E+07
Fe-59	1.66E+08	3.87E+08	1.49E+08	0.00E+00	0.00E+00	1.22E+08	9.15E+08
Co-57	0.00E+00	1.72E+07	2.88E+07	0.00E+00	0.00E+00	0.00E+00	3.21E+08
Co-58	0.00E+00	4.11E+07	9.48E+07	0.00E+00	0.00E+00	0.00E+00	5.67E+08
Co-60	0.00E+00	2.40E+08	5.41E+08	0.00E+00	0.00E+00	0.00E+00	3.13E+09
Ni-63	1.55E+10	1.10E+09	5.26E+08	0.00E+00	0.00E+00	0.00E+00	1.74E+08
Ni-65	3.22E+01	4.11E+00	1.87E+00	0.00E+00	0.00E+00	0.00E+00	2.23E+02
Cu-64	0.00E+00	4.81E+03	2.26E+03	0.00E+00	1.22E+04	0.00E+00	3.73E+05
Zn-65	4.07E+08	1.41E+09	6.59E+08	0.00E+00	9.05E+08	0.00E+00	5.99E+08
Zn-69m	1.20E+04	2.82E+04	2.59E+03	0.00E+00	1.72E+04	0.00E+00	1.55E+06
Zn-69	2.75E-06	5.23E-06	3.66E-07	0.00E+00	3.42E-06	0.00E+00	9.64E-06
Br-82	0.00E+00	0.00E+00	7.67E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-83	0.00E+00	0.00E+00	1.63E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	1.13E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	1.12E-151	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	2.23E+08	1.05E+08	0.00E+00	0.00E+00	0.00E+00	3.30E+07
Rb-88	0.00E+00	1.42E-22	7.55E-23	0.00E+00	0.00E+00	0.00E+00	1.21E-29
Rb-89	0.00E+00	1.50E-26	1.06E-26	0.00E+00	0.00E+00	0.00E+00	2.31E-35
Sr-89	1.41E+10	0.00E+00	4.04E+08	0.00E+00	0.00E+00	0.00E+00	1.68E+09
Sr-90	8.91E+11	0.00E+00	1.78E+10	0.00E+00	0.00E+00	0.00E+00	2.04E+10
Sr-91	1.64E+05	0.00E+00	6.51E+03	0.00E+00	0.00E+00	0.00E+00	7.43E+05
Sr-92	2.24E+02	0.00E+00	9.54E+00	0.00E+00	0.00E+00	0.00E+00	5.70E+03
Y-90	7.20E+03	0.00E+00	1.94E+02	0.00E+00	0.00E+00	0.00E+00	5.94E+07
Y-91m	2.57E-09	0.00E+00	9.82E-11	0.00E+00	0.00E+00	0.00E+00	1.21E-07
Y-91	7.34E+06	0.00E+00	1.97E+05	0.00E+00	0.00E+00	0.00E+00	3.01E+09
Y-92	4.88E-01	0.00E+00	1.41E-02	0.00E+00	0.00E+00	0.00E+00	1.34E+04
Y-93	9.15E+01	0.00E+00	2.51E+00	0.00E+00	0.00E+00	0.00E+00	2.80E+06
Zr-95	1.62E+06	5.11E+05	3.51E+05	0.00E+00	7.50E+05	0.00E+00	1.18E+09
Zr-97	1.80E+02	3.57E+01	1.64E+01	0.00E+00	5.41E+01	0.00E+00	9.66E+06
Nb-95	1.75E+05	9.68E+04	5.33E+04	0.00E+00	9.38E+04	0.00E+00	4.14E+08
Nb-97	1.09E-06	2.70E-07	9.84E-08	0.00E+00	3.15E-07	0.00E+00	6.44E-03
Mo-99	0.00E+00	3.27E+06	6.24E+05	0.00E+00	7.49E+06	0.00E+00	5.86E+06
Tc-99m	1.57E+00	4.37E+00	5.66E+01	0.00E+00	6.51E+01	2.43E+00	2.87E+03
Tc-101	3.20E-31	4.55E-31	4.47E-30	0.00E+00	8.23E-30	2.77E-31	7.78E-38
Ru-103	6.25E+06	0.00E+00	2.67E+06	0.00E+00	2.20E+07	0.00E+00	5.22E+08
Ru-105	2.85E+01	0.00E+00	1.11E+01	0.00E+00	3.60E+02	0.00E+00	2.30E+04

Units are in (m^2·mrem/y) per (μCi/s)
*H-3 and C-14 are in units of (mrem/y) per (μCi/m^3).

Table A13.3.3.3-3 (cont.) **Site-Related Garden Vegetation R_{aipj} Dose Factors, Teenager Age Group**

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ru-106	2.98E+08	0.00E+00	3.75E+07	0.00E+00	5.75E+08	0.00E+00	1.43E+10
Rh-105	4.37E+04	3.16E+04	2.07E+04	0.00E+00	1.34E+05	0.00E+00	4.02E+06
Ag-110m	1.46E+07	1.38E+07	8.38E+06	0.00E+00	2.63E+07	0.00E+00	3.87E+09
Cd-113m	0.00E+00	3.92E+08	1.26E+07	0.00E+00	4.34E+08	0.00E+00	2.35E+09
Sb-124	1.45E+08	2.67E+06	5.65E+07	3.28E+05	0.00E+00	1.26E+08	2.92E+09
Sb-125	2.07E+08	2.26E+06	4.83E+07	1.97E+05	0.00E+00	1.82E+08	1.61E+09
Sb-126	5.19E+06	1.06E+05	1.86E+06	2.93E+04	0.00E+00	3.72E+06	3.07E+08
Sb-127	2.78E+05	5.95E+03	1.05E+05	3.13E+03	0.00E+00	1.89E+05	4.72E+07
Te-125m	1.39E+08	5.00E+07	1.86E+07	3.88E+07	0.00E+00	0.00E+00	4.10E+08
Te-127m	5.25E+08	1.86E+08	6.25E+07	1.25E+08	2.13E+09	0.00E+00	1.31E+09
Te-127	3.07E+03	1.09E+03	6.60E+02	2.12E+03	1.24E+04	0.00E+00	2.37E+05
Te-129m	3.27E+08	1.21E+08	5.18E+07	1.06E+08	1.37E+09	0.00E+00	1.23E+09
Te-129	3.87E-04	1.44E-04	9.43E-05	2.77E-04	1.63E-03	0.00E+00	2.12E-03
Te-131m	4.88E+05	2.34E+05	1.95E+05	3.52E+05	2.44E+06	0.00E+00	1.88E+07
Te-131	6.72E-16	2.77E-16	2.10E-16	5.18E-16	2.94E-15	0.00E+00	5.52E-17
Te-132	2.26E+06	1.43E+06	1.35E+06	1.51E+06	1.38E+07	0.00E+00	4.54E+07
I-129	2.05E+09	1.72E+09	2.87E+09	2.09E+12	3.08E+09	0.00E+00	2.01E+08
I-130	2.02E+05	5.85E+05	2.34E+05	4.77E+07	9.01E+05	0.00E+00	4.50E+05
I-131	4.67E+07	6.54E+07	3.51E+07	1.91E+10	1.13E+08	0.00E+00	1.29E+07
I-132	2.91E+01	7.62E+01	2.74E+01	2.57E+03	1.20E+02	0.00E+00	3.32E+01
I-133	1.12E+06	1.90E+06	5.79E+05	2.65E+08	3.33E+06	0.00E+00	1.44E+06
I-134	4.64E-05	1.23E-04	4.41E-05	2.05E-03	1.94E-04	0.00E+00	1.62E-06
I-135	2.02E+04	5.20E+04	1.93E+04	3.34E+06	8.21E+04	0.00E+00	5.76E+04
Cs-134	6.85E+09	1.61E+10	7.48E+09	0.00E+00	5.12E+09	1.96E+09	2.00E+08
Cs-135	2.44E+09	2.24E+09	5.23E+08	0.00E+00	8.54E+08	3.09E+08	3.92E+07
Cs-136	3.16E+07	1.24E+08	8.34E+07	0.00E+00	6.76E+07	1.07E+07	1.00E+07
Cs-137	9.79E+09	1.30E+10	4.54E+09	0.00E+00	4.43E+09	1.72E+09	1.85E+08
Cs-138	1.81E-11	3.48E-11	1.74E-11	0.00E+00	2.57E-11	2.99E-12	1.58E-14
Ba-139	1.47E-02	1.04E-05	4.29E-04	0.00E+00	9.78E-06	7.15E-06	1.31E-01
Ba-140	9.85E+07	1.21E+05	6.35E+06	0.00E+00	4.09E+04	8.12E+04	1.52E+08
Ba-141	4.85E-22	3.62E-25	1.62E-23	0.00E+00	3.36E-25	2.48E-25	1.03E-27
Ba-142	2.07E-39	2.07E-42	1.28E-40	0.00E+00	1.75E-42	1.38E-42	6.36E-51
La-140	1.05E+03	5.14E+02	1.37E+02	0.00E+00	0.00E+00	0.00E+00	2.95E+07
La-142	1.02E-04	4.55E-05	1.13E-05	0.00E+00	0.00E+00	0.00E+00	1.39E+00
Ce-141	2.55E+05	1.70E+05	1.96E+04	0.00E+00	8.01E+04	0.00E+00	4.87E+08
Ce-143	5.40E+02	3.93E+05	4.39E+01	0.00E+00	1.76E+02	0.00E+00	1.18E+07
Ce-144	5.07E+07	2.10E+07	2.72E+06	0.00E+00	1.25E+07	0.00E+00	1.27E+10
Pr-143	5.12E+04	2.04E+04	2.55E+03	0.00E+00	1.19E+04	0.00E+00	1.68E+08
Pr-144	1.28E-26	5.26E-27	6.51E-28	0.00E+00	3.02E-27	0.00E+00	1.42E-29
Nd-147	2.43E+04	2.64E+04	1.58E+03	0.00E+00	1.55E+04	0.00E+00	9.53E+07
Eu-152	2.13E+07	5.13E+06	4.52E+06	0.00E+00	2.38E+07	0.00E+00	1.89E+09
W-187	2.05E+04	1.67E+04	5.84E+03	0.00E+00	0.00E+00	0.00E+00	4.51E+06
Np-239	8.03E+02	7.57E+01	4.20E+01	0.00E+00	2.38E+02	0.00E+00	1.22E+07

Table A13.3.3.3-4 Site-Related Garden Vegetation R_{aipj} Dose Factors, Child Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3*	0.00E+00	2.23E+03	2.23E+03	2.23E+03	2.23E+03	2.23E+03	2.23E+03
C-14*	3.41E+06	6.83E+05	6.83E+05	6.83E+05	6.83E+05	6.83E+05	6.83E+05
Na-24	2.15E+05	2.15E+05	2.15E+05	2.15E+05	2.15E+05	2.15E+05	2.15E+05
P-32	2.61E+09	1.22E+08	1.01E+08	0.00E+00	0.00E+00	0.00E+00	7.22E+07
Cr-51	0.00E+00	0.00E+00	1.06E+05	5.89E+04	1.61E+04	1.08E+05	5.63E+06
Mn-54	0.00E+00	6.45E+08	1.72E+08	0.00E+00	1.81E+08	0.00E+00	5.42E+08
Mn-56	0.00E+00	1.06E+01	2.38E+00	0.00E+00	1.28E+01	0.00E+00	1.53E+03
Fe-55	7.80E+08	4.14E+08	1.28E+08	0.00E+00	0.00E+00	2.34E+08	7.66E+07
Fe-59	3.74E+08	6.05E+08	3.01E+08	0.00E+00	0.00E+00	1.75E+08	6.30E+08
Co-57	0.00E+00	2.90E+07	5.86E+07	0.00E+00	0.00E+00	0.00E+00	2.37E+08
Co-58	0.00E+00	6.15E+07	1.88E+08	0.00E+00	0.00E+00	0.00E+00	3.59E+08
Co-60	0.00E+00	3.68E+08	1.09E+09	0.00E+00	0.00E+00	0.00E+00	2.04E+09
Ni-63	3.85E+10	2.06E+09	1.31E+09	0.00E+00	0.00E+00	0.00E+00	1.39E+08
Ni-65	5.91E+01	5.56E+00	3.25E+00	0.00E+00	0.00E+00	0.00E+00	6.81E+02
Cu-64	0.00E+00	6.34E+03	3.83E+03	0.00E+00	1.53E+04	0.00E+00	2.97E+05
Zn-65	7.88E+08	2.10E+09	1.31E+09	0.00E+00	1.32E+09	0.00E+00	3.69E+08
Zn-69m	2.19E+04	3.74E+04	4.42E+03	0.00E+00	2.17E+04	0.00E+00	1.22E+06
Zn-69	5.07E-06	7.32E-06	6.77E-07	0.00E+00	4.44E-06	0.00E+00	4.61E-04
Br-82	0.00E+00	0.00E+00	1.18E+06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-83	0.00E+00	0.00E+00	3.02E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	1.92E-11	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	2.08E-151	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	3.82E+08	2.35E+08	0.00E+00	0.00E+00	0.00E+00	2.46E+07
Rb-88	0.00E+00	1.96E-22	1.36E-22	0.00E+00	0.00E+00	0.00E+00	9.60E-24
Rb-89	0.00E+00	1.98E-26	1.76E-26	0.00E+00	0.00E+00	0.00E+00	1.73E-28
Sr-89	3.40E+10	0.00E+00	9.72E+08	0.00E+00	0.00E+00	0.00E+00	1.32E+09
Sr-90	1.82E+12	0.00E+00	3.67E+10	0.00E+00	0.00E+00	0.00E+00	1.63E+10
Sr-91	3.01E+05	0.00E+00	1.14E+04	0.00E+00	0.00E+00	0.00E+00	6.66E+05
Sr-92	4.10E+02	0.00E+00	1.64E+01	0.00E+00	0.00E+00	0.00E+00	7.77E+03
Y-90	1.34E+04	0.00E+00	3.58E+02	0.00E+00	0.00E+00	0.00E+00	3.81E+07
Y-91m	4.71E-09	0.00E+00	1.71E-10	0.00E+00	0.00E+00	0.00E+00	9.22E-06
Y-91	1.77E+07	0.00E+00	4.74E+05	0.00E+00	0.00E+00	0.00E+00	2.36E+09
Y-92	8.99E-01	0.00E+00	2.57E-02	0.00E+00	0.00E+00	0.00E+00	2.60E+04
Y-93	1.69E+02	0.00E+00	4.63E+00	0.00E+00	0.00E+00	0.00E+00	2.51E+06
Zr-95	3.68E+06	8.09E+05	7.20E+05	0.00E+00	1.16E+06	0.00E+00	8.43E+08
Zr-97	3.29E+02	4.76E+01	2.81E+01	0.00E+00	6.83E+01	0.00E+00	7.21E+06
Nb-95	3.80E+05	1.48E+05	1.06E+05	0.00E+00	1.39E+05	0.00E+00	2.74E+08
Nb-97	1.98E-06	3.57E-07	1.67E-07	0.00E+00	3.97E-07	0.00E+00	1.10E-01
Mo-99	0.00E+00	4.47E+06	1.11E+06	0.00E+00	9.54E+06	0.00E+00	3.70E+06
Tc-99m	2.70E+00	5.29E+00	8.77E+01	0.00E+00	7.68E+01	2.69E+00	3.01E+03
Tc-101	5.89E-31	6.17E-31	7.82E-30	0.00E+00	1.05E-29	3.26E-31	1.96E-30
Ru-103	1.43E+07	0.00E+00	5.51E+06	0.00E+00	3.61E+07	0.00E+00	3.70E+08
Ru-105	5.22E+01	0.00E+00	1.89E+01	0.00E+00	4.59E+02	0.00E+00	3.41E+04

Units are in ($m^2 \cdot$mrem/y) per (μCi/s)
*H-3 and C-14 are in units of (mrem/y) per (μCi/m^3).

Table A13.3.3.3-4 (cont.) Site-Related Garden Vegetation R_{aipj} Dose Factors, Child Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ru-106	7.24E+08	0.00E+00	9.03E+07	0.00E+00	9.78E+08	0.00E+00	1.13E+10
Rh-105	8.05E+04	4.32E+04	3.69E+04	0.00E+00	1.72E+05	0.00E+00	2.68E+06
Ag-110m	3.11E+07	2.10E+07	1.68E+07	0.00E+00	3.92E+07	0.00E+00	2.50E+09
Cd-113m	0.00E+00	7.22E+08	3.07E+07	0.00E+00	7.44E+08	0.00E+00	1.86E+09
Sb-124	3.35E+08	4.34E+06	1.17E+08	7.39E+05	0.00E+00	1.86E+08	2.09E+09
Sb-125	4.86E+08	3.75E+06	1.02E+08	4.50E+05	0.00E+00	2.71E+08	1.16E+09
Sb-126	1.01E+07	1.55E+05	3.64E+06	5.94E+04	0.00E+00	4.84E+06	2.04E+08
Sb-127	5.03E+05	7.78E+03	1.75E+05	5.60E+03	0.00E+00	2.18E+05	2.83E+07
Te-125m	3.33E+08	9.03E+07	4.44E+07	9.35E+07	0.00E+00	0.00E+00	3.22E+08
Te-127m	1.27E+09	3.43E+08	1.51E+08	3.04E+08	3.63E+09	0.00E+00	1.03E+09
Te-127	5.66E+03	1.53E+03	1.21E+03	3.92E+03	1.61E+04	0.00E+00	2.21E+05
Te-129m	7.77E+08	2.17E+08	1.21E+08	2.50E+08	2.28E+09	0.00E+00	9.48E+08
Te-129	7.17E-04	2.00E-04	1.70E-04	5.12E-04	2.10E-03	0.00E+00	4.46E-02
Te-131m	8.92E+05	3.08E+05	3.28E+05	6.34E+05	2.99E+06	0.00E+00	1.25E+07
Te-131	1.24E-15	3.78E-16	3.69E-16	9.47E-16	3.75E-15	0.00E+00	6.51E-15
Te-132	4.06E+06	1.80E+06	2.17E+06	2.61E+06	1.67E+07	0.00E+00	1.81E+07
I-129	4.98E+09	3.05E+09	2.73E+09	2.00E+12	5.16E+09	0.00E+00	1.54E+08
I-130	3.55E+05	7.17E+05	3.69E+05	7.90E+07	1.07E+06	0.00E+00	3.35E+05
I-131	8.81E+07	8.86E+07	5.03E+07	2.93E+10	1.45E+08	0.00E+00	7.88E+06
I-132	5.17E+01	9.50E+01	4.37E+01	4.41E+03	1.45E+02	0.00E+00	1.12E+02
I-133	2.04E+06	2.52E+06	9.55E+05	4.69E+08	4.21E+06	0.00E+00	1.02E+06
I-134	8.23E-05	1.53E-04	7.04E-05	3.52E-03	2.34E-04	0.00E+00	1.01E-04
I-135	3.59E+04	6.46E+04	3.05E+04	5.72E+06	9.90E+04	0.00E+00	4.92E+04
Cs-134	1.56E+10	2.56E+10	5.40E+09	0.00E+00	7.93E+09	2.85E+09	1.38E+08
Cs-135	5.94E+09	4.14E+09	4.25E+08	0.00E+00	1.46E+09	4.88E+08	3.10E+07
Cs-136	6.18E+07	1.70E+08	1.10E+08	0.00E+00	9.05E+07	1.35E+07	5.97E+06
Cs-137	2.33E+10	2.23E+10	3.29E+09	0.00E+00	7.27E+09	2.61E+09	1.40E+08
Cs-138	3.30E-11	4.59E-11	2.91E-11	0.00E+00	3.23E-11	3.47E-12	2.11E-11
Ba-139	2.72E-02	1.45E-05	7.88E-04	0.00E+00	1.27E-05	8.53E-06	1.57E+00
Ba-140	2.05E+08	1.80E+05	1.20E+07	0.00E+00	5.85E+04	1.07E+05	1.04E+08
Ba-141	8.95E-22	5.01E-25	2.91E-23	0.00E+00	4.33E-25	2.94E-24	5.10E-22
Ba-142	3.75E-39	2.70E-42	2.09E-40	0.00E+00	2.18E-42	1.59E-42	4.89E-41
La-140	1.88E+03	6.57E+02	2.21E+02	0.00E+00	0.00E+00	0.00E+00	1.83E+07
La-142	1.86E-04	5.92E-05	1.85E-05	0.00E+00	0.00E+00	0.00E+00	1.17E+01
Ce-141	6.04E+05	3.01E+05	4.47E+04	0.00E+00	1.32E+05	0.00E+00	3.76E+08
Ce-143	9.94E+02	5.39E+05	7.80E+01	0.00E+00	2.26E+02	0.00E+00	7.89E+06
Ce-144	1.23E+08	3.87E+07	6.58E+06	0.00E+00	2.14E+07	0.00E+00	1.01E+10
Pr-143	1.11E+05	3.32E+04	5.49E+03	0.00E+00	1.80E+04	0.00E+00	1.19E+08
Pr-144	2.39E-26	7.38E-27	1.20E-27	0.00E+00	3.90E-27	0.00E+00	1.59E-23
Nd-147	4.95E+04	4.01E+04	3.11E+03	0.00E+00	2.20E+04	0.00E+00	6.35E+07
Eu-152	4.36E+07	7.93E+06	9.42E+06	0.00E+00	3.35E+07	0.00E+00	1.30E+09
W-187	3.72E+04	2.20E+04	9.88E+03	0.00E+00	0.00E+00	0.00E+00	3.10E+06
Np-239	1.48E+03	1.06E+02	7.48E+01	0.00E+00	3.08E+02	0.00E+00	7.88E+06

3.3.4 GRASS-COW-MILK PATHWAY FACTOR

For radionuclides other than tritium and carbon-14 in the grass-cow-milk pathway, R_{aipj} in (m^2·mrem/y) per (μCi/s) is calculated as follows (Reference 11, Section 5.3.1.3):

Eqn A13.3.3.4-1

$$R_{aipj} = K_1 \times \frac{r}{(\lambda_i + \lambda_w)} \times Q_F \times U_{ap} \times F_{mi} \times (DFL)_{aij} \times \left[\frac{f_p f_s}{Y_p} + \frac{(1 - f_p f_s) e^{-\lambda_i t_{hm}}}{Y_s}\right] \times e^{-\lambda_i t_f}$$

where:

K_1 = the units conversion factor: 10^6 pCi/μCi.

r = the fraction of deposited activity retained on cow's feed grass. The value used for r is 1.0 for radioiodines and 0.2 for particulates, from (Reference 11, Table E–1).

