WATTS BAR NUCLEAR PLANT

OFFSITE DOSE CALCULATION MANUAL

Revision 2

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WATTS BAR NUCLEAR PLANT
OFFSITE DOSE CALCULATION MANUAL
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INTRODUCTION

The Watts Bar Nuclear Plant (WBN) Offsite Dose Calculation Manual (ODCM) is a supporting document of the WBN Technical Specifications (TS) required by WBN TS 5.7.2.3. The ODCM is divided into two major parts: controls and methodologies.

The first part of the ODCM (Sections 1 through 5) contains:

1) Radioactive Effluent Controls required by Section 5.7.2.7 of the WBN Technical Specifications;
2) Radiological Environmental Monitoring Controls required by Section 5.7.2.8 of the WBN Technical Specifications;
3) Controls for Meteorological Monitoring Instrumentation;
4) Descriptions of the information that should be included in the Annual Radiological Environmental Operating and Radioactive Effluent Release Reports required by WBN Technical Specifications 5.9.1.3 and 5.9.1.4; and,
5) Administrative Controls for the ODCM requirements.

These sections of the document have been prepared using the guidance provided in NUREG-1301, "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors," Generic Letter 89-01, Supplement No. 1. April 1991. Exceptions to this guidance have been documented in Appendix A to the ODCM.

The second part of the ODCM contains the methodologies and parameters used to:

1) Calculate offsite doses resulting from radioactive gaseous and liquid effluents;
2) Calculate gaseous and liquid effluent monitor Alarm/Trip setpoints; and,
3) Conduct the Environmental Radiological Monitoring Program.

These methodologies and parameters were developed using the guidance in NUREG-0133, "Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants," September 1978; 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 Part 50, Appendix I," Revision 1, October 1977; Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors," Revision 1, July 1977; Regulatory Guide 1.113, "Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing 10 CFR Part 50 Appendix I," Revision 1, April 1977 and 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 Reactors," Revision 1, June 1974. Where any methodology or parameter differs from the guidance provided in the above documents, it has been documented in the text and references given for the source of the information.

The WBN ODCM will be maintained for use as a reference guide on accepted methodologies and calculations. Changes in the calculation methods or parameters will be incorporated into the ODCM in order to assure that the ODCM represents the present methodology in all applicable areas. Any licensee initiated ODCM changes will be made and implemented in accordance with WBN TS 5.7.2.3.

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Revision 2 of the Offsite Dose Calculation Manual

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RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

SECTIONS 1.0 AND 2.0

CONTROLS AND

SURVEILLANCE REQUIREMENTS

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

1/2 CONTROLS AND SURVEILLANCE REQUIREMENTS

1/2.0 APPLICABILITY

CONTROLS

1.0.1 Controls shall be met during the MODES or other specified conditions in the Applicability, except as provided in Control 1.0.2.

1.0.2 Upon discovery of a failure to meet a Control, the Action(s) of the associated Conditions shall be met.

If the Control is met or is no longer applicable prior to expiration of the Action(s), completion of the Action(s) is not required unless otherwise stated.

SURVEILLANCE REQUIREMENTS

2.0.1 Surveillance Requirements (SR) shall be met during MODES or other conditions in the Applicability for individual Controls, unless otherwise stated in the SR. Failure to meet the Control occurs when a surveillance is failed or when conditions occur between surveillances that would result in a failed surveillance if testing was performed. Failure to perform a surveillance within the specified frequency shall be failure to meet the Control except as provided in SR 3.0.3. Surveillances do not have to be performed on inoperable equipment or variables outside specified limits.

2.0.2 The specified frequency for each SR is met if the surveillance is performed within 1.25 times the interval specified in the frequency, as measured from the previous performance or as measured from a time a specified condition of the frequency is met.

For frequencies specified as "once," the above interval extension does not apply.

If an Action requires periodic performance on a "once per..." basis, the above frequency extension applies to each performance after the initial performance.

Exceptions to this SR control section are stated in the individual SRs.

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

1/2 CONTROLS AND SURVEILLANCE REQUIREMENTS

1/2.0 APPLICABILITY

SURVEILLANCE REQUIREMENTS

2.0.3 If it is discovered that a surveillance was not performed within its specified frequency, then compliance with the requirement to declare the Control not met may be delayed, from the time of discovery, up to 24 hours or up to the limit of the specified frequency, whichever is less. This delay period is permitted to allow performance of the surveillance.

If the surveillance is not performed within the delay period, the Control must immediately be declared not met, and the applicable Action(s) must be entered. The Action(s) begin immediately upon expiration of the delay period.

When the surveillance is performed within the delay period and the surveillance is not met, the Control must immediately be entered. The Action(s) begin immediately upon failure to meet the surveillance.

2.0.4 Entry into a MODE or other specified condition in the Applicability of a Control shall not be made unless the Control's surveillances have been met within their specified frequency. This provision shall not prevent passage through to MODES or other specified conditions in compliance with Action(s).

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

1/2 CONTROLS AND SURVEILLANCE REQUIREMENTS

1/2.1 INSTRUMENTATION

1/2.1.1 RADIOACTIVE LIQUID EFFLUENT MONITORING INSTRUMENTATION

CONTROLS

1.1.1 As required by WBN TS 5.7.2.7.a, the radioactive liquid effluent monitoring instrumentation channels shown in Table 1.1-1 shall be OPERABLE with their alarm/trip setpoints set to ensure that the limits of ODCM Control 1.2.1.1 are not exceeded. The alarm/trip setpoints of these channels shall be determined in accordance with the methodology and parameters in ODCM Section 6.2.

APPLICABILITY: This requirement is applicable as shown in Table 1.1-1.

ACTION:

a. 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, or declare the channel inoperable, or change the setpoint so that it is acceptably conservative.

b. With less than the minimum number of radioactive liquid effluent monitoring instrumentation channels OPERABLE, take the action shown in Table 1.1-1. Restore the inoperable instruments to OPERABLE status within 30 days and, if unsuccessful, explain in the next Radioactive Effluent Release Report, pursuant to ODCM Administrative Control 5.2, why the inoperability was not corrected within 30 days.

SURVEILLANCE REQUIREMENTS

2.1.1 Each radioactive liquid effluent monitoring instrumentation channel shall be demonstrated OPERABLE by performance of the CHANNEL CHECK, SOURCE CHECK, CHANNEL CALIBRATION, and CHANNEL OPERATIONAL TEST operations at the frequencies shown in Table 2.1-1.

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

Table 1.1-1 (Page 1 of 2)
RADIOACTIVE LIQUID EFFLUENT MONITORING INSTRUMENTATION

INSTRUMENT	MINIMUM CHANNELS OPERABLE	ACTION	APPLICABILITY
1. RADIOACTIVITY MONITORS PROVIDING ALARM AND AUTOMATIC TERMINATION OF RELEASE			
a. Liquid Radwaste Effluent Line (RE 90 122)	1	A	**
b. Steam Generator Blowdown Effluent Line (RE 90 120 and 121)	1	B	***
c. Condensate Demineralizer Regenerant Effluent Line (RE 90 225)	1	A	**
2. RADIOACTIVITY MONITORS PROVIDING ALARM BUT NOT PROVIDING AUTOMATIC TERMINATION OF RELEASE			
a. Essential Raw Cooling Water Effluent Header -140, and -141)	1/Discharge Header	C	*
b. Turbine Building Sump Effluent Line (RE-90-212)	1	C	*
3. FLOW RATE MEASUREMENT DEVICES			
a. Liquid Radwaste Effluent Line (FI-77-42)	1	D	**
b. Steam Generator Blowdown Effluent Line (FI-15-44, FR-15-25)		D	***
c. Condensate Demineralizer Effluent Line (FI-14-456)	1	D	**
d. Diffuser Discharge Effluent Line (FR-27-98)	1	D	*

* At all times.
** During releases via this pathway
*** During operation in MODES 1, 2, 3, and 4.

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

Table 1.1-1 (Page 2 of 2)
RADIOACTIVE LIQUID EFFLUENT MONITORING INSTRUMENTATION
TABLE NOTATION

ACTION A - With the number of channels OPERABLE less than required by the Minimum Channels OPERABLE requirement, effluent releases via this pathway may continue provided that prior to initiating a release:

a. At least two independent samples are analyzed in accordance with ODCM Requirement 2.2.1.1, and

b. At least two technically qualified members of the facility staff independently verify the release rate calculations and discharge line valving;

Otherwise, suspend release of radioactive effluents via this pathway.

ACTION B - With the number of channels OPERABLE less than required by the Minimum Channels OPERABLE requirement, effluent releases via this pathway may continue provided grab samples are analyzed for gamma radioactivity at a lower limit of detection of no more than 10^{-7} µCi/ml:

a. At least once per 12 hours when the specific activity of the secondary coolant is equal to or greater than 0.01 µCi/gram DOSE EQUIVALENT I-131, or

b. At least once per 24 hours when the specific activity of the secondary coolant is less than 0.01 µCi/gram DOSE EQUIVALENT I-131.

ACTION C - With the number of channels OPERABLE less than required by the Minimum Channels OPERABLE requirement, effluent releases via this pathway may continue provided that, at least once per 12 hours, grab samples are collected and analyzed for gamma radioactivity at a lower limit of detection of no more than 10^{-7} µCi/ml.

ACTION D - With the number of channels OPERABLE less than required by the Minimum Channels OPERABLE requirement, effluent releases via this pathway may continue provided the flow rate is estimated at least once per 4 hours during actual releases. Pump curves may be used to estimate flow.

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

Table 2.1-1 (Page 1 of 2)
RADIOACTIVE LIQUID EFFLUENT MONITORING INSTRUMENTATION
SURVEILLANCE REQUIREMENTS*

INSTRUMENT	CHANNEL CHECK	SOURCE CHECK	CHANNEL CALIBRATION	CHANNEL OPERATIONAL TEST
1. RADIOACTIVITY MONITORS PROVIDING ALARM AND AUTOMATIC TERMINATION OF RELEASE				
a. Liquid Radwaste Effluent Line (RE-90-122)	D	P	R(3)	Q(1)
b. Steam Generator Blowdown Effluent Line (RE-90-120 and -121)	D	M	R(3)	Q(5)
c. Condensate Demineralizer Regenerant Effluent Line (RE-90-225)	D	M	R(3)	Q(5)
2. RADIOACTIVITY MONITORS PROVIDING ALARM BUT NOT PROVIDING AUTOMATIC TERMINATION OF RELEASE				
a. Essential Raw Cooling Water Effluent Line (RE-90-133, -134, -140, -141)	D	M	R(3)	Q(2)
b. Turbine Building Sump Effluent Line (RE-90-212)	D	M	R(3)	Q(2)
3. FLOW RATE MEASUREMENT DEVICES				
a. Liquid Radwaste Effluent Line (FI-77-42)	D(4)	N.A.	R	N.A.
b. Steam Generator Blowdown Effluent Line (FI-15-44, FR-15-25)	D(4)	N.A.	5 years	N.A.
c. Condensate Demineralizer Effluent Line (FI-14-456)	D(4)	N.A.	R	N.A.
d. Diffuser Discharge Effluent Line (FR-27-98)	D(4)	N.A.	R	Q

* See Table 3.1 (FREQUENCY NOTATION) for the surveillance frequency definitions.

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

Table 2.1-1 (Page 2 of 2)
RADIOACTIVE LIQUID EFFLUENT MONITORING INSTRUMENTATION
SURVEILLANCE REQUIREMENTS
TABLE NOTATION

(1) The CHANNEL OPERATIONAL TEST shall also demonstrate that automatic isolation of this pathway and control room alarm annunciation occurs if any of the following conditions exists:

1. Instrument indicates measured levels above the alarm/trip setpoint, or
2. Circuit failure, or
3. Indication of downscale failure, or
4. Instrumentation controls not set in operate mode.

(2) The CHANNEL OPERATIONAL TEST shall also demonstrate that control room alarm annunciation occurs if any of the following conditions exists:

1. Instrument indicates measured levels above the alarm setpoint, or
2. Circuit failure, or
3. Indication of downscale failure, or
4. Instrumentation controls not set in operate mode.

(3) The initial CHANNEL CALIBRATION shall be performed using one or more of the reference standards certified by the National Institute of Standards and Technology (NIST) 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 subsequent CHANNEL CALIBRATION, NIST standards or sources that have been related to the initial calibration shall be used.

(4) 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.

(5) The CHANNEL OPERATIONAL TEST shall demostrate that automatic isolation of this pathway occurs if the instrument indicates measured levels above the alarm/trip setpoint. The CHANNEL OPERATIONAL TEST also demonstrates control room annunciation occurs if any of the following conditions exist:

1. Instrument indicates measured levels above the alarm setpoint, or
2. Circuit failure, or
3. Indication of downscale failure, or
4. Instrumentation controls not set in operate mode.

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

1/2 CONTROLS AND SURVEILLANCE REQUIREMENTS

1/2.1 INSTRUMENTATION

1/2.1.2 RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION

CONTROLS

1.1.2 In accordance with WBN TS 5.7.2.7.a, the radioactive gaseous effluent monitoring instrumentation channels shown in Table 1.1-2 shall be OPERABLE with their alarm/trip setpoints set to ensure that the limits of ODCM Control 1.2.2.1 are not exceeded. The alarm/trip setpoints of these channels shall be determined and adjusted in accordance with the methodology and parameters in ODCM Section 7.1.

APPLICABILITY: As shown in Table 1.1-2.

ACTION:

a. 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, or declare the channel inoperable, or change the setpoint so it is acceptably conservative.

b. With less than the minimum number of radioactive gaseous effluent monitoring instrumentation channels OPERABLE, take the ACTION shown in Table 1.1-2. Restore the inoperable instruments to OPERABLE status within 30 days and, if unsuccessful, explain in the next Radioactive Effluent Report, per ODCM Administrative Control 5.2, why the inoperability was not corrected within 30 days.

SURVEILLANCE REQUIREMENTS

2.1.2 Each radioactive gaseous effluent monitoring instrumentation channel shall be demonstrated OPERABLE by performance of the CHANNEL CHECK, SOURCE CHECK, CHANNEL CALIBRATION, and CHANNEL OPERATIONAL TEST at the frequencies shown in Table 2.1-2.

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

Table 1.1-2 (Page 1 of 2)
RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION

INSTRUMENT	MINIMUM CHANNELS OPERABLE	APPLICABILITY	ACTION
1. WASTE GAS DISPOSAL SYSTEM			
a. Noble Gas Activity Monitor (RE-90-118)	1	*	A
b. Effluent Flow Rate Measuring Device (FI-77-230)	1	*	B
2. CONDENSER VACUUM EXHAUST SYSTEM			
a. Noble Gas Activity Monitors (RE-90-119, -404)	2	***	C
b. Iodine and Particulate Sampler (RE-90-129)	1	*	D
c. Flow Rate Monitor (FT-2-257)	1	*	B
d. Sampler Flow Rate Measuring Device (FI-90-129)	1	***	D
3. SHIELD BUILDING EXHAUST SYSTEM			
a. Noble Gas Low Range Activity Monitor (RE-90-400)	1	**	C
b. Iodine and Particulate Sampler (RE-90-402)	1	**	D
c. Effluent Flow Rate Measuring Device	1	**	B
d. Sampler Flow Rate Measuring Device	1	**	D
4. AUXILIARY BUILDING VENTILATION SYSTEM AND FUEL HANDLING AREA VENTILATION SYSTEM			
a. Noble Gas Activity Monitor (RE-90-101B)	1	*	C
b. Iodine and Particulate Sampler	1	*	D
c. ffluent Flow Rate Measuring Device	1	*	B
d. Sampler Flow Rate Measuring Device (FI-90-101B)	1	*	D
5. SERVICE BUILDING VENTILATION SYSTEM			
a. Noble Gas Activity Monitor (RE-90-132B)	1	*	C
b. Effluent Flow Rate Measuring System (FI-90-320/1B)	1	*	B
6. CONTAINMENT PURGE AND EXHAUST SYSTEM			
a. Noble Gas Activity Monitors (RE-90-130, RE-90-131)	1	*	E

Table 1.1-2 (Page 2 of 2)
RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION
TABLE NOTATION

* At all times.

** At all times. Both Unit 1 and 2 Shield Building Exhaust System equipment must be OPERABLE for operation of either unit.

*** During operation in MODES 1, 2, 3, and 4.
During MODES 5 and 6 with Condenser Vacuum Exhaust System in operation.

ACTION A - With the number of channels OPERABLE less than required by the Minimum Channels OPERABLE requirement, the contents of the tank(s) may be released to the environment provided that prior to initiating the release:

a. 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 release rate calculations and discharge valve lineup;

Otherwise, suspend release of radioactive effluents via this pathway.

ACTION B - With the number of channels OPERABLE less than required by the Minimum Channels OPERABLE requirement, effluent releases via this pathway may continue provided the flow rate is estimated at least once per 4 hours during releases via this pathway.

ACTION C - With the number of channels OPERABLE less than required by the Minimum Channels OPERABLE 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 noble gas gross activity within 24 hours.

ACTION D - With the number of channels OPERABLE less than required by the Minimum Channels OPERABLE requirement, effluent releases via the affected pathway may continue provided that samples are continuously collected with auxiliary sampling equipment as required in Table 2.2-2.

ACTION E - With the minimum number of channels OPERABLE less than required by the Minimum Channels OPERABLE requirement, immediately suspend PURGING or VENTING of radioactive effluents via this pathway.

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

Table 2.1-2 (Page 1 of 3)
RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION
SURVEILLANCE REQUIREMENTS*

INSTRUMENT	CHANNEL CHECK	SOURCE CHECK	CHANNEL CALIBRATION	CHANNEL OPERATIONAL TEST
1. WASTE GAS DISPOSAL SYSTEM				
a. Noble Gas Activity Monitor (RE-90-118)	P	P	R(3)	Q(1)
b. Effluent Flow Rate Measurement Device (FI-77-230)	P	N.A.	R	N.A.
2. CONDENSER VACUUM EXHAUST SYSTEM				
a. Noble Gas Activity Monitor (RE-90-119 or -404)	D	M	R(3)	Q(2)
b. Iodine and Particulate Sampler (RE-90-129)	W(4)	N.A.	N.A.	N.A.
c. Effluent Flow Rate Measuring Device (FT-2-257)	D	N.A.	R	N.A.
d. Sampler Flow Rate Measuring Device (FI-90-129)	D	N.A.	5 years	N.A.
3. SHIELD BUILDING EXHAUST SYSTEM				
a. Noble Gas Activity Monitor (RE-90-400)	D	M	R(3)	Q(2)
b. Iodine and Particulate Sampler (RE-90-402)	W(4)	N.A.	N.A.	N.A.
c. Effluent Flow Rate Measuring Device	D	N.A.	R	Q
d. Sampler Flow Rate Measuring Device	D	N.A.	R	N.A.
4. AUXILIARY BUILDING VENTILATION AND FUEL HANDLING AREA VENTILATION SYSTEM				
a. Noble Gas Activity Monitor (RE-90-101)	D	M	R(3)	Q(2)
b. Iodine and Particulate Sampler (RE-90-101)	W(4)	N.A.	N.A.	N.A.
c. Effluent Flow Rate Measuring Device	D	N.A.	R	Q
d. Sampler Flow Rate Measuring Device (FI-90-101B)	D	N.A.	5 years	N.A.

* See Table 3.1 (FREQUENCY NOTATION) for the surveillance frequency definitions.

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

Table 2.1-2 (Page 2 of 3)
RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION
SURVEILLANCE REQUIREMENTS*

INSTRUMENT	CHANNEL CHECK	SOURCE CHECK	CHANNEL CALIBRATION	CHANNEL OPERATIONAL TEST
5. SERVICE BUILDING VENTILATION SYSTEM				
a. Noble Gas Activity Monitor (RE-90-132)	D	M	R(3)	Q(2)
b. Effluent Flow Rate Measuring System (FI-90-320/1B)	D	N.A.	R	Q
6. CONTAINMENT PURGE AND EXHAUST SYSTEM				
Noble Gas Activity Monitors (Re-90-130, RE-90-131)	D	P	R(3)	Q(1)

* See Table 3.1 (FREQUENCY NOTATION) for the surveillance frequency definitions.

Table 2.1-2 (Page 3 of 3)
RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION
SURVEILLANCE REQUIREMENTS
TABLE NOTATION

(1) The CHANNEL OPERATIONAL TEST shall also demonstrate that automatic isolation of this pathway and control room alarm annunciation occurs if any of the following conditions exists:

1. Instrument indicates measured levels above the alarm/trip setpoint, or
2. Circuit failure, or
3. Indication of downscale failure, or
4. Instrumentation controls not set in operate mode.

(2) The CHANNEL OPERATIONAL TEST shall also demonstrate that control room alarm annunciation occurs if any of the following conditions exists:

1. Instrument indicates measured levels above the alarm setpoint, or
2. Circuit failure, or
3. Indication of downscale failure, or
4. Instrumentation controls not set in operate mode.

(3) The initial CHANNEL CALIBRATION shall be performed using one or more of the reference standards certified by the National Institute of Standards and Technology (NIST) 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 subsequent CHANNEL CALIBRATION, NIST standards or sources that have been related to the initial calibration shall be used.

(4) The CHANNEL CHECK shall also include changing filter cartridges when necessary.

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

1/2 CONTROLS AND SURVEILLANCE REQUIREMENTS

1/2.1 INSTRUMENTATION

1/2.1.3 METEOROLOGICAL INSTRUMENTATION/DATA

CONTROLS

1.1.3 The meteorological monitoring instrumentation channels shown in Table 1.1-3 shall be OPERABLE.

APPLICABILITY: At all times.

ACTION:

- With one or more required meteorological monitoring channels inoperable for more than 7 days, prepare and submit a Special Report to the Nuclear Regulatory Commission, pursuant to ODCM Administrative Control 5.4, within the next 10 days outlining the cause of the malfunction and the plans for restoring the channel(s) to OPERABLE status.

SURVEILLANCE REQUIREMENTS

2.1.3 Each of the above meteorological instrumentation channels shall be demonstrated OPERABLE by the performance of the CHANNEL CHECK at least once per 24 hours and the CHANNEL CALIBRATION at least once per 184 days.

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

Table 1.1-3
METEOROLOGICAL MONITORING INSTRUMENTATION

Instrument	Location	Minimum OPERABLE
1. WIND SPEED		
Channel 1	Nominal Height 10 m	
Channel 2	Nominal Height 46 m	2 of 3
Channel 3	Nominal Height 91 m	
2. WIND DIRECTION		
Channel 1	Nominal Height 10 m	
Channel 2	Nominal Height 46 m	2 of 3
Channel 3	Nominal Height 91 m	
3. AIR TEMPERATURE DELTA T		
Channel 1	Nominal Height 10 to 46 m	
Channel 2	Nominal Height 10 to 91 m	1 of 3
Channel 3	Nominal Height 46 to 91 m	

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

1/2 CONTROLS AND SURVEILLANCE REQUIREMENTS

1/2.2 RADIOACTIVE EFFLUENTS

1/2.2.1 LIQUID EFFLUENTS

1/2.2.1.1 CONCENTRATION

CONTROLS

1.2.1.1 In accordance with WBN TS 5.7.2.7.b and c., the concentration of radioactive material released in liquid effluents at the discharge point shall be limited to the concentrations specified in 10 CFR Part 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 $2x10^{-4}$ µCi/ml total activity.

APPLICABILITY: At all times.

ACTION:

With the concentration of radioactive material released at the discharge point exceeding the above limits, immediately restore the concentration to within the above limits.

SURVEILLANCE REQUIREMENTS

2.2.1.1 Radioactive liquid wastes shall be sampled and analyzed according to the sampling and analysis program of Table 2.2-1.

2.2.1.2 The results of the radioactivity analysis shall be used in accordance with the methodology and parameters in ODCM Section 6.1 to assure that the concentrations at the point of release are maintained within the limits stated above.

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

Table 2.2-1 (Page 1 of 3)
RADIOACTIVE LIQUID WASTE SAMPLING AND ANALYSIS PROGRAM*

Liquid Release Type	Sampling Frequency	Minimum Analysis Frequency	Type of Activity Analysis	Lower Limit of Detection (LLD) (μCi/ml)[1]
A. Batch Release Tanks[2] a. Radwaste System Tanks 1. Waste Condensate 2. Cask Decontamination 3. Chemical Drain 4. Monitor 5. Distillate 6. Laundry and Hot Shower	P Each Batch	P Each Batch	Principal Gamma Emitters[3]	5x10^{-7}
			I-131	1x10^{-6}
	P One Batch/M	M	Dissolved/ Entrained Gases (Gamma Emitters)	1x10^{-5}
	P Each Batch	M Lab Composite[4]	H-3	1x10^{-5}
			Gross Alpha	1x10^{-7}
b. Condensate Demineralizer System Tanks[6] 1. Waste Neutralizer 2. Non-Reclaimable Waste 3. High Crud	P Each Batch	Q Lab Composite[4]	Sr-89, Sr-90	5x10^{-8}
			Fe-55	1x10^{-6}
B. Continuous Releases[5] a. Steam Generator[6] Blowdown b. Turbine Building[6] Sump	D Grab Sample	W Lab Composite[4]	Principal Gamma Emitters[3]	5x10^{-7}
			I-131	1x10^{-6}
	M Grab Sample	M	Dissolved/ Entrained Gases (Gamma Emitters)	1x10^{-5}
	D Grab Sample	M Lab Composite[4]	H-3	1x10^{-5}
			Gross Alpha	1x10^{-7}
	D Grab Sample	Q Lab Composite[4]	Sr-89, Sr-90	5x10^{-8}
			Fe-55	1x10^{-6}

Table 2.2-1 (Page 2 of 3)
RADIOACTIVE LIQUID WASTE SAMPLING AND ANALYSIS PROGRAM
TABLE NOTATION

* See Table 3.1 (FREQUENCY NOTATION) for the surveillance frequency definitions.

[1] The LLD is defined for the purpose of these Controls as 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 only a 5% probability of falsely concluding that a blank observation represents a "real" signal.

For a particular measurement system (which may include radiochemical separation):

$$LLD = \frac{4.66 s_b}{E \quad V \quad 2.22 \times 10^6 \quad Y \quad \exp(-\lambda \Delta t)}$$

Where:

LLD = the "a priori" lower limit of detection (microcurie per unit mass or volume)

s_b = the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (counts per minute),

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 microcurie,

Y = the fractional radiochemical yield, when applicable,

λ = the radioactive decay constant for the particular radionuclide (s^{-1}), and

Δt = the elapsed time between midpoint of sample collection and time of counting (s).

It should be recognized that the LLD is defined as an a priori (before the fact) limit representing the capability of a measurement system and not an a posteriori (after the fact) limit for a particular measurement.

Typical values of E, V, Y, and Δt should be used in the calculation.

[2] A batch release is the discharge of liquid wastes of a discrete volume. Prior to sampling for analyses, each batch shall be isolated, and then thoroughly mixed by the method described in ODCM Section 6.1.1 to assure representative sampling.

Table 2.2-1 (Page 3 of 3)
RADIOACTIVE LIQUID WASTE SAMPLING AND ANALYSIS PROGRAM
TABLE NOTATION

[3] The principal gamma emitters for which the LLD Control applies exclusively are the following radionuclides: Mn-54, Fe-59, Co-58, Co-60, Zn-65, Mo-99, Cs-134, Cs-137, Ce-141. Ce-144 shall also be measured, but with an LLD of 5x10-06 μci/ml. This list does not mean that only these nuclides are to be considered. Other gamma peaks which are identifiable, together with those of the the above nuclides, shall also be analyzed and reported in the Radioactive Effluent Release Report pursuant to ODCM Administrative Control 5.2, in the format outlined in Regulatory Guide 1.21, Appendix B, Revision 1, June 1974.

[4] A lab composite sample is one prepared by combining representative samples from each release into one well-mixed, homogeneous sample. The volume of sample added to the composite from each release shall be proportional to the release volume.

[5] A continuous release is the discharge of liquid wastes of a nondiscrete volume; e.g., from a system that has an input flow during the continuous release.

[6] Not applicable when most recent Secondary Coolant System gross activity determination is less than or equal to $1x10^{-6}$ μCi/gm and the Discharge Radiation Monitor setpoint is at $\leq 1x10^{-6}$ μCi/ml above background or compensatory requirements in ACTION B or C of Table 1.1-1 are met.

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

1/2 CONTROLS AND SURVEILLANCE REQUIREMENTS

1/2.2 RADIOACTIVE EFFLUENTS

1/2.2.1 LIQUID EFFLUENTS

1/2.2.1.2 DOSE

CONTROLS

1.2.1.2 In accordance with WBN TS 5.7.2.7.d and e, the dose or dose commitment to a MEMBER OF THE PUBLIC from radioactive materials in liquid effluents discharged 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.

APPLICABILITY: At all times.

ACTION:

With the calculated dose from the release of radioactive materials in liquid effluents exceeding any of the above limits, prepare and submit to the Nuclear Regulatory Commission within 30 days, pursuant to ODCM Administrative Control 5.4, a Special Report that identifies the cause(s) for exceeding the limit(s) and defines the corrective actions that have been taken to reduce the releases and the proposed corrective actions to be taken to assure that subsequent releases will be in compliance with the above limits. This Special Report shall also include (1) the results of radiological analyses of drinking water sources and (2) the radiological impact on finished drinking water supplies with regard to the requirements of 40 CFR 141, Safe Drinking Water Act, (applicable only if drinking water supply is taken from the receiving water body within three miles downstream of the plant discharge).

SURVEILLANCE REQUIREMENTS

2.2.1.2 Cumulative dose contributions from liquid effluents for the current calendar quarter and current calendar year shall be determined in accordance with the methodology and parameters in ODCM Section 6.3 at least once per 31 days.

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

1/2 CONTROLS AND SURVEILLANCE REQUIREMENTS

1/2.2 RADIOACTIVE EFFLUENTS

1/2.2.1 LIQUID EFFLUENTS

1/2.2.1.3 LIQUID RADWASTE TREATMENT SYSTEM

CONTROLS

1.2.1.3 In accordance with WBN TS 5.7.2.7.f, the liquid radwaste treatment system shall be OPERABLE and appropriate portions of the system shall be used to reduce the radioactive materials 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 in a 31-day period.