λ_i = the radioactive decay constant for radionuclide i, in s^{-1}. Values of λ_i used in effluent calculations should be based on decay data from a recognized and current source, such as Reference 46.

λ_w = the rate constant for removal of activity on leaf and plant surfaces by weathering, in s^{-1}, from Table A13.3.3.4-1.

Q_F = the cow's consumption rate of feed, in kg/d, from Table A13.3.3.4-1.

U_{ap} the consumption rate of cow milk by a receptor in age group a, in L/y, from Table A13.3.3.6-2.

F_{mi} = the stable element transfer coefficient applicable to radionuclide i, for cow's milk, in d/L, from Table A13.3.3.6-3.

$(DFL)_{aij}$ = the ingestion dose factor for receptor age group a, radionuclide i, and organ j, in mrem/pCi, from Table A8-5 through Table A8-8.

f_p = the fraction of the year that the cow is on pasture (dimensionless), from Table A13.3.3.4-1.

f_s = the fraction of the cow's feed that is pasture grass while the cow is on pasture (dimensionless), from Table A13.3.3.4-1.

Y_p = the areal density (agricultural productivity) of growing pasture feed grass, in kg/m^2, from Table A13.3.3.4-1.

Y_s = the areal density (agricultural productivity) of growing stored feed, in kg/m^2, from Table A13.3.3.4-1.

t_{hm} = the transport time from pasture, to harvest, to cow, to milk, to receptor, in s, from Table A13.3.3.4-1.

t_f = the transport time from pasture to cow, to milk, to receptor, in s, from Table A13.3.3.4-1.

For tritium in the grass-cow-milk pathway, R_{aipj} in (mrem/y) per (μCi/m^3) is calculated as follows (Reference 24, Section 5.3.1.5), based on the concentration in air rather than deposition onto the ground:

Eqn A13.3.3.4-2

$$R_{aipj} = K_1 \times K_3 \times Q_F \times U_{ap} \times F_{mi} \times (DFL)_{aij} \times 0.75 \times \left(\frac{0.5}{H}\right)$$

where:

K_3 = the units conversion factor: 10^3 g/kg.

H = the absolute humidity of atmospheric air, in g/m^3, from Table A13.3.3.4-1.

0.75 = the fraction of total feed that is water (dimensionless).

0.5 = the ratio of the specific activity of tritium in feed grass water to that in atmospheric water (dimensionless).

Other parameters are as defined above.

For carbon-14 in the grass-cow-milk pathway, R_{aipj} in (mrem/y) per (μCi/m^3) is calculated from the modified formula as follows (Reference 11, Eqn C-8), based on the concentration in air rather than deposition onto the ground:

$$R_{aipj} = K_1 \; x \; K_3 \; x \; U_{ap} \; x \; F_{mi} \; x \; (DFL)_{aij} \; x \; (p) \; x \; \left(\frac{0.11}{0.16}\right)$$ Eqn A13.3.3.4-3

where:

p = The ratio of the total annual release time (for C-14) atmospheric releases) to the total annual time during photosynthesis occurs (taken to be 4400 hrs), under the condition that the value of p should never exceed unity. For continuous C-14 releases, p is taken to be unity.

0.11 = The fraction of total plant mass that is natural carbon, dimensionless.

0.16 = The concentration of natural carbon in the atmosphere, in g/m^3.

Other parameters are as defined above.

Table A13.3.3.4-1 Miscellaneous Parameters for the Grass-Cow-Meat Pathway

The following parameter values are for use in calculating R_{aipj} for the grass-cow-meat pathway only.

Parameter	Value	Reference
λ_w	5.73×10^{-7} s^{-1} (14-day half-life)	Ref. 24, page 33
Q_F	50 kg/d	Ref. 11, Table E-3
f_p	1.0	Ref. 24, page 33
f_s	1.0	Ref. 24, page 33
Y_p	0.7 kg/m^2	Ref. 11, Table E-15
Y_s	2.0 kg/m^2	Ref. 11, Table E-15
t_{hm}	7.78×10^6 s (90 days)	Ref. 11, Table E-15
t_f	1.73×10^6 s (20 days)	Ref. 11, Table E-15
H	8 g/m^3	Ref. 11

Table A13.3.3.4-2 Site-Related Grass-Cow-Milk R_{aipj} Dose Factors, Adult Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3*	0.00E+00	4.35E+02	4.35E+02	4.35E+02	4.35E+02	4.35E+02	4.35E+02
C-14*	3.63E+05	7.26E+04	7.26E+04	7.26E+04	7.26E+04	7.26E+04	7.26E+04
Na-24	2.44E+06	2.44E+06	2.44E+06	2.44E+06	2.44E+06	2.44E+06	2.44E+06
P-32	1.71E+10	1.06E+09	6.61E+08	0.00E+00	0.00E+00	0.00E+00	1.92E+09
Cr-51	0.00E+00	0.00E+00	2.86E+04	1.71E+04	6.30E+03	3.79E+04	7.19E+06
Mn-54	0.00E+00	8.41E+06	1.61E+06	0.00E+00	2.50E+06	0.00E+00	2.58E+07
Mn-56	0.00E+00	4.15E-03	7.36E-04	0.00E+00	5.27E-03	0.00E+00	1.32E-01
Fe-55	2.51E+07	1.74E+07	4.05E+06	0.00E+00	0.00E+00	9.68E+06	9.95E+06
Fe-59	2.97E+07	6.98E+07	2.68E+07	0.00E+00	0.00E+00	1.95E+07	2.33E+08
Co-57	0.00E+00	1.28E+06	2.13E+06	0.00E+00	0.00E+00	0.00E+00	3.25E+07
Co-58	0.00E+00	4.71E+06	1.06E+07	0.00E+00	0.00E+00	0.00E+00	9.55E+07
Co-60	0.00E+00	1.64E+07	3.62E+07	0.00E+00	0.00E+00	0.00E+00	3.08E+08
Ni-63	6.73E+09	4.66E+08	2.26E+08	0.00E+00	0.00E+00	0.00E+00	9.73E+07
Ni-65	3.70E-01	4.81E-02	2.19E-02	0.00E+00	0.00E+00	0.00E+00	1.22E+00
Cu-64	0.00E+00	2.38E+04	1.12E+04	0.00E+00	6.01E+04	0.00E+00	2.03E+06
Zn-65	1.37E+09	4.37E+09	1.97E+09	0.00E+00	2.92E+09	0.00E+00	2.75E+09
Zn-69m	1.79E+05	4.29E+05	3.93E+04	0.00E+00	2.60E+05	0.00E+00	2.62E+07
Zn-69	2.09E-12	4.00E-12	2.78E-13	0.00E+00	2.60E-12	0.00E+00	6.01E-13
Br-82	0.00E+00	0.00E+00	3.23E+07	0.00E+00	0.00E+00	0.00E+00	3.70E+07
Br-83	0.00E+00	0.00E+00	9.72E-02	0.00E+00	0.00E+00	0.00E+00	1.40E-01
Br-84	0.00E+00	0.00E+00	1.61E-23	0.00E+00	0.00E+00	0.00E+00	1.26E-28
Br-85	0.00E+00	0.00E+00	1.95E-301	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	2.59E+09	1.21E+09	0.00E+00	0.00E+00	0.00E+00	5.12E+08
Rb-88	0.00E+00	2.14E-45	1.13E-45	0.00E+00	0.00E+00	0.00E+00	2.96E-56
Rb-89	0.00E+00	4.33E-53	3.05E-53	0.00E+00	0.00E+00	0.00E+00	2.52E-66
Sr-89	1.45E+09	0.00E+00	4.16E+07	0.00E+00	0.00E+00	0.00E+00	2.33E+08
Sr-90	5.38E+10	0.00E+00	1.08E+09	0.00E+00	0.00E+00	0.00E+00	1.35E+09
Sr-91	2.89E+04	0.00E+00	1.17E+03	0.00E+00	0.00E+00	0.00E+00	1.38E+05
Sr-92	4.88E-01	0.00E+00	2.11E-02	0.00E+00	0.00E+00	0.00E+00	9.68E+00
Y-90	7.08E+01	0.00E+00	1.90E+00	0.00E+00	0.00E+00	0.00E+00	7.51E+05
Y-91m	5.98E-20	0.00E+00	2.32E-21	0.00E+00	0.00E+00	0.00E+00	1.76E-19
Y-91	8.59E+03	0.00E+00	2.30E+02	0.00E+00	0.00E+00	0.00E+00	4.73E+06
Y-92	5.58E-05	0.00E+00	1.63E-06	0.00E+00	0.00E+00	0.00E+00	9.77E-01
Y-93	2.23E-01	0.00E+00	6.17E-03	0.00E+00	0.00E+00	0.00E+00	7.08E+03
Zr-95	9.43E+02	3.03E+02	2.05E+02	0.00E+00	4.75E+02	0.00E+00	9.59E+05
Zr-97	4.33E-01	8.74E-02	4.00E-02	0.00E+00	1.32E-01	0.00E+00	2.71E+04
Nb-95	8.26E+04	4.59E+04	2.47E+04	0.00E+00	4.54E+04	0.00E+00	2.79E+08
Nb-97	3.29E-12	8.32E-13	3.04E-13	0.00E+00	9.71E-13	0.00E+00	3.07E-09
Mo-99	0.00E+00	2.48E+07	4.71E+06	0.00E+00	5.61E+07	0.00E+00	5.74E+07
Tc-99m	3.32E+00	9.38E+00	1.20E+02	0.00E+00	1.43E+02	4.60E+00	5.55E+03
Tc-101	2.59E-60	3.74E-60	3.66E-59	0.00E+00	6.73E-59	1.91E-60	1.12E-71
Ru-103	1.02E+03	0.00E+00	4.39E+02	0.00E+00	3.89E+03	0.00E+00	1.19E+05
Ru-105	8.57E-04	0.00E+00	3.38E-04	0.00E+00	1.11E-02	0.00E+00	5.24E-01

Units are in (m^2·mrem/y) per (μCi/s)
*H-3 and C-14 are in units of (mrem/y) per (μCi/m^3).

Table A13.3.3.4-2 (cont.) Site-Related Grass-Cow-Milk R_{aipj} Dose Factors, Adult Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ru-106	2.04E+04	0.00E+00	2.58E+03	0.00E+00	3.94E+04	0.00E+00	1.32E+06
Rh-105	3.47E+05	2.54E+05	1.67E+05	0.00E+00	1.08E+06	0.00E+00	4.04E+07
Ag-110m	5.82E+07	5.39E+07	3.20E+07	0.00E+00	1.06E+08	0.00E+00	2.20E+10
Cd-113m	0.00E+00	2.94E+06	9.43E+04	0.00E+00	3.24E+06	0.00E+00	2.37E+07
Sb-124	2.57E+07	4.86E+05	1.02E+07	6.24E+04	0.00E+00	2.00E+07	7.31E+08
Sb-125	2.04E+07	2.28E+05	4.86E+06	2.08E+04	0.00E+00	1.58E+07	2.25E+08
Sb-126	5.60E+06	1.14E+05	2.02E+06	3.43E+04	0.00E+00	3.43E+06	4.58E+08
Sb-127	4.50E+05	9.85E+03	1.73E+05	5.41E+03	0.00E+00	2.67E+05	1.03E+08
Te-125m	1.63E+07	5.90E+06	2.18E+06	4.90E+06	6.63E+07	0.00E+00	6.50E+07
Te-127m	4.58E+07	1.64E+07	5.58E+06	1.17E+07	1.86E+08	0.00E+00	1.54E+08
Te-127	6.53E+02	2.34E+02	1.41E+02	4.84E+02	2.66E+03	0.00E+00	5.15E+04
Te-129m	6.02E+07	2.25E+07	9.53E+06	2.07E+07	2.51E+08	0.00E+00	3.03E+08
Te-129	2.82E-10	1.06E-10	6.88E-11	2.17E-10	1.19E-09	0.00E+00	2.13E-10
Te-131m	3.61E+05	1.77E+05	1.47E+05	2.80E+05	1.79E+06	0.00E+00	1.75E+07
Te-131	3.60E-33	1.51E-33	1.14E-33	2.96E-33	1.58E-32	0.00E+00	5.10E-34
Te-132	2.40E+06	1.55E+06	1.46E+06	1.72E+06	1.50E+07	0.00E+00	7.35E+07
I-129	7.58E+08	6.52E+08	2.14E+09	1.68E+12	1.40E+09	0.00E+00	1.03E+08
I-130	4.20E+05	1.24E+06	4.89E+05	1.05E+08	1.93E+06	0.00E+00	1.07E+06
I-131	2.96E+08	4.23E+08	2.43E+08	1.39E+11	7.26E+08	0.00E+00	1.12E+08
I-132	1.64E-01	4.39E-01	1.54E-01	1.54E+01	7.00E-01	0.00E+00	8.25E-02
I-133	3.87E+06	6.73E+06	2.05E+06	9.89E+08	1.17E+07	0.00E+00	6.05E+06
I-134	2.02E-12	5.48E-12	1.96E-12	9.49E-11	8.71E-12	0.00E+00	4.77E-15
I-135	1.28E+04	3.36E+04	1.24E+04	2.22E+06	5.39E+04	0.00E+00	3.80E+04
Cs-134	5.65E+09	1.35E+10	1.10E+10	0.00E+00	4.35E+09	1.45E+09	2.35E+08
Cs-135	1.81E+09	1.67E+09	7.41E+08	0.00E+00	6.32E+08	1.89E+08	3.90E+07
Cs-136	2.63E+08	1.04E+09	7.48E+08	0.00E+00	5.78E+08	7.93E+07	1.18E+08
Cs-137	7.38E+09	1.01E+10	6.61E+09	0.00E+00	3.43E+09	1.14E+09	1.95E+08
Cs-138	9.04E-24	1.79E-23	8.85E-24	0.00E+00	1.31E-23	1.30E-24	7.62E-29
Ba-139	4.42E-08	3.15E-11	1.29E-09	0.00E+00	2.94E-11	1.79E-11	7.84E-08
Ba-140	2.69E+07	3.38E+04	1.76E+06	0.00E+00	1.15E+04	1.93E+04	5.53E+07
Ba-141	4.09E-46	3.09E-49	1.38E-47	0.00E+00	2.88E-49	1.76E-49	1.93E-55
Ba-142	2.66E-80	2.73E-83	1.67E-81	0.00E+00	2.31E-83	1.55E-83	3.74E-98
La-140	4.51E+00	2.27E+00	6.01E-01	0.00E+00	0.00E+00	0.00E+00	1.67E+05
La-142	1.86E-11	8.45E-12	2.10E-12	0.00E+00	0.00E+00	0.00E+00	6.17E-08
Ce-141	4.84E+03	3.28E+03	3.72E+02	0.00E+00	1.52E+03	0.00E+00	1.25E+07
Ce-143	4.16E+01	3.07E+04	3.40E+00	0.00E+00	1.35E+01	0.00E+00	1.15E+06
Ce-144	3.58E+05	1.50E+05	1.92E+04	0.00E+00	8.87E+04	0.00E+00	1.21E+08
Pr-143	1.58E+02	6.33E+01	7.83E+00	0.00E+00	3.66E+01	0.00E+00	6.92E+05
Pr-144	5.87E-54	2.44E-54	2.98E-55	0.00E+00	1.37E-54	0.00E+00	8.44E-61
Nd-147	9.42E+01	1.09E+02	6.51E+00	0.00E+00	6.36E+01	0.00E+00	5.22E+05
Eu-152	7.51E+03	1.71E+03	1.50E+03	0.00E+00	1.06E+04	0.00E+00	9.86E+05
W-187	6.51E+03	5.45E+03	1.90E+03	0.00E+00	0.00E+00	0.00E+00	1.78E+06
Np-239	3.67E+00	3.61E-01	1.99E-01	0.00E+00	1.13E+00	0.00E+00	7.41E+04

Table A13.3.3.4-3 Site-Related Grass-Cow-Milk R_{aipj} Dose Factors, Teenager Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3*	0.00E+00	5.66E+02	5.66E+02	5.66E+02	5.66E+02	5.66E+02	5.66E+02
C-14*	6.70E+05	1.34E+05	1.34E+05	1.34E+05	1.34E+05	1.34E+05	1.34E+05
Na-24	4.26E+06	4.26E+06	4.26E+06	4.26E+06	4.26E+06	4.26E+06	4.26E+06
P-32	3.15E+10	1.95E+09	1.22E+09	0.00E+00	0.00E+00	0.00E+00	2.65E+09
Cr-51	0.00E+00	0.00E+00	4.99E+04	2.77E+04	1.09E+04	7.13E+04	8.39E+06
Mn-54	0.00E+00	1.40E+07	2.78E+06	0.00E+00	4.18E+06	0.00E+00	2.87E+07
Mn-56	0.00E+00	7.36E-03	1.31E-03	0.00E+00	9.31E-03	0.00E+00	4.84E-01
Fe-55	4.45E+07	3.16E+07	7.36E+06	0.00E+00	0.00E+00	2.00E+07	1.37E+07
Fe-59	5.18E+07	1.21E+08	4.67E+07	0.00E+00	0.00E+00	3.81E+07	2.86E+08
Co-57	0.00E+00	2.25E+06	3.76E+06	0.00E+00	0.00E+00	0.00E+00	4.19E+07
Co-58	0.00E+00	7.94E+06	1.83E+07	0.00E+00	0.00E+00	0.00E+00	1.09E+08
Co-60	0.00E+00	2.78E+07	6.26E+07	0.00E+00	0.00E+00	0.00E+00	3.62E+08
Ni-63	1.18E+10	8.35E+08	4.01E+08	0.00E+00	0.00E+00	0.00E+00	1.33E+08
Ni-65	6.77E-01	8.65E-02	3.94E-02	0.00E+00	0.00E+00	0.00E+00	4.69E+00
Cu-64	0.00E+00	4.25E+04	2.00E+04	0.00E+00	1.07E+05	0.00E+00	3.29E+06
Zn-65	2.11E+09	7.32E+09	3.41E+09	0.00E+00	4.68E+09	0.00E+00	3.10E+09
Zn-69m	3.26E+05	7.69E+05	7.05E+04	0.00E+00	4.67E+05	0.00E+00	4.22E+07
Zn-69	3.85E-12	7.34E-12	5.13E-13	0.00E+00	4.79E-12	0.00E+00	1.35E-11
Br-82	0.00E+00	0.00E+00	5.61E+07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-83	0.00E+00	0.00E+00	1.79E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	2.88E-23	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	3.59E-301	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	4.73E+09	2.22E+09	0.00E+00	0.00E+00	0.00E+00	7.00E+08
Rb-88	0.00E+00	3.89E-45	2.07E-45	0.00E+00	0.00E+00	0.00E+00	3.33E-52
Rb-89	0.00E+00	7.66E-53	5.42E-53	0.00E+00	0.00E+00	0.00E+00	1.17E-61
Sr-89	2.67E+09	0.00E+00	7.66E+07	0.00E+00	0.00E+00	0.00E+00	3.19E+08
Sr-90	8.13E+10	0.00E+00	1.63E+09	0.00E+00	0.00E+00	0.00E+00	1.86E+09
Sr-91	5.31E+04	0.00E+00	2.11E+03	0.00E+00	0.00E+00	0.00E+00	2.41E+05
Sr-92	8.94E-01	0.00E+00	3.81E-02	0.00E+00	0.00E+00	0.00E+00	2.28E+01
Y-90	1.30E+02	0.00E+00	3.51E+00	0.00E+00	0.00E+00	0.00E+00	1.07E+06
Y-91m	1.10E-19	0.00E+00	4.19E-21	0.00E+00	0.00E+00	0.00E+00	5.17E-18
Y-91	1.58E+04	0.00E+00	4.24E+02	0.00E+00	0.00E+00	0.00E+00	6.48E+06
Y-92	1.03E-04	0.00E+00	2.98E-06	0.00E+00	0.00E+00	0.00E+00	2.83E+00
Y-93	4.12E-01	0.00E+00	1.13E-02	0.00E+00	0.00E+00	0.00E+00	1.26E+04
Zr-95	1.65E+03	5.20E+02	3.58E+02	0.00E+00	7.65E+02	0.00E+00	1.20E+06
Zr-97	7.88E-01	1.56E-01	7.19E-02	0.00E+00	2.37E-01	0.00E+00	4.22E+04
Nb-95	1.41E+05	7.81E+04	4.30E+04	0.00E+00	7.57E+04	0.00E+00	3.34E+08
Nb-97	5.99E-12	1.49E-12	5.43E-13	0.00E+00	1.74E-12	0.00E+00	3.55E-08
Mo-99	0.00E+00	4.47E+07	8.53E+06	0.00E+00	1.02E+08	0.00E+00	8.01E+07
Tc-99m	5.76E+00	1.61E+01	2.08E+02	0.00E+00	2.39E+02	8.92E+00	1.05E+04
Tc-101	4.74E-60	6.74E-60	6.62E-59	0.00E+00	1.22E-58	4.11E-60	1.15E-66
Ru-103	1.81E+03	0.00E+00	7.74E+02	0.00E+00	6.38E+03	0.00E+00	1.51E+05
Ru-105	1.56E-03	0.00E+00	6.07E-04	0.00E+00	1.97E-02	0.00E+00	1.26E+00

Units are in (m^2·mrem/y) per (μCi/s)
*H-3 and C-14 are in units of (mrem/y) per ($\mu Ci/m^3$).

Table A13.3.3.4-3 (cont.) Site-Related Grass-Cow-Milk R_{aipj} Dose Factors, Teenager Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ru-106	3.75E+04	0.00E+00	4.73E+03	0.00E+00	7.24E+04	0.00E+00	1.80E+06
Rh-105	6.40E+05	4.63E+05	3.04E+05	0.00E+00	1.97E+06	0.00E+00	5.89E+07
Ag-110m	9.63E+07	9.11E+07	5.54E+07	0.00E+00	1.74E+08	0.00E+00	2.56E+10
Cd-113m	0.00E+00	5.38E+06	1.73E+05	0.00E+00	5.95E+06	0.00E+00	3.23E+07
Sb-124	4.59E+07	8.46E+05	1.79E+07	1.04E+05	0.00E+00	4.01E+07	9.25E+08
Sb-125	3.65E+07	3.99E+05	8.55E+06	3.49E+04	0.00E+00	3.21E+07	2.84E+08
Sb-126	9.99E+06	2.04E+05	3.59E+06	5.65E+04	0.00E+00	7.16E+06	5.91E+08
Sb-127	8.17E+05	1.75E+04	3.08E+05	9.18E+03	0.00E+00	5.56E+05	1.39E+08
Te-125m	3.00E+07	1.08E+07	4.02E+06	8.39E+06	0.00E+00	0.00E+00	8.86E+07
Te-127m	8.44E+07	2.99E+07	1.00E+07	2.01E+07	3.42E+08	0.00E+00	2.10E+08
Te-127	1.21E+03	4.29E+02	2.60E+02	8.35E+02	4.90E+03	0.00E+00	9.34E+04
Te-129m	1.10E+08	4.09E+07	1.74E+07	3.55E+07	4.61E+08	0.00E+00	4.13E+08
Te-129	5.20E-10	1.94E-10	1.26E-10	3.71E-10	2.18E-09	0.00E+00	2.84E-09
Te-131m	6.57E+05	3.15E+05	2.63E+05	4.74E+05	3.29E+06	0.00E+00	2.53E+07
Te-131	6.58E-33	2.71E-33	2.06E-33	5.07E-33	2.88E-32	0.00E+00	5.40E-34
Te-132	4.29E+06	2.72E+06	2.56E+06	2.87E+06	2.61E+07	0.00E+00	8.61E+07
I-129	1.39E+09	1.17E+09	1.96E+09	1.43E+12	2.10E+09	0.00E+00	1.37E+08
I-130	7.38E+05	2.14E+06	8.53E+05	1.74E+08	3.29E+06	0.00E+00	1.64E+06
I-131	5.37E+08	7.52E+08	4.04E+08	2.19E+11	1.29E+09	0.00E+00	1.49E+08
I-132	2.91E-01	7.62E-01	2.74E-01	2.57E+01	1.20E+00	0.00E+00	3.32E-01
I-133	7.07E+06	1.20E+07	3.66E+06	1.67E+09	2.10E+07	0.00E+00	9.07E+06
I-134	3.58E-12	9.50E-12	3.41E-12	1.58E-10	1.50E-11	0.00E+00	1.25E-13
I-135	2.28E+04	5.87E+04	2.18E+04	3.78E+06	9.27E+04	0.00E+00	6.51E+04
Cs-134	9.82E+09	2.31E+10	1.07E+10	0.00E+00	7.34E+09	2.80E+09	2.87E+08
Cs-135	3.33E+09	3.05E+09	7.13E+08	0.00E+00	1.16E+09	4.21E+08	5.34E+07
Cs-136	4.48E+08	1.76E+09	1.18E+09	0.00E+00	9.60E+08	1.51E+08	1.42E+08
Cs-137	1.34E+10	1.78E+10	6.20E+09	0.00E+00	6.06E+09	2.35E+09	2.53E+08
Cs-138	1.64E-23	3.15E-23	1.57E-23	0.00E+00	2.33E-23	2.71E-24	1.43E-26
Ba-139	8.17E-08	5.75E-11	2.38E-09	0.00E+00	5.42E-11	3.96E-11	7.29E-07
Ba-140	4.85E+07	5.95E+04	3.13E+06	0.00E+00	2.02E+04	4.00E+04	7.48E+07
Ba-141	7.52E-46	5.62E-49	2.51E-47	0.00E+00	5.21E-49	3.85E-49	1.60E-51
Ba-142	4.81E-80	4.81E-83	2.96E-81	0.00E+00	4.07E-83	3.20E-83	1.48E-91
La-140	8.10E+00	3.98E+00	1.06E+00	0.00E+00	0.00E+00	0.00E+00	2.29E+05
La-142	3.35E-11	1.49E-11	3.71E-12	0.00E+00	0.00E+00	0.00E+00	4.53E-07
Ce-141	8.88E+03	5.93E+03	6.81E+02	0.00E+00	2.79E+03	0.00E+00	1.70E+07
Ce-143	7.64E+01	5.56E+04	6.21E+00	0.00E+00	2.49E+01	0.00E+00	1.67E+06
Ce-144	6.58E+05	2.72E+05	3.54E+04	0.00E+00	1.63E+05	0.00E+00	1.66E+08
Pr-143	2.90E+02	1.16E+02	1.44E+01	0.00E+00	6.73E+01	0.00E+00	9.54E+05
Pr-144	1.08E-53	4.43E-54	5.48E-55	0.00E+00	2.54E-54	0.00E+00	1.19E-56
Nd-147	1.81E+02	1.97E+02	1.18E+01	0.00E+00	1.16E+02	0.00E+00	7.11E+05
Eu-152	1.22E+04	2.93E+03	2.58E+03	0.00E+00	1.36E+04	0.00E+00	1.08E+06
W-187	1.19E+04	9.71E+03	3.40E+03	0.00E+00	0.00E+00	0.00E+00	2.63E+06
Np-239	7.01E+00	6.61E-01	3.67E-01	0.00E+00	2.07E+00	0.00E+00	1.06E+05

Table A13.3.3.4-4 Site-Related Grass-Cow-Milk R_{aipj} Dose Factors, Child Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3*	0.00E+00	8.97E+02	8.97E+02	8.97E+02	8.97E+02	8.97E+02	8.97E+02
C-14*	1.65E+06	3.29E+05	3.29E+05	3.29E+05	3.29E+05	3.29E+05	3.29E+05
Na-24	8.85E+06	8.85E+06	8.85E+06	8.85E+06	8.85E+06	8.85E+06	8.85E+06
P-32	7.78E+10	3.64E+09	3.00E+09	0.00E+00	0.00E+00	0.00E+00	2.15E+09
Cr-51	0.00E+00	0.00E+00	1.02E+05	5.65E+04	1.54E+04	1.03E+05	5.40E+06
Mn-54	0.00E+00	2.10E+07	5.59E+06	0.00E+00	5.88E+06	0.00E+00	1.76E+07
Mn-56	0.00E+00	1.28E-02	2.90E-03	0.00E+00	1.55E-02	0.00E+00	1.86E+00
Fe-55	1.12E+08	5.93E+07	1.84E+07	0.00E+00	0.00E+00	3.35E+07	1.10E+07
Fe-59	1.20E+08	1.95E+08	9.69E+07	0.00E+00	0.00E+00	5.64E+07	2.03E+08
Co-57	0.00E+00	3.84E+06	7.77E+06	0.00E+00	0.00E+00	0.00E+00	3.14E+07
Co-58	0.00E+00	1.21E+07	3.71E+07	0.00E+00	0.00E+00	0.00E+00	7.07E+07
Co-60	0.00E+00	4.32E+07	1.27E+08	0.00E+00	0.00E+00	0.00E+00	2.39E+08
Ni-63	2.96E+10	1.59E+09	1.01E+09	0.00E+00	0.00E+00	0.00E+00	1.07E+08
Ni-65	1.66E+00	1.56E-01	9.10E-02	0.00E+00	0.00E+00	0.00E+00	1.91E+01
Cu-64	0.00E+00	7.46E+04	4.51E+04	0.00E+00	1.80E+05	0.00E+00	3.50E+06
Zn-65	4.13E+09	1.10E+10	6.85E+09	0.00E+00	6.94E+09	0.00E+00	1.93E+09
Zn-69m	7.96E+05	1.36E+06	1.60E+05	0.00E+00	7.88E+05	0.00E+00	4.41E+07
Zn-69	9.47E-12	1.37E-11	1.26E-12	0.00E+00	8.30E-12	0.00E+00	8.62E-10
Br-82	0.00E+00	0.00E+00	1.15E+08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-83	0.00E+00	0.00E+00	4.40E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	6.51E-23	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	8.85E-301	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	8.77E+09	5.39E+09	0.00E+00	0.00E+00	0.00E+00	5.64E+08
Rb-88	0.00E+00	7.15E-45	4.97E-45	0.00E+00	0.00E+00	0.00E+00	3.51E-46
Rb-89	0.00E+00	1.34E-52	1.20E-52	0.00E+00	0.00E+00	0.00E+00	1.17E-54
Sr-89	6.62E+09	0.00E+00	1.89E+08	0.00E+00	0.00E+00	0.00E+00	2.56E+08
Sr-90	1.68E+11	0.00E+00	3.38E+09	0.00E+00	0.00E+00	0.00E+00	1.51E+09
Sr-91	1.30E+05	0.00E+00	4.92E+03	0.00E+00	0.00E+00	0.00E+00	2.88E+05
Sr-92	2.18E+00	0.00E+00	8.75E-02	0.00E+00	0.00E+00	0.00E+00	4.13E+01
Y-90	3.22E+02	0.00E+00	8.62E+00	0.00E+00	0.00E+00	0.00E+00	9.17E+05
Y-91m	2.68E-19	0.00E+00	9.74E-21	0.00E+00	0.00E+00	0.00E+00	5.24E-16
Y-91	3.90E+04	0.00E+00	1.04E+03	0.00E+00	0.00E+00	0.00E+00	5.20E+06
Y-92	2.53E-04	0.00E+00	7.24E-06	0.00E+00	0.00E+00	0.00E+00	7.31E+00
Y-93	1.01E+00	0.00E+00	2.78E-02	0.00E+00	0.00E+00	0.00E+00	1.51E+04
Zr-95	3.83E+03	8.42E+02	7.50E+02	0.00E+00	1.21E+03	0.00E+00	8.79E+05
Zr-97	1.92E+00	2.77E-01	1.64E-01	0.00E+00	3.98E-01	0.00E+00	4.20E+04
Nb-95	3.18E+05	1.24E+05	8.84E+04	0.00E+00	1.16E+05	0.00E+00	2.29E+08
Nb-97	1.46E-11	2.63E-12	1.23E-12	0.00E+00	2.92E-12	0.00E+00	8.12E-07
Mo-99	0.00E+00	8.14E+07	2.01E+07	0.00E+00	1.74E+08	0.00E+00	6.73E+07
Tc-99m	1.32E+01	2.59E+01	4.29E+02	0.00E+00	3.76E+02	1.32E+01	1.47E+04
Tc-101	1.16E-59	1.22E-59	1.54E-58	0.00E+00	2.08E-58	6.43E-60	3.87E-59
Ru-103	4.28E+03	0.00E+00	1.65E+03	0.00E+00	1.08E+04	0.00E+00	1.11E+05
Ru-105	3.82E-03	0.00E+00	1.39E-03	0.00E+00	3.36E-02	0.00E+00	2.49E+00

Units are in ($m^2 \cdot mrem/y$) per ($\mu Ci/s$)
*H-3 and C-14 are in units of (mrem/y) per ($\mu Ci/m^3$).

Table A13.3.3.4-4 (cont.) Site-Related Grass-Cow-Milk R_{aipj} Dose Factors, Child Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ru-106	9.24E+04	0.00E+00	1.15E+04	0.00E+00	1.25E+05	0.00E+00	1.44E+06
Rh-105	1.57E+06	8.43E+05	7.21E+05	0.00E+00	3.36E+06	0.00E+00	5.22E+07
Ag-110m	2.09E+08	1.41E+08	1.13E+08	0.00E+00	2.63E+08	0.00E+00	1.68E+10
Cd-113m	0.00E+00	1.00E+07	4.27E+05	0.00E+00	1.03E+07	0.00E+00	2.59E+07
Sb-124	1.09E+08	1.41E+06	3.81E+07	2.40E+05	0.00E+00	6.03E+07	6.79E+08
Sb-125	8.70E+07	6.71E+05	1.82E+07	8.06E+04	0.00E+00	4.85E+07	2.08E+08
Sb-126	2.28E+07	3.49E+05	8.19E+06	1.34E+05	0.00E+00	1.09E+07	4.60E+08
Sb-127	1.97E+06	3.04E+04	6.83E+05	2.19E+04	0.00E+00	8.54E+05	1.11E+08
Te-125m	7.38E+07	2.00E+07	9.84E+06	2.07E+07	0.00E+00	0.00E+00	7.12E+07
Te-127m	2.08E+08	5.60E+07	2.47E+07	4.97E+07	5.93E+08	0.00E+00	1.68E+08
Te-127	2.98E+03	8.02E+02	6.38E+02	2.06E+03	8.47E+03	0.00E+00	1.16E+05
Te-129m	2.71E+08	7.58E+07	4.21E+07	8.75E+07	7.97E+08	0.00E+00	3.31E+08
Te-129	1.28E-09	3.58E-10	3.04E-10	9.15E-10	3.75E-09	0.00E+00	7.98E-08
Te-131m	1.60E+06	5.53E+05	5.89E+05	1.14E+06	5.35E+06	0.00E+00	2.24E+07
Te-131	1.62E-32	4.93E-33	4.81E-33	1.24E-32	4.89E-32	0.00E+00	8.49E-32
Te-132	1.02E+07	4.53E+06	5.48E+06	6.60E+06	4.21E+07	0.00E+00	4.57E+07
I-129	3.43E+09	2.11E+09	1.88E+09	1.38E+12	3.55E+09	0.00E+00	1.06E+08
I-130	1.73E+06	3.49E+06	1.80E+06	3.84E+08	5.22E+06	0.00E+00	1.63E+06
I-131	1.30E+09	1.31E+09	7.45E+08	4.33E+11	2.15E+09	0.00E+00	1.17E+08
I-132	6.89E-01	1.27E+00	5.82E-01	5.87E+01	1.94E+00	0.00E+00	1.49E+00
I-133	1.72E+07	2.12E+07	8.03E+06	3.94E+09	3.54E+07	0.00E+00	8.56E+06
I-134	8.48E-12	1.58E-11	7.25E-12	3.62E-10	2.41E-11	0.00E+00	1.04E-11
I-135	5.40E+04	9.72E+04	4.60E+04	8.61E+06	1.49E+05	0.00E+00	7.40E+04
Cs-134	2.26E+10	3.72E+10	7.84E+09	0.00E+00	1.15E+10	4.13E+09	2.00E+08
Cs-135	8.19E+09	5.71E+09	5.85E+08	0.00E+00	2.01E+09	6.72E+08	4.27E+07
Cs-136	1.01E+09	2.78E+09	1.80E+09	0.00E+00	1.48E+09	2.21E+08	9.77E+07
Cs-137	3.22E+10	3.09E+10	4.55E+09	0.00E+00	1.01E+10	3.62E+09	1.93E+08
Cs-138	3.98E-23	5.53E-23	3.51E-23	0.00E+00	3.89E-23	4.19E-24	2.55E-23
Ba-139	2.01E-07	1.07E-10	5.82E-09	0.00E+00	9.36E-11	6.30E-11	1.16E-05
Ba-140	1.17E+08	1.03E+05	6.84E+06	0.00E+00	3.34E+04	6.12E+04	5.93E+07
Ba-141	1.85E-45	1.04E-48	6.02E-47	0.00E+00	8.96E-49	6.09E-48	1.05E-45
Ba-142	1.16E-79	8.35E-83	6.48E-81	0.00E+00	6.76E-83	4.91E-83	1.51E-81
La-140	1.94E+01	6.78E+00	2.29E+00	0.00E+00	0.00E+00	0.00E+00	1.89E+05
La-142	8.10E-11	2.58E-11	8.08E-12	0.00E+00	0.00E+00	0.00E+00	5.11E-06
Ce-141	2.19E+04	1.09E+04	1.62E+03	0.00E+00	4.78E+03	0.00E+00	1.36E+07
Ce-143	1.87E+02	1.02E+05	1.47E+01	0.00E+00	4.26E+01	0.00E+00	1.49E+06
Ce-144	1.62E+06	5.09E+05	8.66E+04	0.00E+00	2.82E+05	0.00E+00	1.33E+08
Pr-143	7.18E+02	2.16E+02	3.56E+01	0.00E+00	1.17E+02	0.00E+00	7.75E+05
Pr-144	2.68E-53	8.28E-54	1.35E-54	0.00E+00	4.38E-54	0.00E+00	1.78E-50
Nd-147	4.45E+02	3.60E+02	2.79E+01	0.00E+00	1.98E+02	0.00E+00	5.70E+05
Eu-152	2.52E+04	4.59E+03	5.45E+03	0.00E+00	1.94E+04	0.00E+00	7.55E+05
W-187	2.89E+04	1.71E+04	7.68E+03	0.00E+00	0.00E+00	0.00E+00	2.40E+06
Np-239	1.72E+01	1.24E+00	8.71E-01	0.00E+00	3.58E+00	0.00E+00	9.17E+04