APPLICABILITY: At all times.

ACTION:

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, pursuant to ODCM Administrative Control 5.4, a Special Report which includes the following information:

1. Explanation of why liquid waste was being discharged without treatment, identification of the inoperable equipment or subsystems, and the reason for the inoperability,
2. Action(s) taken to restore the inoperable equipment to OPERABLE status, and
3. Summary description of action(s) taken to prevent a recurrence.

SURVEILLANCE REQUIREMENTS

2.2.1.3.1 Doses due to liquid releases from each unit to UNRESTRICTED AREAS shall be projected at least once per 31 days, in accordance with the methodology and parameters in ODCM Section 6.5 when the Liquid Radwaste Treatment Systems are not being fully utilized.

2.2.1.3.2 The installed Liquid Radwaste Treatment System shall be considered OPERABLE by meeting ODCM Controls 1.2.1.1 and 1.2.1.2.

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

1/2 CONTROLS AND SURVEILLANCE REQUIREMENTS

1/2.2 RADIOACTIVE EFFLUENTS

1/2.2.2 GASEOUS EFFLUENTS

1/2.2.2.1 DOSE RATE

CONTROLS

1.2.2.1 In accordance with WBN TS 5.7.2.7.g, 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 the following:

a. For noble gases: Less than or equal to 500 mrem/yr to the total body and less than or equal to 3000 mrem/yr 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 1500 mrem/yr to any organ.

APPLICABILITY: At all times.

ACTION:

With dose rate(s) exceeding the above limits, immediately restore the release rate to within the above limit(s).

SURVEILLANCE REQUIREMENTS

2.2.2.1 The dose rate due to noble gases in gaseous effluents shall be determined to be within the above limits in accordance with the methodology and parameters in ODCM Section 7.2.2 by obtaining representative samples and performing analyses in accordance with the sampling and analysis program specified in Table 2.2-2.

2.2.2.2 The dose rate 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 in accordance with the methodology and parameters in ODCM Section 7.2.3 by obtaining representative samples and performing analyses in accordance with the sampling and analysis program specified in Table 2.2-2.

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

Table 2.2-2 (Page 1 of 4)
RADIOACTIVE GASEOUS WASTE MONITORING SAMPLING AND ANALYSIS PROGRAM*

Gaseous Release Type	Sampling Frequency	Minimum Analysis Frequency	Type of Activity Analysis	Lower Limit of Detection (LLD) (μCi/ml)[1]
A. Waste Gas Holdup Tank	P Each Tank Grab Sample	P Each Tank	Principal Gamma Emitters[2,12]	$1x10^{-4}$
B. Containment 1. Purge	P[8] Each Purge[3] Grab Sample	P[8] Each Purge[3]	Principal Gamma Emitters[2,12]	$1x10^{-4}$
	P[8] Each Purge[3] Grab Sample	M	H-3 (oxide)	$1x10^{-6}$
2. Vent	D[3,9] Grab Sample	D[3,9]	Principal Gamma Emitters[2,12]	$1x10^{-4}$
		M[3]	H-3 (oxide)	$1x10^{-6}$
C. Auxiliary Building Exhaust[5,4] Shield Building Exhaust[4] Condenser Vacuum Exhaust[11]	M[3,10] Grab Sample	M	Principal Gamma Emitters[2,12]	$1x10^{-4}$
			H-3	$1x10^{-6}$
	Continuous[6]	W[7] Charcoal Sample	I-131	$1x10^{-12}$
			I-133	$1x10^{-10}$
	Continuous[6]	W[7] Particulate Sample	Principal Gamma Emitters[2]	$1x10^{-11}$
	Continuous[6]	M Composite Particulate Sample	Gross Alpha	$1x10^{-11}$
	Continuous[6]	Q Composite Particulate Sample	Sr-89, Sr-90	$1x10^{-11}$
D. Service Building Exhaust	M Grab Sample	M	Principal Gamma Emitters[2,12]	$1x10^{-4}$

Table 2.2-2 (Page 2 of 4)

RADIOACTIVE GASEOUS WASTE MONITORING SAMPLING AND ANALYSIS PROGRAM
TABLE NOTATION

* See Table 3.1 (FREQUENCY NOTATION) for the surveillance frequency definitions.

1 The LLD is defined, for the purpose of these requirements, as 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 only a 5% probability of falsely concluding that a blank observation represents a "real" signal.

For a particular measurement system (which may include radiochemical separation):

$$LLD = \frac{4.66 s_b}{E \quad V \quad 2.22x10^6 \quad Y \quad \exp(-\lambda \Delta t)}$$

Where:

LLD	= the "a priori" lower limit of detection (microcurie per unit mass or volume)
s_b	= the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (counts per minute),
E	= the counting efficiency (counts per disintegration)
V	= the sample size (units of mass or volume)
$2.22x10^6$	= the number of disintegrations per minute per microcurie,
Y	= the fractional radiochemical yield, when applicable,
λ	= the radioactive decay constant for the particular radionuclide (s^{-1})
Δt	= the elapsed time between midpoint of sample collection and time of counting (s).

It should be recognized that the LLD is defined as an <u>a priori</u> (before the fact) limit representing the capability of a measurement system and not an <u>a posteriori</u> (after the fact) limit for a particular measurement. Typical values of E, V, Y, and Δt shall be used in the calculation.

2 The principal gamma emitters for which the LLD Control applies include the following radionuclides: Kr-87, Kr-88, Xe-133, Xe-133m, Xe-135, and Xe-138 in noble gas releases and Mn-54, Fe-59, I-131, Co-58, Co-60, Zn-65, Mo-99, Cs-134, Cs-137, Ce-141 and Ce-144 in Iodine and particulate releases. This list does not mean that only these nuclides are to be considered. Other gamma peaks that are identifiable, together with the above nuclides, shall also be analyzed and reported in the Radioactive Effluent Release Report pursuant to ODCM Administrative Control 5.2, in the format outlined in Regulatory Guide 1.21, Appendix B, Revision 1, June 1974.

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

Table 2.2-2 (Page 3 of 4)

RADIOACTIVE GASEOUS WASTE MONITORING SAMPLING AND ANALYSIS PROGRAM
TABLE NOTATION

3 Sampling and analysis shall also be performed following shutdown, startup, or a thermal power change exceeding 15% of RATED THERMAL POWER within a 1 hour period unless (a) analysis shows that the DOSE EQUIVALENT I-131 concentration in the reactor coolant has not increased more than a factor of 3 and (b) the containment noble gas activity monitor (RE-90-106 or RE-90-112) shows that the radioactivity has not increased by more than a factor of 3.

4 Tritium grab samples shall be taken at least once per 24 hours when the refueling canal is flooded.

5 Tritium grab samples shall be taken at least once per 7 days from the ventilation exhaust from the spent fuel pool area, whenever spent fuel is in the spent fuel pool.

6 The ratio of the sample flow rate to the sampled stream flow rate shall be known for the time period covered by each dose or dose rate calculation made in accordance with ODCM Controls 1.2.2.1, 1.2.2.2, and 1.2.2.3.

7 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 within a one hour period and analyses shall be completed within 48 hours of changing. When samples collected for 24 hours are analyzed, the corresponding LLD's 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 reactor coolant has not increased by more than a factor of 3; and (2) the containment noble gas monitor shows that the radioactivity has not increased by more than a factor of 3.

8 In all MODES, the upper and lower compartments of the containment shall be sampled prior to PURGING. The incore instrument room PURGE sample shall be obtained at the shield building exhaust between 5 and 10 minutes following initiation of the incore instrument room PURGE.

9 Prior to venting in MODES 1, 2, 3, and 4, the upper and lower compartments of the containment shall be sampled daily when venting is to occur on that day.

10 Not applicable to the Shield Building Exhaust.

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

Table 2.2-2 (Page 4 of 4)

RADIOACTIVE GASEOUS WASTE MONITORING SAMPLING AND ANALYSIS PROGRAM
TABLE NOTATION

11 Not applicable when the most recent Secondary Coolant System gross radioactivity determination is less than or equal to $1x10^{-6}$ µCi/gm and the Discharge Radiation Monitor setpoint is less than or equal to $1x10^{-6}$ µCi/ml above background.

12 Noble gas only

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

1/2 CONTROLS AND SURVEILLANCE REQUIREMENTS

1/2.2 RADIOACTIVE EFFLUENTS

1/2.2.2 GASEOUS EFFLUENTS

1/2.2.2.2 DOSE - NOBLE GASES

CONTROLS

1.2.2.2 In accordance with WBN TS 5.7.2.7.h, the air dose due to noble gases released in gaseous effluents from each 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.

APPLICABILITY: At all times.

ACTION:

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, pursuant to ODCM Administrative Control 5.4, a Special Report that identifies the cause(s) for exceeding the limit(s) and defines the corrective actions that have been taken to reduce the releases and the proposed corrective actions to be taken to assure that subsequent releases will be in compliance with the above limits.

SURVEILLANCE REQUIREMENTS

2.2.2.2 Cumulative dose contributions for the current calendar quarter and current calendar year for noble gases shall be determined in accordance with the methodology and parameters in ODCM Section 7.3 at least once per 31 days.

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

1/2 CONTROLS AND SURVEILLANCE REQUIREMENTS

1/2.2 RADIOACTIVE EFFLUENTS

1/2.2.2 GASEOUS EFFLUENTS

1/2.2.2.3 DOSE - I-131, I-133, TRITIUM, AND RADIONUCLIDES IN PARTICULATE FORM WITH HALF-LIVES GREATER THAN EIGHT DAYS

CONTROLS

1.2.2.3 In accordance with WBN TS 5.7.2.7.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 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.

APPLICABILITY: At all times.

ACTION:

With the calculated dose from the release of I-131, I-133, tritium and all 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, pursuant to ODCM Administrative Control 5.4, a Special Report which identifies the cause(s) for exceeding the limit(s) and defines the corrective actions that have been taken to reduce the releases and the proposed corrective actions to be taken to assure that subsequent releases will be in compliance with the above limits.

SURVEILLANCE REQUIREMENTS

2.2.2.3 Cumulative dose contributions for the current calendar quarter and current calendar year for I-131, I-133 tritium and all radionuclides in particulate form with half-lives greater than 8 days shall be determined in accordance with the methodology and parameters in ODCM Section 7.4 at least once per 31 days.

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

1/2 CONTROLS AND SURVEILLANCE REQUIREMENTS

1/2.2 RADIOACTIVE EFFLUENTS

1/2.2.2 GASEOUS EFFLUENTS

1/2.2.2.4 GASEOUS RADWASTE TREATMENT

CONTROLS

1.2.2.4 In accordance with WBN TS 5.7.2.7.f, the VENTILATION EXHAUST TREATMENT SYSTEM and the WASTE GAS HOLDUP SYSTEM shall be OPERABLE and appropriate portions of these systems shall be used to reduce releases of radioactivity when the projected doses in 31 days due to gaseous effluent releases from each unit to areas at and beyond the SITE BOUNDARY (See Figure 3.1) would exceed:

a. 0.2 mrad to air from gamma radiation, or

b. 0.4 mrad to air from beta radiation, or

c. 0.3 mrem to any organ of a MEMBER OF THE PUBLIC.

APPLICABILITY: At all times.

ACTION:

With the radioactive gaseous waste being discharged without treatment and in excess of the above limits, prepare and submit to the Commission within 30 days, pursuant to ODCM Administrative Control 5.4, a Special Report that includes the following information:

1. Identification of the inoperable equipment or subsystems and the reason for inoperability.
2. Action(s) taken to restore the inoperable equipment to OPERABLE status, and
3. Summary description of action(s) taken to prevent a recurrence.

SURVEILLANCE REQUIREMENTS

2.2.2.4.1 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 the methodology and parameters in ODCM Section 7.5 when the VENTILATION EXHAUST TREATMENT SYSTEMS and WASTE GAS HOLDUP SYSTEMS are not being fully utilized.

2.2.2.4.2 The installed VENTILATION EXHAUST TREATMENT SYSTEMS and WASTE GAS HOLDUP SYSTEM shall be considered OPERABLE by meeting the requirements in ODCM Controls 1.2.2.1, 1.2.2.2, and 1.2.2.3.

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

1/2 CONTROLS AND SURVEILLANCE REQUIREMENTS

1/2.2 RADIOACTIVE EFFLUENTS

1/2.2.3 TOTAL DOSE

CONTROLS

1.2.3 In accordance with WBN TS 5.7.2.7.j, 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 total body or any organ, except the thyroid, which shall be limited to less than or equal to 75 mrem.

APPLICABILITY: At all times.

ACTION:

With the calculated doses from the release of radioactive materials in liquid or gaseous effluents exceeding twice the limits of ODCM Control 1.2.1.2, 1.2.2.2, or 1.2.2.3, calculations should be made including direct radiation contributions from the reactor units and from outside storage tanks to determine whether the above limits have been exceeded. If such is the case, prepare and submit to the NRC within 30 days, pursuant to ODCM Administrative Control 5.4, a Special Report that defines the corrective action to be taken to reduce subsequent releases to prevent recurrence of exceeding the above limits and includes the schedule for achieving conformance with the above limits. This Special Report, as defined in 10 CFR 20.2203, shall include an analysis that 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. It shall also describe levels of radiation and concentrations of radioactive materials involved, and the cause of the exposure levels or concentrations. If the estimated dose(s) exceeds the above limits, and if the release condition resulting in violation of 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 the staff action on the request is complete.

SURVEILLANCE REQUIREMENTS

2.2.3.1 Cumulative dose contributions from liquid and gaseous effluents shall be determined in accordance with ODCM Controls 2.2.1.2, 2.2.2.2, and 2.2.2.3 and in accordance with the methodology and parameters in ODCM Sections 6.3, 7.3, and 7.4.

2.2.3.2 Cumulative dose contributions from direct radiation from the units and from radwaste storage tanks shall be determined in accordance with the methodology and parameters in ODCM Section 8.1. This requirement is applicable only under conditions set forth in the action above.

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

1/2 CONTROLS AND SURVEILLANCE REQUIREMENTS

1/2.3 RADIOLOGICAL ENVIRONMENTAL MONITORING

1/2.3.1 MONITORING PROGRAM

CONTROLS

1.3.1 In accordance with WBN TS 5.7.2.8.a, the Radiological Environmental Monitoring Program shall be conducted as specified in Table 2.3-1.

APPLICABILITY: At all times.

ACTION:

a. With the Radiological Environmental Monitoring Program not being conducted as specified in Table 2.3-1, prepare and submit to the Nuclear Regulatory Commission, in the Annual Radiological Environmental Operating Report described in ODCM Administrative Control 5.1, a description of the reasons for not conducting the program as required and the plan for preventing a recurrence.

b. With the level of radioactivity as a result of plant effluents in an environmental sampling medium at a specified location exceeding the reporting levels of Table 2.3-2, when averaged over any calendar quarter, prepare and submit to the Commission within 30 days from the end of the affected quarter, pursuant to ODCM Administrative Control 5.4, a Special Report that identifies the cause(s) for exceeding the limit(s) and 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 ODCM Controls 1.2.1.2, 1.2.2.2 and 1.2.2.3. When more than one of the radionuclides in Table 2.3-2 are detected in the sampling medium, this report shall be submitted if:

$$\frac{\text{concentration(1)}}{\text{limit level(1)}} + \frac{\text{concentration(2)}}{\text{limit level(2)}} + \ldots \geq 1.0$$

When radionuclides other than those in Table 2.3-2 are detected and are the result of plant effluents, this report shall be submitted if the potential annual dose* to a MEMBER OF THE PUBLIC from all radionuclides is equal to or greater than the calendar year limits of ODCM Controls 1.2.1.2, 1.2.2.2, and 1.2.2.3. This 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 reported and described in the Annual Radiological Environmental Operating Report described in ODCM Administrative Control 5.1.

* The methodology and parameters used to determine the potential annual dose to a MEMBER OF THE PUBLIC shall be indicated in this report.

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

1/2 CONTROLS AND SURVEILLANCE REQUIREMENTS

1/2.3 RADIOLOGICAL ENVIRONMENTAL MONITORING

1/2.3.1 MONITORING PROGRAM

ACTION (CONTINUED):

c. With milk or fresh leafy vegetation samples unavailable from one or more of the sample locations required by Table 2.3-1, identify specific locations for obtaining replacement samples and add them within 30 days to the radiological environmental monitoring program given in ODCM Section 9.0. The specified locations from which samples were unavailable may then be deleted from the monitoring program.

   Pursuant to ODCM Administrative Controls 5.2 and 5.3, submit in the next Effluent Release Report documentation for a change in the ODCM, with supporting information identifying the cause of the unavailability of samples and justifying the selection of the new location(s) for obtaining samples.

SURVEILLANCE REQUIREMENTS

2.3.1 The radiological environmental monitoring samples shall be collected pursuant to Table 2.3-1 from the specific locations given in the tables and figures in ODCM Section 9.0 and shall be analyzed pursuant to the requirements of Table 2.3-1 and the detection capabilities required by Table 2.3-3.

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

Table 2.3-1 (Page 1 of 7)
MINIMUM REQUIRED RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway and/or Sample	Number of Samples and Sample Locations[1]	Sampling and Collection Frequency	Type and Frequency of Analyses
DIRECT RADIATION[2]	Forty 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; and An outer ring of stations, one in each meteorological sector in the 6- to 8-km range from the site; and The balance of the stations to be placed in special interest areas such as population centers, nearby residences, schools, and in one or two areas to serve as control stations.	Quarterly	Gamma Dose quarterly

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

Table 2.3-1 (Page 2 of 7)
MINIMUM REQUIRED RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway and/or Sample	Number of Samples and Sample Locations[1]	Sampling and Collection Frequency	Type and Frequency of Analyses
AIRBORNE			
Radioiodine and Particulates	Samples from five locations: Three samples from close to the three site boundary locations in different sectors, of the highest calculated annual average ground-level D/Q; One sample from the vicinity of a community having the highest calculated annual average ground level D/Q; and One sample from a control location, as for example 15-30 km distant and in the least prevalent wind direction[3]	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[4]; and gamma isotopic analysis[5] of composite (by location) quarterly

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

Table 2.3-1 (Page 3 of 7)
MINIMUM REQUIRED RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway and/or Sample	Number of Samples and Sample Locations[1]	Sampling and Collection Frequency	Type and Frequency of Analyses
WATERBORNE			
a. Surface[6]	One sample upstream. One sample downstream.	Composite sample over a 1-month period.[7]	Gamma isotopic analysis[5] monthly. Composite for tritium analysis quarterly.
b. Ground	Samples from one or two sources only if likely to be affected[8].	At least once per 92 days.	Gamma isotopic[5] and tritium analysis quarterly.
c. Drinking	One sample of each of one to three of the nearest water supplies that could be affected by the discharge[9]	Composite sample over a one month period.[7]	Gross beta and gamma isotopic analyses[5] monthly. Composite for tritium analysis quarterly.
d. Sediment from Shoreline	One Sample from downstream area with existing or potential recreational value	Semiannually.	Gamma isotopic[5] analysis semiannually

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

Table 2.3-1 (Page 4 of 7)
MINIMUM REQUIRED RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway and/or Sample	Number of Samples and Sample Locations[1]	Sampling and Collection Frequency	Type and Frequency of Analyses
INGESTION			
a. Milk	Samples from milking animals in three locations within 5 km distance having the highest dose potential. If there are none, then one additional sample from milking animals in each of one to three areas between 5 to 8 km distant where doses are calculated to be greater than 1 mrem/yr[10]. One sample from milking animals at a control location 15-30 km distant and in the least prevalent wind direction.	Semimonthly when animals are on pasture; monthly at other times.	Gamma isotopic[5] and I-131 analysis semi-monthly when animals are on pasture; monthly at other times.
b. Fish and Invertebrates	One sample each of three important species, including both commercially and recreationally important species in vicinity of plant discharge area. One sample of same species in areas not influenced by plant discharge.	Sample in season, or semiannually if they are not seasonal	Gamma isotopic analysis[5] on edible portions.

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

Table 2.3-1 (Page 5 of 7)
MINIMUM REQUIRED RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway and/or Sample	Number of Samples and Sample Locations[1]	Sampling and Collection Frequency	Type and Frequency of Analyses
c. Food Products	One sample of each principal class of food products from any area that is irrigated by water in which liquid plant wastes have been discharged.	At time of harvest[11].	Gamma isotopic analysis[5] on edible portion.
	Samples of three different kinds of available broad-leaf vegetation grown nearest each of two different offsite locations of highest predicted annual average ground-level D/Q if milk sampling is not performed as outlined in 4.a. above.		
	One sample of each of the similar broad leaf vegetation grown 15-30 km distant in the least prevalent wind direction if milk sampling is not performed as outlined in 4.a. above.		

Table 2.3-1 (Page 6 of 7)
MINIMUM REQUIRED RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
TABLE NOTATIONS

[1] Specific parameters of distance and direction sector from the centerline of one reactor, and additional description where pertinent, shall be provided for each and every sample location in Table 2.3-1 in a table(s) and figure(s) in ODCM Section 9.0. Refer to NUREG-1301, "Offsite Dose Calculation Manual Guidance: Standard Effluent Controls for Pressurized Water Reactors, Generic Letter 89-01, Supplement 1," April 1991. Deviations are permitted from the required sampling schedule if specimens are unobtainable due to hazardous conditions, seasonal unavailability, malfunction of automatic sampling equipment and other legitimate reasons. If specimens are unobtainable due to sampling equipment malfunction, every effort shall be made to complete corrective action prior to the end of the next sampling period. All deviations from the sampling schedule shall be documented in the Annual Radiological Environmental Operating Report pursuant to ODCM Administrative Control 5.1. It is recognized that, at times, it may not be possible or practicable to continue to obtain samples of the media of choice at the most desired location or time. In these instances suitable specific alternative media and locations may be chosen for the particular pathway in question and appropriate substitutions made within 30 days in the Radiological Environmental Monitoring Program given in ODCM Section 9.0. Pursuant to ODCM Administrative Controls 5.2 and 5.3, submit in the next Radioactive Effluent Release Report documentation for a change in ODCM Section 9.0, including a revised figure(s) and table reflecting the new location(s) with supporting information identifying the cause of the unavialability of samples for that pathway and justifying the selection of the new location(s) for obtaining samples.

[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 purposes 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. (The forty stations is not an absolute number. The number of direct radiation monitoring stations may be reduced according to geographical limitations, e.g., some sectors will be over water so that the number of dosimeters may be reduced accordingly. The frequency of analysis or readout for TLD systems will depend upon the characteristics of the specific system used and should be selected to obtain optimum dose information with minimal fading.)

Table 2.3-1 (Page 7 of 7)
MINIMUM REQUIRED RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
TABLE NOTATIONS

[3] The purpose of this sample is to obtain background information. If it is not practical to establish control locations in accordance with the distance and wind direction criteria, other sites that provide valid background data may be substituted.

[4] 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 that of control samples, gamma isotopic analysis shall be performed on the individual samples.

[5] Gamma isotopic analysis means the identification and quantification of gamma-emitting radionuclides that may be attributable to the effluents from the facility.

[6] 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.

[7] A composite sample is one in which the quantity (aliquot) of liquid sampled is proportional to the quantity of flowing liquid and in which the method of sampling employed results in a specimen that is representative of the liquid flow. In this program 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.

[8] Groundwater samples shall be taken when this source is tapped for drinking or irrigation purposes in areas where the hydraulic gradient or recharge properties are suitable for contamination. Groundwater flow in the area of WBN has been shown to be toward Chickamauga Reservior. There are no sources tapped for drinking or irrigation purposes between the plant and the reservior. Therefore, sampling of the medium is not required.

[9] The surface water control shall be considered a control for the drinking water samples.

[10] The dose shall be calculated for the maximum organ and age group, using the methodology and parameters in ODCM Section 7.4.

[11] If harvest occurs more than once a year, sampling shall be performed during each discrete harvest. If harvest occurs continuously, sampling shall be monthly. Attention shall be paid to including samples of tuberous and root food products.

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

Table 2.3-2
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)	Food Products (pCi/Kg, wet)
H-3	20,000[(1)]	N.A	N.A	N.A.	N.A.
Mn-54	1,000	N.A.	30,000	N.A.	N.A.
Fe-59	400	N.A.	10,000	N.A.	N.A.
Co-58	1,000	N.A.	30,000	N.A.	N.A.
Co-60	300	N.A.	10,000	N.A.	N.A.
Zn-65	300	N.A.	20,000	N.A.	N.A.
Zr-Nb-95	400	N.A.	N.A.	N.A.	N.A.
I-131	2[(2)]	0.9	N.A.	3	100
Cs-134	30	10	1,000	60	1,000
Cs-137	50	20	2,000	70	2,000
Ba-La-140	200	N.A.	N.A.	300	N.A.

[1] For drinking water samples. This is 40 CFR Part 141 value. If no drinking water pathway exists, a value of 30,000 pCi/L may be used.

[2] For drinking water samples. If no drinking water pathway exists, a value of 20 pCi/L may be used.

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

Table 2.3-3 (Page 1 of 2)
DETECTION CAPABILITIES FOR ENVIRONMENTAL SAMPLE ANALYSIS[1,2]
LOWER LIMITS OF DETECTION (LLD)[3]

Analysis	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	0.01	N.A.	N.A	N.A.	N.A.
H-3	2000(4)	N.A	N.A	N.A	N.A.	N.A.
Mn-54	15	N.A.	130	N.A.	N.A.	N.A.
Fe-59	30	N.A.	260	N.A.	N.A.	N.A.
Co-58,60	15	N.A.	130	N.A.	N.A.	N.A.
Zn-65	30	N.A.	260	N.A.	N.A.	N.A.
Zr-95	30	N.A.	N.A.	N.A.	N.A.	N.A.
Nb-95	15	N.A.	N.A.	N.A.	N.A.	N.A.
I-131	1(5)	0.07	N.A.	1	60	N.A.
Cs-134	15	0.05	130	15	60	150
Cs-137	18	0.06	150	18	80	180
Ba-140	60	N.A.	N.A.	60	N.A.	N.A.
La-140	15	N.A.	N.A.	15	N.A.	N.A.

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

Table 2.3-3 (Page 2 of 2)
DETECTION CAPABILITIES FOR ENVIRONMENTAL SAMPLE ANALYSIS[1,2]
LOWER LIMITS OF DETECTION (LLD)[3]
TABLE NOTATION

[1] This list does not mean that only these nuclides are to be considered. Other peaks that are identifiable, together with those of the above nuclides, shall also be analyzed and reported in the Annual Radiological Environmental Operating Report pursuant to ODCM Administrative Control 5.1

[2] Required detection capabilities for thermoluminescent dosimeters used for environmental measurements shall be in accordance with the recommendations of Regulatory Guide 4.13.

[3] The LLD is defined, for the purpose of these specifications, as 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 only a 5% probability of falsely concluding that a blank observation represents a "real" signal.

For a particular measurement system (which may include radiochemical separation):

$$LLD = \frac{4.66 s_b}{E \quad V \quad 2.22 \quad Y \quad \exp(-\lambda \Delta t)}$$

Where:

LLD = the "a priori" lower limit of detection (μCi per unit mass or volume)

s_b = the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (counts per minute),

E = the counting efficiency (counts per disintegration)

V = the sample size (units of mass or volume)

2.22 = the number of disintegrations per minute per microcurie,

Y = the fractional radiochemical yield, when applicable,

λ = the radioactive decay constant for the particular radionuclide (s^{-1}), and

Δt = the elapsed time between midpoint of environmental sample collection and time of counting (s).

Typical values of E, V, Y, and Δt should be used in the calculation.

It should be recognized that the LLD is defined as an a priori (before the fact) limit representing the capability of a measurement system and not an a posteriori (after the fact) limit for a particular measurement. Analysis will be performed in such a manner that the stated LLDs will be achieved under routine conditions. Occasionally background fluctuations, unavoidable small sample sizes, the presence of interfering nuclides, or other uncontrollable circumstances may render these LLD's unachievable. In such cases, the contributing factors shall be identified and described in the Annual Radiological Environmental Operating Report pursuant to ODCM Administrative Control 5.2.

[4] If no drinking water pathway exists, a value of 3000 pCi/L may be used.

[5] If no drinking water pathway exists, a value of 15 pCi/L may be used.

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

1/2 CONTROLS AND SURVEILLANCE REQUIREMENTS

1/2.3 RADIOLOGICAL ENVIRONMENTAL MONITORING

1/2.3.2 LAND USE CENSUS

CONTROLS

1.3.2 In accordance with WBN TS 5.7.2.8.b, a Land Use Census shall be conducted and shall identify within a distance of 8 km (5 miles) the location in each of the 16 meteorological sectors of the nearest milk animal, the nearest residence, and the nearest garden* of greater then 50 m^2 (500 ft^2) producing fresh leafy vegetation.

APPLICABILITY: At all times.

ACTION:

a. With a Land Use Survey identifying a location(s) that yields a calculated dose or dose commitment greater than the values currently being calculated in Control 2.2.2.3, pursuant to ODCM Administrative Controls 5.1 and 5.2, identify the new location(s) in the next Radioactive Effluent Release Report.

b. With a Land Use Census identifying a location(s) that yields a calculated dose or dose commitment (via the same exposure pathway) 20% greater than at a location from which samples are currently being obtained in accordance with the requirements of ODCM Control 1.3.1, add the new location(s) within 30 days to the radiological environmental monitoring program given in ODCM Section 9.0, if samples are available. The sampling location(s), excluding the control station location, having the lowest calculated dose or dose commitment(s), via the same exposure pathway, may be deleted from this monitoring program after October 31 of the year in which this Land Use Census was conducted. Pursuant to ODCM Administrative Controls 5.2 and 5.3, submit in the next Radioactive Effluent Release Report documentation for a change in the ODCM reflecting the new location(s) with the information supporting the change in sampling locations.

SURVEILLANCE REQUIREMENTS

2.3.2 The Land Use Census shall be conducted during the growing season at least once per 12 months using that information that will provide the best results, such as by a door-to-door survey, mail survey, telephone survey, aerial survey, or by consulting local agricultural authorities. The results of the Land Use Census shall be included in the Annual Radiological Environmental Operating Report pursuant to ODCM Administrative Control 5.1.