Table A13.3.3.4-5 Site-Related Grass-Cow-Milk R_{aipj} Dose Factors, Infant Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3*	0.00E+00	1.36E+03	1.36E+03	1.36E+03	1.36E+03	1.36E+03	1.36E+03
C-14*	3.23E+06	6.89E+05	6.89E+05	6.89E+05	6.89E+05	6.89E+05	6.89E+05
Na-24	1.54E+07	1.54E+07	1.54E+07	1.54E+07	1.54E+07	1.54E+07	1.54E+07
P-32	1.60E+11	9.43E+09	6.21E+09	0.00E+00	0.00E+00	0.00E+00	2.17E+09
Cr-51	0.00E+00	0.00E+00	1.61E+05	1.05E+05	2.30E+04	2.05E+05	4.70E+06
Mn-54	0.00E+00	3.90E+07	8.84E+06	0.00E+00	8.64E+06	0.00E+00	1.43E+07
Mn-56	0.00E+00	3.14E-02	5.42E-03	0.00E+00	2.70E-02	0.00E+00	2.85E+00
Fe-55	1.35E+08	8.73E+07	2.33E+07	0.00E+00	0.00E+00	4.27E+07	1.11E+07
Fe-59	2.24E+08	3.92E+08	1.54E+08	0.00E+00	0.00E+00	1.16E+08	1.87E+08
Co-57	0.00E+00	8.95E+06	1.46E+07	0.00E+00	0.00E+00	0.00E+00	3.05E+07
Co-58	0.00E+00	2.42E+07	6.05E+07	0.00E+00	0.00E+00	0.00E+00	6.04E+07
Co-60	0.00E+00	8.82E+07	2.08E+08	0.00E+00	0.00E+00	0.00E+00	2.10E+08
Ni-63	3.49E+10	2.16E+09	1.21E+09	0.00E+00	0.00E+00	0.00E+00	1.07E+08
Ni-65	3.50E+00	3.97E-01	1.80E-01	0.00E+00	0.00E+00	0.00E+00	3.02E+01
Cu-64	0.00E+00	1.86E+05	8.59E+04	0.00E+00	3.14E+05	0.00E+00	3.81E+06
Zn-65	5.55E+09	1.90E+10	8.78E+09	0.00E+00	9.23E+09	0.00E+00	1.61E+10
Zn-69m	1.68E+06	3.43E+06	3.13E+05	0.00E+00	1.39E+06	0.00E+00	4.75E+07
Zn-69	2.02E-11	3.63E-11	2.70E-12	0.00E+00	1.51E-11	0.00E+00	2.96E-09
Br-82	0.00E+00	0.00E+00	1.93E+08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-83	0.00E+00	0.00E+00	9.34E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	1.26E-22	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	1.88E-300	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	2.23E+10	1.10E+10	0.00E+00	0.00E+00	0.00E+00	5.69E+08
Rb-88	0.00E+00	1.87E-44	1.03E-44	0.00E+00	0.00E+00	0.00E+00	1.83E-44
Rb-89	0.00E+00	3.29E-52	2.26E-52	0.00E+00	0.00E+00	0.00E+00	1.12E-52
Sr-89	1.26E+10	0.00E+00	3.61E+08	0.00E+00	0.00E+00	0.00E+00	2.59E+08
Sr-90	1.86E+11	0.00E+00	3.77E+09	0.00E+00	0.00E+00	0.00E+00	1.52E+09
Sr-91	2.72E+05	0.00E+00	9.83E+03	0.00E+00	0.00E+00	0.00E+00	3.21E+05
Sr-92	4.64E+00	0.00E+00	1.72E-01	0.00E+00	0.00E+00	0.00E+00	5.00E+01
Y-90	6.81E+02	0.00E+00	1.83E+01	0.00E+00	0.00E+00	0.00E+00	9.41E+05
Y-91m	5.67E-19	0.00E+00	1.93E-20	0.00E+00	0.00E+00	0.00E+00	1.89E-15
Y-91	7.33E+04	0.00E+00	1.95E+03	0.00E+00	0.00E+00	0.00E+00	5.25E+06
Y-92	5.38E-04	0.00E+00	1.51E-05	0.00E+00	0.00E+00	0.00E+00	1.03E+01
Y-93	2.16E+00	0.00E+00	5.87E-02	0.00E+00	0.00E+00	0.00E+00	1.70E+04
Zr-95	6.80E+03	1.66E+03	1.18E+03	0.00E+00	1.79E+03	0.00E+00	8.26E+05
Zr-97	4.06E+00	6.97E-01	3.18E-01	0.00E+00	7.03E-01	0.00E+00	4.45E+04
Nb-95	5.93E+05	2.44E+05	1.41E+05	0.00E+00	1.75E+05	0.00E+00	2.06E+08
Nb-97	3.08E-11	6.57E-12	2.37E-12	0.00E+00	5.13E-12	0.00E+00	2.07E-06
Mo-99	0.00E+00	2.08E+08	4.06E+07	0.00E+00	3.11E+08	0.00E+00	6.85E+07
Tc-99m	2.75E+01	5.67E+01	7.30E+02	0.00E+00	6.10E+02	2.96E+01	1.65E+04
Tc-101	2.47E-59	3.11E-59	3.07E-58	0.00E+00	3.69E-58	1.69E-59	5.28E-57
Ru-103	8.67E+03	0.00E+00	2.90E+03	0.00E+00	1.80E+04	0.00E+00	1.05E+05
Ru-105	8.05E-03	0.00E+00	2.71E-03	0.00E+00	5.92E-02	0.00E+00	3.20E+00

Units are in ($m^2 \cdot$mrem/y) per (μCi/s)
*H-3 and C-14 are in units of (mrem/y) per ($\mu Ci/m^3$).

Table A13.3.3.4-5 (cont.) Site-Related Grass-Cow-Milk R_{aipj} Dose Factors, Infant Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ru-106	1.90E+05	0.00E+00	2.38E+04	0.00E+00	2.25E+05	0.00E+00	1.44E+06
Rh-105	3.33E+06	2.18E+06	1.46E+06	0.00E+00	6.05E+06	0.00E+00	5.41E+07
Ag-110m	3.86E+08	2.82E+08	1.86E+08	0.00E+00	4.03E+08	0.00E+00	1.46E+10
Cd-113m	0.00E+00	1.74E+07	6.42E+05	0.00E+00	1.32E+07	0.00E+00	2.62E+07
Sb-124	2.09E+08	3.08E+06	6.49E+07	5.56E+05	0.00E+00	1.31E+08	6.46E+08
Sb-125	1.50E+08	1.45E+06	3.08E+07	1.87E+05	0.00E+00	8.66E+07	1.99E+08
Sb-126	4.18E+07	8.19E+05	1.51E+07	3.21E+05	0.00E+00	2.63E+07	4.33E+08
Sb-127	4.14E+06	7.39E+04	1.28E+06	5.27E+04	0.00E+00	2.13E+06	1.10E+08
Te-125m	1.51E+08	5.04E+07	2.04E+07	5.07E+07	0.00E+00	0.00E+00	7.18E+07
Te-127m	4.21E+08	1.40E+08	5.10E+07	1.22E+08	1.04E+09	0.00E+00	1.70E+08
Te-127	6.32E+03	2.12E+03	1.36E+03	5.14E+03	1.54E+04	0.00E+00	1.33E+05
Te-129m	5.57E+08	1.91E+08	8.58E+07	2.14E+08	1.39E+09	0.00E+00	3.33E+08
Te-129	2.72E-09	9.37E-10	6.35E-10	2.28E-09	6.77E-09	0.00E+00	2.17E-07
Te-131m	3.38E+06	1.36E+06	1.12E+06	2.75E+06	9.35E+06	0.00E+00	2.29E+07
Te-131	3.43E-32	1.27E-32	9.62E-33	3.06E-32	8.76E-32	0.00E+00	1.38E-30
Te-132	2.11E+07	1.04E+07	9.75E+06	1.54E+07	6.53E+07	0.00E+00	3.87E+07
I-129	7.06E+09	5.23E+09	3.83E+09	3.36E+12	6.20E+09	0.00E+00	1.05E+08
I-130	3.55E+06	7.81E+06	3.13E+06	8.75E+08	8.58E+06	0.00E+00	1.67E+06
I-131	2.72E+09	3.20E+09	1.41E+09	1.05E+12	3.74E+09	0.00E+00	1.14E+08
I-132	1.43E+00	2.90E+00	1.03E+00	1.36E+02	3.24E+00	0.00E+00	2.35E+00
I-133	3.63E+07	5.28E+07	1.55E+07	9.60E+09	6.21E+07	0.00E+00	8.93E+06
I-134	1.76E-11	3.60E-11	1.28E-11	8.40E-10	4.03E-11	0.00E+00	3.73E-11
I-135	1.12E+05	2.23E+05	8.14E+04	2.00E+07	2.49E+05	0.00E+00	8.08E+04
Cs-134	3.65E+10	6.80E+10	6.87E+09	0.00E+00	1.75E+10	7.18E+09	1.85E+08
Cs-135	1.31E+10	1.19E+10	6.22E+08	0.00E+00	3.40E+09	1.29E+09	4.31E+07
Cs-136	1.98E+09	5.81E+09	2.17E+09	0.00E+00	2.32E+09	4.74E+08	8.82E+07
Cs-137	5.15E+10	6.02E+10	4.27E+09	0.00E+00	1.62E+10	6.55E+09	1.88E+08
Cs-138	8.39E-23	1.36E-22	6.61E-23	0.00E+00	6.80E-23	1.06E-23	2.18E-22
Ba-139	4.27E-07	2.83E-10	1.24E-08	0.00E+00	1.70E-10	1.72E-10	2.71E-05
Ba-140	2.41E+08	2.41E+05	1.24E+07	0.00E+00	5.72E+04	1.48E+05	5.92E+07
Ba-141	3.93E-45	2.69E-48	1.24E-46	0.00E+00	1.62E-48	1.64E-48	4.80E-44
Ba-142	2.44E-79	2.03E-82	1.20E-80	0.00E+00	1.17E-82	1.23E-82	1.01E-78
La-140	4.05E+01	1.60E+01	4.11E+00	0.00E+00	0.00E+00	0.00E+00	1.88E+05
La-142	1.70E-10	6.24E-11	1.49E-11	0.00E+00	0.00E+00	0.00E+00	1.06E-05
Ce-141	4.34E+04	2.64E+04	3.11E+03	0.00E+00	8.15E+03	0.00E+00	1.37E+07
Ce-143	3.97E+02	2.63E+05	3.00E+01	0.00E+00	7.67E+01	0.00E+00	1.54E+06
Ce-144	2.33E+06	9.52E+05	1.30E+05	0.00E+00	3.85E+05	0.00E+00	1.33E+08
Pr-143	1.49E+03	5.55E+02	7.36E+01	0.00E+00	2.06E+02	0.00E+00	7.84E+05
Pr-144	5.69E-53	2.20E-53	2.86E-54	0.00E+00	7.97E-54	0.00E+00	1.02E-48
Nd-147	8.81E+02	9.05E+02	5.55E+01	0.00E+00	3.49E+02	0.00E+00	5.74E+05
Eu-152	2.76E+04	7.34E+03	6.19E+03	0.00E+00	2.06E+04	0.00E+00	6.52E+05
W-187	6.08E+04	4.23E+04	1.46E+04	0.00E+00	0.00E+00	0.00E+00	2.48E+06
Np-239	3.65E+01	3.26E+00	1.84E+00	0.00E+00	6.51E+00	0.00E+00	9.43E+04

3.3.5 GRASS-GOAT-MILK PATHWAY FACTOR

For radionuclides other than tritium and C-14 in the grass-goat-milk pathway, R_{aipj} in (m^2·mrem/y) per (μCi/s) is calculated as follows (Reference 24, Section 5.3.1.3):

Eqn A13.3.3.5-1

$$R_{aipj} = K_1 \times \frac{r}{(\lambda_i + \lambda_w)} \times Q_F \times U_{ap} \times F_{mi} \times (DFL)_{aij} \times \left[\frac{f_p f_s}{Y_p} + \frac{(1 - f_p f_s)e^{-\lambda_i t_{hm}}}{Y_s}\right] \times e^{-\lambda_i t_f}$$

where:

K_1	=	the units conversion factor: 10^6 pCi/μCi.
r	=	the fraction of deposited activity retained on goat's feed grass. The value used for r is 1.0 for radioiodines and 0.2 for particulates, from (Reference 11, Table E–1).
λ_i	=	the radioactive decay constant for radionuclide i, in s^{-1}. Values of λ_i used in effluent calculations should be based on decay data from a recognized and current source, such as Reference 46.
λ_w		the rate constant for removal of activity on leaf and plant surfaces by weathering, in s^{-1}, from Table A13.3.3.5-1.
Q_F	=	the goat's consumption rate of feed, in kg/d, from Table A13.3.3.5-1.
U_{ap}	=	the consumption rate of goat milk by a receptor in age group a, in L/y, from Table A13.3.3.6-2.
F_{mi}	=	the stable element transfer coefficient applicable to radionuclide i, for goat's milk, in d/L, from Table A13.3.3.6-3.
$(DFL)_{aij}$	=	the ingestion dose factor for receptor age group a, radionuclide i, and organ j, in mrem/pCi, from Table A8-5 through Table A8-8.
f_p	=	the fraction of the year that the goat is on pasture (dimensionless), from Table A13.3.3.5-1.
f_s	=	the fraction of the goat's feed that is pasture grass while the goat is on pasture (dimensionless), from Table A13.3.3.5-1.
Y_p	=	the areal density (agricultural productivity) of growing pasture feed grass, in kg/m^2, from Table A13.3.3.5-1.
Y_s	=	the areal density (agricultural productivity) of growing stored feed, in kg/m^2, from Table A13.3.3.5-1.
t_{hm}	=	the transport time from pasture, to harvest, to goat, to milk, to receptor, in s, from Table A13.3.3.5-1.
t_f	=	the transport time from pasture to goat, to milk, to receptor, in s, from Table A13.3.3.5-1.

For tritium in the grass-goat-milk pathway, R_{aipj} in (mrem/y) per ($\mu Ci/m^3$) is calculated as follows

(Reference 24, Section 5.3.1.5), based on the concentration in air rather than deposition onto the ground:

Eqn A13.3.3.5-2

$$R_{aipj} = K_1 \times K_3 \times Q_F \times U_{ap} \times F_{mi} \times (DFL)_{aij} \times 0.75 \times \left(\frac{0.5}{H}\right)$$

where:

K_3 = the units conversion factor: 10^3 g/kg.

H = the absolute humidity of atmospheric air, in g/m^3, from Table A13.3.3.5-1.

0.75 = the fraction of total feed that is water (dimensionless).

0.5 = the ratio of the specific activity of tritium in feed grass water to that in atmospheric water (dimensionless).

and other parameters are as defined above.

Forcarbon-14 in the grass-goat-milk pathway, R_{aipj} in (mrem/y) per (μCi/m^3) is calculated from the modified formula as follows (Reference 11, Eqn C-8), based on the concentration in air rather than deposition onto the ground:

$$R_{aipj} = K_1 \ x \ K_3 \ x \ U_{ap} \ x \ F_{mi} \ x \ (DFL)_{aij} \ x \ (p) \ x \ \left(\frac{0.11}{0.16}\right)$$ Eqn A13.3.3.5-3

where:

p = The ratio of the total annual release time (for C-14) atmospheric releases) to the total annual time during photosynthesis occurs (taken to be 4400 hrs), under the condition that the value of p should never exceed unity. For continuous C-14 releases, p is taken to be unity.

0.11 = The fraction of total plant mass that is natural carbon, dimensionless.

0.16 = The concentration of natural carbon in the atmosphere, in g/m^3.

Other parameters are as defined above.

Table A13.3.3.5-1 Miscellaneous Parameters for the Grass-Goat-Milk Pathway

The following parameter values are for use in calculating R_{aipj} for the grass-goat-milk pathway only.

Parameter	Value	Reference
λ_w	5.73×10^{-7} s^{-1} (14-day half-life)	Ref. 24, page 33
Q_F	6 kg/d	Ref. 11, Table E-3
f_p	1.0	Ref. 24, page 33
f_s	1.0	Ref. 24, page 33
Y_p	0.7 kg/m^2	Ref. 11, Table E-15
Y_s	2.0 kg/m^2	Ref. 11, Table E-15
t_{hm}	7.78×10^6 s (90 days)	Ref. 11, Table E-15
t_f	1.73×10^5 s (2 days)	Ref. 11, Table E-15
H	8 g/m^3	Ref. 11

Table A13.3.3.5-2 Site-Related Grass-Goat-Milk R_{aipj} Dose Factors, Adult Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3*	0.00E+00	8.88E+02	8.88E+02	8.88E+02	8.88E+02	8.88E+02	8.88E+02
C-14*	3.63E+05	7.26E+04	7.26E+04	7.26E+04	7.26E+04	7.26E+04	7.26E+04
Na-24	2.93E+05	2.93E+05	2.93E+05	2.93E+05	2.93E+05	2.93E+05	2.93E+05
P-32	2.05E+10	1.28E+09	7.93E+08	0.00E+00	0.00E+00	0.00E+00	2.31E+09
Cr-51	0.00E+00	0.00E+00	3.43E+03	2.05E+03	7.55E+02	4.55E+03	8.62E+05
Mn-54	0.00E+00	1.01E+06	1.93E+05	0.00E+00	3.00E+05	0.00E+00	3.09E+06
Mn-56	0.00E+00	4.98E-04	8.84E-05	0.00E+00	6.32E-04	0.00E+00	1.59E-02
Fe-55	3.26E+05	2.26E+05	5.26E+04	0.00E+00	0.00E+00	1.26E+05	1.29E+05
Fe-59	3.86E+05	9.07E+05	3.48E+05	0.00E+00	0.00E+00	2.54E+05	3.02E+06
Co-57	0.00E+00	1.54E+05	2.55E+05	0.00E+00	0.00E+00	0.00E+00	3.90E+06
Co-58	0.00E+00	5.66E+05	1.27E+06	0.00E+00	0.00E+00	0.00E+00	1.15E+07
Co-60	0.00E+00	1.97E+06	4.34E+06	0.00E+00	0.00E+00	0.00E+00	3.70E+07
Ni-63	8.07E+08	5.60E+07	2.71E+07	0.00E+00	0.00E+00	0.00E+00	1.17E+07
Ni-65	4.44E-02	5.77E-03	2.63E-03	0.00E+00	0.00E+00	0.00E+00	1.46E-01
Cu-64	0.00E+00	2.66E+03	1.25E+03	0.00E+00	6.70E+03	0.00E+00	2.26E+05
Zn-65	1.65E+08	5.24E+08	2.37E+08	0.00E+00	3.50E+08	0.00E+00	3.30E+08
Zn-69m	2.15E+04	5.15E+04	4.71E+03	0.00E+00	3.12E+04	0.00E+00	3.15E+06
Zn-69	2.51E-13	4.80E-13	3.34E-14	0.00E+00	3.12E-13	0.00E+00	7.21E-14
Br-82	0.00E+00	0.00E+00	3.88E+06	0.00E+00	0.00E+00	0.00E+00	4.44E+06
Br-83	0.00E+00	0.00E+00	1.17E-02	0.00E+00	0.00E+00	0.00E+00	1.68E-02
Br-84	0.00E+00	0.00E+00	1.93E-24	0.00E+00	0.00E+00	0.00E+00	1.52E-29
Br-85	0.00E+00	0.00E+00	2.34E-302	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	3.11E+08	1.45E+08	0.00E+00	0.00E+00	0.00E+00	6.14E+07
Rb-88	0.00E+00	2.57E-46	1.36E-46	0.00E+00	0.00E+00	0.00E+00	3.55E-57
Rb-89	0.00E+00	5.20E-54	3.65E-54	0.00E+00	0.00E+00	0.00E+00	3.02E-67
Sr-89	3.05E+09	0.00E+00	8.75E+07	0.00E+00	0.00E+00	0.00E+00	4.89E+08
Sr-90	1.13E+11	0.00E+00	2.27E+09	0.00E+00	0.00E+00	0.00E+00	2.84E+09
Sr-91	6.07E+04	0.00E+00	2.45E+03	0.00E+00	0.00E+00	0.00E+00	2.89E+05
Sr-92	1.03E+00	0.00E+00	4.44E-02	0.00E+00	0.00E+00	0.00E+00	2.03E+01
Y-90	8.50E+00	0.00E+00	2.28E-01	0.00E+00	0.00E+00	0.00E+00	9.01E+04
Y-91m	7.18E-21	0.00E+00	2.78E-22	0.00E+00	0.00E+00	0.00E+00	2.11E-20
Y-91	1.03E+03	0.00E+00	2.76E+01	0.00E+00	0.00E+00	0.00E+00	5.67E+05
Y-92	6.69E-06	0.00E+00	1.96E-07	0.00E+00	0.00E+00	0.00E+00	1.17E-01
Y-93	2.68E-02	0.00E+00	7.40E-04	0.00E+00	0.00E+00	0.00E+00	8.50E+02
Zr-95	1.13E+02	3.63E+01	2.46E+01	0.00E+00	5.70E+01	0.00E+00	1.15E+05
Zr-97	5.20E-02	1.05E-02	4.80E-03	0.00E+00	1.58E-02	0.00E+00	3.25E+03
Nb-95	9.91E+03	5.51E+03	2.96E+03	0.00E+00	5.45E+03	0.00E+00	3.34E+07
Nb-97	3.95E-13	9.98E-14	3.65E-14	0.00E+00	1.16E-13	0.00E+00	3.68E-10
Mo-99	0.00E+00	2.97E+06	5.66E+05	0.00E+00	6.73E+06	0.00E+00	6.89E+06
Tc-99m	3.98E-01	1.13E+00	1.43E+01	0.00E+00	1.71E+01	5.52E-01	6.66E+02
Tc-101	3.11E-61	4.48E-61	4.40E-60	0.00E+00	8.07E-60	2.29E-61	1.35E-72
Ru-103	1.22E+02	0.00E+00	5.26E+01	0.00E+00	4.66E+02	0.00E+00	1.43E+04
Ru-105	1.03E-04	0.00E+00	4.06E-05	0.00E+00	1.33E-03	0.00E+00	6.29E-02

Units are in ($m^2 \cdot$mrem/y) per (μCi/s)
*H-3 and C-14 are in units of (mrem/y) per (μCi/m^3).

Table A13.3.3.5-2 (cont.) Site-Related Grass-Goat-Milk R_{aipj} Dose Factors, Adult Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ru-106	2.45E+03	0.00E+00	3.10E+02	0.00E+00	4.73E+03	0.00E+00	1.58E+05
Rh-105	4.17E+04	3.05E+04	2.01E+04	0.00E+00	1.29E+05	0.00E+00	4.85E+06
Ag-110m	6.99E+06	6.46E+06	3.84E+06	0.00E+00	1.27E+07	0.00E+00	2.64E+09
Cd-113m	0.00E+00	3.53E+05	1.13E+04	0.00E+00	3.88E+05	0.00E+00	2.84E+06
Sb-124	3.09E+06	5.83E+04	1.22E+06	7.49E+03	0.00E+00	2.40E+06	8.77E+07
Sb-125	2.45E+06	2.74E+04	5.84E+05	2.49E+03	0.00E+00	1.89E+06	2.70E+07
Sb-126	6.72E+05	1.37E+04	2.42E+05	4.11E+03	0.00E+00	4.12E+05	5.49E+07
Sb-127	5.40E+04	1.18E+03	2.07E+04	6.49E+02	0.00E+00	3.20E+04	1.23E+07
Te-125m	1.95E+06	7.08E+05	2.62E+05	5.88E+05	7.95E+06	0.00E+00	7.80E+06
Te-127m	5.49E+06	1.96E+06	6.69E+05	1.40E+06	2.23E+07	0.00E+00	1.84E+07
Te-127	7.83E+01	2.81E+01	1.70E+01	5.80E+01	3.19E+02	0.00E+00	6.18E+03
Te-129m	7.22E+06	2.69E+06	1.14E+06	2.48E+06	3.02E+07	0.00E+00	3.64E+07
Te-129	3.39E-11	1.27E-11	8.25E-12	2.60E-11	1.42E-10	0.00E+00	2.56E-11
Te-131m	4.33E+04	2.12E+04	1.77E+04	3.36E+04	2.15E+05	0.00E+00	2.10E+06
Te-131	4.32E-34	1.81E-34	1.37E-34	3.56E-34	1.89E-33	0.00E+00	6.12E-35
Te-132	2.88E+05	1.86E+05	1.75E+05	2.06E+05	1.80E+06	0.00E+00	8.82E+06
I-129	9.10E+08	7.82E+08	2.56E+09	2.01E+12	1.68E+09	0.00E+00	1.24E+08
I-130	5.04E+05	1.49E+06	5.87E+05	1.26E+08	2.32E+06	0.00E+00	1.28E+06
I-131	3.55E+08	5.08E+08	2.91E+08	1.67E+11	8.71E+08	0.00E+00	1.34E+08
I-132	1.97E-01	5.27E-01	1.84E-01	1.84E+01	8.40E-01	0.00E+00	9.90E-02
I-133	4.64E+06	8.08E+06	2.46E+06	1.19E+09	1.41E+07	0.00E+00	7.26E+06
I-134	2.42E-12	6.57E-12	2.35E-12	1.14E-10	1.05E-11	0.00E+00	5.73E-15
I-135	1.54E+04	4.03E+04	1.49E+04	2.66E+06	6.47E+04	0.00E+00	4.56E+04
Cs-134	1.70E+10	4.04E+10	3.30E+10	0.00E+00	1.31E+10	4.34E+09	7.06E+08
Cs-135	5.43E+09	5.01E+09	2.22E+09	0.00E+00	1.89E+09	5.68E+08	1.17E+08
Cs-136	7.90E+08	3.12E+09	2.24E+09	0.00E+00	1.73E+09	2.38E+08	3.54E+08
Cs-137	2.21E+10	3.03E+10	1.98E+10	0.00E+00	1.03E+10	3.42E+09	5.86E+08
Cs-138	2.71E-23	5.36E-23	2.65E-23	0.00E+00	3.94E-23	3.89E-24	2.29E-28
Ba-139	5.30E-09	3.78E-12	1.55E-10	0.00E+00	3.53E-12	2.14E-12	9.40E-09
Ba-140	3.23E+06	4.05E+03	2.11E+05	0.00E+00	1.38E+03	2.32E+03	6.64E+06
Ba-141	4.91E-47	3.71E-50	1.66E-48	0.00E+00	3.45E-50	2.11E-50	2.32E-56
Ba-142	3.19E-81	3.28E-84	2.01E-82	0.00E+00	2.77E-84	1.86E-84	4.49E-99
La-140	5.41E-01	2.73E-01	7.21E-02	0.00E+00	0.00E+00	0.00E+00	2.00E+04
La-142	2.23E-12	1.01E-12	2.53E-13	0.00E+00	0.00E+00	0.00E+00	7.40E-09
Ce-141	5.81E+02	3.93E+02	4.46E+01	0.00E+00	1.83E+02	0.00E+00	1.50E+06
Ce-143	4.99E+00	3.69E+03	4.08E-01	0.00E+00	1.62E+00	0.00E+00	1.38E+05
Ce-144	4.29E+04	1.79E+04	2.30E+03	0.00E+00	1.06E+04	0.00E+00	1.45E+07
Pr-143	1.89E+01	7.60E+00	9.39E-01	0.00E+00	4.39E+00	0.00E+00	8.30E+04
Pr-144	7.04E-55	2.92E-55	3.58E-56	0.00E+00	1.65E-55	0.00E+00	1.01E-61
Nd-147	1.13E+01	1.31E+01	7.81E-01	0.00E+00	7.63E+00	0.00E+00	6.27E+04
Eu-152	9.01E+02	2.05E+02	1.80E+02	0.00E+00	1.27E+03	0.00E+00	1.18E+05
W-187	7.82E+02	6.53E+02	2.28E+02	0.00E+00	0.00E+00	0.00E+00	2.14E+05
Np-239	4.41E-01	4.33E-02	2.39E-02	0.00E+00	1.35E-01	0.00E+00	8.89E+03

Table A13.3.3.5-3 Site-Related Grass-Goat-Milk R_{aipj} Dose Factors, Teenager Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3*	0.00E+00	1.16E+03	1.16E+03	1.16E+03	1.16E+03	1.16E+03	1.16E+03
C-14*	6.70E+05	1.34E+05	1.34E+05	1.34E+05	1.34E+05	1.34E+05	1.34E+05
Na-24	5.11E+05	5.11E+05	5.11E+05	5.11E+05	5.11E+05	5.11E+05	5.11E+05
P-32	3.78E+10	2.34E+09	1.47E+09	0.00E+00	0.00E+00	0.00E+00	3.18E+09
Cr-51	0.00E+00	0.00E+00	5.99E+03	3.33E+03	1.31E+03	8.55E+03	1.01E+06
Mn-54	0.00E+00	1.68E+06	3.34E+05	0.00E+00	5.02E+05	0.00E+00	3.45E+06
Mn-56	0.00E+00	8.83E-04	1.57E-04	0.00E+00	1.12E-03	0.00E+00	5.81E-02
Fe-55	5.79E+05	4.11E+05	9.57E+04	0.00E+00	0.00E+00	2.60E+05	1.78E+05
Fe-59	6.74E+05	1.57E+06	6.07E+05	0.00E+00	0.00E+00	4.96E+05	3.72E+06
Co-57	0.00E+00	2.69E+05	4.52E+05	0.00E+00	0.00E+00	0.00E+00	5.03E+06
Co-58	0.00E+00	9.52E+05	2.19E+06	0.00E+00	0.00E+00	0.00E+00	1.31E+07
Co-60	0.00E+00	3.34E+06	7.52E+06	0.00E+00	0.00E+00	0.00E+00	4.35E+07
Ni-63	1.42E+09	1.00E+08	4.81E+07	0.00E+00	0.00E+00	0.00E+00	1.59E+07
Ni-65	8.12E-02	1.04E-02	4.73E-03	0.00E+00	0.00E+00	0.00E+00	5.63E-01
Cu-64	0.00E+00	4.73E+03	2.23E+03	0.00E+00	1.20E+04	0.00E+00	3.67E+05
Zn-65	2.53E+08	8.78E+08	4.10E+08	0.00E+00	5.62E+08	0.00E+00	3.72E+08
Zn-69m	3.91E+04	9.22E+04	8.46E+03	0.00E+00	5.61E+04	0.00E+00	5.07E+06
Zn-69	4.62E-13	8.80E-13	6.16E-14	0.00E+00	5.75E-13	0.00E+00	1.62E-12
Br-82	0.00E+00	0.00E+00	6.73E+06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-83	0.00E+00	0.00E+00	2.15E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	3.45E-24	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	4.30E-302	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	5.67E+08	2.67E+08	0.00E+00	0.00E+00	0.00E+00	8.40E+07
Rb-88	0.00E+00	4.66E-46	2.49E-46	0.00E+00	0.00E+00	0.00E+00	4.00E-53
Rb-89	0.00E+00	9.20E-54	6.50E-54	0.00E+00	0.00E+00	0.00E+00	1.41E-62
Sr-89	5.62E+09	0.00E+00	1.61E+08	0.00E+00	0.00E+00	0.00E+00	6.69E+08
Sr-90	1.71E+11	0.00E+00	3.41E+09	0.00E+00	0.00E+00	0.00E+00	3.90E+09
Sr-91	1.12E+05	0.00E+00	4.44E+03	0.00E+00	0.00E+00	0.00E+00	5.06E+05
Sr-92	1.88E+00	0.00E+00	8.00E-02	0.00E+00	0.00E+00	0.00E+00	4.78E+01
Y-90	1.56E+01	0.00E+00	4.21E-01	0.00E+00	0.00E+00	0.00E+00	1.29E+05
Y-91m	1.31E-20	0.00E+00	5.02E-22	0.00E+00	0.00E+00	0.00E+00	6.21E-19
Y-91	1.90E+03	0.00E+00	5.08E+01	0.00E+00	0.00E+00	0.00E+00	7.77E+05
Y-92	1.24E-05	0.00E+00	3.58E-07	0.00E+00	0.00E+00	0.00E+00	3.39E-01
Y-93	4.94E-02	0.00E+00	1.36E-03	0.00E+00	0.00E+00	0.00E+00	1.51E+03
Zr-95	1.98E+02	6.25E+01	4.30E+01	0.00E+00	9.18E+01	0.00E+00	1.44E+05
Zr-97	9.46E-02	1.87E-02	8.62E-03	0.00E+00	2.84E-02	0.00E+00	5.07E+03
Nb-95	1.69E+04	9.37E+03	5.16E+03	0.00E+00	9.08E+03	0.00E+00	4.01E+07
Nb-97	7.19E-13	1.79E-13	6.52E-14	0.00E+00	2.09E-13	0.00E+00	4.26E-09
Mo-99	0.00E+00	5.37E+06	1.02E+06	0.00E+00	1.23E+07	0.00E+00	9.61E+06
Tc-99m	6.91E-01	1.93E+00	2.50E+01	0.00E+00	2.87E+01	1.07E+00	1.27E+03
Tc-101	5.69E-61	8.09E-61	7.95E-60	0.00E+00	1.46E-59	4.93E-61	1.38E-67
Ru-103	2.17E+02	0.00E+00	9.29E+01	0.00E+00	7.66E+02	0.00E+00	1.81E+04
Ru-105	1.88E-04	0.00E+00	7.29E-05	0.00E+00	2.37E-03	0.00E+00	1.52E-01

Units are in ($m^2 \cdot$mrem/y) per (μCi/s)
*H-3 and C-14 are in units of (mrem/y) per ($\mu Ci/m^3$).

Table A13.3.3.5-3 (cont.) Site-Related Grass-Goat-Milk R_{aipj} Dose Factors, Teenager Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ru-106	4.50E+03	0.00E+00	5.67E+02	0.00E+00	8.68E+03	0.00E+00	2.16E+05
Rh-105	7.68E+04	5.55E+04	3.64E+04	0.00E+00	2.36E+05	0.00E+00	7.06E+06
Ag-110m	1.16E+07	1.09E+07	6.65E+06	0.00E+00	2.08E+07	0.00E+00	3.07E+09
Cd-113m	0.00E+00	6.46E+05	2.08E+04	0.00E+00	7.14E+05	0.00E+00	3.88E+06
Sb-124	5.51E+06	1.01E+05	2.15E+06	1.25E+04	0.00E+00	4.81E+06	1.11E+08
Sb-125	4.38E+06	4.79E+04	1.03E+06	4.19E+03	0.00E+00	3.85E+06	3.41E+07
Sb-126	1.20E+06	2.45E+04	4.30E+05	6.78E+03	0.00E+00	8.59E+05	7.09E+07
Sb-127	9.80E+04	2.09E+03	3.70E+04	1.10E+03	0.00E+00	6.67E+04	1.66E+07
Te-125m	3.60E+06	1.30E+06	4.82E+05	1.01E+06	0.00E+00	0.00E+00	1.06E+07
Te-127m	1.01E+07	3.59E+06	1.20E+06	2.41E+06	4.10E+07	0.00E+00	2.52E+07
Te-127	1.45E+02	5.15E+01	3.12E+01	1.00E+02	5.88E+02	0.00E+00	1.12E+04
Te-129m	1.32E+07	4.90E+06	2.09E+06	4.26E+06	5.53E+07	0.00E+00	4.96E+07
Te-129	6.24E-11	2.33E-11	1.52E-11	4.46E-11	2.62E-10	0.00E+00	3.41E-10
Te-131m	7.88E+04	3.78E+04	3.15E+04	5.69E+04	3.94E+05	0.00E+00	3.03E+06
Te-131	7.90E-34	3.26E-34	2.47E-34	6.09E-34	3.45E-33	0.00E+00	6.49E-35
Te-132	5.15E+05	3.26E+05	3.07E+05	3.44E+05	3.13E+06	0.00E+00	1.03E+07
I-129	1.67E+09	1.41E+09	2.35E+09	1.71E+12	2.52E+09	0.00E+00	1.64E+08
I-130	8.86E+05	2.56E+06	1.02E+06	2.09E+08	3.95E+06	0.00E+00	1.97E+06
I-131	6.45E+08	9.03E+08	4.85E+08	2.63E+11	1.55E+09	0.00E+00	1.79E+08
I-132	3.50E-01	9.15E-01	3.28E-01	3.08E+01	1.44E+00	0.00E+00	3.98E-01
I-133	8.48E+06	1.44E+07	4.39E+06	2.01E+09	2.52E+07	0.00E+00	1.09E+07
I-134	4.30E-12	1.14E-11	4.09E-12	1.90E-10	1.80E-11	0.00E+00	1.50E-13
I-135	2.74E+04	7.04E+04	2.61E+04	4.53E+06	1.11E+05	0.00E+00	7.81E+04
Cs-134	2.94E+10	6.93E+10	3.22E+10	0.00E+00	2.20E+10	8.41E+09	8.62E+08
Cs-135	9.98E+09	9.15E+09	2.14E+09	0.00E+00	3.49E+09	1.26E+09	1.60E+08
Cs-136	1.34E+09	5.29E+09	3.55E+09	0.00E+00	2.88E+09	4.54E+08	4.26E+08
Cs-137	4.02E+10	5.34E+10	1.86E+10	0.00E+00	1.82E+10	7.06E+09	7.60E+08
Cs-138	4.92E-23	9.45E-23	4.72E-23	0.00E+00	6.98E-23	8.12E-24	4.29E-26
Ba-139	9.81E-09	6.90E-12	2.86E-10	0.00E+00	6.50E-12	4.75E-12	8.75E-08
Ba-140	5.82E+06	7.13E+03	3.75E+05	0.00E+00	2.42E+03	4.80E+03	8.98E+06
Ba-141	9.03E-47	6.74E-50	3.01E-48	0.00E+00	6.26E-50	4.62E-50	1.92E-52
Ba-142	5.78E-81	5.78E-84	3.55E-82	0.00E+00	4.89E-84	3.84E-84	1.77E-92
La-140	9.72E-01	4.78E-01	1.27E-01	0.00E+00	0.00E+00	0.00E+00	2.74E+04
La-142	4.02E-12	1.79E-12	4.45E-13	0.00E+00	0.00E+00	0.00E+00	5.44E-08
Ce-141	1.07E+03	7.12E+02	8.17E+01	0.00E+00	3.35E+02	0.00E+00	2.04E+06
Ce-143	9.17E+00	6.67E+03	7.45E-01	0.00E+00	2.99E+00	0.00E+00	2.00E+05
Ce-144	7.90E+04	3.27E+04	4.24E+03	0.00E+00	1.95E+04	0.00E+00	1.99E+07
Pr-143	3.48E+01	1.39E+01	1.73E+00	0.00E+00	8.08E+00	0.00E+00	1.15E+05
Pr-144	1.30E-54	5.31E-55	6.58E-56	0.00E+00	3.05E-55	0.00E+00	1.43E-57
Nd-147	2.17E+01	2.36E+01	1.42E+00	0.00E+00	1.39E+01	0.00E+00	8.53E+04
Eu-152	1.46E+03	3.52E+02	3.10E+02	0.00E+00	1.63E+03	0.00E+00	1.29E+05
W-187	1.43E+03	1.17E+03	4.08E+02	0.00E+00	0.00E+00	0.00E+00	3.15E+05
Np-239	8.41E-01	7.93E-02	4.41E-02	0.00E+00	2.49E-01	0.00E+00	1.28E+04