* 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 D/Qs in lieu of the garden census. Controls for broad leaf vegetation sampling in Table 2.3-1 Part 4.c., shall be followed, including analysis of control samples.

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

1/2 CONTROLS AND SURVEILLANCE REQUIREMENTS

1/2.3 RADIOLOGICAL ENVIRONMENTAL MONITORING

1/2.3.3 INTERLABORATORY COMPARISON PROGRAM

CONTROLS

1.3.3 In accordance with WBN TS 5.7.2.8.c, analyses shall be performed on all radioactive materials, supplied as part of an Interlaboratory Comparison Program which has been approved by the Commission, that correspond to samples required by Table 2.3-1.

APPLICABILITY: At all times.

ACTION:

With analyses not being performed as required above, report the corrective actions being taken to prevent a recurrence to the Commission in the Annual Radiological Environmental Operating Report pursuant to ODCM Administrative Control 5.1.

SURVEILLANCE REQUIREMENTS

2.3.3 The Interlaboratory Comparison Program shall be described in ODCM Section 9.0. A summary of the results obtained as a part of the above required Interlaboratory Comparison Program and in accordance with the guidance below shall be included in the Annual Radiological Environmental Operating Report pursuant to ODCM Administrative Control 5.1.

BASES FOR

SECTIONS 1.0 AND 2.0

CONTROLS

AND

SURVEILLANCE REQUIREMENTS

NOTE

The BASES contained in succeeding pages summarize the reasons for the Controls in Sections 1.0 and 2.0, but are not part of these Controls.

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

BASES

INSTRUMENTATION

1/2.1.1 RADIOACTIVE LIQUID EFFLUENT MONITORING INSTRUMENTATION

The radioactive liquid effluent instrumentation is provided to monitor and control, as applicable, the releases of radioactive materials in liquid effluents during actual and 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 ODCM Section 6.2 to ensure that the alarm/trip will occur prior to exceeding the concentration limits of 10 CFR Part 20. The OPERABILITY 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.

1/2.1.2 RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION

The radioactive gaseous effluent instrumentation is provided to monitor and control, as applicable, the releases of radioactive materials in gaseous effluents during actual and 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 ODCM Section 7.1 to ensure that the alarm/trip will occur prior to exceeding the dose rate limits of ODCM Control 1.2.2.1. The OPERABILITY 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. The sensitivity of any noble gas activity monitor used to show compliance with the gaseous effluent release requirements of Control 1.2.2.1 shall be such that the concentrations as low as 1×10^{-6} µCi/cc are measurable.

1/2.1.3 METEOROLOGICAL INSTRUMENTATION/DATA

The OPERABILITY of the meteorological instrumentation ensures that sufficient meteorological data is available for estimating potential radiation doses to the public as a result of routine or accidental release of radioactive materials to the atmosphere. This capability is required to evaluate the need for initiating protective measures to protect the health and safety of the public and is consistent with the recommendations of Regulatory Guide 1.23, "Onsite Meteorological Programs," February 1972 and ANSI/ANS-2.5-1984, "Standard for Determining Meteorological Information at Nuclear Power Sites," 1984.

The interval for the sensor calibration portion of the CHANNEL CALIBRATION is based on the length of time a sensor has been in service (i.e., non-service or "shelf" time, not to exceed six months, is not included).

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

BASES

1/2.2 RADIOACTIVE EFFLUENTS

1/2.2.1.1 CONCENTRATION

This control is provided to ensure that the concentration of radioactive materials released in liquid waste effluents at the discharge point will be less than the concentration levels specified in 10 CFR Part 20, Appendix B, Table 2, Column 2. This limitation provides additional assurance that the levels of radioactive materials in bodies of water at the discharge point will result in exposures within (1) the Section II.A design objectives of Appendix I, 10 CFR 50, and (2) the limits of 10 CFR 20.1301(a)(1) to a MEMBER OF THE PUBLIC. 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 of Radiological Protection (ICRP) Publication 2.

This control applies to the release of radioactive materials in liquid effluents from all reactors at the site.

The required detection capabilities for radioactive materials in liquid waste samples are tabulated in terms of the lower limits of detection (LLDs). Detailed description of the LLD, and other detection limits can be found in HASL Procedures Manual, HASL-300 (revised annually), Curie, L. A., "Limits for Qualitative Detection and Quantitative Determination - Application to Radiochemistry," Anal. Chem. 40, 586-93 (1968), and Hartwell, J. K., "Detection Limits for Radioanalytical Counting Techniques," Atlantic Richfield Hanford Company Report ARH-SA-215 (June 1975).

1/2.2.1.2 DOSE

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 Control implements the guides set forth in Section II.A of Appendix I. Compliance with this control will be considered to demonstrate compliance with the 0.1 rem limit of 10 CFR Part 20.1301(a)(1) per 56 FR 23374. The ACTION statements 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 liquid effluents to UNRESTRICTED AREAS will be kept "as low as reasonable achievable." Also, for fresh water sites with drinking water supplies which 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

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

BASES

1/2.2 RADIOACTIVE EFFLUENTS

1/2.2.1.2 DOSE (CONTINUED)

Part 141. The dose calculation methodology and parameters in the ODCM Section 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 equations specified in the ODCM section 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, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purposes of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision 1, October 1977 and Regulatory Guide 1.113, "Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I," April 1977.

This Control applies to the release of radioactive materials in liquid effluents from each unit at the site. When shared Radwaste Treatment Systems are used by more than one unit on a site, the wastes from all units are mixed for shared treatment; by such mixing, the effluent releases cannot accurately be ascribed to a specific unit. An estimate should be made of the contributions from each unit based on input conditions, e.g., flow rates and radioactivity concentrations, or, if not practicable, the treated effluent releases be allocated equally to each of the radioactive producing units sharing the Radwaste Treatment System. For determining conformance to controls, these allocations from shared Radwaste Treatment Systems are to be added to the releases specifically attributed to each unit to obtain the total release per site.

For those nuclides whose activities are determined from composite samples (as noted in Table 2.2-1), the concentrations for the previous composite period will be assumed as the concentration for the next period to perform the calculations in ODCM Sections 6.1 and 6.3.

1/2.2.1.3 LIQUID RADWASTE TREATMENT SYSTEM

The OPERABILITY 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 environment. The Control 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 reasonable achievable." This

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

BASES

1/2.2 RADIOACTIVE EFFLUENTS

1/2.2.1.3 LIQUID RADWASTE TREATMENT SYSTEM (CONTINUED)

requirement implements the requirements of 10 CFR Part 50.36a, General Design Criteria 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 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. When shared Radwaste Treatment Systems are used by more than one unit on a site, the wastes from all units are mixed for shared treatment; by such mixing, the effluent releases cannot accurately be ascribed to a specific unit. An estimate should be made of the contributions from each unit based on input conditions, e.g., flow rates and radioactivity concentrations, or, if not practicable, the treated effluent releases be allocated equally to each of the radioactive producing units sharing the Radwaste Treatment System. For determining conformance to controls, these allocations from shared Radwaste Treatment Systems are to be added to the releases specifically attributed to each unit to obtain the total release per site.

1/2.2.2.1 DOSE RATE

This Control is provided to ensure that the external dose rate at any time at and beyond the SITE BOUNDARY from gaseous effluents from all units on the site will be within the limits of 10 CFR Part 20.1301(a)(2) for UNRESTRICTED AREAS. The 500 mrem/year dose rate will ensure that the instaneous dose rate is well below 2 mrem/hour. These limits provide reasonable assurance that radioactive material discharged in gaseous effluents will not result in the exposure of a MEMBER OF THE PUBLIC, to annual average concentrations exceeding the limits specified in Appendix B, Table 2 of 10 CFR Part 20. For MEMBERS OF THE PUBLIC who may at times be within the CONTROLLED AREA, the occupancy of that MEMBER OF THE PUBLIC will usually be sufficiently low to compensate for any increase in the atmospheric dispersion factor above that for the SITE BOUNDARY. Examples of calculations for such MEMBERS OF THE PUBLIC, with the appropriate occupancy factors, shall be given in the ODCM. The specified limits restrict, at all times, the corresponding gamma and beta dose rates above background to a MEMBER OF THE PUBLIC at or beyond the SITE BOUNDARY to $\leq$500 mrem/year to the total body or to $\leq$3000 mrem/year to the skin. These limits also restrict, at all times, the corresponding thyroid dose rate above background to a child via the inhalation pathway to $\leq$1500 mrem/year. This requirement applies to the

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

BASES

1/2.2 RADIOACTIVE EFFLUENTS

1/2.2.2.1 DOSE RATE (CONTINUED)

release of gaseous effluents from all reactors at the site.

The required detection capabilities for radioactive materials in gaseous waste samples are tabulated in terms of the lower limits of detection (LLDs). Detailed description of the LLD, and other detection limits can be found in HASL Procedures Manual, HASL-300 (revised annually), Curie, L. A., "Limits for Qualitative Detection and Quantitative Determination - Application to Radiochemistry," Anal. Chem. 40, 586-93 (1968), and Hartwell, J. K., "Detection Limits for Radioanalytical Counting Techniques," Atlantic Richfield Hanford Company Report ARH-SA-215 (June 1975).

For those nuclides whose activities are determined from composite samples (as noted in Table 1.2-1), the concentrations for the previous composite period will be assumed as the concentration for the next period to perform the calculations in ODCM Sections 7.2.

1/2.2.2.2 DOSE - NOBLE GASES

This Control is provided to implement the requirements of Sections II.B, III.A and IV.A of Appendix I, 10 CFR Part 50. The requirement implements the guides set forth in Section I.B of Appendix I. Compliance with this control will be considered to demonstrate compliance with the 0.1 rem limit of 10 CFR Part 20.1301(a)(1) per 56 FR 23374. The ACTIONs to be taken 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 gaseous effluents to UNRESTRICTED AREAS will be kept "as low as reasonably achievable." The surveillance implements 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 dose calculation methodology and parameters established in ODCM Section 7.3 for calculating the doses due to the actual release rates of radioactive noble gases in gaseous effluents are consistent with the methodology provided in Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purposes of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision 1, October 1977 and Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water Cooled Reactors," Revision 1, July 1977. The equations provided for determining the air

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

BASES

1/2.2 RADIOACTIVE EFFLUENTS

1/2.2.2.2 DOSE - NOBLE GASES (CONTINUED)

doses at and beyond the SITE BOUNDARY are based upon the historical average atmospheric conditions.

This Control applies to the release of gaseous effluents from each reactor at the site. When shared Radwaste Treatment Systems are used by more than one unit on a site, the wastes from all units are mixed for shared treatment; by such mixing, the effluent releases cannot accurately be ascribed to a specific unit. An estimate should be made of the contributions from each unit based on input conditions, e.g., flow rates and radioactivity concentrations, or, if not practicable, the treated effluent releases be allocated equally to each of the radioactive producing units sharing the Radwaste Treatment System. For determining conformance to requirements, these allocations from shared Radwaste Treatment Systems are to be added to the releases specifically attributed to each unit to obtain the total release per site.

1/2.2.2.3 DOSE - IODINE-131, IODINE-133, TRITIUM, AND RADIONUCLIDES IN PARTICULATE FORM WITH HALF-LIFE GREATER THAN EIGHT DAYS

This Control is provided to implement the requirements of Sections II.C, III.A and IV.A of Appendix I, 10 CFR Part 50. The Control implements the guides set forth in Section II.C of Appendix I. Compliance with this control will be considered to demonstrate compliance with the 0.1 rem limit of 10 CFR Part 20.1301(a)(1) per 56 FR 23374. The ACTION to be taken provides the required operating flexibility and at the same time implements the guides set forth in Section IV.A of Appendix I to assure that the releases of radioactive material in gaseous effluents will be kept "as low as reasonably achievable." ODCM Section 7.4 calculational methods specified in the Surveillance Requirement 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 appropriately modeled pathways is unlikely to be substantially underestimated. ODCM Section 7.4 calculational methodology and parameters for calculating the doses due to the actual release rates of the subject materials are consistent with the methodologies provided in NUREG/CR-1004, "A Statistical Analysis of Selected Parameters for Predicting Food Chain Transport and Internal Dose of Radionuclides," October 1979 and Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purposes of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision 1, October 1977 and Regulatory Guide 1.111, "Methods for Estimating Atmospheric

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

BASES

1/2.2 RADIOACTIVE EFFLUENTS

1/2.2.2.3 DOSE - IODINE-131, IODINE-133, TRITIUM, AND RADIOACTIVE MATERIAL IN PARTICULATE FORM WITH HALF-LIFE GREATER THAN EIGHT DAYS (CONTINUED)

Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water Cooled Reactors," Revision 1, July 1977. These equations also provide for determining the actual doses based upon the historical average atmospheric conditions. The release rate controls for I-131, I-133, tritium and particulate radionuclides with half-lives greater than eight days are dependent upon the existing radionuclide pathways to man in the areas at and beyond the SITE BOUNDARY. The pathways that were examined in the development of the calculations were: (1) individual inhalation of airborne radionuclides, (2) deposition of radionuclides onto green leafy 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.

For those nuclides whose activities are determined from composite samples, the concentrations for the previous composite period will be assumed as the concentration for the next period to perform the calculations in ODCM Section 7.4.

1/2.2.2.4 GASEOUS RADWASTE TREATMENT SYSTEM

The OPERABILITY of the WASTE GAS HOLDUP SYSTEM and the VENTILATION EXHAUST TREATMENT SYSTEM ensures that the systems will be available for use whenever gaseous effluents require treatment prior to release to the environment. The Control that the appropriate portions of these systems 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 requirement implements the requirements of 10 CFR Part 50.36a, General Design Criteria 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 systems 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. When shared Radwaste Treatment Systems are used by more than one unit on a site, the wastes from all units are mixed for shared treatment; by such mixing, the effluent releases cannot accurately be ascribed to a specific unit. An estimate

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

BASES

1/2.2 RADIOACTIVE EFFLUENTS

1/2.2.2.4 GASEOUS RADWASTE TREATMENT SYSTEM (continued)

should be made of the contributions from each unit based on input conditions, e.g., flow rates and radioactivity concentrations, or, if not practicable, the treated effluent releases be allocated equally to each of the radioactive producing units sharing the Radwaste Treatment System. For determining conformance to Controls, these allocations from shared Radwaste Treatment Systems are to be added to the releases specifically attributed to each unit to obtain the total release per site.

1/2.2.3 TOTAL DOSE

This Control is provided to meet the dose limitations of 40 CFR Part 190. Compliance with this Control will be considered to demonstrate compliance with the 0.1 rem limit of 10 CFR Part 20.1301(a)(1) per 56 FR 23374. The ACTION requires the preparation and submittal of a Special Report whenever the calculated doses due to releases of radioactivity and to radiation from uranium fuel cycle sources exceed 25 mrem to the total body or any other organ except thyroid, which shall be limited to less than or equal to 75 mrem. 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 and from outside storage tanks are kept small. The Special Report will describe a course of action that should result in the limitation of annual dose to a MEMBER OF THE PUBLIC to within the 40 CFR Part 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 nuclear fuel cycle facilities at the same site or within a radius of 8 km must be considered.

If the dose to any MEMBER OF THE PUBLIC is estimated to exceed the requirements of 40 CFR Part 190, the Special Report with a request for a variance (provided the release conditions resulting in violation of 40 CFR Part 190 have not already been corrected), in accordance with the provisions of 40 CFR 190.11 and 10 CFR 20.2203, is considered to be a timely request and fulfills the requirements of 40 CFR Part 190 until NRC staff action is completed. The variance only relates to the limits of 40 CFR Part 190, and does not apply in any way to the other requirements for dose limitation of 10 CFR Part 20, as addressed in ODCM Controls 1.2.1.1 and 1.2.2.1. An individual is not considered a MEMBER OF THE PUBLIC during any period in which he/she receives an occupational radiation dose.

BASES

1/2.3 RADIOLOGICAL ENVIRONMENTAL MONITORING

1/2.3.1 MONITORING PROGRAM

The Radiological Environmental Monitoring Program required by this Control provides representative measurements of radiation and of radioactive materials in those exposure pathways and for those radionuclides that lead to the highest potential radiation exposures of MEMBERS OF THE PUBLIC resulting from the plant operation. This monitoring program implements Section IV.B.2 of Appendix I to 10 CFR Part 50 and thereby supplements the Radiological Effluent Monitoring Program by verifying that the measurable concentration of radioactive materials and levels of radiation are not higher than expected on the basis of the effluent measurements and modeling of the environmental exposure pathways. Guidance for this monitoring program is provided by the Radiological Assessment Branch Technical Position on Environmental Monitoring, Revision 1, November 1979. The initially specified monitoring program will be effective for at least the first three years of commercial operation. Following this period, program changes may be initiated based on operational experience.

The required detection capabilities for environmental sample analyses are tabulated in terms of the lower limits of detection (LLDs). The LLDs required by Table 2.3-3 are considered optimum for routine environmental measurements in industrial laboratories. It should be recognized that the LLD is defined as an *a priori* (before the fact) limit representing the capability of a measurement system and not as *a posteriori* (after the fact) limit for a particular measurement.

Detailed description of the LLD, and other detection limits can be found in HASL Procedures Manual, HASL-300 (revised annually), Curie, L. A., "Limits for Qualitative Detection and Quantitative Determination - Application to Radiochemistry," Anal. Chem. 40, 586-93 (1968), and Hartwell, J. K., "Detection Limits for Radioanalytical Counting Techniques," Atlantic Richfield Hanford Company Report ARH-SA-215 (June 1975).

1/2.3.2 LAND USE CENSUS

This Control is provided to ensure that changes in the use of areas at and beyond the SITE BOUNDARY are identified and that modifications to the monitoring program are made if required by the results of that census. The best information from the door-to-door survey, mail survey, telephone survey, aerial survey, or by consulting with local agricultural authorities shall be used. 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 50 m^2 provides

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

BASES

1/2.4 RADIOLOGICAL ENVIRONMENTAL MONITORING

1/2.3.2 LAND USE CENSUS (continued)

assurance that significant exposure pathways via leafy vegetables will be identified and monitored since a garden of this size is the minimum required to provide the quantity (26 kg/yr) of leafy vegetables assumed in Regulatory Guide 1.109 for consumption by a child. To determine this minimum garden size, the following assumptions were used, 1) that 20% 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.

1/2.3.3 INTERLABORATORY COMPARISON

The Control 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 valid for the purposes of Section IV.B.2 of Appendix I to 10 CFR Part 50.

SECTION 3.0

DEFINITIONS

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

3.0 DEFINITIONS

The defined terms in this section appear in capitalized type in the text and are applicable throughout these Controls and Bases.

3.1 ACTION

ACTION shall be that part of a Control that prescribes remedial measures required under designated conditions.

3.2 CHANNEL CALIBRATION

A CHANNEL CALIBRATION shall be the adjustment, as necessary, of the channel such that it responds within the necessary range and accuracy to known values of input. The CHANNEL CALIBRATION shall encompass the entire channel including the sensor and alarm, interlock, display, and/or trip functions. Calibration of instrument channels with resistance temperature detector (RTD) or thermocouple sensors shall consist of an in place cross calibration of the remaining adjustable devices in the channel. Whenever a sensing element is replaced, the next required in place cross calibration consists of comparing the other sensing elements with the recently installed sensing element. The CHANNEL CALIBRATION may be performed by any series of sequential, overlapping channel calibrations or total channel steps such that the entire channel is calibrated.

3.3 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.

3.4 CHANNEL OPERATIONAL TEST

An CHANNEL OPERATIONAL TEST shall be the injection of a simulated signal or actual signal into the channel as close to the sensor as practicable to verify OPERABILITY of alarm, interlock, and/or trip functions. The CHANNEL OPERATIONAL TEST shall include adjustments, as necessary, of the required alarm, interlock, and/or trip setpoints such that the setpoints are within the required range and accuracy.

3.5 CONTROLLED AREA

A CONTROLLED AREA, as defined in 10 CFR 20, is the area outside the RESTRICTED AREA but inside the 10 CFR 20 defined SITE BOUNDARY, access to which can be limited by the licensee for any reason (see Figure 3.1).

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

3.0 DEFINITIONS

3.6 DOSE EQUIVALENT I-131

DOSE EQUIVALENT I-131 shall be that concentration of I-131 (μCi/gram) that 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 Table E-7 of NRC Regulatory Guide 1.109, Revision 1, October 1977.

3.7 FREQUENCY NOTATION

The FREQUENCY NOTATION specified for the performance of Surveillance Requirements shall correspond to the intervals defined in Table 3.1.

3.8 MEMBER(S) OF THE PUBLIC

MEMBER(S) OF THE PUBLIC, as defined in 10 CFR 20, shall include all individuals in CONTROLLED or UNRESTRICTED AREAS. However, an individual is not a MEMBER OF THE PUBLIC during any period in which the individual receives an occupational dose.

3.9 MODE

A MODE shall correspond to any one inclusive combination of core reactivity condition, power level, and average reactor coolant temperature specified in Table 3.2 with fuel in the reactor vessel and reactor vessel head closure bolt tensioning.

3.10 OPERABLE - OPERABILITY

A system, subsystem, train, component, or device shall be OPERABLE or have OPERABILITY 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 specified function(s) are also capable of performing their related support function(s).

3.11 PURGE - PURGING

PURGE or PURGING shall be any controlled process of discharging air or gas from a confinement to maintain temperature, pressure, humidity, concentration or other operating condition, in such a manner that replacement air or gas is required to purify the confinement.

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

3.0 DEFINITIONS

3.12 RATED THERMAL POWER

RATED THERMAL POWER shall be a total reactor core heat transfer rate to the reactor coolant of 3411 MWt.

3.13 REPORTABLE EVENT

A REPORTABLE EVENT shall be any of those conditions specified in Section 50.73 of 10 CFR Part 50.

3.14 RESTRICTED AREA

The RESTRICTED AREA, as defined in 10 CFR 20, is that area, access to which is limited by the licensee for the purposes of protecting individuals against undue risks from exposure to radiation and radioactive materials. RESTRICTED AREA does not include areas used as residential quarters, but separate rooms in a residential building may be set apart as a RESTRICTED AREA (see Figure 3.1).

3.15 SITE BOUNDARY

The site boundary is defined in 10 CFR 20 as that line beyond which the land or property is not owned, leased, or otherwise controlled by the licensee (see Figure 3.1). The ODCM SITE BOUNDARY is completely within the CONTROLLED AREA.

3.16 SOURCE CHECK

A SOURCE CHECK shall be the qualitative assessment of channel response when the channel sensor is exposed to a radioactive source or other channel sensor internal test circuits.

3.17 UNRESTRICTED AREA

An UNRESTRICTED AREA, as defined in 10 CFR 20, shall be any area, access to which is neither limited nor controlled by the licensee (see Figure 3.1).

3.18 VENTILATION EXHAUST TREATMENT SYSTEM

A 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 noble gas

3.0 DEFINITIONS

3.18 VENTILATION EXHAUST TREATMENT SYSTEM (continued)

effluents). Engineered Safety Feature (ESF) atmospheric cleanup systems are not considered to be VENTILATION EXHAUST TREATMENT SYSTEM components.

3.19 VENTING

VENTING is the controlled process of discharging air or gas from a confinement to maintain temperature, pressure, humidity, concentration, or other operating condition, in such a manner that replacement air gas is not provided or required during VENTING. Vent, used in system names, does not imply a VENTING process.

3.20 WASTE GAS HOLDUP SYSTEM

A WASTE GAS HOLDUP SYSTEM is 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.

Table 3.1

FREQUENCY NOTATION

NOTATION	FREQUENCY
S	At least once per 12 hours.
D	At least once per 24 hours.
W	At least once per 7 days.
M	At least once per 31 days.
Q	At least once per 92 days.
SA	At least once per 184 days.
R	At least once per 18 months.
S/U	Prior to each reactor startup.
N/A	Not applicable.
P	Completed prior to each release.

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

Table 3.2

OPERATIONAL MODES

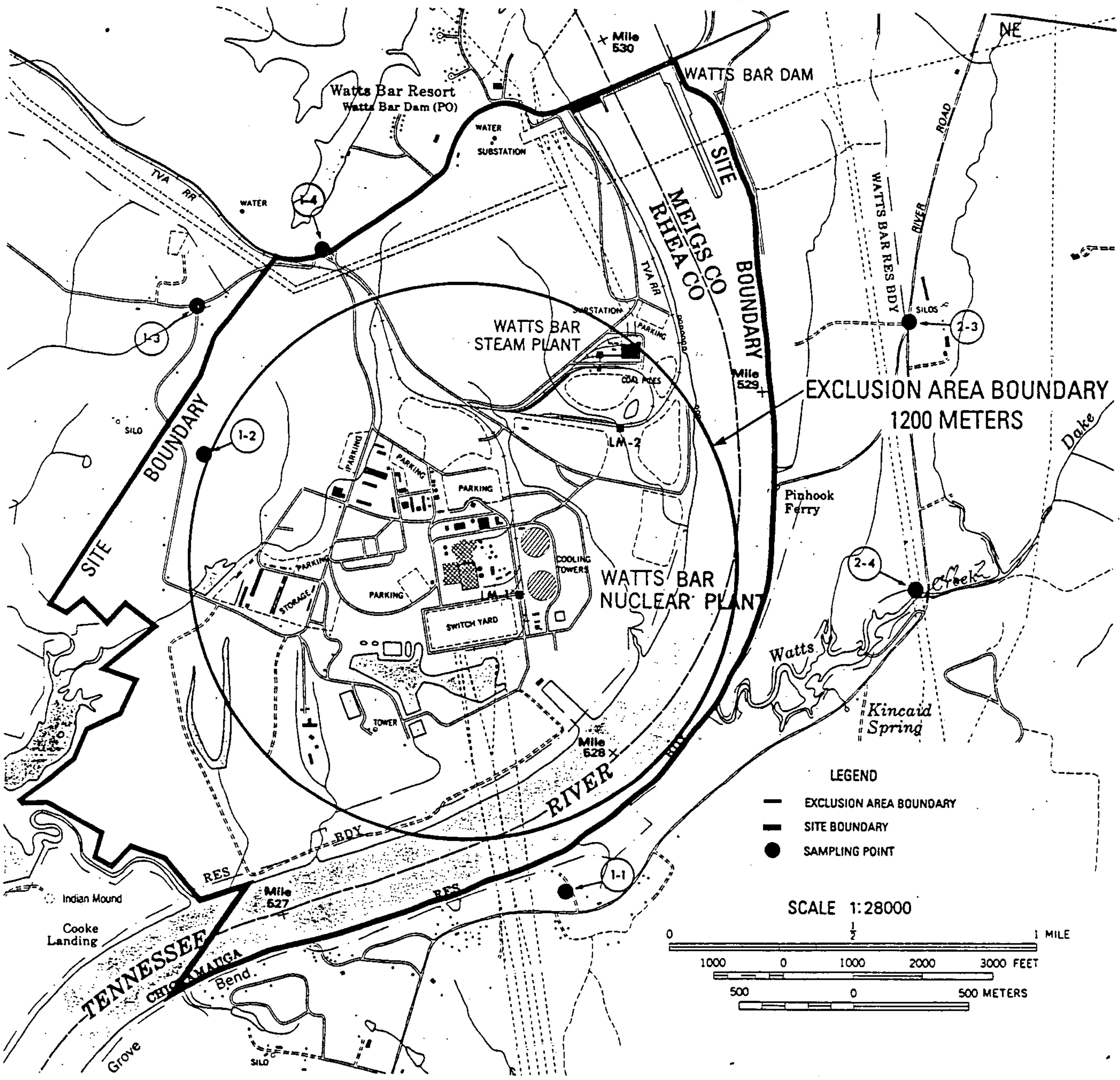
MODE	REACTIVITY CONDITION, K_{eff}	% RATED THERMAL POWER*	AVERAGE COOLANT TEMPERATURE
1. Power Operation	$\geq$ 0.99	> 5%	N/A
2. Startup	$\geq$ 0.99	$\leq$ 5%	N/A
3. Hot Standby	< 0.99	N/A	$\geq$ 350°F
4. Hot Shutdown	< 0.99	N/A	350°F > T_{avg} > 200°F
5. Cold Shutdown	< 0.99	N/A	$\leq$ 200°F
6. Refueling**	NA	N/A	N/A

* Excluding decay heat.

** Fuel in the reactor vessel with the vessel head closure bolts less than fully tensioned or with the head removed.

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

Figure 3.1
WBN SITE AREA MAP



SECTION 4.0

(NOT USED)

SECTION 5.0

ADMINISTRATIVE CONTROLS

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

5.0 ADMINISTRATIVE CONTROLS

5.1 ANNUAL RADIOLOGICAL ENVIRONMENTAL OPERATING REPORT

As required by WBN TS 5.9.1.3, Routine Annual Radiological Environmental Operating Reports covering the operation of the unit during the previous calendar year shall be submitted prior to May 15 of each year.

The annual radiological environmental operating reports shall include summaries, interpretations, and an analysis of trends of the results of the radiological environmental surveillance activities for the report period, including a comparison with preoperational studies, with operational controls, and with previous environmental surveillance reports and an assessment of the observed impacts of the plant operation on the environment. The reports shall also include the results of land use censuses required by ODCM Control 1/2.3.2.

The annual radiological environmental operating reports shall include summarized and tabulated results of these analyses and measurements in the format of the table in the Radiological Assessment Branch Technical Position, Revision 1, November 1979. 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 reports shall also include the following: a summary description of the radiological environmental monitoring program; at least two legible maps (one map shall cover stations near the SITE BOUNDARY, a second shall include the more distant stations) covering all sampling locations keyed to a table giving distances and directions from the centerline of one reactor; and the results of licensee participation in the Interlaboratory Comparison Program and the corrective actions being taken if the specified program is not being performed as required by ODCM Control 1/2.3.1; discussion of all deviations from the sampling schedule of Table 2.3-1; reasons for not conducting the radiological environmental monitoring program as required by ODCM Control 1/2.3.1 and discussions of environmental sample measurements that exceed the reporting levels of Table 2.3-2 but are not the result of plant effluents, pursuant to the action described in step b. of ODCM Control 1/2.3.1; and discussion of all analyses in which the LLD required by Table 2.3-3 was not achievable.