Table A13.3.3.5-4 Site-Related Grass-Goat-Milk R_{aipj} Dose Factors, Child Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3*	0.00E+00	1.83E+03	1.83E+03	1.83E+03	1.83E+03	1.83E+03	1.83E+03
C-14*	1.65E+06	3.29E+05	3.29E+05	3.29E+05	3.29E+05	3.29E+05	3.29E+05
Na-24	1.06E+06	1.06E+06	1.06E+06	1.06E+06	1.06E+06	1.06E+06	1.06E+06
P-32	9.33E+10	4.37E+09	3.60E+09	0.00E+00	0.00E+00	0.00E+00	2.58E+09
Cr-51	0.00E+00	0.00E+00	1.22E+04	6.78E+03	1.85E+03	1.24E+04	6.48E+05
Mn-54	0.00E+00	2.52E+06	6.70E+05	0.00E+00	7.06E+05	0.00E+00	2.11E+06
Mn-56	0.00E+00	1.54E-03	3.48E-04	0.00E+00	1.86E-03	0.00E+00	2.23E-01
Fe-55	1.45E+06	7.71E+05	2.39E+05	0.00E+00	0.00E+00	4.36E+05	1.43E+05
Fe-59	1.56E+06	2.53E+06	1.26E+06	0.00E+00	0.00E+00	7.33E+05	2.63E+06
Co-57	0.00E+00	4.60E+05	9.32E+05	0.00E+00	0.00E+00	0.00E+00	3.77E+06
Co-58	0.00E+00	1.45E+06	4.45E+06	0.00E+00	0.00E+00	0.00E+00	8.49E+06
Co-60	0.00E+00	5.18E+06	1.53E+07	0.00E+00	0.00E+00	0.00E+00	2.87E+07
Ni-63	3.56E+09	1.90E+08	1.21E+08	0.00E+00	0.00E+00	0.00E+00	1.28E+07
Ni-65	1.99E-01	1.87E-02	1.09E-02	0.00E+00	0.00E+00	0.00E+00	2.29E+00
Cu-64	0.00E+00	8.32E+03	5.02E+03	0.00E+00	2.01E+04	0.00E+00	3.90E+05
Zn-65	4.96E+08	1.32E+09	8.22E+08	0.00E+00	8.33E+08	0.00E+00	2.32E+08
Zn-69m	9.55E+04	1.63E+05	1.92E+04	0.00E+00	9.45E+04	0.00E+00	5.30E+06
Zn-69	1.14E-12	1.64E-12	1.52E-13	0.00E+00	9.96E-13	0.00E+00	1.03E-10
Br-82	0.00E+00	0.00E+00	1.38E+07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-83	0.00E+00	0.00E+00	5.28E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	7.81E-24	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	1.06E-301	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	1.05E+09	6.47E+08	0.00E+00	0.00E+00	0.00E+00	6.77E+07
Rb-88	0.00E+00	8.58E-46	5.96E-46	0.00E+00	0.00E+00	0.00E+00	4.21E-47
Rb-89	0.00E+00	1.61E-53	1.43E-53	0.00E+00	0.00E+00	0.00E+00	1.41E-55
Sr-89	1.39E+10	0.00E+00	3.97E+08	0.00E+00	0.00E+00	0.00E+00	5.38E+08
Sr-90	3.53E+11	0.00E+00	7.11E+09	0.00E+00	0.00E+00	0.00E+00	3.16E+09
Sr-91	2.74E+05	0.00E+00	1.03E+04	0.00E+00	0.00E+00	0.00E+00	6.04E+05
Sr-92	4.58E+00	0.00E+00	1.84E-01	0.00E+00	0.00E+00	0.00E+00	8.68E+01
Y-90	3.87E+01	0.00E+00	1.03E+00	0.00E+00	0.00E+00	0.00E+00	1.10E+05
Y-91m	3.21E-20	0.00E+00	1.17E-21	0.00E+00	0.00E+00	0.00E+00	6.29E-17
Y-91	4.68E+03	0.00E+00	1.25E+02	0.00E+00	0.00E+00	0.00E+00	6.24E+05
Y-92	3.04E-05	0.00E+00	8.69E-07	0.00E+00	0.00E+00	0.00E+00	8.77E-01
Y-93	1.21E-01	0.00E+00	3.33E-03	0.00E+00	0.00E+00	0.00E+00	1.81E+03
Zr-95	4.60E+02	1.01E+02	9.00E+01	0.00E+00	1.45E+02	0.00E+00	1.05E+05
Zr-97	2.30E-01	3.33E-02	1.96E-02	0.00E+00	4.78E-02	0.00E+00	5.04E+03
Nb-95	3.81E+04	1.49E+04	1.06E+04	0.00E+00	1.40E+04	0.00E+00	2.75E+07
Nb-97	1.75E-12	3.16E-13	1.47E-13	0.00E+00	3.50E-13	0.00E+00	9.74E-08
Mo-99	0.00E+00	9.76E+06	2.42E+06	0.00E+00	2.09E+07	0.00E+00	8.08E+06
Tc-99m	1.59E+00	3.11E+00	5.15E+01	0.00E+00	4.52E+01	1.58E+00	1.77E+03
Tc-101	1.40E-60	1.46E-60	1.85E-59	0.00E+00	2.49E-59	7.72E-61	4.64E-60
Ru-103	5.14E+02	0.00E+00	1.98E+02	0.00E+00	1.29E+03	0.00E+00	1.33E+04
Ru-105	4.58E-04	0.00E+00	1.66E-04	0.00E+00	4.03E-03	0.00E+00	2.99E-01

Units are in ($m^2 \cdot$mrem/y) per (μCi/s)
*H-3 and C-14 are in units of (mrem/y) per ($\mu Ci/m^3$).

Table A13.3.3.5-4 (cont.) Site-Related Grass-Goat-Milk R_{aipj} Dose Factors, Child Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ru-106	1.11E+04	0.00E+00	1.38E+03	0.00E+00	1.50E+04	0.00E+00	1.72E+05
Rh-105	1.88E+05	1.01E+05	8.65E+04	0.00E+00	4.03E+05	0.00E+00	6.27E+06
Ag-110m	2.51E+07	1.69E+07	1.35E+07	0.00E+00	3.15E+07	0.00E+00	2.01E+09
Cd-113m	0.00E+00	1.20E+06	5.13E+04	0.00E+00	1.24E+06	0.00E+00	3.11E+06
Sb-124	1.30E+07	1.69E+05	4.57E+06	2.88E+04	0.00E+00	7.23E+06	8.15E+07
Sb-125	1.04E+07	8.05E+04	2.19E+06	9.67E+03	0.00E+00	5.82E+06	2.49E+07
Sb-126	2.74E+06	4.19E+04	9.83E+05	1.60E+04	0.00E+00	1.31E+06	5.52E+07
Sb-127	2.36E+05	3.65E+03	8.20E+04	2.63E+03	0.00E+00	1.02E+05	1.33E+07
Te-125m	8.85E+06	2.40E+06	1.18E+06	2.48E+06	0.00E+00	0.00E+00	8.54E+06
Te-127m	2.50E+07	6.72E+06	2.96E+06	5.97E+06	7.12E+07	0.00E+00	2.02E+07
Te-127	3.57E+02	9.63E+01	7.66E+01	2.47E+02	1.02E+03	0.00E+00	1.40E+04
Te-129m	3.26E+07	9.09E+06	5.06E+06	1.05E+07	9.56E+07	0.00E+00	3.97E+07
Te-129	1.54E-10	4.30E-11	3.65E-11	1.10E-10	4.50E-10	0.00E+00	9.58E-09
Te-131m	1.92E+05	6.64E+04	7.06E+04	1.36E+05	6.42E+05	0.00E+00	2.69E+06
Te-131	1.94E-33	5.91E-34	5.77E-34	1.48E-33	5.86E-33	0.00E+00	1.02E-32
Te-132	1.23E+06	5.44E+05	6.57E+05	7.93E+05	5.05E+06	0.00E+00	5.48E+06
I-129	4.12E+09	2.53E+09	2.26E+09	1.65E+12	4.27E+09	0.00E+00	1.27E+08
I-130	2.07E+06	4.19E+06	2.16E+06	4.61E+08	6.26E+06	0.00E+00	1.96E+06
I-131	1.56E+09	1.57E+09	8.94E+08	5.20E+11	2.58E+09	0.00E+00	1.40E+08
I-132	8.27E-01	1.52E+00	6.99E-01	7.05E+01	2.33E+00	0.00E+00	1.79E+00
I-133	2.06E+07	2.55E+07	9.64E+06	4.73E+09	4.25E+07	0.00E+00	1.03E+07
I-134	1.02E-11	1.89E-11	8.70E-12	4.35E-10	2.89E-11	0.00E+00	1.25E-11
I-135	6.48E+04	1.17E+05	5.52E+04	1.03E+07	1.79E+05	0.00E+00	8.88E+04
Cs-134	6.79E+10	1.11E+11	2.35E+10	0.00E+00	3.45E+10	1.24E+10	6.01E+08
Cs-135	2.46E+10	1.71E+10	1.76E+09	0.00E+00	6.04E+09	2.02E+09	1.28E+08
Cs-136	3.03E+09	8.34E+09	5.40E+09	0.00E+00	4.44E+09	6.63E+08	2.93E+08
Cs-137	9.67E+10	9.26E+10	1.37E+10	0.00E+00	3.02E+10	1.09E+10	5.80E+08
Cs-138	1.19E-22	1.66E-22	1.05E-22	0.00E+00	1.17E-22	1.26E-23	7.64E-23
Ba-139	2.41E-08	1.29E-11	6.98E-10	0.00E+00	1.12E-11	7.57E-12	1.39E-06
Ba-140	1.41E+07	1.23E+04	8.20E+05	0.00E+00	4.01E+03	7.34E+03	7.12E+06
Ba-141	2.22E-46	1.24E-49	7.23E-48	0.00E+00	1.08E-49	7.31E-49	1.27E-46
Ba-142	1.39E-80	1.00E-83	7.78E-82	0.00E+00	8.11E-84	5.90E-84	1.82E-82
La-140	2.33E+00	8.14E-01	2.74E-01	0.00E+00	0.00E+00	0.00E+00	2.27E+04
La-142	9.72E-12	3.10E-12	9.70E-13	0.00E+00	0.00E+00	0.00E+00	6.14E-07
Ce-141	2.62E+03	1.31E+03	1.94E+02	0.00E+00	5.74E+02	0.00E+00	1.63E+06
Ce-143	2.25E+01	1.22E+04	1.77E+00	0.00E+00	5.12E+00	0.00E+00	1.79E+05
Ce-144	1.95E+05	6.11E+04	1.04E+04	0.00E+00	3.38E+04	0.00E+00	1.59E+07
Pr-143	8.62E+01	2.59E+01	4.28E+00	0.00E+00	1.40E+01	0.00E+00	9.30E+04
Pr-144	3.21E-54	9.94E-55	1.62E-55	0.00E+00	5.26E-55	0.00E+00	2.14E-51
Nd-147	5.33E+01	4.32E+01	3.35E+00	0.00E+00	2.37E+01	0.00E+00	6.85E+04
Eu-152	3.03E+03	5.51E+02	6.55E+02	0.00E+00	2.33E+03	0.00E+00	9.05E+04
W-187	3.47E+03	2.05E+03	9.21E+02	0.00E+00	0.00E+00	0.00E+00	2.88E+05
Np-239	2.07E+00	1.49E-01	1.04E-01	0.00E+00	4.30E-01	0.00E+00	1.10E+04

Table A13.3.3.5-5 Site-Related Grass-Goat-Milk R_{aipj} Dose Factors, Infant Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3*	0.00E+00	2.78E+03	2.78E+03	2.78E+03	2.78E+03	2.78E+03	2.78E+03
C-14*	3.23E+06	6.89E+05	6.89E+05	6.89E+05	6.89E+05	6.89E+05	6.89E+05
Na-24	1.85E+06	1.85E+06	1.85E+06	1.85E+06	1.85E+06	1.85E+06	1.85E+06
P-32	1.92E+11	1.13E+10	7.46E+09	0.00E+00	0.00E+00	0.00E+00	2.60E+09
Cr-51	0.00E+00	0.00E+00	1.94E+04	1.26E+04	2.76E+03	2.46E+04	5.64E+05
Mn-54	0.00E+00	4.68E+06	1.06E+06	0.00E+00	1.04E+06	0.00E+00	1.72E+06
Mn-56	0.00E+00	3.77E-03	6.50E-04	0.00E+00	3.24E-03	0.00E+00	3.43E-01
Fe-55	1.76E+06	1.13E+06	3.03E+05	0.00E+00	0.00E+00	5.55E+05	1.44E+05
Fe-59	2.92E+06	5.10E+06	2.01E+06	0.00E+00	0.00E+00	1.51E+06	2.43E+06
Co-57	0.00E+00	1.07E+06	1.75E+06	0.00E+00	0.00E+00	0.00E+00	3.66E+06
Co-58	0.00E+00	2.91E+06	7.26E+06	0.00E+00	0.00E+00	0.00E+00	7.25E+06
Co-60	0.00E+00	1.06E+07	2.50E+07	0.00E+00	0.00E+00	0.00E+00	2.52E+07
Ni-63	4.19E+09	2.59E+08	1.45E+08	0.00E+00	0.00E+00	0.00E+00	1.29E+07
Ni-65	4.21E-01	4.76E-02	2.17E-02	0.00E+00	0.00E+00	0.00E+00	3.62E+00
Cu-64	0.00E+00	2.07E+04	9.57E+03	0.00E+00	3.50E+04	0.00E+00	4.24E+05
Zn-65	6.66E+08	2.28E+09	1.05E+09	0.00E+00	1.11E+09	0.00E+00	1.93E+09
Zn-69m	2.02E+05	4.11E+05	3.75E+04	0.00E+00	1.67E+05	0.00E+00	5.70E+06
Zn-69	2.42E-12	4.36E-12	3.24E-13	0.00E+00	1.81E-12	0.00E+00	3.55E-10
Br-82	0.00E+00	0.00E+00	2.32E+07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-83	0.00E+00	0.00E+00	1.12E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	1.51E-23	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	2.26E-301	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	2.67E+09	1.32E+09	0.00E+00	0.00E+00	0.00E+00	6.83E+07
Rb-88	0.00E+00	2.25E-45	1.23E-45	0.00E+00	0.00E+00	0.00E+00	2.19E-45
Rb-89	0.00E+00	3.95E-53	2.72E-53	0.00E+00	0.00E+00	0.00E+00	1.34E-53
Sr-89	2.64E+10	0.00E+00	7.58E+08	0.00E+00	0.00E+00	0.00E+00	5.43E+08
Sr-90	3.91E+11	0.00E+00	7.92E+09	0.00E+00	0.00E+00	0.00E+00	3.19E+09
Sr-91	5.70E+05	0.00E+00	2.06E+04	0.00E+00	0.00E+00	0.00E+00	6.75E+05
Sr-92	9.75E+00	0.00E+00	3.62E-01	0.00E+00	0.00E+00	0.00E+00	1.05E+02
Y-90	8.17E+01	0.00E+00	2.19E+00	0.00E+00	0.00E+00	0.00E+00	1.13E+05
Y-91m	6.81E-20	0.00E+00	2.32E-21	0.00E+00	0.00E+00	0.00E+00	2.27E-16
Y-91	8.79E+03	0.00E+00	2.34E+02	0.00E+00	0.00E+00	0.00E+00	6.30E+05
Y-92	6.45E-05	0.00E+00	1.81E-06	0.00E+00	0.00E+00	0.00E+00	1.23E+00
Y-93	2.59E-01	0.00E+00	7.05E-03	0.00E+00	0.00E+00	0.00E+00	2.04E+03
Zr-95	8.17E+02	1.99E+02	1.41E+02	0.00E+00	2.14E+02	0.00E+00	9.91E+04
Zr-97	4.87E-01	8.37E-02	3.82E-02	0.00E+00	8.43E-02	0.00E+00	5.34E+03
Nb-95	7.12E+04	2.93E+04	1.70E+04	0.00E+00	2.10E+04	0.00E+00	2.48E+07
Nb-97	3.70E-12	7.88E-13	2.84E-13	0.00E+00	6.16E-13	0.00E+00	2.49E-07
Mo-99	0.00E+00	2.50E+07	4.87E+06	0.00E+00	3.73E+07	0.00E+00	8.22E+06
Tc-99m	3.30E+00	6.80E+00	8.76E+01	0.00E+00	7.32E+01	3.56E+00	1.98E+03
Tc-101	2.96E-60	3.73E-60	3.69E-59	0.00E+00	4.43E-59	2.03E-60	6.34E-58
Ru-103	1.04E+03	0.00E+00	3.48E+02	0.00E+00	2.17E+03	0.00E+00	1.27E+04
Ru-105	9.66E-04	0.00E+00	3.25E-04	0.00E+00	7.11E-03	0.00E+00	3.84E-01

Units are in ($m^2 \cdot$mrem/y) per (μCi/s)
*H-3 and C-14 are in units of (mrem/y) per ($\mu Ci/m^3$).

Table A13.3.3.5-5 (cont.) Site-Related Grass-Goat-Milk R_{aipj} Dose Factors, Infant Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ru-106	2.28E+04	0.00E+00	2.85E+03	0.00E+00	2.70E+04	0.00E+00	1.73E+05
Rh-105	3.99E+05	2.61E+05	1.76E+05	0.00E+00	7.26E+05	0.00E+00	6.49E+06
Ag-110m	4.63E+07	3.38E+07	2.24E+07	0.00E+00	4.83E+07	0.00E+00	1.75E+09
Cd-113m	0.00E+00	2.09E+06	7.70E+04	0.00E+00	1.58E+06	0.00E+00	3.14E+06
Sb-124	2.51E+07	3.70E+05	7.78E+06	6.67E+04	0.00E+00	1.57E+07	7.75E+07
Sb-125	1.79E+07	1.74E+05	3.69E+06	2.25E+04	0.00E+00	1.04E+07	2.39E+07
Sb-126	5.01E+06	9.83E+04	1.81E+06	3.85E+04	0.00E+00	3.15E+06	5.19E+07
Sb-127	4.97E+05	8.86E+03	1.54E+05	6.33E+03	0.00E+00	2.56E+05	1.32E+07
Te-125m	1.81E+07	6.05E+06	2.45E+06	6.09E+06	0.00E+00	0.00E+00	8.62E+06
Te-127m	5.05E+07	1.68E+07	6.12E+06	1.46E+07	1.24E+08	0.00E+00	2.04E+07
Te-127	7.58E+02	2.54E+02	1.63E+02	6.17E+02	1.85E+03	0.00E+00	1.59E+04
Te-129m	6.69E+07	2.29E+07	1.03E+07	2.57E+07	1.67E+08	0.00E+00	3.99E+07
Te-129	3.26E-10	1.12E-10	7.62E-11	2.73E-10	8.12E-10	0.00E+00	2.61E-08
Te-131m	4.05E+05	1.63E+05	1.35E+05	3.31E+05	1.12E+06	0.00E+00	2.75E+06
Te-131	4.11E-33	1.52E-33	1.15E-33	3.67E-33	1.05E-32	0.00E+00	1.66E-31
Te-132	2.53E+06	1.25E+06	1.17E+06	1.85E+06	7.84E+06	0.00E+00	4.64E+06
I-129	8.47E+09	6.28E+09	4.59E+09	4.03E+12	7.43E+09	0.00E+00	1.26E+08
I-130	4.26E+06	9.37E+06	3.76E+06	1.05E+09	1.03E+07	0.00E+00	2.01E+06
I-131	3.26E+09	3.85E+09	1.69E+09	1.26E+12	4.49E+09	0.00E+00	1.37E+08
I-132	1.72E+00	3.48E+00	1.24E+00	1.63E+02	3.89E+00	0.00E+00	2.82E+00
I-133	4.35E+07	6.34E+07	1.86E+07	1.15E+10	7.45E+07	0.00E+00	1.07E+07
I-134	2.11E-11	4.33E-11	1.54E-11	1.01E-09	4.84E-11	0.00E+00	4.47E-11
I-135	1.35E+05	2.68E+05	9.77E+04	2.40E+07	2.99E+05	0.00E+00	9.70E+04
Cs-134	1.09E+11	2.04E+11	2.06E+10	0.00E+00	5.25E+10	2.15E+10	5.54E+08
Cs-135	3.94E+10	3.58E+10	1.87E+09	0.00E+00	1.02E+10	3.88E+09	1.29E+08
Cs-136	5.93E+09	1.74E+10	6.51E+09	0.00E+00	6.95E+09	1.42E+09	2.65E+08
Cs-137	1.54E+11	1.81E+11	1.28E+10	0.00E+00	4.85E+10	1.96E+10	5.65E+08
Cs-138	2.52E-22	4.09E-22	1.98E-22	0.00E+00	2.04E-22	3.19E-23	6.54E-22
Ba-139	5.13E-08	3.40E-11	1.48E-09	0.00E+00	2.04E-11	2.06E-11	3.25E-06
Ba-140	2.89E+07	2.89E+04	1.49E+06	0.00E+00	6.87E+03	1.78E+04	7.10E+06
Ba-141	4.72E-46	3.23E-49	1.49E-47	0.00E+00	1.94E-49	1.97E-49	5.76E-45
Ba-142	2.93E-80	2.44E-83	1.44E-81	0.00E+00	1.40E-83	1.48E-83	1.21E-79
La-140	4.86E+00	1.92E+00	4.93E-01	0.00E+00	0.00E+00	0.00E+00	2.25E+04
La-142	2.04E-11	7.49E-12	1.79E-12	0.00E+00	0.00E+00	0.00E+00	1.27E-06
Ce-141	5.20E+03	3.17E+03	3.74E+02	0.00E+00	9.79E+02	0.00E+00	1.64E+06
Ce-143	4.76E+01	3.16E+04	3.60E+00	0.00E+00	9.20E+00	0.00E+00	1.84E+05
Ce-144	2.79E+05	1.14E+05	1.56E+04	0.00E+00	4.62E+04	0.00E+00	1.60E+07
Pr-143	1.78E+02	6.67E+01	8.84E+00	0.00E+00	2.48E+01	0.00E+00	9.41E+04
Pr-144	6.82E-54	2.64E-54	3.44E-55	0.00E+00	9.56E-55	0.00E+00	1.23E-49
Nd-147	1.06E+02	1.09E+02	6.65E+00	0.00E+00	4.19E+01	0.00E+00	6.88E+04
Eu-152	3.32E+03	8.81E+02	7.43E+02	0.00E+00	2.47E+03	0.00E+00	7.82E+04
W-187	7.30E+03	5.07E+03	1.75E+03	0.00E+00	0.00E+00	0.00E+00	2.98E+05
Np-239	4.38E+00	3.91E-01	2.21E-01	0.00E+00	7.81E-01	0.00E+00	1.13E+04

3.3.6 GRASS-COW-MEAT PATHWAY FACTOR

For radionuclides other than tritium and carbon-14 in the grass-cow-meat pathway, R_{aipj} in (m^2·mrem/y) per (μCi/s) is calculated as follows (Reference 11, Section 5.3.1.4):

Eqn A13.3.3.6-1

$$R_{aipj} = K_1 \times \frac{r}{(\lambda_i + \lambda_w)} \times Q_F \times U_{ap} \times F_{fi} \times (DFL)_{aij} \times \left[\frac{f_p f_s}{Y_p} + \frac{(1 - f_p f_s) e^{-\lambda_i t_{hm}}}{Y_s}\right] \times e^{-\lambda_i t_f}$$

where:

K_1 = the units conversion factor: 10^6 pCi/μCi.

r = the fraction of deposited activity retained on the cow's feed grass. The value used for r is 1.0 for radioiodines and 0.2 for particulates, from (Reference 11, Table E–1).

λ_i = the radioactive decay constant for radionuclide i, in s^{-1}. Values of λ_i used in effluent calculations should be based on decay data from a recognized and current source, such as Reference 46.

λ_w = the rate constant for removal of activity on leaf and plant surfaces by weathering, in s^{-1}, from Table A13.3.3.6-1.

Q_F = the cow's consumption rate of feed, in kg/d, from Table A13.3.3.6-1.

U_{ap} = the consumption rate of meat by a receptor in age group a, in kg/y, from Table A13.3.3.6-2.

F_{fi} = the stable element transfer coefficient applicable to radionuclide i, for meat, in d/kg, from Table A13.3.3.6-3.

$(DFL)_{aij}$ = the ingestion dose factor for receptor age group a, radionuclide i, and organ j, in mrem/pCi, from Table A8-5 through Table A8-8.

f_p = the fraction of the year that the cow is on pasture (dimensionless), from Table A13.3.3.6-1.

f_s = the fraction of the cow's feed that is pasture grass while the cow is on pasture (dimensionless), from Table A13.3.3.6-1.

Y_p = the areal density (agricultural productivity) of growing pasture feed grass, in kg/m^2, from Table A13.3.3.6-1.

Y_s = the areal density (agricultural productivity) of growing stored feed, in kg/m^2, from Table A13.3.3.6-1.

t_{hm} = the transport time from crop field to receptor, in s, from Table A13.3.3.6-1.

t_f = the transport time from pasture to receptor, in s, from Table A13.3.3.6-1.

For tritium in the grass-cow-meat pathway, R_{aipj} in (mrem/y) per ($\mu Ci/m^3$) is calculated as follows (Reference 24, Section 5.3.1.4), based on the concentration in air rather than deposition onto the ground:

Eqn A13.3.3.6-2

$$R_{aipj} = K_1 \times K_3 \times Q_F \times U_{ap} \times F_{fi} \times (DFL)_{aij} \times 0.75 \times \left(\frac{0.5}{H}\right)$$

where:

K_3 = the units conversion factor: 10^3 g/kg.

H = the absolute humidity of atmospheric air, in g/m^3, from Table A13.3.3.6-1.

0.75 = the fraction of total feed that is water (dimensionless).

0.5 = the ratio of the specific activity of tritium in feed grass water to that in atmospheric water (dimensionless).

and other parameters are as defined above.

For carbon-14 in the grass-cow-meat pathway, R_{aipj} in (mrem/y) per (μCi/m^3) is calculated from the modified formula as follows (Reference 11, Eqn C-8), based on the concentration in air rather than deposition onto the ground:

$$R_{aipj} = K_1 \; x \; K_3 \; x \; U_{ap} \; x \; F_{mi} \; x \; (DFL)_{aij} \; x \; (p) \; x \; \left(\frac{0.11}{0.16}\right) \qquad \text{Eqn A13.3.3.6-3}$$

where:

p = The ratio of the total annual release time (for C-14) atmospheric releases) to the total annual time during photosynthesis occurs (taken to be 4400 hrs), under the condition that the value of p should never exceed unity. For continuous C-14 releases, p is taken to be unity.

0.11 = The fraction of total plant mass that is natural carbon, dimensionless.

0.16 = The concentration of natural carbon in the atmosphere, in g/m^3.

Other parameters are as defined above.

Table A13.3.3.6-1 Miscellaneous Parameters for the Grass-Cow-Meat Pathway

The following parameter values are for use in calculating R_{aipj} for the grass-cow-meat pathway only.

Parameter	Value	Reference
λ_w	5.73×10^{-7} s^{-1} (14-day half-life)	Ref. 24, page 33
Q_F	50 kg/d	Ref. 11, Table E-3
f_p	1.0	Ref. 24, page 33
f_s	1.0	Ref. 24, page 33
Y_p	0.7 kg/m^2	Ref. 11, Table E-15
Y_s	2.0 kg/m^2	Ref. 11, Table E-15
t_{hm}	7.78×10^6 s (90 days)	Ref. 11, Table E-15
t_f	1.73×10^6 s (20 days)	Ref. 11, Table E-15
H	8 g/m^3	Ref. 24. Page 27

~~* - Values from Reference 11 (Table E-1) except as follows: Reference 10 (Table C-5) for Br and Sb.~~

~~+ - Values from Reference 11, Table E-2 for H, C, P, Fe, Cu, Sr, I, and Cs in goat milk, and Table E-1 for all other elements in cow milk, except as follows: Reference 10 (Table C-5) for Br and Sb in cow milk.~~

Table A13.3.3.6-2 Site-Related Grass-Cow-Meat R_{aipj} Dose Factors, Adult Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3*	0.00E+00	1.85E+02	1.85E+02	1.85E+02	1.85E+02	1.85E+02	1.85E+02
C-14*	3.33E+05	6.66E+04	6.66E+04	6.66E+04	6.66E+04	6.66E+04	6.66E+04
Na-24	1.36E-03	1.36E-03	1.36E-03	1.36E-03	1.36E-03	1.36E-03	1.36E-03
P-32	4.66E+09	2.90E+08	1.80E+08	0.00E+00	0.00E+00	0.00E+00	5.24E+08
Cr-51	0.00E+00	0.00E+00	7.05E+03	4.21E+03	1.55E+03	9.35E+03	1.77E+06
Mn-54	0.00E+00	9.18E+06	1.75E+06	0.00E+00	2.73E+06	0.00E+00	2.81E+07
Mn-56	0.00E+00	1.52E-53	2.69E-54	0.00E+00	1.92E-53	0.00E+00	4.84E-52
Fe-55	2.93E+08	2.03E+08	4.72E+07	0.00E+00	0.00E+00	1.13E+08	1.16E+08
Fe-59	2.66E+08	6.24E+08	2.39E+08	0.00E+00	0.00E+00	1.74E+08	2.08E+09
Co-57	0.00E+00	5.64E+06	9.37E+06	0.00E+00	0.00E+00	0.00E+00	1.43E+08
Co-58	0.00E+00	1.82E+07	4.09E+07	0.00E+00	0.00E+00	0.00E+00	3.69E+08
Co-60	0.00E+00	7.52E+07	1.66E+08	0.00E+00	0.00E+00	0.00E+00	1.41E+09
Ni-63	1.89E+09	1.31E+08	6.33E+07	0.00E+00	0.00E+00	0.00E+00	2.73E+07
Ni-65	2.25E-53	2.92E-54	1.33E-54	0.00E+00	0.00E+00	0.00E+00	7.40E-53
Cu-64	0.00E+00	2.71E-07	1.27E-07	0.00E+00	6.84E-07	0.00E+00	2.31E-05
Zn-65	3.56E+08	1.13E+09	5.12E+08	0.00E+00	7.57E+08	0.00E+00	7.13E+08
Zn-69m	1.68E-05	4.02E-05	3.68E-06	0.00E+00	2.43E-05	0.00E+00	2.45E-03
Zn-69	1.81E-153	3.46E-153	2.41E-154	0.00E+00	2.25E-153	0.00E+00	5.20E-154
Br-82	0.00E+00	0.00E+00	1.22E+03	0.00E+00	0.00E+00	0.00E+00	1.40E+03
Br-83	0.00E+00	0.00E+00	6.00E-57	0.00E+00	0.00E+00	0.00E+00	8.65E-57
Br-84	0.00E+00	0.00E+00	6.62E-270	0.00E+00	0.00E+00	0.00E+00	5.19E-275
Br-85	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	4.87E+08	2.27E+08	0.00E+00	0.00E+00	0.00E+00	9.60E+07
Rb-88	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-89	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr-89	3.02E+08	0.00E+00	8.66E+06	0.00E+00	0.00E+00	0.00E+00	4.84E+07
Sr-90	1.43E+10	0.00E+00	2.87E+08	0.00E+00	0.00E+00	0.00E+00	3.59E+08
Sr-91	1.52E-10	0.00E+00	6.14E-12	0.00E+00	0.00E+00	0.00E+00	7.23E-10
Sr-92	1.18E-49	0.00E+00	5.10E-51	0.00E+00	0.00E+00	0.00E+00	2.33E-48
Y-90	1.08E+02	0.00E+00	2.89E+00	0.00E+00	0.00E+00	0.00E+00	1.14E+06
Y-91m	6.98E-175	0.00E+00	2.70E-176	0.00E+00	0.00E+00	0.00E+00	2.05E-174
Y-91	1.13E+06	0.00E+00	3.03E+04	0.00E+00	0.00E+00	0.00E+00	6.23E+08
Y-92	1.52E-39	0.00E+00	4.43E-41	0.00E+00	0.00E+00	0.00E+00	2.66E-35
Y-93	4.69E-12	0.00E+00	1.30E-13	0.00E+00	0.00E+00	0.00E+00	1.49E-07
Zr-95	1.87E+06	6.01E+05	4.07E+05	0.00E+00	9.42E+05	0.00E+00	1.90E+09
Zr-97	2.07E-05	4.17E-06	1.91E-06	0.00E+00	6.30E-06	0.00E+00	1.29E+00
Nb-95	2.30E+06	1.28E+06	6.87E+05	0.00E+00	1.26E+06	0.00E+00	7.76E+09
Nb-97	5.90E-119	1.49E-119	5.45E-120	0.00E+00	1.74E-119	0.00E+00	5.50E-116
Mo-99	0.00E+00	1.00E+05	1.90E+04	0.00E+00	2.26E+05	0.00E+00	2.32E+05
Tc-99m	4.45E-21	1.26E-20	1.60E-19	0.00E+00	1.91E-19	6.16E-21	7.44E-18

Tc-101	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ru-103	1.05E+08	0.00E+00	4.53E+07	0.00E+00	4.01E+08	0.00E+00	1.23E+10
Ru-105	5.78E-28	0.00E+00	2.28E-28	0.00E+00	7.46E-27	0.00E+00	3.53E-25

Units are in (m^2·mrem/y) per (μCi/s)
*H-3 and C-14 are in units of (mrem/y) per (μCi/m^3).

Table A13.3.3.6-2 (cont.) Site-Related Grass-Cow-Meat R_{aipj} Dose Factors, Adult Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ru-106	2.80E+09	0.00E+00	3.54E+08	0.00E+00	5.40E+09	0.00E+00	1.81E+11
Rh-105	3.84E+00	2.81E+00	1.85E+00	0.00E+00	1.19E+01	0.00E+00	4.48E+02
Ag-110m	6.68E+06	6.18E+06	3.67E+06	0.00E+00	1.22E+07	0.00E+00	2.52E+09
Cd-113m	0.00E+00	4.60E+06	1.47E+05	0.00E+00	5.06E+06	0.00E+00	3.70E+07
Sb-124	1.98E+07	3.74E+05	7.84E+06	4.80E+04	0.00E+00	1.54E+07	5.62E+08
Sb-125	1.91E+07	2.13E+05	4.55E+06	1.94E+04	0.00E+00	1.47E+07	2.10E+08
Sb-126	1.93E+06	3.94E+04	6.98E+05	1.18E+04	0.00E+00	1.19E+06	1.58E+08
Sb-127	1.66E+04	3.63E+02	6.37E+03	1.99E+02	0.00E+00	9.84E+03	3.80E+06
Te-125m	3.59E+08	1.30E+08	4.81E+07	1.08E+08	1.46E+09	0.00E+00	1.43E+09
Te-127m	1.12E+09	3.99E+08	1.36E+08	2.85E+08	4.53E+09	0.00E+00	3.74E+09
Te-127	2.12E-10	7.62E-11	4.59E-11	1.57E-10	8.64E-10	0.00E+00	1.67E-08
Te-129m	1.13E+09	4.23E+08	1.79E+08	3.90E+08	4.73E+09	0.00E+00	5.71E+09
Te-129	4.47E-121	1.68E-121	1.09E-121	3.43E-121	1.88E-120	0.00E+00	3.37E-121
Te-131m	4.51E+02	2.21E+02	1.84E+02	3.49E+02	2.23E+03	0.00E+00	2.19E+04
Te-131	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Te-132	1.42E+06	9.18E+05	8.62E+05	1.01E+06	8.84E+06	0.00E+00	4.34E+07
I-129	1.30E+08	1.12E+08	3.66E+08	2.88E+11	2.40E+08	0.00E+00	1.77E+07
I-130	2.11E-06	6.22E-06	2.45E-06	5.27E-04	9.71E-06	0.00E+00	5.35E-06
I-131	1.07E+07	1.54E+07	8.80E+06	5.03E+09	2.63E+07	0.00E+00	4.05E+06
I-132	6.97E-59	1.86E-58	6.52E-59	6.52E-57	2.97E-58	0.00E+00	3.50E-59
I-133	3.65E-01	6.35E-01	1.94E-01	9.34E+01	1.11E+00	0.00E+00	5.71E-01
I-134	1.06E-161	2.89E-161	1.03E-161	5.01E-160	4.60E-161	0.00E+00	2.52E-164
I-135	4.43E-17	1.16E-16	4.28E-17	7.64E-15	1.86E-16	0.00E+00	1.31E-16
Cs-134	6.58E+08	1.56E+09	1.28E+09	0.00E+00	5.06E+08	1.68E+08	2.74E+07
Cs-135	2.14E+08	1.97E+08	8.76E+07	0.00E+00	7.47E+07	2.24E+07	4.62E+06
Cs-136	1.21E+07	4.76E+07	3.43E+07	0.00E+00	2.65E+07	3.63E+06	5.41E+06
Cs-137	8.72E+08	1.19E+09	7.81E+08	0.00E+00	4.05E+08	1.35E+08	2.31E+07
Cs-138	2.68E-267	5.30E-267	2.63E-267	0.00E+00	3.90E-267	3.85E-268	2.26E-272
Ba-139	1.24E-101	8.86E-105	3.64E-103	0.00E+00	8.28E-105	5.02E-105	2.20E-101
Ba-140	2.87E+07	3.61E+04	1.88E+06	0.00E+00	1.23E+04	2.07E+04	5.92E+07
Ba-141	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ba-142	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
La-140	3.71E-02	1.87E-02	4.94E-03	0.00E+00	0.00E+00	0.00E+00	1.37E+03
La-142	3.45E-92	1.57E-92	3.90E-93	0.00E+00	0.00E+00	0.00E+00	1.14E-88
Ce-141	1.40E+04	9.50E+03	1.08E+03	0.00E+00	4.41E+03	0.00E+00	3.63E+07
Ce-143	2.01E-02	1.48E+01	1.64E-03	0.00E+00	6.53E-03	0.00E+00	5.55E+02
Ce-144	1.46E+06	6.09E+05	7.83E+04	0.00E+00	3.61E+05	0.00E+00	4.93E+08
Pr-143	2.10E+04	8.41E+03	1.04E+03	0.00E+00	4.85E+03	0.00E+00	9.18E+07
Pr-144	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Nd-147	7.07E+03	8.17E+03	4.89E+02	0.00E+00	4.78E+03	0.00E+00	3.92E+07
Eu-152	2.55E+06	5.81E+05	5.11E+05	0.00E+00	3.60E+06	0.00E+00	3.35E+08
W-187	2.07E-02	1.73E-02	6.04E-03	0.00E+00	0.00E+00	0.00E+00	5.66E+00
Np-239	2.59E-01	2.55E-02	1.40E-02	0.00E+00	7.95E-02	0.00E+00	5.23E+03