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

5.0 ADMINISTRATIVE CONTROLS

5.2 RADIOACTIVE EFFLUENT RELEASE REPORT

As required by WBN TS 5.9.1.4, a Radioactive Effluent Release Report covering the operation of the unit during the previous period of operation shall be submitted in accordance with 10 CFR 50.36a. The initial report will be submitted by January or July 1 of the year following at least six months of operation after initial criticality.

Radioactive release reports shall include a summary of the quantities of radioactive liquid and gaseous effluents and solid waste released from the unit as outlined in 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 data summarized on a quarterly basis following the format of Appendix B thereof, as applicable. Additional requirements for reporting solid waste are specified in the Process Control Program.

The radioactive effluent release reports shall include a list and description of unplanned releases from the site to UNRESTRICTED AREAS of radioactive materials in gaseous and liquid effluents made during the reporting period.

The radioactive effluent release reports shall include any changes made during the reporting period to the Process Control Program pursuant to WBN TS 5.7.2.2, and to the Offsite Dose Calculation Manual (ODCM) pursuant to ODCM Administrative Control 5.3, as well as any major changes to Liquid, Gaseous, or Solid Radwaste Treatment Systems, pursuant to WBN Technical Specifications.

The radioactive effluent release reports shall also include the following: an explanation as to why the inoperability of liquid or gaseous effluent monitoring instrumentation was not corrected within the time specified in ODCM Controls 1.1.1 or 1.1.2, respectively.

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 on magnetic tape of wind speed, wind direction, atmospheric stability, and precipitation (if measured), or in the form of joint frequency distributions of wind speed, wind direction, and atmospheric stability. In lieu

RADIOACTIVE EFFLUENT/RADIOLOGICAL ENVIRONMENTAL MONITORING CONTROLS

5.0 ADMINISTRATIVE CONTROLS

5.2 RADIOACTIVE EFFLUENT RELEASE REPORT (CONTINUED)

of submission with the radioactive effluent release report, this summary of required meteorological data may be retained on site in a file that shall be provided to NRC upon request. This same report shall include an assessment of the radiation doses due to radioactive liquid and gaseous effluents released from the unit or station during the previous calendar year. This same 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. All assumptions used in making these assessments (i.e., specific activity, exposure time, and location) shall be included in these reports. Actual meteorological data for the period containing the releases of radioactive materials in gaseous effluents shall be used for determining the gaseous pathway doses. The assessment of radiation doses shall be performed in accordance with Sections 6.6 and 7.6. It shall also include a listing of new locations for dose calculations identified by the Land Use Census pursuant to ODCM Control 2.3.2.

The radioactive effluent release 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 effluents and direct radiation, for the previous calendar year to show conformance with 40 CFR 190, in accordance with ODCM Section 8.1.

5.3 OFFSITE DOSE CALCULATION MANUAL CHANGES

As required by WBN TS 5.7.2.3, changes to the ODCM:

1. Shall be documented and records of reviews performed shall be retained as required by WBN TS 5.10.3.o. This documentation shall contain:

   a. Sufficient information to support the change together with the appropriate analyses or evaluations justifying the change(s) and

   b. A determination that the change will maintain the level of radioactive effluent control required by 10 CFR 20.106, 40 CFR 190, 10 CFR 50.36a, and Appendix I to 10 CFR 50 and not adversely impact the accuracy or reliability of effluent, dose, or setpoint calculations.

5.3 OFFSITE DOSE CALCULATION MANUAL CHANGES (continued)

2. Shall become effective after review and acceptance by the PORC and the approval of the Plant Manager.

3. Shall be submitted to the NRC in the form of a complete, legible copy of the entire ODCM as a part of or concurrent with the Radioactive Effluent Release Report for the period of the report in which any change to the ODCM 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 (i.e., month/year) the change was implemented.

5.4 SPECIAL REPORTS

Special Reports shall be submitted to the Regional Administrator, Region II, within the time period specified for each report.

SECTION 6.0

LIQUID EFFLUENTS

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

RELEASE POINTS

There are five release paths from which liquid effluents are released. These are the Liquid Radwaste System, the Condensate Demineralizer System, the Turbine Building Sump, and the Units 1 and 2 Steam Generator Blowdown. All liquid effluents are ultimately discharged through a diffuser to the Tennessee River. The Cooling Tower Blowdown (CTBD) provides dilution for liquid effluents at a minimum flow rate of 20,000 gpm. The Essential Raw Cooling Water (ERCW), which is not a routine release point, is monitored by radiation monitors 0-RM-90-133, -134, -140, -141. The sole discharge point, at the inlet to the diffuser, is monitored by radiation monitor 0-RE-90-211. Figure 6.1 provides an outline of the liquid release points and discharge point with associated flow rates and radiation monitors.

Liquid Radwaste System

The Liquid Radwaste System processes liquid from the Reactor Building and Auxiliary Building Floor Drains and the laundry/hot shower and chemical drain tanks. Figure 6.2 provides a schematic of the Liquid Radwaste System, showing the liquid pathways, flow rate and radiation monitors. The Radwaste System has individual release points for each of the tanks. The routine release points for liquid radwaste are the Monitor Tank and the Cask Decontamination Collector Tank (CDCT). The Monitor Tank has a capacity of 18,000 gal and can be released at a maximum flow rate of 300 gpm. The CDCT has a capacity of 15,000 gal and can be released at a maximum flow rate of 80 gpm. The Monitor Tank and CDCT discharge to the Cooling Tower Blowdown (CTBD) line as a batch release and are monitored by radiation monitor 0-RE-90-122.

Condensate Demineralizer System

The Condensate Demineralizer System liquid wastes are released from the High Crud Tanks (HCT-1 and -2), the Neutralization Tank, and the Non-Reclaimable Waste Tank (NRWT). The HCTs have a capacity of 19,000 gal and a maximum discharge flow rate of 300 gpm. The Neutralization Tank has a capacity of 20,000 gal and a maximum discharge flow rate of 80 gpm. The NRWT has a capacity of 11,000 gal and a maximum discharge flow rate of 60 gpm. Each of these tanks is defined as a release point for the system. When tank contents are radioactive, The Condensate Demineralizer System waste is routinely released to the CTBD line and is monitored by radiation monitor 0-RE-90-225.

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

Turbine Building Sump

The Turbine Building Sump (TBS) normally releases to the Low Volume Waste Treatment Pond, but can be released to the 35 acre Yard Holding Pond or to the CTBD. The TBS has a capacity of 30,000 gal and a design discharge release rate of 1,750 gpm per pump. TBS releases are monitored by radiation monitor 0-RE-90-212.

Steam Generator Blowdown

The Steam Generator Blowdown (SGBD) is processed in the Steam Generator Blowdown Flash Tanks or SGBD Heat Exchangers. The SGBD discharge has a maximum flow rate of 80 gpm per steam generator. SGBD is recycled or is released to the CTBD line and monitored by radiation monitors 1,2-RE-90-120 and 1,2-RE-90-121.

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

6.1 LIQUID RELEASES

6.1.1 Pre-Release analysis

Radwaste tanks will be recirculated for the appropriate times prior to sampling to ensure that a representative sample is obtained. The condensate demineralizer waste evaporator blowdown tanks cannot be recirculated; however, the contents will be transferred to the waste distillate tanks prior to release.

Condensate demineralizer tanks are routinely continuously released and utilize a composite sampler to obtain a representative sample while being discharged. In the event of an inoperable effluent radiation monitor or composite sampler, a two volume recirculation and two independent samples and analyses will be performed. Releases from the steam generator blowdown and turbine building sump are considered continuous and grab sampled as required.

Prior to a batch release, a grab sample will be taken and analyzed to determine the concentration, µCi/ml, of each gamma-emitting nuclide. For continuous releases, daily grab or composite samples will be taken and analyzed to determine the concentration, µCi/ml, of each gamma-emitting nuclide nuclide. Composite samples are maintained to determine the concentration of certain nuclides (H-3, Fe-55, Sr-89, Sr-90, and alpha emitters).

6.1.2 MPC-Sum of the Ratios

The sum of the ratios (R_j) for each release point will be calculated by the following relationship.

$$R_j = \sum_i \frac{C_i}{MPC_i} \qquad (6.1)$$

where:

R_j = the sum of the ratios for release point j.
MPC_i = the MPC of radionuclide i, µCi/ml.
C_i = undiluted concentration of radionuclide i, µCi/ml.

The total sum of the MPC ratios for the site must be $\leq$ 1 due to the releases from any or all of the release points described above.

The following relationship is used to ensure this criterion is met:

$$\frac{f_1R_1 + f_2R_2 + f_3R_3 + f_4R_3 + f_5R_5}{F} \leq 1.0 \qquad (6.2)$$

where

R_i = sum of the ratios for the turbine building sump, radwaste, condensate demineralizer system and each of the steam generators, respectively.

f_i = effluent flow rate for turbine building sump, radwaste, condensate demineralizer system and each of the steam generators, respectively, gpm.

F = minimum dilution flow rate for CTBD, 20,000 gpm.

6.1.3 Post-Release Analysis

A post-release analysis will be done using actual release data to ensure that the limits given in ODCM Control 1.2.2.1 were not exceeded.

A composite list of concentrations (C_i), by isotope, will be used with the actual waste (f) and dilution (F) flow rates (or volumes) during the release. The data will be substituted into Equation 6.2 to demonstrate compliance with the limits in ODCM Control 1.2.2.1. This data and radiation monitor setpoints will be recorded in auditable records by plant personnel.

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

6.2 INSTRUMENT SETPOINTS

Liquid effluent monitor setpoints are determined to ensure that the concentration of radioactive material released at any time from the site to UNRESTRICTED AREAS does not exceed the MPC limits referenced in ODCM Control 1.2.1.1 or to identify any unexpected releases.

6.2.1 Discharge Point Monitor Setpoints

The setpoints for ERCW monitors (RE-90-133, -134, -140, and -141) are set to ensure that the concentration of radioactive materials released at any time from the site do not exceed the limits given in ODCM Control 1.2.1.1.

6.2.2 Release Point Monitor Setpoints

There are two types of releases from WBN: batch and continuous. The setpoints for release point monitors are set to identify any unexpected discharges of radioactivity.

6.2.2.1 Batch Release Monitor Setpoints

For each batch release, the expected monitor response, R in cpm, is calculated using the following equation:

$$R = B + \sum_i Eff_i * C_i \qquad (6.3)$$

where

B = monitor background, cpm.

Eff_i = monitor efficiency for nuclide i, cpm per μCi/cc.

C_i = tank concentration of nuclide i, μCi/cc.

It is desired that the setpoint be set equal to 2 times the expected response where 2 is an administrative factor designed to account for uncertainties associated with radiation monitoring equipment and the calculation of expected response. However, the setpoint shall be set conservative with respect to established safety limits for the release point. The degree of conservatism with release limits shall take into account uncertainties associated with radiation monitor equipment and the calculation of expected response.

6.2.2.2 Concinuous Release Monitor Setpoints

For the continuous release points, the steam generator blowdowns and turbine building sump, the monitor setpoint is designed to indicate the presence of elevated activity levels in these systems. These systems will not contain radioactivity unless there is a primary to secondary leak. The setpoints will be set to indicate when this is occurring.

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

6.3 CUMULATIVE LIQUID EFFLUENT DOSE CALCULATIONS

Doses due to liquid effluents are calculated for each release for all age groups (adult, teen, child and infant) and organs (bone, liver, total body, thyroid, skin, kidney, lung and GI tract). Pathways considered are ingestion of drinking water, fish consumption and recreation-shoreline. The maximum individual dose from drinking water is assumed to be that calculated at the first public water supply immediately downstream from the diffuser. The maximum individual dose from fish ingestion is assumed to be that calculated for the consumption of fish caught anywhere between the plant and the 100% mixing point (Tennessee River Mile 510.0). The maximum potential recreation dose is calculated for a location immediately downstream of the plant outfall. Dose factors for these age groups and pathways are calculated as described in Section 6.7. For pathways with no age or organ specific dose factors (i.e., shoreline recreation), the total body dose will be added to the internal organ doses for all age groups.

The general equation for the dose calculations is:

$$\text{Dose} = \sum_i A_{it} \, T \, C_i \, D \qquad (6.4)$$

where:

A_{it} = the total dose factor to the total body or any organ t for nuclide i, mrem/hr per µCi/ml. The total dose factor is the sum of the dose factors for water ingestion, fish ingestion, and shoreline recreation, as defined in Section 6.7.

T = the length of time period over which the concentrations and the flows are averaged for the liquid release, hours.

C_i = the average concentration of radionuclide i, in undiluted liquid effluent during the time period T from any liquid release, µCi/ml.

D = the near field average dilution factor for C_i during any effluent release. D is calculated by the following equation:

$$D = \frac{FLOW_w}{0.10 \quad RF}$$

where:

$FLOW_w$ = maximum undiluted liquid waste flow during the release, cfs. For TBS releases, this term is the diluted waste flow into the pond.

0.10 = mixing factor of effluent in river, defined as the percentage of the riverflow which is available for dilution of the release.

RF = historical average riverflow, cfs. For each release, this value is set to 20,000 cfs (the average quarterly riverflow recorded from the period 1985-1989).

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

From the four age groups considered, the maximum is determined by comparing all organ doses for all age groups. The age group with the highest single organ dose is selected as the critical age group.

6.3.1 Cumulative Doses

Cumulative quarterly and annual sums of all doses are determined for each release to compare to the limits given in ODCM Control 1.2.1.2. These quarterly and annual sums will be the sum of the doses for each release which occurred in that quarter or year. These doses will be used in the comparison to the limits.

6.3.2 Comparison to Limits

The cumulative calendar quarter and calendar year doses are compared to the limits in ODCM Control 1.2.1.2 at least once per 31 days to determine compliance.

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

6.4 LIQUID RADWASTE TREATMENT SYSTEM

The liquid radwaste treatment system described in the WBN FSAR shall be maintained and operated to keep releases ALARA. A flow diagram for the LRTS is given in Figure 6.2.

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

6.5 DOSE PROJECTIONS

In accordance with ODCM Surveillance Requirement 2.2.1.3, dose projections will be performed for each release using the equation below:

$$d_t = \frac{(a_t + b_t)}{d} * 31 + c_t$$

where

d_t = the 31-day dose projection for organ t, mrem.
a = the cumulative dose for the quarter for organ t, mrem
b = the projected dose to organ t for this release, mrem
c = any anticipated additional dose to organ t in the next month from other sources, mrem
d = current number of days into the quarter up to the time of the release under consideration.

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

6.6 DOSE CALCULATIONS FOR REPORTING

A complete dose analysis utilizing the total estimated liquid releases for each calendar quarter will be performed and reported as required in ODCM Administrative Control 5.2. Methodology for this analysis is that which is described in this section using the total quarterly release values. The releases are assumed for this calculation to be continuous over the 90 day period.

The average dilution factor, D, used for the quarterly calculations is:

$$D = \frac{1}{F_R * 0.10} \quad \text{(for receptors upstream of TRM 510.0)} \qquad (6.5)$$

and

$$D = \frac{1}{F_R} \quad \text{(for receptors downstream of TRM 510.0)} \qquad (6.6)$$

where:

F_R = the average actual riverflow for the location at which the dose is being determined, cfs.
0.10 = the fraction of the riverflow available for dilution in the near field, dimensionless.

6.6.1 Water Ingestion

Water ingestion doses are calculated for each water supply identified within a 50 mile radius downstream of WBN (Table 6.1). Water ingestion doses are calculated for the total body and each internal organ as described below:

$$D_{org} = 10^6 \; 9.80E\text{-}09 \; A_{Wit} \; Q_i \; D \; \exp(-8.64E{+}04 \; \lambda_i \; t_d) \qquad (6.7)$$

where

10^6 = conversion factor, µCi/Ci.
9.80E-09 = conversion factor, cfs per ml/hour.
A_{Wit} = Dose factor for water ingestion for nuclide i, age group t, mrem/hour per µCi/ml, as calculated in Section 6.7.1.
Q_i = Quantity of nuclide i released during the quarter, Curies.
D = dilution factor, as described above, cfs^{-1}.
λ_i = radiological decay constant of nuclide i, $seconds^{-1}$ (Table 6.2).
t_d = decay time for water ingestion, equal to the travel time from the plant to the water supply plus one day to account for the time of processing at the water supply (per Regulatory Guide 1.109), days.
8.64E+04 = conversion factor, seconds per day.

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

6.6.2 Fish Ingestion

Fish ingestion doses are calculated for each identified reach (section of river) within a 50 mile radius downstream of WBN (Table 6.1). Individual fish ingestion doses are calculated for the total body and each internal organ as described below:

$$D_{org} = 10^6 \; 9.80E\text{-}09 \; 0.25 \; A_{Fit} \; Q_i \; D \; \exp(-8.64E{+}04 \; \lambda_i \; t_d) \qquad (6.8)$$

where

10^6 = conversion factor, µCi/Ci.
9.80E-09 = conversion factor, cfs per ml/hour.
0.25 = fraction of the yearly fish consumption eaten in one quarter, dimensionless.
A_{Fit} = Dose factor for fish ingestion for nuclide i, age group t, mrem/hour per µCi/ml, as calculated in Section 6.7.2.
Q_i = Quantity of nuclide i released during the quarter, Curies.
D = dilution factor, as described above, cfs^{-1}.
λ_i = radiological decay constant of nuclide i, $seconds^{-1}$ (Table 6.2).
t_d = decay time for fish ingestion, equal to the travel time from the plant to the center of the reach plus one day to account for transit through the food chain and food preparation time (per Regulatory Guide 1.109), days.
8.64E+04 = conversion factor, seconds per day.

6.6.3 Shoreline Recreation

Recreation doses are calculated for each identified reach within a 50 mile radius downstream of WBN (Table 6.1). It is assumed that the maximum exposed individual spends 500 hours per year on the shoreline at a location immediately downstream from the diffusers. Individual recreation shoreline doses are calculated for the total body and skin as described below:

$$D_{org} = 10^6 \; 9.80E\text{-}09 \; rf \; A_{Rit} \; Q_i \; D \; \exp(-8.64E{+}04 \; \lambda_i \; t_d) \qquad (6.9)$$

where

10^6 = conversion factor, µCi/Ci.
9.80E-09 = conversion factor, cfs per ml/hour.

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

rf = recreation factor, used to account for seasonal variations in the amount of time spent at a recreation site. Recreation factors used are:

1st quarter - 0.1
2nd quarter - 0.3
3rd quarter - 0.4
4th quarter - 0.2.

A_{Rit} = Dose factor for shoreline recreation for nuclide i, age group t, mrem/hour per µCi/ml, as calculated in Section 6.7.3.

Q_i = quantity of nuclide i released during the quarter, Curies.

D = dilution factor, as described above, cfs^{-1}.

λ_i = radiological decay constant of nuclide i, $seconds^{-1}$ (Table 6.2).

t_d = decay time for recreation, equal to the travel time from the plant to the center of the reach, days.

8.64E+04 = conversion factor, seconds per day.

6.6.4 Total Maximum Individual Dose

The total maximum individual total body dose is obtained by summing the following for each age group: the highest total body water ingestion dose from among all the public water supplies; the highest total body fish ingestion dose from among all the reaches; and the total body maximum shoreline recreation dose. The total maximum individual organ dose is obtained by summing the following for each organ and each age group: that organ's highest water ingestion dose from among all the public water supplies; that organ's highest fish ingestion dose from among all the reaches; and the total body maximum shoreline recreation dose. The total maximum individual skin dose is that skin dose calculated for the maximum shoreline dose.

6.6.5 Population Doses

For determining population doses to the 50-mile population around the plant, an average dose is calculated for each age group and each pathway and then multiplied by the population.

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

For water ingestion, the general equation used for calculating the population doses, POPWTR, in man-rem for a given PWS is:

$$POPWTR_t = 10^{-3} \sum_{m=1}^{5} POP_m \sum_{a=1}^{4} POP_a \ ATMW_a \ TWDOS_{amt} \tag{6.10}$$

where:

$POPWTR_t$ = water ingestion population dose to organ t, man-rem.
POP_a = fraction of population in each age group a (from NUREG CR-1004, Table 3.39).
= 0.665 for adult
= 0.168 for child
= 0.015 for infant
= 0.153 for teen
POP_m = population at PWS m. The PWSs and their populations are listed in Table 6.1.
$ATMW_a$ = ratio of average to maximum water ingestion rates for each age group a. Maximum water ingestion rates are given in Table 6.3. Average water ingestion rates are obtained from R.G. 1.109 Table E-4). The ratios are:
= 0.5069 for adult
= 0.5098 for child
= 0.7879 for infant
= 0.5098 for teen
$TWDOS_{amt}$ = total individual water ingestion dose to organ t at PWS m, to the age group a, as described in Section 6.6.1, mrem.
10^{-3} = conversion factor for rem/mrem.

For population doses resulting from fish ingestion the calculation assumes that all fish caught within a 50-mile radius downstream of WBN are consumed by local population. An additional 7-day decay term is added due to distribution time of sport fish (per Regulatory Guide 1.109). The general equation for calculating population doses, POPF, in man-rem from fish ingestion of all fish caught within a 50-mile radius downstream is:

$$POPF_t = 10^{-3} \ 10^{-3} \sum_{r=1}^{4} \sum_{a=1}^{3} \frac{453.6 \ HVST \ APR_r}{FISH_a \ POP_a} POP_a \ TFDOS_{art} \tag{6.11}$$

where:

$POPF_t$ = total fish ingestion population dose to organ t, man-rem.
HVST = fish harvest for the Tennessee River, 8.32 lbs/acre/year.
APR_r = size of reach r, acres (Table 6.1).
$TFDOS_{art}$ = total fish ingestion dose to organ t for reach r, for the age group a, as described in Section 6.6.2, mrem.

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

POP_a = fraction of population in each age group a, as given above.
$FISH_a$ = amount of fish ingested by each age group a, kg/year per person. The average fish ingestion rates (R.G. 1.109 Table E-4) are:

Adult = 6.9
Child = 2.2
Teen = 5.2

453.6 = conversion factor, g/lb.
10^3 = conversion factor, mrem/rem.
10^3 = conversion factor, g/kg.

For recreation shoreline, the general equation used for calculating the population doses, POPR, in man-rem is:

$$POPR_t = \frac{REQFRA}{10^3} \sum_{r=1}^{4} SHVIS_r \; HRSVIS_r \; TSHDOS_{rt} \qquad (6.12)$$

where:

$POPR_t$ = total recreation population dose for all reaches to organ t, man-rem.
REQFRA = fraction of yearly recreation which occurs in that quarter, as given in Section 6.6.3, year per quarter.
$SHVIS_r$ = shoreline visits per year at each reach r, (Table 6.1).
$HRSVIS_r$ = length of shoreline recreation visit at reach r, 5 hours.
10^3 = conversion factor, mrem/rem.
$TSHDOS_{rt}$ = total shoreline dose rate for organ t, in reach r, mrem/h per quarter.

$$= \frac{Q_i \exp(-\lambda_i t_r) \; K_c \; M \; DF_{Git} \; 10^{12} \; 24 \; 10^3 \; D_r}{2.22E11 \; \lambda_i}$$

where:

Q_i = total activity released during the quarter, Ci.
λ_i = decay constant for nuclide i, day^{-1}.
t_r = travel time from the plant to reach r, days.
K_c = transfer coefficient from water to sediment, L/kg-hr, (Table 6.3).
M = mass density of sediment, kg/m^2, (Table 6.3).
DF_{Git} = dose conversion factor for standing on contaminated ground for nuclide i and organ t (total body and skin), mrem/hr per pCi/m^2.
10^{12} = conversion factor, pCi/Ci.
24 = conversion factor, hr/day.
10^3 = conversion factor, ml/L.
D_r = dilution factor for reach r, cfs^{-1}. Calculated as described in Equations 6.5 and 6.6.
2.2E11 = conversion factor, ml/quarter per cfs.

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

6.7.3 Shoreline Recreation Dose Factors
A_{Rit} (mrem/hr per µCi/ml).

$$A_{Rit} = \frac{DF_{Git}\ K_c\ M\ W\ 10^3\ 10^6\ U}{8760 * 3600\ \lambda_i} [1-\exp(-\lambda_i t_b)]$$

where:

DF_{Git} = dose conversion factor for standing on contaminated ground for nuclide i and organ t (total body and skin), mrem/hr per pCi/m^2, (Table 6.6).
K_c = transfer coefficient from water to shoreline sediment, l/kg-hr, (Table 6.3).
M = mass density of sediment, kg/m^2, (Table 6.3).
W = shoreline width factor, dimensionless, (Table 6.3).
10^3 = conversion factor, ml/l.
10^6 = conversion factor, pCi/µCi.
3600 = conversion factor, seconds/hour.
λ_i = decay constant for nuclide i, $seconds^{-1}$, (Table 6.2).
t_b = time shoreline is exposed to the concentration on the water, seconds, (Table 6.3).
U = usage factor, 500 hours/year.
8760 = conversion factor, hours/year.

Table 6.1
RECEPTORS FOR LIQUID DOSE CALCULATIONS

Tennessee River Reaches Within 50 Mile Radius Downstream of WBN

Name	Beginning TRM	Ending TRM	Size (acres)	Recreation visits/year
Chickamauga Lake below WBN	528.0	510.0*	4799	85,200
Chickamauga Lake above SQN	510.0	484.0	22101	914,000
Chickamauga Lake below SQN	484.0	471.0	9889	5,226,700
Nickajack Lake (Part 1)	471.0	460.0	1799	200,000

* 100% Mixing Point

Public Water Supplies Within 50 Mile Radius Downstream of WBN

Name	TRM	Population
Dayton, TN	503.7	7,654
E. I. DuPont	469.9	1,400
Chattanooga, TN	465.3	224,000

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

Table 6.2 (1 of 3)
RADIONUCLIDE DECAY AND STABLE ELEMENT TRANSFER DATA

	Half-Life (minutes)	λ (1/s)	B_{iv}	F_{mi} (cow)	F_{mi} (goat)	F_{fi} (beef)
H-3	6.46E+06	1.79E-09	4.80E+00	1.00E-02	1.70E-01	1.20E-02
C-14	3.01E+09	3.84E-12	5.50E+00	1.20E-02	1.00E-01	3.10E-02
Na-24	9.00E+02	1.28E-05	5.20E-02	4.00E-02	4.00E-02	3.00E-02
P-32	2.06E+04	5.61E-07	1.10E+00	2.50E-02	2.50E-01	4.60E-02
Cr-51	3.99E+04	2.90E-07	2.50E-04	2.20E-03	2.20E-03	2.40E-03
Mn-54	4.50E+05	2.57E-08	2.90E-02	2.50E-04	2.50E-04	8.00E-04
Mn-56	1.55E+02	7.45E-05	2.90E-02	2.50E-04	2.50E-04	8.00E-04
Fe-55	1.42E+06	8.13E-09	6.60E-04	1.20E-03	1.30E-04	1.20E-02
Fe-59	6.43E+04	1.80E-07	6.60E-04	1.20E-03	1.30E-04	1.20E-02
Co-57	3.90E+05	2.96E-08	9.40E-03	1.00E-03	1.00E-03	1.30E-02
Co-58	1.02E+05	1.13E-07	9.40E-03	1.00E-03	1.00E-03	1.30E-02
Co-60	2.77E+06	4.17E-09	9.40E-03	1.00E-03	1.00E-03	1.30E-02
Ni-63	5.27E+07	2.19E-10	1.90E-02	6.70E-03	6.70E-03	5.30E-02
Ni-65	1.51E+02	7.65E-05	1.90E-02	6.70E-03	6.70E-03	5.30E-02
Cu-64	7.62E+02	1.52E-05	1.20E-01	1.40E-02	1.30E-02	9.70E-04
Zn-65	3.52E+05	3.28E-08	4.00E-01	3.90E-02	3.90E-02	3.00E-02
Zn-69m	8.26E+02	1.40E-05	4.00E-01	3.90E-02	3.90E-02	3.00E-02
Zn-69	5.56E+01	2.08E-04	4.00E-01	3.90E-02	3.90E-02	3.00E-02
Br-82	2.12E+03	5.45E-06	7.60E-01	5.00E-02	5.00E-02	2.60E-02
Br-83	1.43E+02	8.08E-05	7.60E-01	5.00E-02	5.00E-02	2.60E-02
Br-84	3.18E+01	3.63E-04	7.60E-01	5.00E-02	5.00E-02	2.60E-02
Br-85	2.87E+00	4.02E-03	7.60E-01	5.00E-02	5.00E-02	2.60E-02
Rb-86	2.69E+04	4.29E-07	1.30E-01	3.00E-02	3.00E-02	3.10E-02
Rb-88	1.78E+01	6.49E-04	1.30E-01	3.00E-02	3.00E-02	3.10E-02
Rb-89	1.54E+01	7.50E-04	1.30E-01	3.00E-02	3.00E-02	3.10E-02
Sr-89	7.28E+04	1.59E-07	1.70E-02	1.40E-03	1.40E-02	6.00E-04
Sr-90	1.50E+07	7.70E-10	1.70E-02	1.40E-03	1.40E-02	6.00E-04
Sr-91	5.70E+02	2.03E-05	1.70E-02	1.40E-03	1.40E-02	6.00E-04
Sr-92	1.63E+02	7.09E-05	1.70E-02	1.40E-03	1.40E-02	6.00E-04
Y-90	3.85E+03	3.00E-06	2.60E-03	1.00E-05	1.00E-05	4.60E-03
Y-91m	4.97E+01	2.32E-04	2.60E-03	1.00E-05	1.00E-05	4.60E-03
Y-91	8.43E+04	1.37E-07	2.60E-03	1.00E-05	1.00E-05	4.60E-03
Y-92	2.12E+02	5.45E-05	2.60E-03	1.00E-05	1.00E-05	4.60E-03
Y-93	6.06E+02	1.91E-05	2.60E-03	1.00E-05	1.00E-05	4.60E-03
Zr-95	9.22E+04	1.25E-07	1.70E-04	5.00E-06	5.00E-06	3.40E-02
Zr-97	1.01E+03	1.14E-05	1.70E-04	5.00E-06	5.00E-06	3.40E-02
Nb-95	5.05E+04	2.29E-07	9.40E-03	2.50E-03	2.50E-03	2.80E-01
Nb-97	7.21E+01	1.60E-04	9.40E-03	2.50E-03	2.50E-03	2.80E-01
Mo-99	3.96E+03	2.92E-06	1.20E-01	7.50E-03	7.50E-03	1.10E-03
Tc-99m	3.61E+02	3.20E-05	2.50E-01	2.50E-02	2.50E-02	4.00E-01
Tc-101	1.42E+01	8.13E-04	2.50E-01	2.50E-02	2.50E-02	4.00E-01
Ru-103	5.67E+04	2.04E-07	5.00E-02	1.00E-06	1.00E-06	4.00E-01
Ru-105	2.66E+02	4.34E-05	5.00E-02	1.00E-06	1.00E-06	4.00E-01
Ru-106	5.30E+05	2.18E-08	5.00E-02	1.00E-06	1.00E-06	4.00E-01
Ag-110m	3.60E+05	3.21E-08	1.50E-01	5.00E-02	5.00E-02	1.70E-02