Table A13.3.3.6-3 Site-Related Grass-Cow-Meat R_{aipj} Dose Factors, Teenager Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3*	0.00E+00	1.10E+02	1.10E+02	1.10E+02	1.10E+02	1.10E+02	1.10E+02
C-14*	2.81E+05	5.62E+04	5.62E+04	5.62E+04	5.62E+04	5.62E+04	5.62E+04
Na-24	1.08E-03	1.08E-03	1.08E-03	1.08E-03	1.08E-03	1.08E-03	1.08E-03
P-32	3.93E+09	2.44E+08	1.53E+08	0.00E+00	0.00E+00	0.00E+00	3.31E+08
Cr-51	0.00E+00	0.00E+00	5.64E+03	3.13E+03	1.24E+03	8.05E+03	9.47E+05
Mn-54	0.00E+00	7.00E+06	1.39E+06	0.00E+00	2.09E+06	0.00E+00	1.44E+07
Mn-56	0.00E+00	1.23E-53	2.19E-54	0.00E+00	1.56E-53	0.00E+00	8.10E-52
Fe-55	2.38E+08	1.69E+08	3.94E+07	0.00E+00	0.00E+00	1.07E+08	7.31E+07
Fe-59	2.12E+08	4.95E+08	1.91E+08	0.00E+00	0.00E+00	1.56E+08	1.17E+09
Co-57	0.00E+00	4.53E+06	7.59E+06	0.00E+00	0.00E+00	0.00E+00	8.45E+07
Co-58	0.00E+00	1.41E+07	3.24E+07	0.00E+00	0.00E+00	0.00E+00	1.94E+08
Co-60	0.00E+00	5.83E+07	1.31E+08	0.00E+00	0.00E+00	0.00E+00	7.60E+08
Ni-63	1.52E+09	1.07E+08	5.15E+07	0.00E+00	0.00E+00	0.00E+00	1.71E+07
Ni-65	1.88E-53	2.41E-54	1.10E-54	0.00E+00	0.00E+00	0.00E+00	1.30E-52
Cu-64	0.00E+00	2.21E-07	1.04E-07	0.00E+00	5.60E-07	0.00E+00	1.72E-05
Zn-65	2.50E+08	8.69E+08	4.05E+08	0.00E+00	5.56E+08	0.00E+00	3.68E+08
Zn-69m	1.40E-05	3.30E-05	3.02E-06	0.00E+00	2.00E-05	0.00E+00	1.81E-03
Zn-69	1.53E-153	2.91E-153	2.04E-154	0.00E+00	1.90E-153	0.00E+00	5.36E-153
Br-82	0.00E+00	0.00E+00	9.72E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-83	0.00E+00	0.00E+00	5.07E-57	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	5.42E-270	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	4.07E+08	1.91E+08	0.00E+00	0.00E+00	0.00E+00	6.02E+07
Rb-88	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-89	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr-89	2.55E+08	0.00E+00	7.29E+06	0.00E+00	0.00E+00	0.00E+00	3.03E+07
Sr-90	9.89E+09	0.00E+00	1.98E+08	0.00E+00	0.00E+00	0.00E+00	2.26E+08
Sr-91	1.28E-10	0.00E+00	5.08E-12	0.00E+00	0.00E+00	0.00E+00	5.79E-10
Sr-92	9.88E-50	0.00E+00	4.21E-51	0.00E+00	0.00E+00	0.00E+00	2.52E-48
Y-90	9.06E+01	0.00E+00	2.44E+00	0.00E+00	0.00E+00	0.00E+00	7.47E+05
Y-91m	5.85E-175	0.00E+00	2.24E-176	0.00E+00	0.00E+00	0.00E+00	2.76E-173
Y-91	9.54E+05	0.00E+00	2.56E+04	0.00E+00	0.00E+00	0.00E+00	3.91E+08
Y-92	1.28E-39	0.00E+00	3.71E-41	0.00E+00	0.00E+00	0.00E+00	3.52E-35
Y-93	3.96E-12	0.00E+00	1.09E-13	0.00E+00	0.00E+00	0.00E+00	1.21E-07
Zr-95	1.50E+06	4.73E+05	3.25E+05	0.00E+00	6.95E+05	0.00E+00	1.09E+09
Zr-97	1.72E-05	3.41E-06	1.57E-06	0.00E+00	5.17E-06	0.00E+00	9.23E-01
Nb-95	1.79E+06	9.95E+05	5.48E+05	0.00E+00	9.65E+05	0.00E+00	4.26E+09
Nb-97	4.92E-119	1.22E-119	4.46E-120	0.00E+00	1.43E-119	0.00E+00	2.92E-115
Mo-99	0.00E+00	8.27E+04	1.58E+04	0.00E+00	1.89E+05	0.00E+00	1.48E+05
Tc-99m	3.53E-21	9.86E-21	1.28E-19	0.00E+00	1.47E-19	5.47E-21	6.47E-18
Tc-101	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ru-103	8.57E+07	0.00E+00	3.66E+07	0.00E+00	3.02E+08	0.00E+00	7.16E+09
Ru-105	4.83E-28	0.00E+00	1.87E-28	0.00E+00	6.09E-27	0.00E+00	3.90E-25

Units are in (m^2·mrem/y) per (μCi/s)
*H-3 and C-14 are in units of (mrem/y) per (μCi/m^3).

Table A13.3.3.6-3 (cont.) Site-Related Grass-Cow-Meat R_{aipj} Dose Factors, Teenager Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ru-106	2.36E+09	0.00E+00	2.97E+08	0.00E+00	4.55E+09	0.00E+00	1.13E+11
Rh-105	3.25E+00	2.35E+00	1.54E+00	0.00E+00	9.96E+00	0.00E+00	2.98E+02
Ag-110m	5.06E+06	4.79E+06	2.91E+06	0.00E+00	9.13E+06	0.00E+00	1.34E+09
Cd-113m	0.00E+00	3.85E+06	1.24E+05	0.00E+00	4.26E+06	0.00E+00	2.31E+07
Sb-124	1.62E+07	2.98E+05	6.31E+06	3.67E+04	0.00E+00	1.41E+07	3.26E+08
Sb-125	1.56E+07	1.71E+05	3.66E+06	1.49E+04	0.00E+00	1.37E+07	1.22E+08
Sb-126	1.58E+06	3.23E+04	5.68E+05	8.94E+03	0.00E+00	1.13E+06	9.35E+07
Sb-127	1.38E+04	2.95E+02	5.21E+03	1.55E+02	0.00E+00	9.39E+03	2.34E+06
Te-125m	3.03E+08	1.09E+08	4.05E+07	8.47E+07	0.00E+00	0.00E+00	8.94E+08
Te-127m	9.41E+08	3.34E+08	1.12E+08	2.24E+08	3.82E+09	0.00E+00	2.35E+09
Te-127	1.80E-10	6.38E-11	3.88E-11	1.24E-10	7.29E-10	0.00E+00	1.39E-08
Te-129m	9.50E+08	3.53E+08	1.50E+08	3.07E+08	3.97E+09	0.00E+00	3.57E+09
Te-129	3.76E-121	1.40E-121	9.16E-122	2.69E-121	1.58E-120	0.00E+00	2.06E-120
Te-131m	3.76E+02	1.80E+02	1.50E+02	2.71E+02	1.88E+03	0.00E+00	1.45E+04
Te-131	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Te-132	1.16E+06	7.36E+05	6.92E+05	7.76E+05	7.06E+06	0.00E+00	2.33E+07
I-129	1.10E+08	9.21E+07	1.54E+08	1.12E+11	1.65E+08	0.00E+00	1.07E+07
I-130	1.70E-06	4.91E-06	1.96E-06	4.00E-04	7.56E-06	0.00E+00	3.77E-06
I-131	8.92E+06	1.25E+07	6.71E+06	3.65E+09	2.15E+07	0.00E+00	2.47E+06
I-132	5.66E-59	1.48E-58	5.31E-59	4.99E-57	2.33E-58	0.00E+00	6.45E-59
I-133	3.05E-01	5.18E-01	1.58E-01	7.23E+01	9.09E-01	0.00E+00	3.92E-01
I-134	8.66E-162	2.30E-161	8.24E-162	3.83E-160	3.62E-161	0.00E+00	3.02E-163
I-135	3.60E-17	9.27E-17	3.44E-17	5.96E-15	1.46E-16	0.00E+00	1.03E-16
Cs-134	5.23E+08	1.23E+09	5.71E+08	0.00E+00	3.91E+08	1.49E+08	1.53E+07
Cs-135	1.80E+08	1.65E+08	3.86E+07	0.00E+00	6.31E+07	2.28E+07	2.89E+06
Cs-136	9.40E+06	3.70E+07	2.48E+07	0.00E+00	2.01E+07	3.17E+06	2.98E+06
Cs-137	7.24E+08	9.63E+08	3.36E+08	0.00E+00	3.28E+08	1.27E+08	1.37E+07
Cs-138	2.23E-267	4.28E-267	2.14E-267	0.00E+00	3.16E-267	3.68E-268	1.94E-270
Ba-139	1.05E-101	7.41E-105	3.07E-103	0.00E+00	6.98E-105	5.10E-105	9.39E-101
Ba-140	2.38E+07	2.91E+04	1.53E+06	0.00E+00	9.87E+03	1.96E+04	3.66E+07
Ba-141	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ba-142	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
La-140	3.05E-02	1.50E-02	3.99E-03	0.00E+00	0.00E+00	0.00E+00	8.61E+02
La-142	2.85E-92	1.26E-92	3.15E-93	0.00E+00	0.00E+00	0.00E+00	3.85E-88
Ce-141	1.18E+04	7.87E+03	9.04E+02	0.00E+00	3.71E+03	0.00E+00	2.25E+07
Ce-143	1.69E-02	1.23E+01	1.37E-03	0.00E+00	5.51E-03	0.00E+00	3.69E+02
Ce-144	1.23E+06	5.08E+05	6.60E+04	0.00E+00	3.04E+05	0.00E+00	3.09E+08
Pr-143	1.76E+04	7.04E+03	8.78E+02	0.00E+00	4.09E+03	0.00E+00	5.80E+07
Pr-144	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Nd-147	6.23E+03	6.77E+03	4.06E+02	0.00E+00	3.98E+03	0.00E+00	2.44E+07
Eu-152	1.90E+06	4.56E+05	4.02E+05	0.00E+00	2.12E+06	0.00E+00	1.68E+08
W-187	1.73E-02	1.41E-02	4.95E-03	0.00E+00	0.00E+00	0.00E+00	3.82E+00
Np-239	2.26E-01	2.14E-02	1.19E-02	0.00E+00	6.70E-02	0.00E+00	3.44E+03

Table A13.3.3.6-4 Site-Related Grass-Cow-Meat R_{aipj} Dose Factors, Child Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3*	0.00E+00	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02	1.34E+02
C-14*	5.29E+05	1.06E+05	1.06E+05	1.06E+05	1.06E+05	1.06E+05	1.06E+05
Na-24	1.72E-03	1.72E-03	1.72E-03	1.72E-03	1.72E-03	1.72E-03	1.72E-03
P-32	7.42E+09	3.47E+08	2.86E+08	0.00E+00	0.00E+00	0.00E+00	2.05E+08
Cr-51	0.00E+00	0.00E+00	8.79E+03	4.88E+03	1.33E+03	8.91E+03	4.66E+05
Mn-54	0.00E+00	8.01E+06	2.13E+06	0.00E+00	2.25E+06	0.00E+00	6.72E+06
Mn-56	0.00E+00	1.64E-53	3.70E-54	0.00E+00	1.98E-53	0.00E+00	2.38E-51
Fe-55	4.57E+08	2.42E+08	7.51E+07	0.00E+00	0.00E+00	1.37E+08	4.49E+07
Fe-59	3.76E+08	6.09E+08	3.03E+08	0.00E+00	0.00E+00	1.77E+08	6.34E+08
Co-57	0.00E+00	5.92E+06	1.20E+07	0.00E+00	0.00E+00	0.00E+00	4.85E+07
Co-58	0.00E+00	1.64E+07	5.02E+07	0.00E+00	0.00E+00	0.00E+00	9.58E+07
Co-60	0.00E+00	6.93E+07	2.04E+08	0.00E+00	0.00E+00	0.00E+00	3.84E+08
Ni-63	2.91E+09	1.56E+08	9.91E+07	0.00E+00	0.00E+00	0.00E+00	1.05E+07
Ni-65	3.52E-53	3.31E-54	1.93E-54	0.00E+00	0.00E+00	0.00E+00	4.06E-52
Cu-64	0.00E+00	2.97E-07	1.80E-07	0.00E+00	7.19E-07	0.00E+00	1.40E-05
Zn-65	3.75E+08	1.00E+09	6.22E+08	0.00E+00	6.30E+08	0.00E+00	1.76E+08
Zn-69m	2.61E-05	4.45E-05	5.25E-06	0.00E+00	2.58E-05	0.00E+00	1.45E-03
Zn-69	2.87E-153	4.15E-153	3.83E-154	0.00E+00	2.52E-153	0.00E+00	2.61E-151
Br-82	0.00E+00	0.00E+00	1.52E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-83	0.00E+00	0.00E+00	9.52E-57	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	9.37E-270	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	5.77E+08	3.55E+08	0.00E+00	0.00E+00	0.00E+00	3.71E+07
Rb-88	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-89	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr-89	4.82E+08	0.00E+00	1.38E+07	0.00E+00	0.00E+00	0.00E+00	1.87E+07
Sr-90	1.57E+10	0.00E+00	3.15E+08	0.00E+00	0.00E+00	0.00E+00	1.40E+08
Sr-91	2.40E-10	0.00E+00	9.05E-12	0.00E+00	0.00E+00	0.00E+00	5.29E-10
Sr-92	1.84E-49	0.00E+00	7.39E-51	0.00E+00	0.00E+00	0.00E+00	3.49E-48
Y-90	1.71E+02	0.00E+00	4.59E+00	0.00E+00	0.00E+00	0.00E+00	4.88E+05
Y-91m	1.09E-174	0.00E+00	3.98E-176	0.00E+00	0.00E+00	0.00E+00	2.14E-171
Y-91	1.80E+06	0.00E+00	4.82E+04	0.00E+00	0.00E+00	0.00E+00	2.40E+08
Y-92	2.41E-39	0.00E+00	6.89E-41	0.00E+00	0.00E+00	0.00E+00	6.96E-35
Y-93	7.44E-12	0.00E+00	2.04E-13	0.00E+00	0.00E+00	0.00E+00	1.11E-07
Zr-95	2.66E+06	5.85E+05	5.21E+05	0.00E+00	8.38E+05	0.00E+00	6.11E+08
Zr-97	3.21E-05	4.63E-06	2.73E-06	0.00E+00	6.65E-06	0.00E+00	7.02E-01
Nb-95	3.10E+06	1.21E+06	8.62E+05	0.00E+00	1.13E+06	0.00E+00	2.23E+09
Nb-97	9.14E-119	1.65E-119	7.71E-120	0.00E+00	1.83E-119	0.00E+00	5.10E-114
Mo-99	0.00E+00	1.15E+05	2.84E+04	0.00E+00	2.46E+05	0.00E+00	9.51E+04
Tc-99m	6.20E-21	1.22E-20	2.01E-19	0.00E+00	1.77E-19	6.17E-21	6.91E-18
Tc-101	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ru-103	1.55E+08	0.00E+00	5.96E+07	0.00E+00	3.90E+08	0.00E+00	4.01E+09
Ru-105	9.02E-28	0.00E+00	3.27E-28	0.00E+00	7.93E-27	0.00E+00	5.88E-25

Units are in ($m^2 \cdot$mrem/y) per (μCi/s)
*H-3 and C-14 are in units of (mrem/y) per ($\mu Ci/m^3$).

Table A13.3.3.6-4 (cont.) Site-Related Grass-Cow-Meat R_{aipj} Dose Factors, Child Age Group

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ru-106	4.44E+09	0.00E+00	5.54E+08	0.00E+00	5.99E+09	0.00E+00	6.90E+10
Rh-105	6.08E+00	3.27E+00	2.79E+00	0.00E+00	1.30E+01	0.00E+00	2.02E+02
Ag-110m	8.39E+06	5.67E+06	4.53E+06	0.00E+00	1.06E+07	0.00E+00	6.74E+08
Cd-113m	0.00E+00	5.50E+06	2.34E+05	0.00E+00	5.66E+06	0.00E+00	1.42E+07
Sb-124	2.92E+07	3.79E+05	1.02E+07	6.45E+04	0.00E+00	1.62E+07	1.83E+08
Sb-125	2.85E+07	2.20E+05	5.97E+06	2.64E+04	0.00E+00	1.59E+07	6.80E+07
Sb-126	2.76E+06	4.22E+04	9.91E+05	1.62E+04	0.00E+00	1.32E+06	5.56E+07
Sb-127	2.54E+04	3.93E+02	8.82E+03	2.83E+02	0.00E+00	1.10E+04	1.43E+06
Te-125m	5.69E+08	1.54E+08	7.59E+07	1.60E+08	0.00E+00	0.00E+00	5.49E+08
Te-127m	1.77E+09	4.78E+08	2.11E+08	4.24E+08	5.06E+09	0.00E+00	1.44E+09
Te-127	3.39E-10	9.13E-11	7.26E-11	2.34E-10	9.63E-10	0.00E+00	1.32E-08
Te-129m	1.79E+09	5.00E+08	2.78E+08	5.77E+08	5.26E+09	0.00E+00	2.18E+09
Te-129	7.10E-121	1.98E-121	1.69E-121	5.07E-121	2.08E-120	0.00E+00	4.42E-119
Te-131m	7.00E+02	2.42E+02	2.58E+02	4.98E+02	2.34E+03	0.00E+00	9.82E+03
Te-131	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Te-132	2.12E+06	9.38E+05	1.13E+06	1.37E+06	8.71E+06	0.00E+00	9.45E+06
I-129	2.06E+08	1.26E+08	1.13E+08	8.27E+10	2.13E+08	0.00E+00	6.36E+06
I-130	3.04E-06	6.13E-06	3.16E-06	6.76E-04	9.17E-06	0.00E+00	2.87E-06
I-131	1.65E+07	1.66E+07	9.46E+06	5.50E+09	2.73E+07	0.00E+00	1.48E+06
I-132	1.02E-58	1.88E-58	8.65E-59	8.72E-57	2.88E-58	0.00E+00	2.21E-58
I-133	5.67E-01	7.02E-01	2.66E-01	1.30E+02	1.17E+00	0.00E+00	2.83E-01
I-134	1.57E-161	2.91E-161	1.34E-161	6.70E-160	4.45E-161	0.00E+00	1.93E-161
I-135	6.52E-17	1.17E-16	5.55E-17	1.04E-14	1.80E-16	0.00E+00	8.94E-17
Cs-134	9.22E+08	1.51E+09	3.19E+08	0.00E+00	4.69E+08	1.68E+08	8.16E+06
Cs-135	3.39E+08	2.36E+08	2.42E+07	0.00E+00	8.34E+07	2.78E+07	1.77E+06
Cs-136	1.62E+07	4.46E+07	2.88E+07	0.00E+00	2.37E+07	3.54E+06	1.57E+06
Cs-137	1.33E+09	1.28E+09	1.88E+08	0.00E+00	4.16E+08	1.50E+08	7.99E+06
Cs-138	4.13E-267	5.75E-267	3.64E-267	0.00E+00	4.04E-267	4.35E-268	2.65E-267
Ba-139	1.98E-101	1.06E-104	5.73E-103	0.00E+00	9.22E-105	6.21E-105	1.14E-99
Ba-140	4.38E+07	3.84E+04	2.56E+06	0.00E+00	1.25E+04	2.29E+04	2.22E+07
Ba-141	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ba-142	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
La-140	5.59E-02	1.95E-02	6.58E-03	0.00E+00	0.00E+00	0.00E+00	5.44E+02
La-142	5.26E-92	1.68E-92	5.25E-93	0.00E+00	0.00E+00	0.00E+00	3.32E-87
Ce-141	2.22E+04	1.11E+04	1.64E+03	0.00E+00	4.86E+03	0.00E+00	1.38E+07
Ce-143	3.17E-02	1.72E+01	2.49E-03	0.00E+00	7.21E-03	0.00E+00	2.52E+02
Ce-144	2.32E+06	7.26E+05	1.24E+05	0.00E+00	4.02E+05	0.00E+00	1.89E+08
Pr-143	3.34E+04	1.00E+04	1.66E+03	0.00E+00	5.43E+03	0.00E+00	3.60E+07
Pr-144	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Nd-147	1.17E+04	9.47E+03	7.33E+02	0.00E+00	5.19E+03	0.00E+00	1.50E+07
Eu-152	3.00E+06	5.46E+05	6.49E+05	0.00E+00	2.31E+06	0.00E+00	8.98E+07
W-187	3.21E-02	1.90E-02	8.53E-03	0.00E+00	0.00E+00	0.00E+00	2.67E+00
Np-239	4.26E-01	3.06E-02	2.15E-02	0.00E+00	8.85E-02	0.00E+00	2.26E+03