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

Table 6.2 (2 of 3)
RADIONUCLIDE DECAY AND STABLE ELEMENT TRANSFER DATA

	Half-Life (minutes)	λ (1/s)	B_{iv}	F_{mi} (cow)	F_{mi} (goat)	F_{fi} (beef)
Sb-124	8.67E+04	1.33E-07	N/A	1.50E-03	1.50E-03	N/A
Sb-125	1.46E+06	7.91E-09	N/A	1.50E-03	1.50E-03	N/A
Te-125m	8.35E+04	1.38E-07	1.30E+00	1.00E-03	1.00E-03	7.70E-02
Te-127m	1.57E+05	7.36E-08	1.30E+00	1.00E-03	1.00E-03	7.70E-02
Te-127	5.61E+02	2.06E-05	1.30E+00	1.00E-03	1.00E-03	7.70E-02
Te-129m	4.84E+04	2.39E-07	1.30E+00	1.00E-03	1.00E-03	7.70E-02
Te-129	6.96E+01	1.66E-04	1.30E+00	1.00E-03	1.00E-03	7.70E-02
Te-131m	1.80E+03	6.42E-06	1.30E+00	1.00E-03	1.00E-03	7.70E-02
Te-131	2.50E+01	4.62E-04	1.30E+00	1.00E-03	1.00E-03	7.70E-02
Te-132	4.69E+03	2.46E-06	1.30E+00	1.00E-03	1.00E-03	7.70E-02
I-130	7.42E+02	1.56E-05	2.00E-02	1.20E-02	4.30E-01	2.90E-03
I-131	1.16E+04	9.96E-07	2.00E-02	1.20E-02	4.30E-01	2.90E-03
I-132	1.38E+02	8.37E-05	2.00E-02	1.20E-02	4.30E-01	2.90E-03
I-133	1.25E+03	9.24E-06	2.00E-02	1.20E-02	4.30E-01	2.90E-03
I-134	5.26E+01	2.20E-04	2.00E-02	1.20E-02	4.30E-01	2.90E-03
I-135	3.97E+02	2.91E-05	2.00E-02	1.20E-02	4.30E-01	2.90E-03
Cs-134	1.08E+06	1.06E-08	1.00E-02	8.00E-03	3.00E-01	1.50E-02
Cs-136	1.90E+04	6.08E-07	1.00E-02	8.00E-03	3.00E-01	1.50E-02
Cs-137	1.59E+07	7.26E-10	1.00E-02	8.00E-03	3.00E-01	1.50E-02
Cs-138	3.22E+01	3.59E-04	1.00E-02	8.00E-03	3.00E-01	1.50E-02
Ba-139	8.31E+01	1.39E-04	5.00E-03	4.00E-04	4.00E-04	3.20E-03
Ba-140	1.84E+04	6.28E-07	5.00E-03	4.00E-04	4.00E-04	3.20E-03
Ba-141	1.83E+01	6.31E-04	5.00E-03	4.00E-04	4.00E-04	3.20E-03
Ba-142	1.07E+01	1.08E-03	5.00E-03	4.00E-04	4.00E-04	3.20E-03
La-140	2.41E+03	4.79E-06	2.50E-03	5.00E-06	5.00E-06	2.00E-04
La-142	9.54E+01	1.21E-04	2.50E-03	5.00E-06	5.00E-06	2.00E-04
Ce-141	4.68E+04	2.47E-07	2.50E-03	1.00E-04	1.00E-04	1.20E-03
Ce-143	1.98E+03	5.83E-06	2.50E-03	1.00E-04	1.00E-04	1.20E-03
Ce-144	4.09E+05	2.82E-08	2.50E-03	1.00E-04	1.00E-04	1.20E-03
Pr-143	1.95E+04	5.92E-07	2.50E-03	5.00E-06	5.00E-06	4.70E-03
Pr-144	1.73E+01	6.68E-04	2.50E-03	5.00E-06	5.00E-06	4.70E-03
Nd-147	1.58E+04	7.31E-07	2.40E-03	5.00E-06	5.00E-06	3.30E-03
W-187	1.43E+03	8.08E-06	1.80E-02	5.00E-04	5.00E-04	1.30E-03
Np-239	3.39E+03	3.41E-06	2.50E-03	5.00E-06	5.00E-06	2.00E-04
Ar-41	1.10E+02	1.05E-04	N/A	N/A	N/A	N/A
Kr-83m	1.10E+02	1.05E-04	N/A	N/A	N/A	N/A
Kr-85m	2.69E+02	4.29E-05	N/A	N/A	N/A	N/A
Kr-85	5.64E+06	2.05E-09	N/A	N/A	N/A	N/A
Kr-87	7.63E+01	1.51E-04	N/A	N/A	N/A	N/A
Kr-88	1.70E+02	6.79E-05	N/A	N/A	N/A	N/A
Kr-89	3.16E+00	3.66E-03	N/A	N/A	N/A	N/A
Kr-90	5.39E-01	2.14E-02	N/A	N/A	N/A	N/A
Xe-131m	1.70E+04	6.79E-07	N/A	N/A	N/A	N/A
Xe-133m	3.15E+03	3.67E-06	N/A	N/A	N/A	N/A

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

Table 6.2 (3 of 3)
RADIONUCLIDE DECAY AND STABLE ELEMENT TRANSFER DATA

	Half-Life (minutes)	λ (1/s)	B_{iv}	F_{mi} (cow)	F_{mi} (goat)	F_{fi} (beef)
Xe-133	7.55E+03	1.53E-06	N/A	N/A	N/A	N/A
Xe-135m	1.54E+01	7.50E-04	N/A	N/A	N/A	N/A
Xe-135	5.47E+02	2.11E-05	N/A	N/A	N/A	N/A
Xe-137	3.83E+00	3.02E-03	N/A	N/A	N/A	N/A
Xe-138	1.41E+01	8.19E-04	N/A	N/A	N/A	N/A

References:

Half lives for all nuclides: DOE-TIC-11026, "Radioactive Decay Data Tables - A handbook of Decay Data for Application to Radiation Dosimetry and Radiological Assessment," D. C. Kocher, 1981.

Transfer factors for Sb- isotopes are from ORNL 4992, "Methodology for Calculating Radiation Doses from Radioactivity Released to the Environment," March 1976, Table 2-7.

Cow-milk transfer factors for Iodine, Strontium, and Cesium nuclides are from NUREG/CR-1004, Table 3.17.

Goat-milk transfer factors for Iodine nuclides are from NUREG/CR-1004, Table 3.17.

Beef transfer factors for Iron, Copper, Molybdenum, and Cesium nuclides are from NUREG/CR-1004, Table 3.18.

All other nuclides' transfer factors are from Regulatory Guide 1.109, Tables E-1 and E-2.

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

Table 6.3 (1 of 2)
DOSE CALCULATION FACTORS

Factor	Value	Units	Reference
BR_a (infant)	1400	m^3/year	ICRP 23
BR_a (child)	5500	m^3/year	ICRP 23
BR_a (teen)	8000	m^3/year	ICRP 23
BR_a (adult)	8100	m^3/year	ICRP 23
f_g	1		TVA Assumption
f_L	1		R. G. 1.109 (Table E-15)
f_p	1		TVA Assumption
f_s	0		TVA Assumption
H	9	g/m^3	TVA Value
K_c	0.072	L/kg-hr	R. G. 1.109 (Section 2.C.)
M	40	kg/m^2	R. G. 1.109 (Section 2.C.)
P	240	kg/m^2	R. G. 1.109 (Table E-15)
Q_f (cow)	64	kg/day	NUREG/CR-1004 (Sect. 3.4)
Q_f (goat)	08	kg/day	NUREG/CR-1004 (Sect. 3.4)
r	0.47		NUREG/CR-1004 (Sect. 3.2)
t_b	4.73E+08 (15 years)	seconds	R. G. 1.109 (Table E-15)
t_{cb}	7.78E+06 (90 days)	seconds	WBN FSAR Section 11.3.9.1
t_{csf}	1.56E+07 (180 days)	seconds	WBN FSAR Section 11.3.9.1
t_e	5.18E+06 (60 days)	seconds	R. G. 1.109 (Table E-15)
t_{ep}	2.59E+06 (30 days)	seconds	R. G. 1.109 (Table E-15)
t_{esf}	7.78E+06 (90 days)	seconds	R. G. 1.109 (Table E-15)
t_{fm}	8.64E+04 (1 day)	seconds	WBN FSAR Section 11.3.9.1
t_{hc}	8.64E+04 (1 day)	seconds	NUREG/CR-1004, Table 3.40
t_s	1.12E+06 (13 days)	seconds	NUREG/CR-1004, Table 3.40
t_{sv}	2.38E+07 (275 days)	seconds	WBN FSAR Section 11.3.9.1
U_{am} (infant)	0	kg/year	R. G. 1.109 (Table E-5)
U_{am} (child)	41	kg/year	R. G. 1.109 (Table E-5)
U_{am} (teen)	65	kg/year	R. G. 1.109 (Table E-5)
U_{am} (adult)	110	kg/year	R. G. 1.109 (Table E-5)
U_{ap} (infant)	330	L/year	R. G. 1.109 (Table E-5)
U_{ap} (child)	330	L/year	R. G. 1.109 (Table E-5)
U_{ap} (teen)	400	L/year	R. G. 1.109 (Table E-5)
U_{ap} (adult)	310	L/year	R. G. 1.109 (Table E-5)

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

Table 6.3 (2 of 2)
DOSE CALCULATION FACTORS

Factor	Value	Units	Reference
U_{fa}(infant)	0	kg/year	R. G. 1.109 (Table E-5)
U_{fa}(child)	6.9	kg/year	R. G. 1.109 (Table E-5)
U_{fa}(teen)	16	kg/year	R. G. 1.109 (Table E-5)
U_{fa}(adult)	21	kg/year	R. G. 1.109 (Table E-5)
U_{FLa} (infant)	0	kg/year	R. G. 1.109 (Table E-5)
U_{FLa} (child)	26	kg/year	R. G. 1.109 (Table E-5)
U_{FLa} (teen)	42	kg/year	R. G. 1.109 (Table E-5)
U_{FLa} (adult)	64	kg/year	R. G. 1.109 (Table E-5)
U_{Sa} (infant)	0	kg/year	R. G. 1.109 (Table E-5)
U_{Sa} (child)	520	kg/year	R. G. 1.109 (Table E-5)
U_{Sa} (teen)	630	kg/year	R. G. 1.109 (Table E-5)
U_{Sa} (adult)	520	kg/year	R. G. 1.109 (Table E-5)
U_{wa}(infant)	330	L/year	R. G. 1.109 (Table E-5)
U_{wa}(child)	510	L/year	R. G. 1.109 (Table E-5)
U_{wa}(teen)	510	L/year	R. G. 1.109 (Table E-5)
U_{wa}(adult)	730	L/year	R. G. 1.109 (Table E-5)
W	0.2	none	R. G. 1.109 (Table A-2)
Y_f	1.85	kg/m^2	NUREG/CR-1004 (Table 3.4)
Y_p	1.18	kg/m^2	NUREG/CR-1004 (Table 3.3)
Y_{sf}	0.64	kg/m^2	NUREG/CR-1004 (Table 3.3)
Y_{sv}	0.57	kg/m^2	NUREG/CR-1004 (Table 3.4) (value selected is for non-leafy vegetables)
λ_w (iodines)	7.71E-07 (15.4 d half-life)	sec^{-1}	NUREG/CR-1004 (Table 3.10)
λ_w (particulates)	5.21E-07 (10.4 d half-life)	sec^{-1}	NUREG/CR-1004 (Table 3.10)

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

Table 6.4 (1 of 8)
INGESTION DOSE FACTORS
(mrem/pCi ingested)

ADULT

	bone	liver	t body	thyroid	kidney	lung	gi-lli
H-3	1.05E-07	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	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-69	1.03E-08	1.97E-08	1.37E-09	0.00E+00	1.28E-08	0.00E+00	2.96E-09
Zn-69m	1.70E-07	4.08E-07	3.73E-08	0.00E+00	2.47E-07	0.00E+00	2.49E-05
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	7.58E-03	0.00E+00	1.86E-03	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
Nb-97	5.22E-11	1.32E-11	4.82E-12	0.00E+00	1.54E-11	0.00E+00	4.87E-08
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
Ag-110m	1.60E-07	1.48E-07	8.79E-08	0.00E+00	2.91E-07	0.00E+00	6.04E-05
Sb-124	2.80E-06	5.29E-08	1.11E-06	6.79E-09	0.00E-00	2.18E-06	7.95E-05

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

Table 6.4 (2 of 8)
INGESTION DOSE FACTORS
(mrem/pCi ingested)

ADULT

	bone	liver	t body	thyroid	kidney	lung	gi-lli
Sb-125	1.79E-06	2.00E-08	4.26E-07	1.82E-09	0.00E-00	1.38E-06	1.97E-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-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-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
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

References:

Regulatory Guide 1.109, Table E-11.

Dose Factors for Co-57, Zn-69m, Br-82, Nb-97, Sb-124 and Sb-125 are from NUREG-0172 Age Specific Radiation Dose Commitment Factors for a One Year Chronic Intake., November, 1977, Table 4.

NOTE: The tritium dose factor for bone is assumed to be equal to the total body dose factor.

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

Table 6.4 (3 of 8)
INGESTION DOSE FACTORS
(mrem/pCi ingested)

TEEN

	bone	liver	t body	thyroid	kidney	lung	gi-lli
H-3	1.06E-07	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	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-69	1.47E-08	2.80E-08	1.96E-09	0.00E+00	1.83E-08	0.00E+00	5.16E-08
Zn-69m	2.40E-07	5.66E-07	5.19E-08	0.00E+00	3.44E-07	0.00E+00	3.11E-05
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	8.30E-03	0.00E+00	2.05E-03	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
Nb-97	7.37E-11	1.83E-11	6.68E-12	0.00E+00	2.14E-11	0.00E+00	4.37E-07
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
Ag-110m	2.05E-07	1.94E-07	1.18E-07	0.00E+00	3.70E-07	0.00E+00	5.45E-05
Sb-124	3.87E-06	7.13E-08	1.51E-06	8.78E-09	0.00E-00	3.38E-06	7.80E-05

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

Table 6.4 (4 of 8)
INGESTION DOSE FACTORS
(mrem/pCi ingested)

TEEN

	bone	liver	t body	thyroid	kidney	lung	gi-lli
Sb-125	2.48E-06	2.71E-08	5.80E-07	2.37E-09	0.00E+00	2.18E-06	1.93E-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-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-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
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

References:

- Regulatory Guide 1.109, Table E-12.

  Dose Factors for Co-57, Zn-69m, Br-82, Nb-97, Sb-124 and Sb-125 are from NUREG-0172 Age Specific Radiation Dose Commitment Factors for a One Year Chronic Intake., November, 1977, Table 4.

NOTE: The tritium dose factor for bone is assumed to be equal to the total body dose factor.

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

Table 6.4 (5 of 8)
INGESTION DOSE FACTORS
(mrem/pCi ingested)

CHILD

	bone	liver	t body	thyroid	kidney	lung	gi-lli
H-3	2.03E-07	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	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-69	4.38E-08	6.33E-08	5.85E-09	0.00E+00	3.84E-08	0.00E+00	3.99E-06
Zn-69m	7.10E-07	1.21E-06	1.43E-07	0.00E+00	7.03E-07	0.00E+00	3.94E-05
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	1.70E-02	0.00E+00	4.31E-03	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
Nb-97	2.17E-10	3.92E-11	1.83E-11	0.00E+00	4.35E-11	0.00E+00	1.21E-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
Ag-110m	5.39E-07	3.64E-07	2.91E-07	0.00E+00	6.78E-07	0.00E+00	4.33E-05
Sb-124	1.11E-05	1.44E-07	3.89E-06	2.45E-08	0.00E+00	6.16E-06	6.94E-05

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

Table 6.4 (6 of 8)
INGESTION DOSE FACTORS
(mrem/pCi ingested)

CHILD

	bone	liver	t body	thyroid	kidney	lung	gi-lli
Sb-125	7.16E-06	5.52E-08	1.50E-06	6.63E-09	0.00E+00	3.99E-06	1.71E-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-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-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
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

References:
Regulatory Guide 1.109, Table E-13.

Dose Factors for Co-57, Zn-69m, Br-82, Nb-97, Sb-124 and Sb-125 are from NUREG-0172 Age Specific Radiation Dose Commitment Factors for a One Year Chronic Intake,, November, 1977, Table 4.

NOTE: The tritium dose factor for bone is assumed to be equal to the total body dose factor.

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

Table 6.4 (7 of 8)
INGESTION DOSE FACTORS
(mrem/pCi ingested)

INFANT

	bone	liver	t body	thyroid	kidney	lung	gi-lli
H-3	3.08E-07	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	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-69	9.33E-08	1.68E-07	1.25E-08	0.00E+00	6.98E-08	0.00E+00	1.37E-05
Zn-69m	1.50E-06	3.06E-06	2.79E-07	0.00E+00	1.24E-06	0.00E+00	4.24E-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	1.85E-02	0.00E+00	4.71E-03	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
Nb-97	4.59E-10	9.79E-11	3.53E-11	0.00E+00	7.65E-11	0.00E+00	3.09E-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
Ag-110m	9.96E-07	7.27E-07	4.81E-07	0.00E+00	1.04E-06	0.00E+00	3.77E-05
Sb-124	2.14E-05	3.15E-07	6.63E-06	5.68E-08	0.00E+00	1.34E-05	6.60E-05

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

Table 6.5
BIOACCUMULATION FACTORS FOR FRESHWATER FISH

H-3	9.0E-01	Tc-99m	1.5E+01
C-14	4.6E+03	Tc-101	1.5E+01
Na-24	1.0E+02	Ru-103	1.0E+01
P-32	1.0E+05	Ru-105	1.0E+01
Cr-51	2.0E+02	Ru-106	1.0E+01
Mn-54	4.0E+02	Ag-110m	0.0E+00
Mn-56	4.0E+02	Sb-124	1.0E+00
Fe-55	1.0E+02	Sb-125	1.0E+00
Fe-59	1.0E+02	Te-125m	4.0E+02
Co-57	5.0E+01	Te-127m	4.0E+02
Co-58	5.0E+01	Te-127	4.0E+02
Co-60	5.0E+01	Te-129m	4.0E+02
Ni-63	1.0E+02	Te-129	4.0E+02
Ni-65	1.0E+02	Te-131m	4.0E+02
Cu-64	5.0E+01	Te-131	4.0E+02
Zn-65	2.0E+03	Te-132	4.0E+02
Zn-69	2.0E+03	I-130	4.0E+01
Zn-69m	2.0E+03	I-131	4.0E+01
Br-82	4.2E+02	I-132	4.0E+01
Br-83	4.2E+02	I-133	4.0E+01
Br-84	4.2E+02	I-134	4.0E+01
Br-85	4.2E+02	I-135	4.0E+01
Rb-86	2.0E+03	Cs-134	1.9E+03
Rb-88	2.0E+03	Cs-136	1.9E+03
Rb-89	2.0E+03	Cs-137	1.9E+03
Sr-89	5.6E+01	Cs-138	1.9E+03
Sr-90	5.6E+01	Ba-139	4.0E+00
Sr-91	5.6E+01	Ba-140	4.0E+00
Sr-92	5.6E+01	Ba-141	4.0E+00
Y-90	2.5E+01	Ba-142	4.0E+00
Y-91m	2.5E+01	La-140	2.5E+01
Y-91	2.5E+01	La-142	2.5E+01
Y-92	2.5E+01	Ce-141	1.0E+00
Y-93	2.5E+01	Ce-143	1.0E+00
Zr-95	3.3E+00	Ce-144	1.0E+00
Zr-97	3.3E+00	Pr-143	2.5E+01
Nb-95	3.0E+04	Pr-144	2.5E+01
Nb-97	3.0E+04	Nd-147	2.5E+01
Mo-99	1.0E+01	W-187	1.2E+03
		Np-239	1.0E+01

References:
Bioaccumulation factors for Sb- nuclides are from ORNL-4992, "A Methodology for Calculating Radiation Doses from Radioactivity Released to the Environment, March 1976, Table 4.12A.

Bioaccumulation factors for Iodine, Cesium, and Strontium nuclides are from NUREG/CR-1004, Table 3.2.4.

All other nuclides' bioaccumulation factors are from Regulatory Guide 1.109, Table A-1.

Table 6.6 (2 of 2)
EXTERNAL DOSE FACTORS FOR STANDING ON CONTAMINATED GROUND
(mrem/h per pCi/m^2)

Nuclide	Total Body	Skin
Sb-125	5.48E-09	6.80E-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
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	0.0	0.0
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

References:

Regulatory Guide 1.109, Table E-6.

Dose Factors for Co-57, Zn-69m, Br-82, Nb-97, Sb-124 and Sb-125 are from Dose-Rate Conversion Factors for External Exposure to Photon and Electron Radiation from Radionuclides Occurring in Routine Releases from Nuclear Fuel Cycle Facilities, D. C. Kocher, Health Physics Volume 38, April 1980.

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

Figure 6.1
LIQUID EFFLUENT RELEASE POINTS

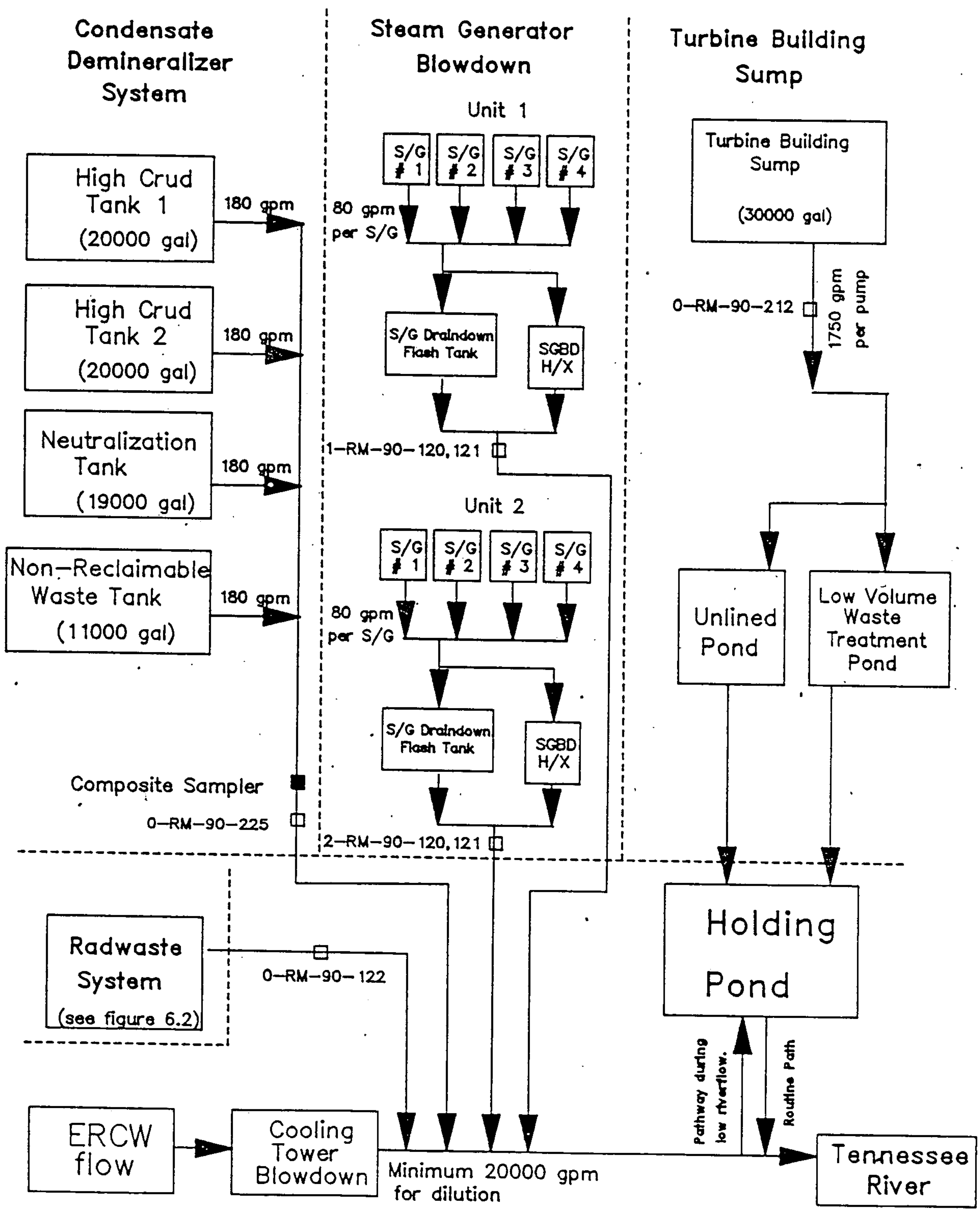
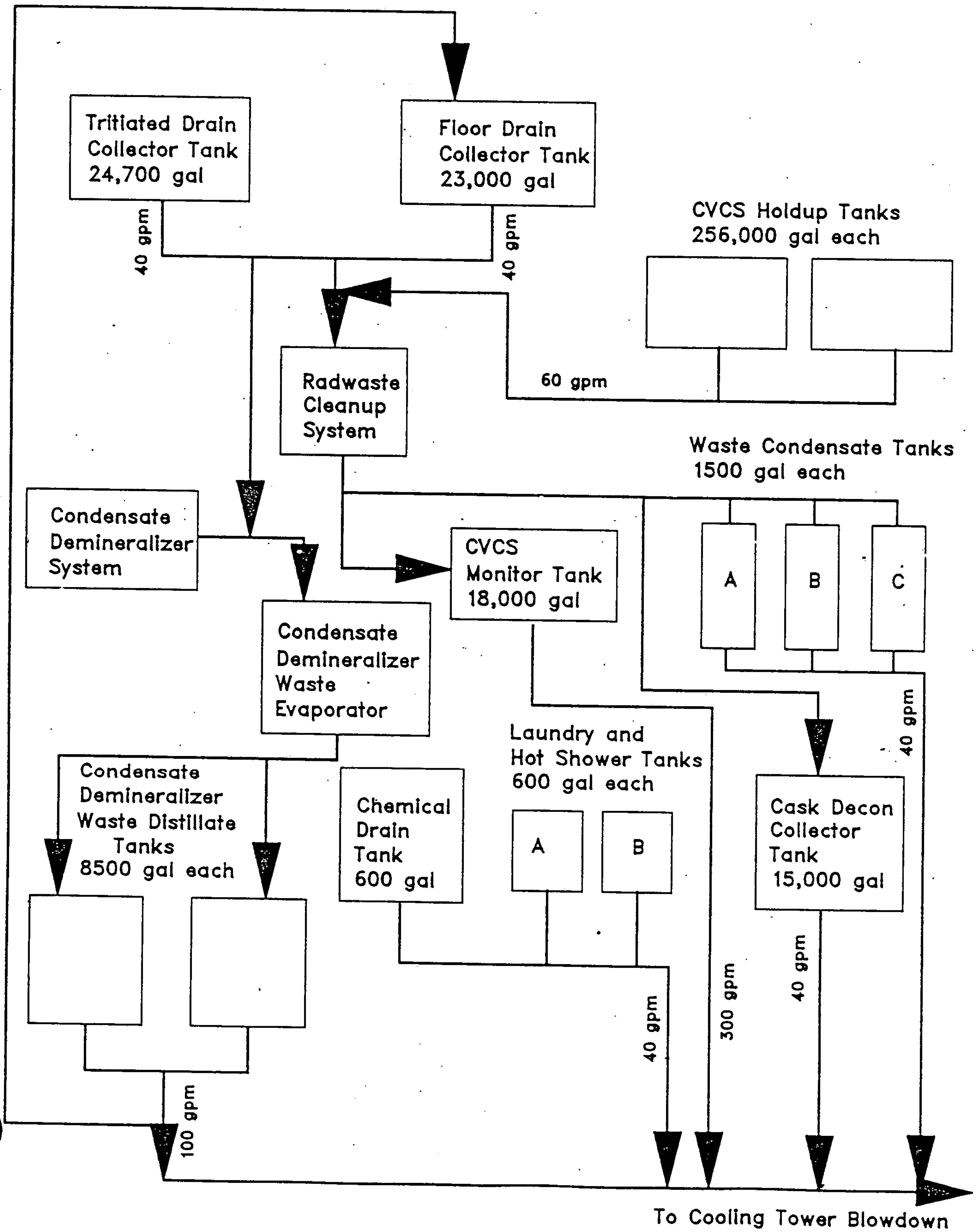


Figure 6.2
LIQUID RADWASTE SYSTEM



SECTION 7.0

GASEOUS EFFLUENTS

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

RELEASE/DISCHARGE POINTS DESCRIPTION

There are six discharge points at Watts Bar Nuclear Plant that are monitored for airborne radioactive effluents. These are: a Condenser Vacuum Exhaust for each unit, a Service Building Vent, an Auxiliary Building Vent and a Shield Building Vent for each unit. Each of these discharge points may have one or more release points associated with it as described below. Figure 7.1 provides an outline of the airborne effluent release and discharge points with associated radiation monitor identifications.

Condenser Vacuum Exhaust

The Condenser Vacuum Pump Exhausts (CVEs) are located in the turbine building. They exhaust at a maximum design flow rate of 45 cubic feet per minute per pump. These discharge points are monitored by radiation monitors 1,2-RE-90-119 and 1,2-RE-90-404 for normal operation.

Service Building Vent

Areas in the Service Building in which work is conducted which may produce radioactive effluents all exhaust to the Service Building Vent. This discharge point exhausts at a maximum design flow rate of approximately 14,950 cfm and is monitored by radiation monitor 0-RE-90-132.

Auxiliary Building Exhaust

The annulus vacuum priming fans (2 fans at 1000 cfm each) exhaust to the auxiliary building atmosphere. The Auxiliary Building exhausts at a maximum total design flow of 288,000 cfm (2 of 4 ventilation fans at 84,000 cfm each, and 2 fuel handling fans at 60,000 cfm each). This discharge point exhaust is monitored by radiation monitor 0-RE-90-101.

Shield Building Vent

There are nine Waste Gas Decay Tanks (WGDTs) that discharge into the waste gas header which is released into the shield building vent. Either the Auxiliary Building Gas Treatment System (ABGTS) or the Containment Purge System is normally operated during a WGDT release. Each WGDT has a design capacity of 600 cubic feet and a design release rate of 22.5 cfm. The WGDT release point is monitored by radiation monitor 0-RE-90-118.

The Auxiliary Building Gas Treatment System (ABGTS) draws from the Auxiliary Building Secondary Containment Enclosure and exhausts to the Shield Building Vent. An Auxiliary Building Isolation signal starts the ABGTS.Under emergency conditions, and sometimes during normal operation, the Emergency Gas Treatment System is used to draw a vacuum in the annulus and exhaust to the Shield Building Vent.

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

Both the Containment Purge and the Incore Instrument Room Purge from each unit tie into the Shield Building Vent. The Containment Purge release point exhausts at a maximum of 28,000 cfm and is monitored by radiation monitors 1,2-RE-90-130 and 1,2-RE-90-131. If the Incore Instrument Room Purge is operating exclusively, it exhausts at 800 cfm. The common header exhausts to the Shield Building Vent.

There is one Shield Building Vent for each unit. These discharge points are monitored by radiation monitors 1,2-RE-90-400.

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

7.1 GASEOUS EFFLUENT MONITOR INSTRUMENT SETPOINTS

7.1.1 Discharge Point Monitor Setpoints

Setpoints for discharge points (Shield Building Vents, Condenser Vacuum Exhausts, Service Building Vent, and the Auxiliary Building Vent) are set to ensure that the dose rate limits defined in ODCM Control 1.2.2.1, are met for the site discharges or to identify any unexpected discharges of radioactivity.

7.1.1.1 Normal Default Setpoint

A normal default or initial setpoint is determined for each discharge point monitor. The default setpoints should be set to ensure that the limits given in ODCM Control 1.2.2.1 are not violated. The discharge point default setpoints should be set high enough such that, in most cases, the value will not need to be changed for each release. These setpoints would normally be one of two types: for discharge points which are expected to release most of the radioactive effluents, it would be the calculated maximum setpoint (or a fraction of this) as defined below using a design basis mix or a historical mix of nuclides; for other discharge points not normally releasing radioactivity, the setpoint would be set to ensure that any abnormal release of radioactivity will be identified (e.g., at 2 times background). The default setpoints for each discharge point monitor are defined and documented in approved plant procedures.

7.1.1.2 Expected Monitor Response

For each release to be made through a discharge point, an expected monitor response will be calculated. This will be the monitor reading expected for the monitor under the predicted release conditions. The expected monitor response, R in cpm, is calculated using the following equation:

$$R = B + \sum_i eff_i \, C_i \qquad (7.1)$$

where

B = monitor background, cpm.
eff_i = efficiency factor for the monitor for nuclide i, cpm per µCi/cc.
C_i = concentration of nuclide i at the discharge point, µCi/cc.
= C_{ri} ($flow_{rp}/flow_{dp}$)
where
C_{ri} = concentration of nuclide i in the release point stream
$flow_{rp}$ = flow rate for the release point
$flow_{dp}$ = flow rate for the discharge point

The expected monitor response for any one release is added to the responses predicted for any other ongoing releases through the discharge point to obtain the total monitor response.

7.1.1.3 Calculated Maximum Setpoint

For each release to be made through a particular discharge point, a calculated maximum setpoint is determined for the appropriate monitor. This value corresponds to the dose rate limit for the release for the measured radionuclide concentrations. This maximum setpoint is calculated as follows:

1. The ratio, r, of the dose rate limit to the calculated dose rate for the release is obtained using the following equation:

$$r = \frac{DR_{lim}}{DR} \qquad (7.2)$$

where

DR_{lim} = the dose rate limit, mrem/year.
= 500 mrem/year to the total body for noble gases,
= 3000 mrem/year to the skin for noble gases, and
= 1500 mrem/year to the maximum organ for iodines and particulates.

DR = the calculated dose rate for the release plus any calculated dose rates for ongoing releases from the discharge point, mrem/year.
= DR_{TB} for total body (as described in Section 7.2.1.1),
= DR_S for skin (as described in Section 7.2.1.2), and
= DR_{org} for maximum organ (as described in Section 7.2.2).

2. The calculated maximum monitor response, R_{lim} in cpm, corresponding to the dose rate limit is determined using the following equation:

$$R_{lim} = (r(R - B)) + B \qquad (7.3)$$

where

r = ratio of dose rate limit to calculated dose rate for the release, as calculated above. For noble gases, the smaller of the two ratios for total body or skin is used.
R = expected monitor response (as calculated in Section 7.1.1.2), cpm.
B = monitor background, cpm.

3. The calculated maximum setpoint, S_{max} in cpm, corresponding to the dose rate limit is calculated using the following equation:

$$S_{max} = ((A*SF)(R_{lim} - B)) + B \qquad (7.4)$$

where

A = dose rate allocation factor for the discharge point, dimensionless. The dose rate allocation factors for discharge points are:

Unit 1 Shield Building Vent	0.30
Unit 2 Shield Building Vent	0.30
Unit 1 Condenser Vacuum Exhaust	0.10
Unit 2 Condenser Vacuum Exhaust	0.10
Service Building Exhaust	0.10
Auxiliary Building Exhaust	0.10

SF = Dimensionless safety factor for the monitor's maximum setpoint. The safety factors used to calculate radiation monitor maximum setpoints are established in approved plant procedures to ensure that setpoints are established conservative with respect to established release limits. The degree of conservatism with release limits shall take into account uncertainties associated with radiation monitor equipment and the calculation of expected response.

R_{lim} = the calculated monitor response, as calculated above, cpm.

B = the monitor background, cpm.

7.1.1.4 Actual Discharge Point Monitor Setpoints

For each release made, the above parameters will be calculated for the discharge point and the following comparisons will be made:

1. If the calculated maximum setpoint is less than the normal default, then the setpoint shall be set equal to the calculated maximum setpoint.

2. If the calculated maximum setpoint is greater than the normal default, and 2 times the expected monitor response is less than the normal default setpoint, then the setpoint shall be set equal to the normal default setpoint.

3. If the calculated maximum setpoint is greater than the normal default, and 2 times the expected monitor response is greater than the normal default setpoint, then the setpoint shall be set equal to 2 times the expected response or at the calculated maximum setpoint, whichever is lower.

The factor of 2 in the above comparisons is a factor designed to account for expected variations in the monitor reading. Under most routine release circumstances, choice 2 above will determine the setpoints for the monitors.

7.1.2 Release Point Monitor Setpoints

Setpoints for release point monitors (Waste Gas Decay Tanks and Containment Purges) are determined in order to ensure that the releases being made from these points do not exceed the expected response of the monitor for the measured release. In order to calculate these setpoints, an expected monitor response will be calculated as described below.

Expected Monitor Response

For each release to be made through a release point, an expected monitor response will be calculated. This will be the monitor reading expected for the release under the predicted release conditions. The expected monitor response, R in cpm, is calculated using the following equation:

$$R = B + \sum_i eff_i \, C_i \qquad (7.5)$$

where

B = monitor background, cpm.
eff_i = efficiency factor for the monitor for nuclide i, cpm per µCi/cc.
C_i = measured concentration of nuclide i, µCi/cc.

It is desired that the setpoint be set equal to 2 times the expected response where 2 is an administrative factor designed to account for uncertainties associated with radiation monitoring equipment and the calculation of expected response. However, the setpoint shall be set conservative with respect to established safety limits for the release point. The degree of conservatism with release limits shall take into account uncertainties associated with radiation monitor equipment and the calculation of expected response.

7.2 GASEOUS EFFLUENTS - DOSE RATES

7.2.1 Noble Gas Dose Rates

Dose rates are calculated for total body and skin due to submersion within a cloud of noble gases using a semi-infinite cloud model.

7.2.1.1 Total Body Dose Rate

The dose rate to the total body, DR_{TB} in mrem/year, is calculated using the following equation:

$$DR_{TB} = W_A \; F \sum_i C_i \; DFB_i \qquad (7.6)$$

where

W_A = dispersion factor, s/m^3. For dose rate calculations, the highest value from the sixteen SITE BOUNDARY locations is used.
= (X/Q) TAF.
= 1.03E-05 s/m^3

X/Q = relative concentration, s/m^3 (from Table 7.1). Relative air concentrations are calculated for the SITE BOUNDARY in each of the sixteen sectors as described in Section 7.8.2 using the historical meteorological data for the period 1974-1988 given in Table 7.2.

TAF = site specific terrain adjustment factor (from Table 7.3). Calculated as described in Section 7.8.4.

F = flowrate of effluent stream, cc/s.

C_i = concentration of noble gas nuclide i in effluent stream, μCi/cc.

DFB_i = total body dose factor due to gamma radiation for noble gas nuclide i, mrem/y per μCi/m^3 (Table 7.4).

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7.2.1.2 Skin Dose Rate

The dose rate to the skin, DR_S in mrem/year, is calculated using the following equation:

$$DR_S = W_A \, F \sum_i C_i (DFS_i + 1.11 \, DF_{\gamma i}) \tag{7.7}$$

where

W_A	= dispersion factor, s/m^3. For dose rate calculations, the highest value from the sixteen SITE BOUNDARY locations is used.
	= (X/Q) TAF.
	= 1.03E-05 s/m^3.
X/Q	= relative concentration, s/m^3 (from Table 7.1). Relative air concentrations are calculated for the SITE BOUNDARY in each of the sixteen sectors as described in Section 7.8.2 using the historical meteorological data for the period 1974-1988 given in Table 7.2.
TAF	= site specific terrain adjustment factor (from Table 7.3). Calculated as described in Section 7.8.4.
F	= flowrate of effluent stream, cc/s.
C_i	= concentration of noble gas nuclide i in effluent stream, μCi/cc.
DFS_i	= skin dose factor due to beta radiation for noble gas nuclide i, mrem/y per $\mu Ci/m^3$ (Table 7.4).
1.11	= the average ratio of tissue to air energy absorption coefficients, mrem/mrad.
$DF_{\gamma i}$	= dose conversion factor for external gamma for noble gas nuclide i, mrad/year per $\mu Ci/m^3$ (Table 7.4).

7.2.2 I-131, I-133, Tritium and all Radionuclides in Particulate Form with Half-lives of Greater than 8 Days - Organ Dose Rate

Organ dose rates due to I-131, I-133, Tritium and all radionuclides in particulate form with half-lives of greater than 8 days, DR_{org} in mrem/year, are calculated for all age groups (adult, teen, child, and infant) and all organs (bone, liver, total body, thyroid, kidney, lung, and GI Tract) using the following equation:

$$DR_{org} = F[C_T(W_A)[R_{IT}+R_{CTP}]+\sum_i C_i[(W_A)R_{Ii}+(W_G)[R_{CPi}+R_{Gi}]]] \qquad (7.8)$$

where:

F = flowrate of effluent stream, cc/s.

C_T = concentration of tritium in effluent stream, µCi/cc.

W_A = dispersion factor for air concentrations, s/m^3. For dose rate calculations, the highest value from the sixteen SITE BOUNDARY locations is used.
= (X/Q) TAF.
= 1.03E-05 s/m^3

X/Q = relative concentration, s/m^3 (from Table 7.1). Relative air concentrations are calculated for the SITE BOUNDARY in each of the sixteen sectors as described in Section 7.8.2 using the historical meteorological data for the period 1974-1988 given in Table 7.2.

TAF = site specific terrain adjustment factor (from Table 7.3). Calculated as described in Section 7.8.4.

R_{IT} = inhalation dose factor for tritium, mrem/year per $\mu Ci/m^3$. Dose factor is calculated as described in Section 7.7.13.

R_{CTP} = Grass-cow-milk dose factor for tritium, mrem/year per $\mu Ci/m^3$. Dose factor is calculated as described in Section 7.7.7.

C_i = concentration of nuclide i in effluent stream, µCi/cc.

R_{Ii} = inhalation dose factor for each identified nuclide i, mrem/year per $\mu Ci/m^3$. Dose factors are calculated as described in Section 7.7.13.

W_G = dispersion factor for ground concentrations, $1/m^2$. For dose rate calculations, the highest value from the sixteen SITE BOUNDARY locations is used.
= (D/Q) TAF.
= 1.21E-08, $1/m^2$.

D/Q = relative deposition, $1/m^2$ (from Table 7.3). Relative deposition is calculated for the SITE BOUNDARY in each of the sixteen sectors as described in Section 7.8.3 using the historical meteorological data for the period 1974-1988 given in Table 7.2.

TAF = site specific terrain adjustment factor (from Table 7.3). Calculated as described in Section 7.8.4.

R_{CPi} = Grass-cow-milk dose factor for each identified nuclide i, m^2-mrem/year per µCi/s. Dose factors are calculated as described in Section 7.7.1.

R_{Gi} = ground plane dose factor for each identified nuclide i, m^2-mrem/year per µCi/s. Dose factors are calculated as described in Section 7.7.14.

The maximum organ dose rate is selected from among the dose rates calculated for all the organs and all age groups.

7.2.3 DOSE TO A MEMBER OF THE PUBLIC INSIDE THE CONTROLLED AREA

The Bases for ODCM Control 1.2.2.1 states that for MEMBERS OF THE PUBLIC who may at times be within the CONTROLLED AREA, the occupancy of that MEMBER OF THE PUBLIC will usually be sufficiently low to compensate for any increase in the atmospheric dispersion factor above that for the SITE BOUNDARY. Examples of calculations for such MEMBERS OF THE PUBLIC, with the appropriate occupancy factors, shall be given in the ODCM.

The probable most exposed MEMBER OF THE PUBLIC is expected to be an individual who is fishing from a boat just off the shore at the intake. This individual might spend an average of 10 hours a week, fifty weeks a year at this location, for a total of 500 hours. The closest point of the river to the plant is approximately 270 meters from the center of the plant in the SE sector. The X/Q for this sector and distance is calculated to be 1.22E-04 s/m^3 (using the methodology in Section 7.8.2). This can be compared to the SITE BOUNDARY X/Q in that sector of 1.03E-05 s/m^3. The ratio of these relative concentration values is about 12. The ratio of the occupancy times is 500/8760 or 0.06. For these times and dispersion values, the dose to the highest exposed member of the public within the owner controlled area will be about seventy percent of the dose to a member of the public continually present at the worst site boundary location.

7.3.2 Beta dose to air

The beta air dose, D_β in mrad, is calculated for each release using the following equation:

$$D_\beta = 1.9E\text{-}06\ W_A \sum_i Q_i\ DF_{\beta i}\ T \qquad (7.10)$$

where:

1.9E-06 = conversion factor, years per minute.
W_A = dispersion factor, s/m^3. For dose rate calculations, the highest value from the sixteen SITE BOUNDARY locations is used.
= ($^X/Q$) TAF.
= 1.03E-05 s/m^3.
X/Q = relative concentration, s/m^3 (from Table 7.1). Relative air concentrations are calculated for the SITE BOUNDARY in each of the sixteen sectors as described in Section 7.8.2 us ing the historical meteorological data for the period 1974-1 988 given in Table 7.2.
TAF = site specific terrain adjustment factor (from Table 7.3). Calculated as described in Section 7.8.4.
Q_i = release rate for nuclide i, µCi/s.
$DF_{\beta i}$ = dose conversion factor for external beta for nuclide i, mrad/year per µCi/m^3 (from Table 7.4).
T = duration of release, minutes.

The beta-air dose calculated by this method will be used in the cumulative dose calculations discussed in Section 7.3.3.

7.3.3 Cumulative Dose - Noble Gas

Quarterly and annual sums of all doses are calculated for each release as described below to compare to the limits given in ODCM Control 1.2.2.2.

For noble gases, cumulative doses are calculated for gamma and beta air doses. Doses due to each release are summed with the doses for all previous release in the quarter or year to obtain cumulative quarterly and annual doses.

7.3.4 Comparison to Limits

The cumulative calendar quarter and calendar year doses are compared to their respective limits at least once per 31 days to determine compliance.

7.4 DOSE DUE TO I-131, I-133, TRITIUM AND ALL RADIONUCLIDES IN PARTICULATE FORM WITH HALF-LIVES OF GREATER THAN 8 DAYS

7.4.1 Organ dose Calculation

Organ doses due to I-131, I-133, tritium and all radionuclides in particulate form with half-lives of greater than 8 days are calculated for each release for the critical receptor. The critical receptor is defined as a SITE BOUNDARY location with the highest annual average dispersion factors. The annual average X/Q and D/Q are calculated using the methodology in Sections 7.8.2 and 7.8.3 using the historical 1974-1988 meteorological data (Table 7.2). A conservative assumption is used to select the dispersion factors for the critical receptor. The highest calculated X/Q and D/Q values are chosen from Table 6.1 values which have been multiplied by the applicable terrain adjustment factors (from Table 7.3), and may not be for the same sector.

Pathways considered to exist at this location are inhalation, ground plane exposure, grass-cow-milk ingestion, grass-cow-beef ingestion and fresh leafy and stored vegetable ingestion. All age groups are considered (adult, teen, child and infant). Dose factors for these age groups and pathways are calculated as described in Section 7.7. For the ground exposure pathway, which has no age or organ specific dose factors, the total body dose will be added to the internal organ doses for all age groups.

No credit is taken for radioactive decay.

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The general equation for the calculation of organ dose is:

$$D_{org} = 3.17E\text{-}08\ T \sum_{i} \sum_{P} R_{Pi} \, [\, W_P \, Q_i \,] \qquad (7.11)$$

where:

3.17E-08 = conversion factor, year/second.

T = duration of release, seconds.

R_{Pi} = dose factor for pathway P for each identified nuclide i, m^2-mrem/year per µCi/s for ground plane, grass-cow-milk, grass-cow-meat, and vegetation pathways, and mrem/year per µCi/m^3 for inhalation and tritium ingestion pathways. Equations for calculating these dose factors are given in Section 7.7.

W_P = dispersion factor for the location and pathway. For dose calculations, the highest value from the sixteen SITE BOUNDARY locations is used.
= ($^X/Q$) TAF for the inhalation and tritium ingestion pathways,
= 1.03E-05 s/m^3.
= ($^D/Q$) TAF for the food and ground plane pathways,
= 1.21E-08 m^{-2}.

$^X/Q$ = relative concentration, s/m^3 (from Table 7.1). Relative air concentrations are calculated for the SITE BOUNDARY in each of the sixteen sectors as described in Section 7.8.2 using the historical meteorological data for the period 1974-1988 given in Table 7.2.

TAF = site specific terrain adjustment factor (from Table 7.3). Calculated as described in Section 7.8.4.

D/Q = relative deposition, 1/m^2 (from Table 7.1). Relative depositions are calculated for the SITE BOUNDARY in each of the sixteen sectors as described in Section 7.8.3 using the historical meteorological data for the period 1974-1988 given in Table 7.2.

Q_i = release rate for radionuclide i, µCi/s.

From the four age groups considered, the maximum is determined by comparing all organ doses for all age groups. The age group with the highest single organ dose is selected as the critical age group. The organ doses for the critical age group will be used in the cumulative doses discussed in Section 7.4.2.

7.4.2 Cumulative Doses

Quarterly and annual sums of all doses are calculated for each release as described below to compare to the limits given in ODCM Control 3.2.2.3.

For maximum organ dose, cumulative quarterly and annual doses are maintained for each of the eight organs considered. The cumulative dose is obtained by summing the doses for each organ of the critical age group as determined for each release with the organ doses for all previous releases in the quarter or year to obtain the cumulative quarterly and annual doses. Thus, the cumulative organ doses will be conservative values, consisting of doses belonging to various age groups depending on the mix of radionuclides. The highest of these cumulative organ doses is used for the comparison to the limits given in ODCM Control 1.2.2.3.

7.4.3 Comparison to Limits

The cumulative calendar quarter and calendar year doses are compared to their respective limits at least once per 31 days to determine compliance.

7.6 DOSE CALCULATIONS FOR REPORTING

A complete dose analysis utilizing the total estimated gaseous releases for each calendar quarter will be performed and reported as required in ODCM Administrative Control 5.2. Methodology for this analysis is that which is described in this section using the total quarterly release values. For those nuclides whose activities are determined from composite samples, the actual concentrations for the period will be used to perform these calculations. All real pathways and receptor locations identified by the most recent land use survey are considered. In addition, actual meteorological data representative of a ground level release for each corresponding calendar quarter will be used. For iodine releases, it is assumed that half the iodine released is in organic form. Organic iodine causes a dose only by inhalation. For cow-milk and beef ingestion doses, the fraction of the time the animals are on stored feed (identified in the land use survey) is used in the calculation.

The highest organ dose for a real receptor is determined by summing the dose contribution from all identified pathways for each receptor including ground contamination, inhalation, vegetable ingestion (for identified garden locations), cow and/or goat milk ingestion (if a cow or goat is identified for the location), beef ingestion (the beef ingestion dose for the location of highest beef dose for all receptors will be considered the beef dose for all receptors).

7.6.1 Noble Gas - Gamma Air Dose

Gamma air doses due to exposure to noble gases, D_γ in mrem, are calculated using the following equation:

$$D_\gamma = \sum_i X_{im} \, DF_{\gamma i} \, TAF_m \qquad (7.12)$$

where:

X_{im} = annual average concentration of nuclide i at location m, μCi-year/m^3. Calculated as described by Equation 1.16.

$DF_{\gamma i}$ = dose conversion factor for external gamma for nuclide i, mrad/year per μCi/m^3 (Table 7.4).

TAF_m = site specific terrain adjustment factor for location m. Calculated as described in Section 7.8.4.

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D/Q_m = relative deposition, $1/m^2$. Relative deposition values are calculated for the SITE BOUNDARY in each of the sixteen sectors, and the nearest resident, garden and milk animal locations identified in the most recent land use census. Meteorological data for the calendar quarter in question is used to calculate these dispersion factors using Equation 1.18.

R_{PT} = ingestion dose factor for pathway P for tritium, m^2-mrem/year per µCi/s. Ingestion pathways available for consideration are the same as those listed above for R_{Pi}. Equations for calculating ingestion dose factors for tritium are given in Sections 7.7.7 through 7.7.12.

Q_T = adjusted release for tritium for location under consideration, µCi. The initial release is adjusted to account for decay between the release point and the location, depending on the frequency of wind speeds applicable to that sector. Hence, the adjusted release is equal to the actual release decayed for an average travel time during the period.

$$= Q_{T0} \sum_{j=1}^{9} f_j \exp(-\lambda_T x/u_j)$$

where

Q_{T0} = initial average release for tritium over the period, µCi.

f_j = joint relative frequency of occurrence of winds in windspeed class j blowing toward this exposure point, expressed as a fraction.

λ_T = radiological decay constant for tritium, s^{-1}.

x = downwind distance, meters.

u_j = midpoint value of wind speed class interval j, m/s.

R_{Pi} = ingestion dose factor for pathway P for each identified nuclide i (except tritium), m^2-mrem/year per µCi/s. Ingestion pathways available for consideration include:
pasture grass-cow-milk ingestion
stored feed-cow-milk ingestion
pasture grass-goat-milk ingestion
stored feed-goat-milk ingestion
pasture grass-beef ingestion
stored feed-beef ingestion
fresh leafy vegetable ingestion
stored vegetable ingestion
Equations for calculating these ingestion dose factors are given in Sections 7.7.1 through 7.7.6.

R_{Gi} = Dose factor for standing on contaminated ground, m^2-mrem/year per µCi/s. The equation for calculating the ground plane dose factor is given in Section 7.7.14.

R_{Ii} = Inhalation dose factor, mrem/year per µCi/m^3. The equation for calculating the inhalation dose factor is given in Section 7.7.13.

Q_i = adjusted release for nuclide i for location under consideration, µCi. Calculated in the same manner as Q_T above.

$DOSE_P$ = the dose for pathway P to the maximum individual at the location under consideration, mrem. For ingestion pathways, this dose is multiplied by an average decay correction to account for decay as the food is moved through the food distribution cycle. This average decay correction, ADC, is defined as follows:

For milk and vegetables, $ADC = \exp(-\lambda_i t)$

where

λ_i = decay constant for nuclide i, seconds.

t = distribution time for food product under consideration (values from Regulatory Guide 1.109, Table D-1).
= 1.21E+06 seconds (14 days) for vegetables.
= 3.46E+05 seconds (4 days) for milk.

$$\text{For meat, } ADC = \frac{\exp(-\lambda_i t)\ \lambda_i t_{cb}}{1 - \exp(-\lambda_i t_{cb})}$$

where

λ_i = decay constant for nuclide i, seconds.

t = additional distribution time for meat, over and above the time for slaughter to consumption described in Section 7.7.3, 7 days.

t_{cb} = time to consume a whole beef, as described in Section 7.7.3.

For beef ingestion, the additional factors in the calculation of ADC negate the integration of the dose term over the period during which a whole beef is consumed, for the calculation of population dose. In other words, this assumes that the maximum individual freezes and eats a whole beef, while the average individual buys smaller portions at a time.

Population doses are summed over all sector elements to obtain a total population dose for the 50-mile population.

7.6.5 Reporting of Doses

The calculated quarterly doses and calculated population doses described in this section are reported in the Semi-Annual Effluent Release Report submitted to the NRC for the period ending December 31 of each year, as required by ODCM Administrative Control 5.2.

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7.7 GASEOUS RELEASES - DOSE FACTORS

7.7.1 Pasture Grass-cow/goat-milk Ingestion Dose Factors - R_{CPi} (m^2-mrem/year per µCi/second)

$$R_{CPi} = 10^6 DFL_{iao} U_{ap} F_{mi} Q_f \exp(-\lambda_i t_{fm}) f_p \left\{ \frac{r(1-\exp(-\lambda_E t_{ep}))}{Y_p \lambda_E} + \frac{B_{iv}(1-\exp(-\lambda_i t_b))}{P \lambda_i} \right\}$$

where:

10^6	=	conversion factor, pCi/µCi.
DFL_{iao}	=	ingestion dose conversion factor for nuclide i, age group a, organ o, mrem/pCi (Table 6.4).
U_{ap}	=	milk ingestion rate for age group a, l/year.
F_{mi}	=	transfer factor for nuclide i from animal's feed to milk, days/liter (Table 6.2).
Q_f	=	animal's consumption rate, kg/day.
λ_i	=	decay constant for nuclide i, $seconds^{-1}$ (Table 6.2).
t_{fm}	=	transport time from milking to receptor, seconds.
f_p	=	fraction of time animal spends on pasture, dimensionless.
r	=	fraction of activity retained on pasture grass, dimensionless.
λ_E	=	the effective decay constant, due to radioactive decay and weathering, $seconds^{-1}$, equal to $\lambda_i + \lambda_w$.
λ_w	=	weathering decay constant for leaf and plant surfaces, $seconds^{-1}$.
t_{ep}	=	time pasture is exposed to deposition, seconds.
Y_p	=	agricultural productivity by unit area of pasture grass, kg/m^2.
B_{iv}	=	transfer factor for nuclide i from soil to vegetation, pCi/kg (wet weight of vegetation) per pCi/kg (dry soil).
t_b	=	time period over which accumulation on the ground is evaluated, seconds.
P	=	effective surface density of soil, kg/m^2.

NOTE: Factors defined above which do not reference a table for their numerical values are listed in Table 6.3.

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7.7.2 Stored Feed-cow/goat-milk Ingestion Dose Factors - R_{CSi} (m^2-mrem/year per μCi/second)

$$R_{CSi} = 10^6\, DFL_{iac}\, U_{ap}\, F_{mi}\, Q_f\, f_s\, \exp(-\lambda_i t_{fm}) \frac{(1-\exp(-\lambda_i t_{csf}))}{t_{csf}\,\lambda_i} \left\{ \frac{r(1-\exp(-\lambda_E t_{esf}))}{Y_{sf}\,\lambda_E} + \frac{B_{iv}(1-\exp(-\lambda_i t_b))}{P\,\lambda_i} \right\}$$

where:

- 10^6 = conversion factor, pCi/μCi.
- DFL_{iao} = ingestion dose conversion factor for nuclide i, age group a, organ o, mrem/pCi (Table 6.4).
- U_{ap} = milk ingestion rate for age group a, l/year.
- F_{mi} = transfer factor for nuclide i from animal's feed to milk, days/liter (Table 6.2).
- Q_f = animal's consumption rate, kg/day.
- f_s = fraction of time animal spends on stored feed, dimensionless.
- λ_i = decay constant for nuclide i, seconds^{-1} (Table 6.2).
- t_{fm} = transport time from milking to receptor, seconds.
- t_{csf} = time between harvest of stored feed and consumption by animal, seconds.
- r = fraction of activity retained on pasture grass, dimensionless.
- λ_E = the effective decay constant, due to radioactive decay and weathering, seconds^{-1}, equal to $\lambda_i + \lambda_w$.
- λ_w = weathering decay constant for leaf and plant surfaces, seconds^{-1}.
- t_{esf} = time stored feed is exposed to deposition, seconds.
- Y_{sf} = agricultural productivity by unit area of stored feed, kg/m^2.
- B_{iv} = transfer factor for nuclide i from soil to vegetation, pCi/kg (wet weight of vegetation) per pCi/kg (dry soil).
- t_b = time period over which accumulation on the ground is evaluated, seconds.
- P = effective surface density of soil, kg/m^2.

NOTE: Factors defined above which do not reference a table for their numerical values are listed in Table 6.3.

7.7.3 Pasture Grass-beef Ingestion Dose Factors - R_{MPi}
(m^2-mrem/year per µCi/second)

$$R_{MPi} = 10^6 \, DFL_{iao} \, U_{am} \, F_{fi} \, Q_f \frac{(1-\exp(-\lambda_i t_{cb}))}{\lambda_i \, t_{cb}} \exp(-\lambda_i t_s)$$

$$f_p\left\{\frac{r(1-\exp(-\lambda_E t_{ep}))}{Y_p \, \lambda_E} + \frac{B_{iv}(1-\exp(-\lambda_i t_b))}{P \, \lambda_i}\right\}$$

where:

10^6 = conversion factor, pCi/µCi.
DFL_{iao} = ingestion dose conversion factor for nuclide i, age group a, organ o, mrem/pCi (Table 6.4).
U_{am} = meat ingestion rate for age group a, kg/year.
F_{fi} = transfer factor for nuclide i from cow's feed to meat, days/kg (Table 6.2).
Q_f = cow's consumption rate, kg/day.
λ_i = decay constant for nuclide i, $seconds^{-1}$ (Table 6.2).
t_{cb} = time for receptor to consume a whole beef, seconds.
t_s = transport time from slaughter to consumer, seconds.
f_p = fraction of time cow spends on pasture, dimensionless.
r = fraction of activity retained on pasture grass, dimensionless.
λ_E = the effective decay constant, due to radioactive decay and weathering, $seconds^{-1}$, equal to $\lambda_i + \lambda_w$.
λ_w = weathering decay constant for leaf and plant surfaces, $seconds^{-1}$.
t_{ep} = time pasture is exposed to deposition, seconds.
Y_p = agricultural productivity by unit area of pasture grass, kg/m^2.
B_{iv} = transfer factor for nuclide i from soil to vegetation, pCi/kg (wet weight of vegetation) per pCi/kg (dry soil).
t_b = time over which accumulation on the ground is evaluated, seconds.
P = effective surface density of soil, kg/m^2.

NOTE: Factors defined above which do not reference a table for their numerical values are listed in Table 6.3.

7.7.4 Stored Feed-beef Ingestion Dose Factors - R_{MSi}
(m^2-mrem/year per µCi/second)

$$R_{MSi} = 10^6\ DFL_{iao}\ U_{am}\ F_{fi}\ Q_f\ \frac{(1-\exp(-\lambda_i t_{cb}))}{\lambda_i\ t_{cb}}\ \exp(-\lambda_i t_s)$$

$$f_s\ \frac{(1-\exp(-\lambda_i t_{csf}))}{\lambda_i\ t_{csf}} \left\{ \frac{r(1-\exp(-\lambda_E t_{esf}))}{Y_{sf}\ \lambda_E} + \frac{B_{iv}(1-\exp(-\lambda_i t_b))}{P\ \lambda_i} \right\}$$

where:

10^6 = conversion factor, pCi/µCi.
DFL_{iao} = ingestion dose conversion factor for nuclide i, age group a, organ o, mrem/pCi (Table 6.4).
U_{am} = meat ingestion rate for age group a, kg/year.
F_{fi} = transfer factor for nuclide i from cow's feed to meat, days/kg (Table 6.2).
Q_f = cow's consumption rate, kg/day.
λ_i = decay constant for nuclide i, seconds^{-1} (Table 6.2).
t_{cb} = time for receptor to consume a whole beef, seconds.
t_s = transport time from slaughter to consumer, seconds.
f_s = fraction of time cow spends on stored feed, dimensionless.
t_{csf} = time between harvest of stored feed and consumption by cow, seconds.
r = fraction of activity retained on pasture grass, dimensionless.
t_{esf} = time stored feed is exposed to deposition, seconds.
Y_{sf} = agricultural productivity by unit area of stored feed, kg/m^2.
λ_E = the effective decay constant, due to radioactive decay and weathering, seconds^{-1}, equal to $\lambda_i + \lambda_w$.
λ_w = weathering decay constant for leaf and plant surfaces, seconds^{-1}.
B_{iv} = transfer factor for nuclide i from soil to vegetation, pCi/kg (wet weight of vegetation) per pCi/kg (dry soil).
t_b = time over which accumulation on the ground is evaluated, seconds.
P = effective surface density of soil, kg/m^2.

NOTE: Factors defined above which do not reference a table for their numerical values are listed in Table 6.3.

7.7.5 Fresh Leafy Vegetable Ingestion Dose Factors - R_{VFi}
(m^2-mrem/year per µCi/second)

$$R_{VFi}=10^6 DFL_{iao} \exp(-\lambda_i t_{hc}) U_{FLa} f_L \left\{ \frac{r(1-\exp(-\lambda_E t_e))}{Y_f \lambda_E} + \frac{B_{iv}(1-\exp(-\lambda_i t_b))}{P \lambda_i} \right\}$$

where:

10^6 = conversion factor, pCi/µCi.
DFL_{iao} = ingestion dose conversion factor for nuclide i, age group a, organ o, mrem/pCi (Table 6.4).
λ_i = decay constant for nuclide i, seconds^{-1} (Table 6.2).
t_{hc} = average time between harvest of vegetables and their consumption and/or storage, seconds.
U_{FLa} = consumption rate of fresh leafy vegetables by the receptor in age group a, kg/year.
f_L = fraction of fresh leafy vegetables grown locally, dimensionless.
r = fraction of deposited activity retained on vegetables, dimensionless.
λ_E = the effective decay constant, due to radioactive decay and weathering, seconds^{-1}.
= $\lambda_i + \lambda_w$
λ_w = decay constant for removal of activity on leaf and plant surfaces by weathering, seconds^{-1}.
t_e = exposure time in garden for fresh leafy and/or stored vegetables, seconds.
Y_f = agricultural yield for fresh leafy vegetables, kg/m^2.
B_{iv} = transfer factor for nuclide i from soil to vegetables, pCi/kg (wet weight of vegetation) per pCi/kg (dry soil).
t_b, = time period over which accumulation on the ground is evaluated, seconds.
P = effective surface density of soil, kg/m^2.

NOTE: Factors defined above which do not reference a table for their numerical values are listed in Table 6.3.

7.7.6 Stored Vegetable Ingestion Dose Factors - R_{VSi}
m^2-mrem/year per µCi/second)

$$R_{VSi} = 10^6\ DFL_{iao}\ \exp(-\lambda_i t_{hc})\ U_{Sa} f_g\ \frac{(1-\exp(-\lambda_i t_{sv}))}{\lambda_i\ t_{sv}} \left\{ \frac{r(1-\exp(-\lambda_E t_e))}{Y_{sv}\ \lambda_E} + \frac{B_{iv}(1-\exp(-\lambda_i t_b))}{P\ \lambda_i} \right\}$$

where:

10^6 = conversion factor, pCi/µCi.
DFL_{iao} = ingestion dose conversion factor for nuclide i, age group a, organ o, mrem/pCi (Table 6.4).
λ_i = decay constant for nuclide i, seconds^{-1} (Table 6.2).
t_{hc} = average time between harvest of vegetables and their consumption and/or storage, seconds.
U_{Sa} = consumption rate of stored vegetables by the receptor in age group a, kg/year.
f_g = fraction of stored vegetables grown locally, dimensionless.
t_{sv} = time between storage of vegetables and their consumption, seconds.
r = fraction of deposited activity retained on vegetables, dimensionless.
λ_E = the effective decay constant, due to radioactive decay and weathering, seconds^{-1}.
= $\lambda_i + \lambda_w$
λ_w = decay constant for removal of activity on leaf and plant surfaces by weathering, seconds^{-1}.
t_e = exposure time in garden for fresh leafy and/or stored vegetables, seconds.
Y_{sv} = agricultural yield for stored vegetables, kg/m^2.
B_{iv} = transfer factor for nuclide i from soil to vegetables, pCi/kg (wet weight of vegetation) per pCi/kg (dry soil).
t_b = time period over which accumulation on the ground is evaluated, seconds.
P = effective surface density of soil, kg/m^2.

NOTE: Factors defined above which do not reference a table for their numerical values are listed in Table 6.3.

7.7.7 Tritium - Pasture Grass-cow/goat-milk Dose Factor - R_{CTP} (mrem/year per µCi/m³)

$$R_{CTP} = 10^3 \; 10^6 \; DFL_{Tao} \; F_{mT} \; Q_f \; U_{ap} \; [0.75(0.5/H)] \; f_p \; \exp(-\lambda_T t_{fm})$$

where:

10^3	= conversion factor, grams/kg.
10^6	= conversion factor, pCi/µCi.
DFL_{Tao}	= ingestion dose conversion factor for tritium for age group a, organ o, mrem/pCi (Table 6.4).
F_{mT}	= transfer factor for tritium from animal's feed to milk, days/liter (Table 6.2).
Q_f	= animal's consumption rate, kg/day.
U_{ap}	= milk ingestion rate for age group a, l/year.
0.75	= the fraction of total feed that is water.
0.5	= the ratio of the specific activity of the feed grass water to the atmospheric water.
H	= absolute humidity of the atmosphere, g/m³.
f_p	= fraction of time animal spends on pasture, dimensionless.
λ_T	= decay constant for tritium, seconds^{-1} (Table 6.2).
t_{fm}	= transport time from milking to receptor, seconds.

NOTE: Factors defined above which do not reference a table for their numerical values are listed in Table 6.3.

7.7.9 Tritium - Pasture Grass-beef Dose Factor - R_{MTP}
(mrem/year per µCi/m³)

$$R_{MTP} = 10^3\ 10^6\ DFL_{Tao}\ F_{fT}\ Q_f\ U_{am}\ [0.75(0.5/H)]\ f_p\ \exp(-\lambda_T t_s)\ \frac{(1-\exp(-\lambda_T t_{ep}))}{\lambda_T\ t_{ep}}\ \frac{(1-\exp(-\lambda_T t_{cb}))}{\lambda_T\ t_{cb}}$$

where:

10^3	= conversion factor, grams/kg.
10^6	= conversion factor, pCi/µCi.
DFL_{Tao}	= ingestion dose conversion factor for H-3 for age group a, organ o, mrem/pCi (Table 6.4).
F_{fT}	= transfer factor for H-3 from cow's feed to meat, days/kg (Table 6.2).
Q_f	= cow's consumption rate, kg/day.
U_{am}	= meat ingestion rate for age group a, kg/year.
0.75	= the fraction of total feed that is water.
0.5	= the ratio of the specific activity of the feed grass water to the atmospheric water.
H	= absolute humidity of the atmosphere, g/m³.
f_p	= fraction of time cow spends on pasture, dimensionless.
λ_T	= decay constant for tritium, seconds^{-1} (Table 6.2).
t_s	= transport time from slaughter to consumer, seconds.
t_{ep}	= time pasture is exposed to deposition, seconds.
t_{cb}	= time for receptor to consume a whole beef, seconds.

NOTE: Factors defined above which do not reference a table for their numerical values are listed in Table 6.3.

7.7.11 Tritium - Fresh Leafy Vegetables Dose Factor - R_{VTF} (mrem/year per µCi/m^3)

$$R_{VTF} = 10^3\ 10^6\ DFL_{Tao}\ [0.75(0.5/H)]\ U_{FLa}\ f_L\ \exp(-\lambda_T t_{hc})$$

where:

10^3	=	conversion factor, grams/kg.
10^6	=	conversion factor, pCi/µCi.
DFL_{Tao}	=	ingestion dose conversion factor for tritium for age group a, organ o, mrem/pCi (Table 6.4).
0.75	=	the fraction of total vegetation that is water.
0.5	=	the ratio of the specific activity of the vegetables water to the atmospheric water.
H	=	absolute humidity of the atmosphere, g/m^3.
U_{FLa}	=	consumption rate of fresh leafy vegetables by the receptor in age group a, kg/year.
f_L	=	fraction of fresh leafy vegetables grown locally, dimensionless.
λ_T	=	decay constant for tritium, seconds^{-1} (Table 6.2).
t_{hc}	=	time between harvest of vegetables and their consumption and/or storage, seconds.

NOTE: Factors defined above which do not reference a table for their numerical values are listed in Table 6.3.

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7.7.13 Inhalation Dose Factors- R_{Ii}
(mrem/year per µCi/m³)

$$R_{Ii} = DFA_{iao}\ BR_a\ 10^6$$

where:

DFA_{iao} = inhalation dose conversion factor for nuclide i, age group a and organ o, mrem/pCi (Table 7.7).
BR_a = breathing rate for age group a, m^3/year (Table 6.3).
10^6 = conversion factor, pCi/µCi.

7.7.14 Ground Plane Dose Factors - R_{Gi}
(m^2-mrem/year per µCi/second)

$$R_{Gi} = DFG_{io}\ (1/\lambda_i)\ 10^6\ 8760\ [1 - \exp(-\lambda_i t_b)]$$

where:

DFG_{io} = dose conversion factor for standing on contaminated ground for nuclide i and organ o (total body and skin), mrem/hr per pCi/m^2 (Table 6.6).
λ_i = decay constant of nuclide i, $seconds^{-1}$ (Table 6.2).
10^6 = conversion factor, pCi/µCi.
8760 = conversion factor, hours/year.
t_b = time period over which the ground accumulation is evaluated, seconds (Table 6.3).

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7.8 DISPERSION METHODOLOGY

Dispersion factors are calculated for radioactive effluent releases using hourly average meteorological data consisting of wind speed and direction measurements at 10m and temperature measurements at 10m and 46m.

A sector-average dispersion equation consistent with Regulatory Guide 1.111 is used. The dispersion model considers plume depletion (using information from Figure 7.3), and building wake effects. The straight-line dispersion model results have been modified according to Section 7.8.4 to account for spatial and temporal variations in the airflow in the vicinity of the site.

Hourly average meteorological data are expressed as a joint-frequency distribution of wind speed, wind direction, and atmospheric stability. The joint-frequency distribution which represents the historical meteorological data for the period January 1974 through December 1988 is given in Table 7.2.

The wind speed classes that are used are as follows:

Number	Range (m/s)	Midpoint (m/s)
1	<0.3	0.13
2	0.3-0.6	0.45
3	0.7-1.5	1.10
4	1.6-2.4	1.99
5	2.5-3.3	2.88
6	3.4-5.5	4.45
7	5.6-8.2	6.91
8	8.3-10.9	9.59
9	>10.9	10.95

The stability classes that will be used are the standard A through G classifications. The stability classes 1-7 will correspond to A=1, B=2, ..., G=7.

7.8.1 Annual Average Air Concentration

Annual average air concentrations of nuclides at downwind locations are calculated using the following equation:

$$X_{im} = \sum_{j=1}^{9} \sum_{k=1}^{7} (2/\pi)^{1/2} \frac{f_{jk}\, Q_i\, p}{\Sigma_{zk}\, u_j\, (2\pi x/n)} \exp(-\lambda_i\, x/u_j)\, 10^6\, 3.17E\text{-}8 \qquad (7.16)$$

where

f_{jk} = joint relative frequency of occurrence of winds in windspeed class j, stability class k, blowing toward this exposure point, expressed as a fraction.

Q_i = amount released of radionuclide i, Ci.
p = fraction of radionuclide remaining in plume (Figure 7.3).
Σ_{zk} = vertical dispersion coefficient for stability class k which includes a building wake adjustment,
= $(\sigma_{zk}^2 + cA/\pi)^{1/2}$, or
= $\sqrt{3}\ \sigma_{zk}$, whichever is smaller.
where
σ_{zk} is the vertical dispersion coefficient for stability class k (m) (Figure 7.4),
c is a building shape factor (c=0.5),
A is the minimum building cross-sectional area (1630 m^2).
u_j = midpoint value of wind speed class interval j, m/s.
x = downwind distance, m.
n = number of sectors, 16.
λ_i = radioactive decay coefficient of radionuclide i, s^{-1}
$2\pi x/n$ = sector width at point of interest, m.
10^6 = conversion factor, µCi/Ci.
3.17E-08= conversion factor, year/sec.

7.8.2 Relative Concentration

Relative concentrations of nuclides at downwind locations are calculated using the following equation:

$$X/Q = \sum_{j=1}^{9} \sum_{k=1}^{7} (2/\pi)^{1/2} \frac{f_{jk}}{\Sigma_{zk}\ u_j\ (2\pi x/n)} \qquad (7.17)$$

where

f_{jk} = joint relative frequency of occurrence of winds in windspeed class j, stability class k, blowing toward this exposure point, expressed as a fraction.
Σ_{zk} = vertical dispersion coefficient for stability class k which includes a building wake adjustment,
= $(\sigma_{zk}^2 + cA/\pi)^{1/2}$, or
= $\sqrt{3}\ \sigma_{zk}$, whichever is smaller.
where
σ_{zk} is the vertical dispersion coefficient for stability class k (m) (Figure 7.4),
c is a building shape factor (c=0.5),
A is the minimum building cross-sectional area (1630 m^2).
u_j = midpoint value of wind speed class interval j, m/s.
x = downwind distance, m.
n = number of sectors, 16.
$2\pi x/n$ = sector width at point of interest, m.

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7.8.3 Relative Deposition

Relative deposition of nuclides at downwind locations is calculated using the following equation:

$$D/Q = \sum_{j=1}^{9} \sum_{k=1}^{7} \frac{f_{jk}\,DR}{(2\pi x/n)} \quad (7.18)$$

where

f_{jk} = joint relative frequency of occurrence of winds in windspeed class j and stability class k, blowing toward this exposure point, expressed as a fraction.
DR = relative deposition rate, m^{-1} (from Figure 7.5).
x = downwind distance, m.
n = number of sectors, 16.
$2\pi x/n$ = sector width at point of interest, m.

7.8.4 Terrain Adjustment Factor - TAF

The straight-line dispersion model does not account for spatial and temporal variations in the airflow expected from the southwest-northeast aligned river valley. Such variations are considered by application of site-specific terrain adjustment factors, TAF. These factors were developed through the comparison of variable trajectory model results with straight-line model results for onsite meteorological data for 1978. The ratio of the variable trajectory model dispersion factors to the straight-line model dispersion factors is defined as the TAF (see Table 7.3).

The dispersion factors used in the dose rate and dose calculations described in Sections 7.2.2, 7.2.3, 7.3.1, 7.3.2, and 7.4.1 are calculated using the meteorological data from the 1974 to 1988 period (in Table 7.2). X/Q and D/Q values are calculated for each of the sixteen SITE BOUNDARY locations (Table 7.1). These are multiplied by the TAF associated with each of these sectors. The highest of these dispersion values are chosen for the dose or dose rate calculations.

The dispersion factors used in the dose calculations described in Section 7.6 are calculated using the actual meteorological data for the period. X/Q or D/Q values are calculated using Equations 1.17 and 7.18 for the sixteen site boundary locations identified in Table 7.1, for the sixteen nearest resident locations, and all garden and milk animal locations identified in the annual land use census described in Section 9.3. The TAF values associated with these dispersion factors is the ratio of the dispersion factor calculated by the variable trajectory model to that calculated by

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

the straight-line model for each of these locations using the 1978 meteorological data. These values will be calculated for all locations identified by the land use census and then used to modify the X/Q and D/Q values determined with the actual meteorological data. Any TAF values of less than 1.0 will be defined as 1.0.

Table 7.1
WBN - OFFSITE RECEPTOR LOCATION DATA

		DISTANCE from plant (m)	X/Q* (s/m³)	D/Q* (1/m²)
Site Boundary	N	1550	2.54E-06	4.77E-09
Site Boundary	NNE	1980	2.49E-06	6.74E-09
Site Boundary	NE	1580	2.79E-06	4.12E-09
Site Boundary	ENE	1370	4.28E-06	4.41E-09
Site Boundary	E	1280	5.18E-06	5.48E-09
Site Boundary	ESE	1250	5.10E-06	5.39E-09
Site Boundary	SE	1250	6.89E-06	7.17E-09
Site Boundary	SSE	1250	4.15E-06	5.89E-09
Site Boundary	S	1340	2.47E-06	5.59E-09
Site Boundary	SSW	1550	1.94E-06	5.45E-09
Site Boundary	SW	1670	1.84E-06	3.45E-09
Site Boundary	WSW	1430	3.52E-06	4.55E-09
Site Boundary	W	1460	2.20E-06	2.56E-09
Site Boundary	WNW	1400	8.20E-07	9.15E-09
Site Boundary	NW	1400	1.31E-06	1.49E-09
Site Boundary	NNW	1460	2.02E-06	2.61E-09
Liquid Discharge			N/A	N/A

NOTE: For quarterly airborne dose calculations, doses will also be calculated for all locations identified in the most recent land use census, and for any additional points deemed necessary.

* These X/Q and D/Q values must be multiplied by the sector specific Terrain Adjustment Factor (from Table 7.3) prior to selecting the critical SITE BOUNDARY location to be used in dose calculations

Table 7.2 (1 of 7)
JOINT PERCENTAGE FREQUENCIES OF WIND DIRECTION AND WIND SPEED FOR DIFFERENT STABILITY CLASSES

Stability Class A (Delta-T<=-1.9 C/100 M)
Watts Bar Nuclear Plant
JAN 1, 74 - DEC 31, 88

WIND DIR	WIND SPEED(MPH) Calm	0.6-1.4	1.5-3.4	3.5-5.4	5.5-7.4	7.5-12.4	12.5-18.4	18.5-24.4	≥24.5	TOTAL
N	0.000	0.001	0.009	0.020	0.030	0.067	0.003	0.000	0.000	0.129
NNE	0.000	0.001	0.009	0.063	0.077	0.156	0.006	0.000	0.000	0.311
NE	0.000	0.000	0.030	0.077	0.074	0.092	0.000	0.000	0.000	0.273
ENE	0.000	0.001	0.028	0.067	0.080	0.037	0.000	0.000	0.000	0.213
E	0.000	0.002	0.031	0.037	0.019	0.006	0.000	0.000	0.000	0.095
ESE	0.000	0.000	0.014	0.011	0.002	0.001	0.000	0.000	0.000	0.028
SE	0.000	0.001	0.015	0.026	0.005	0.002	0.001	0.000	0.000	0.050
SSE	0.000	0.001	0.030	0.047	0.020	0.016	0.002	0.000	0.000	0.117
S	0.000	0.001	0.037	0.103	0.112	0.121	0.015	0.001	0.000	0.391
SSW	0.000	0.001	0.032	0.167	0.388	0.744	0.130	0.007	0.000	1.468
SW	0.000	0.000	0.009	0.067	0.113	0.120	0.015	0.000	0.000	0.323
WSW	0.000	0.000	0.005	0.020	0.015	0.072	0.025	0.002	0.000	0.139
W	0.000	0.000	0.003	0.010	0.012	0.060	0.019	0.001	0.000	0.105
WNW	0.000	0.000	0.001	0.005	0.008	0.028	0.007	0.000	0.000	0.049
NW	0.000	0.000	0.003	0.006	0.011	0.029	0.008	0.000	0.000	0.057
NNW	0.000	0.001	0.005	0.024	0.040	0.068	0.013	0.000	0.000	0.151
SUB-TOTAL	0.001	0.009	0.262	0.747	1.006	1.618	0.244	0.011	0.000	3.898

Total hours of valid stability observations 125417
Total hours of Stability Class A 4884
Total hours of valid wind direction-wind speed-Stability Class A 4789
Total hours of valid wind direction-wind speed-stability observations 122869

Meteorological facility located 0.8 km SSW of Watts Bar Nuclear Plant
Stability based on delta-T between 9.51 and 45.63 meters
Wind speed and direction measured at 9.72 meter level
Mean wind speed = 7.57

NOTE: Totals and subtotals are obtained from unrounded numbers.

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

Table 7.2 (2 of 7)
JOINT PERCENTAGE FREQUENCIES OF WIND DIRECTION AND WIND SPEED
FOR DIFFERENT STABILITY CLASSES

Stability Class B (-1.9< Delta-T<=-1.7 C/100 M)
Watts Bar Nuclear Plant
JAN 1, 74 - DEC 31, 88

WIND SPEED(MPH)

WIND DIR	Calm	0.6-1.4	1.5-3.4	3.5-5.4	5.5-7.4	7.5-12.4	12.5-18.4	18.5-24.4	>24.5	TOTAL
N	0.000	0.000	0.015	0.051	0.046	0.080	0.007	0.000	0.000	0.199
NNE	0.000	0.001	0.037	0.103	0.124	0.203	0.015	0.000	0.000	0.483
NE	0.000	0.000	0.051	0.112	0.107	0.085	0.002	0.000	0.000	0.357
ENE	0.000	0.001	0.045	0.096	0.077	0.029	0.000	0.000	0.000	0.248
E	0.000	0.001	0.055	0.061	0.019	0.002	0.000	0.000	0.000	0.137
ESE	0.000	0.002	0.018	0.024	0.002	0.001	0.000	0.000	0.000	0.047
SE	0.000	0.000	0.023	0.029	0.003	0.002	0.002	0.000	0.000	0.059
SSE	0.000	0.001	0.042	0.050	0.017	0.007	0.000	0.000	0.000	0.116
S	0.000	0.002	0.043	0.115	0.072	0.061	0.011	0.002	0.000	0.306
SSW	0.000	0.000	0.047	0.176	0.296	0.257	0.049	0.004	0.000	0.829
SW	0.000	0.000	0.020	0.088	0.093	0.033	0.004	0.000	0.000	0.238
WSW	0.000	0.000	0.007	0.019	0.026	0.025	0.008	0.000	0.000	0.085
W	0.000	0.000	0.003	0.009	0.024	0.056	0.011	0.001	0.000	0.104
WNW	0.000	0.000	0.005	0.005	0.013	0.056	0.008	0.000	0.000	0.087
NW	0.000	0.000	0.007	0.015	0.015	0.061	0.007	0.002	0.000	0.107
NNW	0.000	0.000	0.009	0.031	0.034	0.081	0.009	0.001	0.000	0.165
SUB-TOTAL	0.000	0.007	0.425	0.984	0.969	1.040	0.133	0.010	0.000	3.568

Total hours of valid stability observations 125417
Total hours of Stability Class B 4466
Total hours of valid wind direction-wind speed-stability class B 4384
Total hours of valid wind direction-wind speed-stability observations 122869

Meteorological facility located 0.8 km SSW of Watts Bar Nuclear Plant
Stability based on delta-T between 9.51 and 45.63 meters
Wind speed and direction measured at 9.72 meter level
Mean wind speed = 6.61

NOTE: Totals and subtotals are obtained from unrounded numbers.

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

Table 7.2 (3 of 7)
JOINT PERCENTAGE FREQUENCIES OF WIND DIRECTION AND WIND SPEED
FOR DIFFERENT STABILITY CLASSES

Stability Class C (-1.7< Delta-T<=-1.5 C/100 M)
Watts Bar Nuclear Plant
JAN 1, 74 - DEC 31, 88

	WIND SPEED(MPH)									
WIND DIR	Calm	0.6-1.4	1.5-3.4	3.5-5.4	5.5-7.4	7.5-12.4	12.5-18.4	18.5-24.4	≥24.5	TOTAL
N	0.000	0.001	0.037	0.094	0.118	0.168	0.009	0.000	0.000	0.427
NNE	0.000	0.001	0.094	0.214	0.238	0.300	0.022	0.000	0.000	0.868
NE	0.000	0.002	0.118	0.225	0.168	0.138	0.002	0.000	0.000	0.652
ENE	0.000	0.000	0.109	0.181	0.098	0.033	0.001	0.000	0.000	0.423
E	0.000	0.003	0.109	0.152	0.027	0.007	0.001	0.000	0.000	0.299
ESE	0.000	0.001	0.042	0.046	0.004	0.000	0.000	0.000	0.000	0.094
SE	0.000	0.000	0.049	0.058	0.011	0.002	0.003	0.000	0.000	0.122
SSE	0.000	0.001	0.088	0.123	0.037	0.013	0.004	0.000	0.000	0.266
S	0.000	0.001	0.106	0.242	0.122	0.081	0.020	0.002	0.000	0.573
SSW	0.000	0.000	0.085	0.420	0.430	0.305	0.075	0.006	0.000	1.320
SW	0.000	0.001	0.046	0.181	0.120	0.046	0.009	0.000	0.000	0.403
WSW	0.000	0.000	0.024	0.063	0.040	0.028	0.012	0.000	0.000	0.168
W	0.000	0.001	0.020	0.031	0.053	0.070	0.013	0.003	0.000	0.191
WNW	0.000	0.000	0.012	0.020	0.037	0.120	0.016	0.000	0.000	0.205
NW	0.000	0.000	0.022	0.043	0.057	0.161	0.019	0.001	0.000	0.303
NNW	0.000	0.000	0.024	0.066	0.092	0.137	0.011	0.000	0.000	0.330
SUB-TOTAL	0.000	0.011	0.986	2.160	1.651	1.609	0.216	0.011	0.000	6.644

Total hours of valid stability observations 125417
Total hours of Stability Class C 8348
Total hours of valid wind direction-wind speed-Stability Class C 8164
Total hours of valid wind direction-wind speed-stability observations 122869

Meteorological facility located 0.8 km SSW of Watts Bar Nuclear Plant
Stability based on delta-T between 9.51 and 45.63 meters
Wind speed and direction measured at 9.72 meter level
Mean wind speed = 6.20

NOTE: Totals and subtotals are obtained from unrounded numbers.

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

Table 7.2 (4 of 7)
JOINT PERCENTAGE FREQUENCIES OF WIND DIRECTION AND WIND SPEED
FOR DIFFERENT STABILITY CLASSES

Stability Class D (-1.5< Delta-T<=-0.5 C/100 M)
Watts Bar Nuclear Plant
JAN 1, 74 - DEC 31, 88

WIND DIR	WIND SPEED(MPH) Calm	0.6-1.4	1.5-3.4	3.5-5.4	5.5-7.4	7.5-12.4	12.5-18.4	18.5-24.4	≥24.5	TOTAL
N	0.002	0.037	0.437	0.850	0.938	1.164	0.049	0.000	0.000	3.477
NNE	0.002	0.037	0.544	1.219	1.335	1.464	0.061	0.000	0.000	4.663
NE	0.003	0.057	0.648	0.976	0.632	0.384	0.008	0.001	0.000	2.709
ENE	0.003	0.092	0.814	0.597	0.178	0.059	0.002	0.000	0.000	1.745
E	0.003	0.125	0.619	0.295	0.079	0.020	0.000	0.000	0.000	1.140
ESE	0.001	0.057	0.232	0.089	0.015	0.009	0.000	0.000	0.000	0.403
SE	0.002	0.069	0.365	0.173	0.031	0.028	0.009	0.000	0.000	0.677
SSE	0.003	0.123	0.610	0.264	0.059	0.058	0.021	0.002	0.000	1.139
S	0.004	0.108	0.941	0.872	0.358	0.330	0.110	0.013	0.001	2.737
SSW	0.005	0.095	1.161	1.878	1.141	1.244	0.300	0.028	0.000	5.851
SW	0.003	0.094	0.696	0.750	0.255	0.182	0.022	0.002	0.001	2.005
WSW	0.002	0.071	0.478	0.347	0.182	0.136	0.039	0.001	0.000	1.255
W	0.002	0.081	0.429	0.353	0.387	0.439	0.055	0.003	0.000	1.751
WNW	0.002	0.094	0.343	0.371	0.408	0.558	0.061	0.004	0.000	1.842
NW	0.002	0.072	0.354	0.409	0.544	0.794	0.079	0.000	0.000	2.252
NNW	0.001	0.046	0.350	0.518	0.628	0.948	0.050	0.000	0.000	2.542
SUB-TOTAL	0.037	1.260	9.020	9.962	7.170	7.816	0.866	0.054	0.002	36.187

Total hours of valid stability observations 125417
Total hours of Stability Class D 45215
Total hours of valid wind direction-wind speed-Stability Class D 44463
Total hours of valid wind direction-wind speed-stability observations 122869

Meteorological facility located 0.8 km SSW of Watts Bar Nuclear Plant
Stability based on delta-T between 9.51 and 45.63 meters
Wind speed and direction measured at 9.72 meter level
Mean wind speed = 5.52

NOTE: Totals and subtotals are obtained from unrounded numbers.

Table 7.2 (5 of 7)
JOINT PERCENTAGE FREQUENCIES OF WIND DIRECTION AND WIND SPEED
FOR DIFFERENT STABILITY CLASSES

Stability Class E (-0.5< Delta-T<= 1.5 C/100 M)
Watts Bar Nuclear Plant
JAN 1, 74 - DEC 31, 88

WIND DIR	WIND SPEED(MPH) Calm	0.6-1.4	1.5-3.4	3.5-5.4	5.5-7.4	7.5-12.4	12.5-18.4	18.5-24.4	≥24.5	TOTAL
N	0.015	0.157	0.531	0.639	0.299	0.091	0.002	0.000	0.000	1.734
NNE	0.011	0.132	0.398	0.466	0.235	0.087	0.004	0.000	0.000	1.334
NE	0.013	0.139	0.471	0.239	0.098	0.038	0.000	0.000	0.000	0.999
ENE	0.027	0.243	1.015	0.337	0.049	0.011	0.001	0.000	0.000	1.683
E	0.018	0.290	0.522	0.101	0.021	0.013	0.002	0.000	0.000	0.966
ESE	0.006	0.135	0.147	0.032	0.009	0.002	0.001	0.000	0.000	0.332
SE	0.009	0.192	0.228	0.046	0.029	0.024	0.004	0.000	0.000	0.532
SSE	0.019	0.308	0.591	0.122	0.060	0.079	0.015	0.001	0.000	1.195
S	0.030	0.382	1.016	0.475	0.222	0.187	0.062	0.009	0.000	2.383
SSW	0.039	0.434	1.389	1.145	0.771	0.811	0.165	0.021	0.000	4.776
SW	0.031	0.461	0.971	0.306	0.198	0.150	0.027	0.003	0.000	2.147
WSW	0.031	0.605	0.824	0.186	0.108	0.081	0.014	0.001	0.000	1.850
W	0.029	0.662	0.698	0.229	0.109	0.073	0.011	0.000	0.000	1.811
WNW	0.028	0.641	0.639	0.203	0.090	0.042	0.002	0.002	0.000	1.646
NW	0.032	0.719	0.753	0.255	0.122	0.058	0.002	0.000	0.000	1.940
NNW	0.020	0.383	0.553	0.336	0.152	0.083	0.002	0.000	0.000	1.530
SUB-TOTAL	0.360	5.882	10.746	5.116	2.573	1.832	0.314	0.037	0.000	26.859

Total hours of valid stability observations 125417
Total hours of Stability Class E 33679
Total hours of valid wind direction-wind speed-Stability Class E 33002
Total hours of valid wind direction-wind speed-stability observations 122869

Meteorological facility located 0.8 km SSW of Watts Bar Nuclear Plant
Stability based on delta-T between 9.51 and 45.63 meters
Wind speed and direction measured at 9.72 meter level
Mean wind speed = 3.43

NOTE: Totals and subtotals are obtained from unrounded numbers.

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

Table 7.2 (6 of 7)
JOINT PERCENTAGE FREQUENCIES OF WIND DIRECTION AND WIND SPEED
FOR DIFFERENT STABILITY CLASSES

Stability Class F (1.5< Delta-T<= 4.0 C/100 M)
Watts Bar Nuclear Plant
JAN 1, 74 - DEC 31, 88

		WIND SPEED(MPH)								
WIND DIR	Calm	0.6-1.4	1.5-3.4	3.5-5.4	5.5-7.4	7.5-12.4	12.5-18.4	18.5-24.4	≥24.5	TOTAL
N	0.027	0.274	0.269	0.032	0.008	0.001	0.000	0.000	0.000	0.610
NNE	0.022	0.215	0.238	0.033	0.001	0.001	0.000	0.000	0.000	0.511
NE	0.028	0.238	0.322	0.024	0.002	0.001	0.000	0.000	0.000	0.616
ENE	0.048	0.339	0.636	0.065	0.002	0.002	0.000	0.000	0.000	1.093
E	0.026	0.292	0.228	0.009	0.001	0.001	0.000	0.000	0.000	0.556
ESE	0.008	0.112	0.054	0.001	0.000	0.000	0.000	0.000	0.000	0.175
SE	0.013	0.168	0.100	0.004	0.001	0.000	0.000	0.000	0.000	0.287
SSE	0.025	0.281	0.226	0.020	0.003	0.002	0.000	0.000	0.000	0.558
S	0.032	0.323	0.326	0.043	0.006	0.005	0.000	0.000	0.000	0.734
SSW	0.039	0.350	0.443	0.192	0.073	0.015	0.000	0.000	0.000	1.112
SW	0.046	0.440	0.497	0.075	0.019	0.007	0.001	0.000	0.000	1.085
WSW	0.064	0.673	0.623	0.041	0.008	0.000	0.000	0.000	0.000	1.408
W	0.069	0.843	0.557	0.033	0.001	0.002	0.000	0.000	0.000	1.505
WNW	0.066	0.918	0.432	0.024	0.002	0.001	0.000	0.000	0.000	1.443
NW	0.104	1.257	0.856	0.045	0.005	0.002	0.001	0.000	0.000	2.270
NNW	0.056	0.680	0.457	0.034	0.005	0.000	0.000	0.000	0.000	1.231
SUB-TOTAL	0.672	7.405	6.263	0.676	0.138	0.040	0.002	0.000	0.000	15.194

Total hours of valid stability observations 125417
Total hours of Stability Class F 19142
Total hours of valid wind direction-wind speed-Stability Class F 18669
Total hours of valid wind direction-wind speed-stability observations 122869

Meteorological facility located 0.8 km SSW of Watts Bar Nuclear Plant
Stability based on delta-T between 9.51 and 45.63 meters
Wind speed and direction measured at 9.72 meter level
Mean wind speed = 1.63

NOTE: Totals and subtotals are obtained from unrounded numbers.

Table 7.2 (7 of 7)
JOINT PERCENTAGE FREQUENCIES OF WIND DIRECTION AND WIND SPEED
FOR DIFFERENT STABILITY CLASSES

Stability Class G (Delta-T > 4.0 C/100 M)
Watts Bar Nuclear Plant
JAN 1, 74 - DEC 31, 88

WIND DIR	Calm	0.6-1.4	1.5-3.4	3.5-5.4	5.5-7.4	7.5-12.4	12.5-18.4	18.5-24.4	≥24.5	TOTAL
		WIND SPEED(MPH)								
N	0.021	0.194	0.077	0.002	0.000	0.000	0.000	0.000	0.000	0.292
NNE	0.022	0.194	0.101	0.002	0.000	0.000	0.000	0.000	0.000	0.320
NE	0.032	0.255	0.168	0.001	0.000	0.000	0.000	0.000	0.000	0.455
ENE	0.057	0.384	0.363	0.009	0.000	0.001	0.000	0.000	0.000	0.814
E	0.030	0.276	0.117	0.001	0.000	0.000	0.000	0.000	0.000	0.424
ESE	0.009	0.096	0.027	0.000	0.000	0.000	0.000	0.000	0.000	0.132
SE	0.017	0.163	0.058	0.000	0.000	0.000	0.000	0.000	0.000	0.237
SSE	0.021	0.190	0.081	0.002	0.000	0.000	0.000	0.000	0.000	0.293
S	0.021	0.188	0.090	0.005	0.002	0.000	0.000	0.000	0.000	0.306
SSW	0.024	0.201	0.110	0.013	0.002	0.000	0.000	0.000	0.000	0.349
SW	0.029	0.248	0.126	0.007	0.000	0.000	0.000	0.000	0.000	0.409
WSW	0.050	0.402	0.256	0.006	0.000	0.000	0.000	0.000	0.000	0.714
W	0.056	0.438	0.291	0.006	0.000	0.000	0.000	0.000	0.000	0.790
WNW	0.046	0.420	0.181	0.004	0.000	0.000	0.000	0.000	0.000	0.651
NW	0.066	0.556	0.308	0.011	0.001	0.000	0.000	0.000	0.000	0.942
NNW	0.037	0.326	0.153	0.003	0.000	0.000	0.000	0.000	0.000	0.519
SUB-TOTAL	0.537	4.530	2.505	0.072	0.004	0.001	0.000	0.000	0.000	7.649

Total hours of valid stability observations 125417
Total hours of Stability Class G 9683
Total hours of valid wind direction-wind speed-Stability Class G 9398
Total hours of valid wind direction-wind speed-stability observations 122869

Meteorological facility located 0.8 km SSW of Watts Bar Nuclear Plant
Stability based on delta-T between 9.51 and 45.63 meters
Wind speed and direction measured at 9.72 meter level
Mean wind speed = 1.30

NOTE: Totals and subtotals are obtained from unrounded numbers.

Table 7.3
SITE SPECIFIC TERRAIN ADJUSTMENT FACTORS AT SITE BOUNDARY

Sector	Straight-line X/Q s/m³	Variable Trajectory X/Q s/m³	TAF*
N	1.92E-06	3.19E-06	1.7
NNE	2.02E-06	3.59E-06	1.8
NE	1.68E-06	3.49E-06	2.1
ENE	2.75E-06	4.80E-06	1.7
E	4.83E-06	7.58E-06	1.6
ESE	4.05E-06	7.15E-06	1.8
SE	5.57E-06	8.36E-06	1.5
SSE	3.43E-06	4.98E-06	1.5
S	2.25E-06	4.26E-06	1.9
SSW	1.63E-06	3.23E-06	2.0
SW	1.37E-06	2.88E-06	2.1
WSW	2.53E-06	4.54E-06	1.8
W	2.39E-06	2.98E-06	1.2
WNW	7.70E-07	1.90E-06	2.5
NW	1.28E-06	2.19E-06	1.7
NNW	1.82E-06	2.96E-06	1.6

* The TAF is equal to the ratio of the variable trajectory X/Q to the straight-line X/Q. See ODCM Section 7.8.4 for a full explanation.

Table 7.4
DOSE FACTORS FOR SUBMERSION IN NOBLE GASES

	Submersion dose mrem/yr per µCi/m^3		Air dose mrad/yr per µCi/m^3	
	DFB_i	DFS_i	$DF_{\gamma i}$	$DF_{\beta i}$
Kr-83m	7.56E-02	---	1.93E+01	2.88E+02
Kr-85m	1.17E+03	1.46E+03	1.23E+03	1.97E+03
Kr-85	1.61E+01	1.34E+03	1.72E+01	1.95E+03
Kr-87	5.92E+03	9.73E+03	6.17E+03	1.03E+04
Kr-88	1.47E+04	2.37E+03	1.52E+04	2.93E+03
Kr-89	1.66E+04	1.01E+04	1.73E+04	1.06E+04
Kr-90	1.56E+04	7.29E+03	1.63E+04	7.83E+03
Xe-131m	9.15E+01	4.76E+02	1.56E+02	1.11E+03
Xe-133m	2.51E+02	9.94E+02	3.27E+02	1.48E+03
Xe-133	2.94E+02	3.06E+02	3.53E+02	1.05E+03
Xe-135m	3.12E+03	7.11E+02	3.36E+03	7.39E+02
Xe-135	1.81E+03	1.86E+03	1.92E+03	2.46E+03
Xe-137	1.42E+03	1.22E+04	1.51E+03	1.27E+04
Xe-138	8.83E+03	4.13E+03	9.21E+03	4.75E+03
Ar-41	8.84E+03	2.69E+03	9.30E+03	3.28E+03

Reference:
Regulatory Guide 1.109, Table B-1.

Table 7.5
SECTOR ELEMENTS CONSIDERED FOR POPULATION DOSES

Range of Sector Element	Midpoint of Sector Element
Site boundary - 1 mile	0.8 mile
1 - 2 miles	1.5 miles
2 - 3 miles	2.5 miles
3 - 4 miles	3.5 miles
4 - 5 miles	4.5 miles
5 - 10 miles	7.5 miles
10 - 20 miles	15 miles
20 - 30 miles	25 miles
30 - 40 miles	35 miles
40 - 50 miles	45 miles

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

Table 7.6
POPULATION WITHIN EACH SECTOR ELEMENT

	Sector Midpoint (miles)									
	0.8	1.5	2.5	3.5	4.5	7.5	15	25	35	45
N	0	0	10	0	0	525	1555	255	1315	3165
NNE	0	0	30	10	20	145	7160	20470	8210	710
NE	0	5	80	80	30	510	1685	11030	18435	50310
ENE	0	10	25	55	60	320	1565	9170	22540	127910
E	0	0	10	35	35	350	9160	5270	5385	9050
ESE	5	5	10	50	115	480	2730	11230	2360	90
SE	0	0	30	60	55	580	27185	11770	1520	3575
SSE	0	5	20	55	35	745	3430	3955	3590	6285
S	0	35	50	25	160	2120	1480	26825	62715	5695
SSW	10	15	10	50	25	660	1225	6905	9245	117530
SW	10	10	10	20	0	380	2830	5605	24005	134905
WSW	15	20	65	40	35	810	11945	940	11575	7220
W	10	10	10	40	45	470	520	4700	1380	890
WNW	5	40	20	80	75	180	705	3035	2920	15770
NW	0	15	45	95	145	1940	635	1995	4620	5355
NNW	0	0	0	75	25	1730	720	18290	3575	3320

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

Table 7.7 (1 of 8)
INHALATION DOSE FACTORS
(mrem/pCi inhaled)

ADULT

	bone	liver	t body	thyroid	kidney	lung	gi-lli
H-3	1.58E-07	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	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-69	4.23E-12	8.14E-12	5.65E-13	0.00E+00	5.27E-12	1.15E-07	2.04E-09
Zn-69m	1.02E-09	2.45E-09	2.24E-10	0.00E+00	1.48E-09	2.38E-06	1.71E-05
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	1.24E-02	0.00E+00	7.62E-04	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
Nb-97	2.78E-11	7.03E-12	2.56E-12	0.00E+00	8.18E-12	3.00E-07	3.02E-08
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
Ag-110m	1.35E-06	1.25E-06	7.43E-07	0.00E+00	2.46E-06	5.79E-04	3.78E-05
Sb-124	3.90E-06	7.36E-08	1.55E-06	9.44E-09	0.00E+00	3.10E-04	5.08E-05

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

Table 7.7 (2 of 8)
INHALATION DOSE FACTORS
(mrem/pCi inhaled)

ADULT

	bone	liver	t body	thyroid	kidney	lung	gi-lli
Sb-125	6.67E-06	7.44E-08	1.58E-06	6.75E-09	0.00E+00	2.18E-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
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	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-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
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

Reference:

Regulatory Guide 1.109, Table E-7.

Dose Factors for Co-57, Zn-69m, Br-82, Nb-97, Sb-124 and Sb-125 are from NUREG-0172 Age Specific Radiation Dose Commitment Factors for a One Year Chronic Intake, November 1977, Table 8.

NOTE: The tritium dose factor for bone is assumed to be equal to the total body dose factor.

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

Table 7.7 (3 of 8)
INHALATION DOSE FACTORS
(mrem/pCi inhaled)

TEEN

	bone	liver	t body	thyroid	kidney	lung	gi-lli
H-3	1.59E-07	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-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-69	6.04E-12	1.15E-11	8.07E-13	0.00E+00	7.53E-12	1.98E-07	3.56E-08
Zn-69m	1.44E-09	3.39E-09	3.11E-10	0.00E+00	2.06E-09	3.92E-06	2.14E-05
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	1.35E-02	0.00E+00	8.35E-04	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
Nb-97	3.92E-11	9.72E-12	3.55E-12	0.00E+00	1.14E-11	4.91E-07	2.71E-07
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
Ag-110m	1.73E-06	1.64E-06	9.99E-07	0.00E+00	3.13E-06	8.44E-04	3.41E-05
Sb-124	5.38E-06	9.92E-08	2.10E-06	1.22E-08	0.00E+00	4.81E-04	4.98E-05

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

Table 7.7 (4 of 8)
INHALATION DOSE FACTORS
(mrem/pCi inhaled)

TEEN

	bone	liver	t body	thyroid	kidney	lung	gi-lli
Sb-125	9.23E-06	1.01E-07	2.15E-06	8.80E-09	0.00E+00	3.42E-04	1.24E-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-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-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
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

Reference:

Regulatory Guide 1.109, Table E-8.

Dose Factors for Co-57, Zn-69m, Br-82, Nb-97, Sb-124 and Sb-125 are from NUREG-0172 Age Specific Radiation Dose Commitment Factors for a One Year Chronic Intake, November 1977, Table 8.

NOTE: The tritium dose factor for bone is assumed to be equal to the total body dose factor.

Table 7.7 (5 of 8)
INHALATION DOSE FACTORS
(mrem/pCi inhaled)

CHILD

	bone	liver	t body	thyroid	kidney	lung	gi-lli
H-3	3.04E-07	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	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-69	1.81E-11	2.61E-11	2.41E-12	0.00E+00	1.58E-11	3.84E-07	2.75E-06
Zn-69m	4.26E-09	7.28E-09	8.59E-10	0.00E+00	4.22E-09	7.36E-06	2.71E-05
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	2.73E-02	0.00E+00	1.74E-03	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
Nb-97	1.16E-10	2.08E-11	9.74E-12	0.00E+00	2.31E-11	9.23E-07	7.52E-06
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
Ag-110m	4.56E-06	3.08E-06	2.47E-06	0.00E+00	5.74E-06	1.48E-03	2.71E-05
Sb-124	1.55E-05	2.00E-07	5.41E-06	3.41E-08	0.00E+00	8.76E-04	4.43E-05

Table 7.7 (6 of 8)
INHALATION DOSE FACTORS
(mrem/pCi inhaled)

CHILD

	bone	liver	t body	thyroid	kidney	lung	gi-lli
Sb-125	2.66E-05	2.05E-07	5.59E-06	2.46E-08	0.00E+00	6.27E-04	1.09E-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-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-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
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

Reference:

Regulatory Guide 1.109, Table E-9.

Dose Factors for Co-57, Zn-69m, Br-82, Nb-97, Sb-124 and Sb-125 are from NUREG-0172 Age Specific Radiation Dose Commitment Factors for a One Year Chronic Intake, November 1977, Table 8.

NOTE: The tritium dose factor for bone is assumed to be equal to the total body dose factor.

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

Table 7.7 (7 of 8)
INHALATION DOSE FACTORS
(mrem/pCi inhaled)

INFANT

	bone	liver	t body	thyroid	kidney	lung	gi-lli
H-3	4.62E-07	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	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-69	3.85E-11	6.91E-11	5.13E-12	0.00E+00	2.87E-11	1.05E-06	9.44E-06
Zn-69m	8.98E-09	1.84E-08	1.67E-09	0.00E+00	7.45E-09	1.91E-05	2.92E-05
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	2.92E-02	0.00E+00	1.85E-03	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
Nb-97	2.44E-10	5.21E-11	1.88E-11	0.00E+00	4.07E-11	2.37E-06	1.92E-05
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-04	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
Ag-110m	7.13E-06	5.16E-06	3.57E-06	0.00E+00	7.80E-06	2.62E-03	2.36E-05
Sb-124	2.71E-05	3.97E-07	8.56E-06	7.18E-08	0.00E+00	1.89E-03	4.22E-05

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

Table 7.7 (8 of 8)
INHALATION DOSE FACTORS
(mrem/pCi inhaled)

INFANT

	bone	liver	t body	thyroid	kidney	lung	gi-lli
Sb-125	3.69E-05	3.41E-07	7.78E-06	4.45E-08	0.00E+00	1.17E-03	1.05E-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-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-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
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

Reference:

Regulatory Guide 1.109, Table E-10.

Dose Factors for Co-57, Zn-69m, Br-82, Nb-97, Sb-124 and Sb-125 are from NUREG-0172 Age Specific Radiation Dose Commitment Factors for a One Year Chronic Intake, November 1977, Table 8.

NOTE: The tritium dose factor for bone is assumed to be equal to the total body dose factor.

Figure 7.1
GASEOUS EFFLUENT RELEASE POINTS

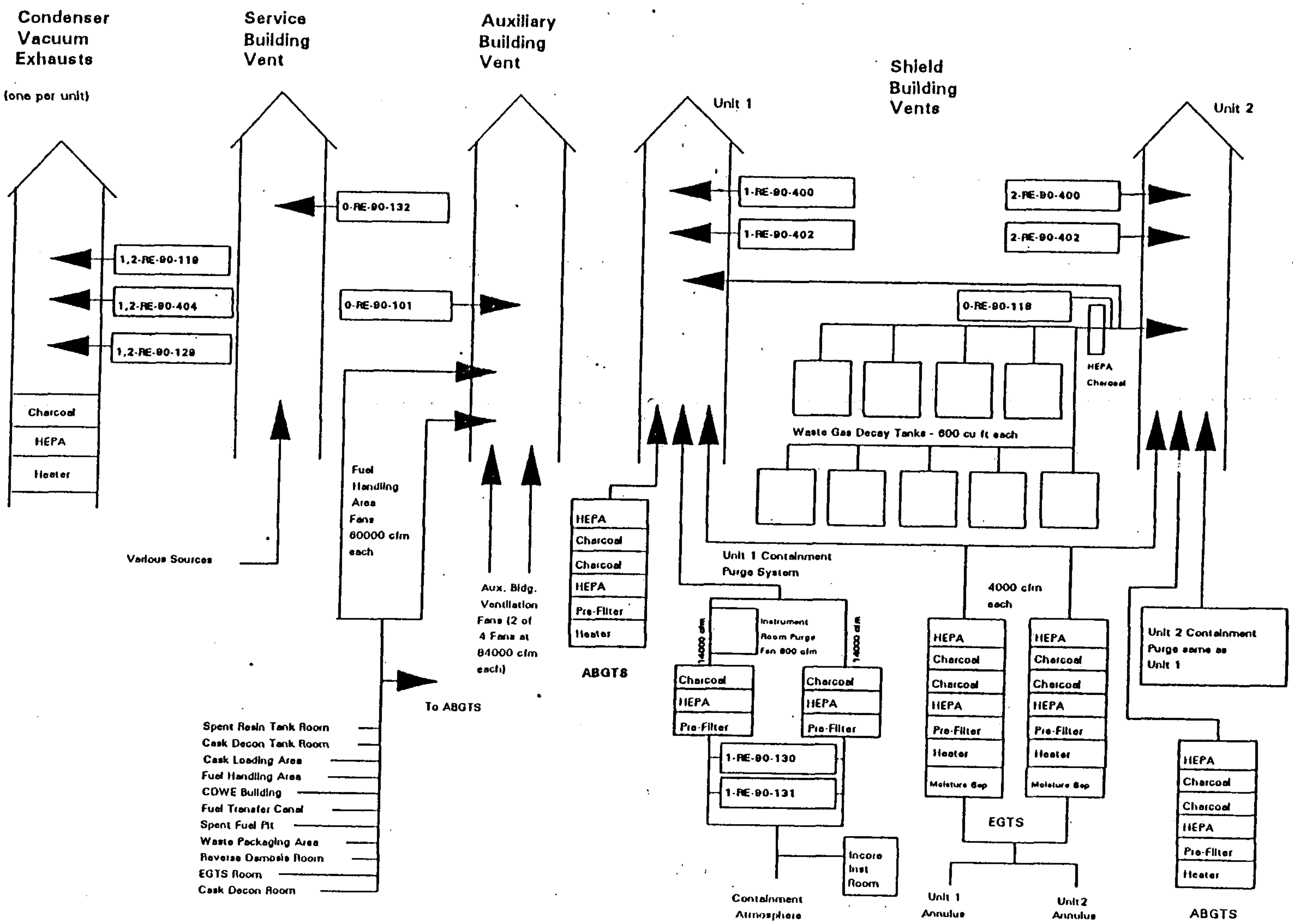


Figure 7.2
GASEOUS RADWASTE TREATMENT SYSTEM

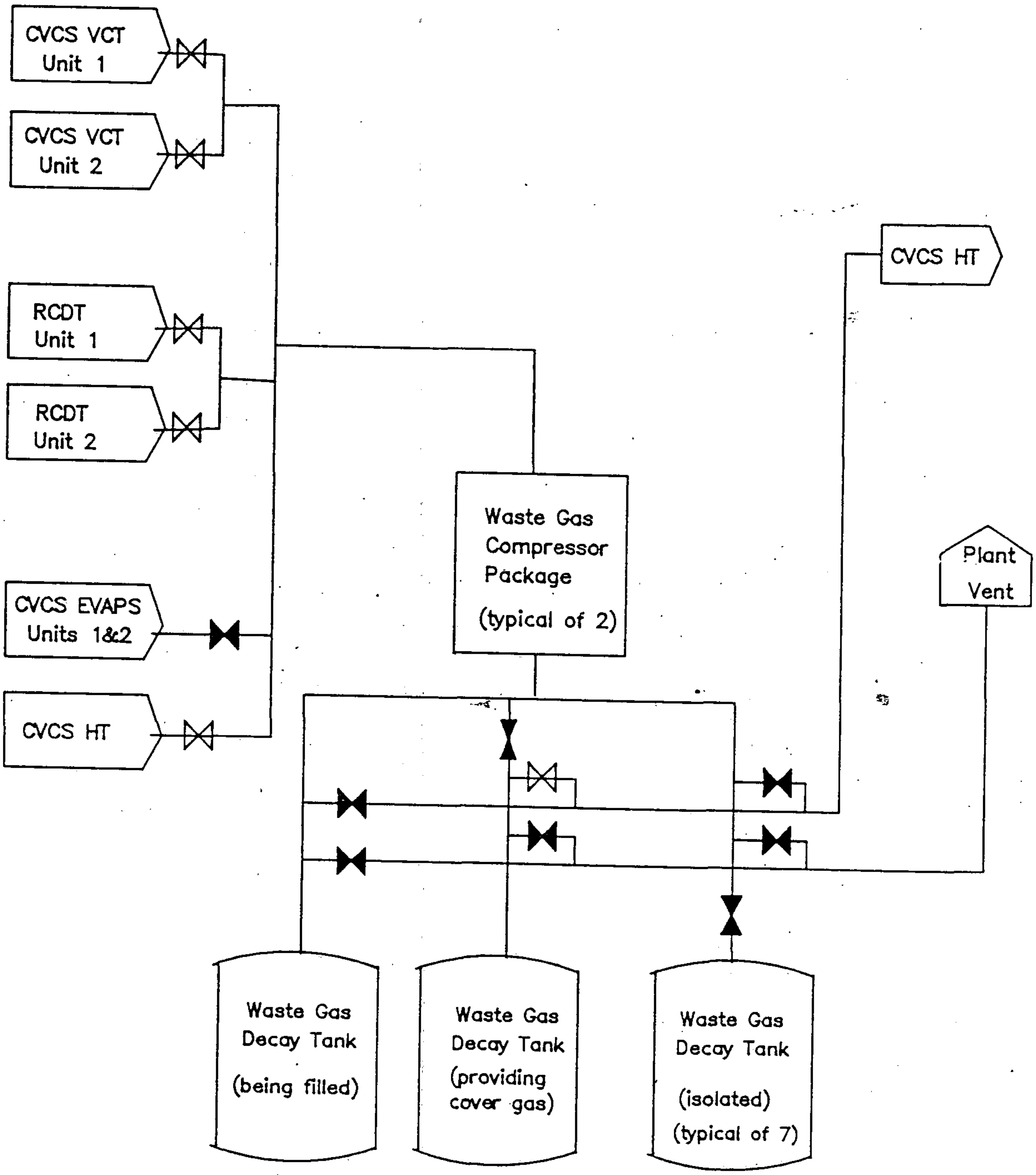


Figure 7.3
PLUME DEPLETION EFFECT FOR GROUND LEVEL RELEASES
(All Stability Classes)

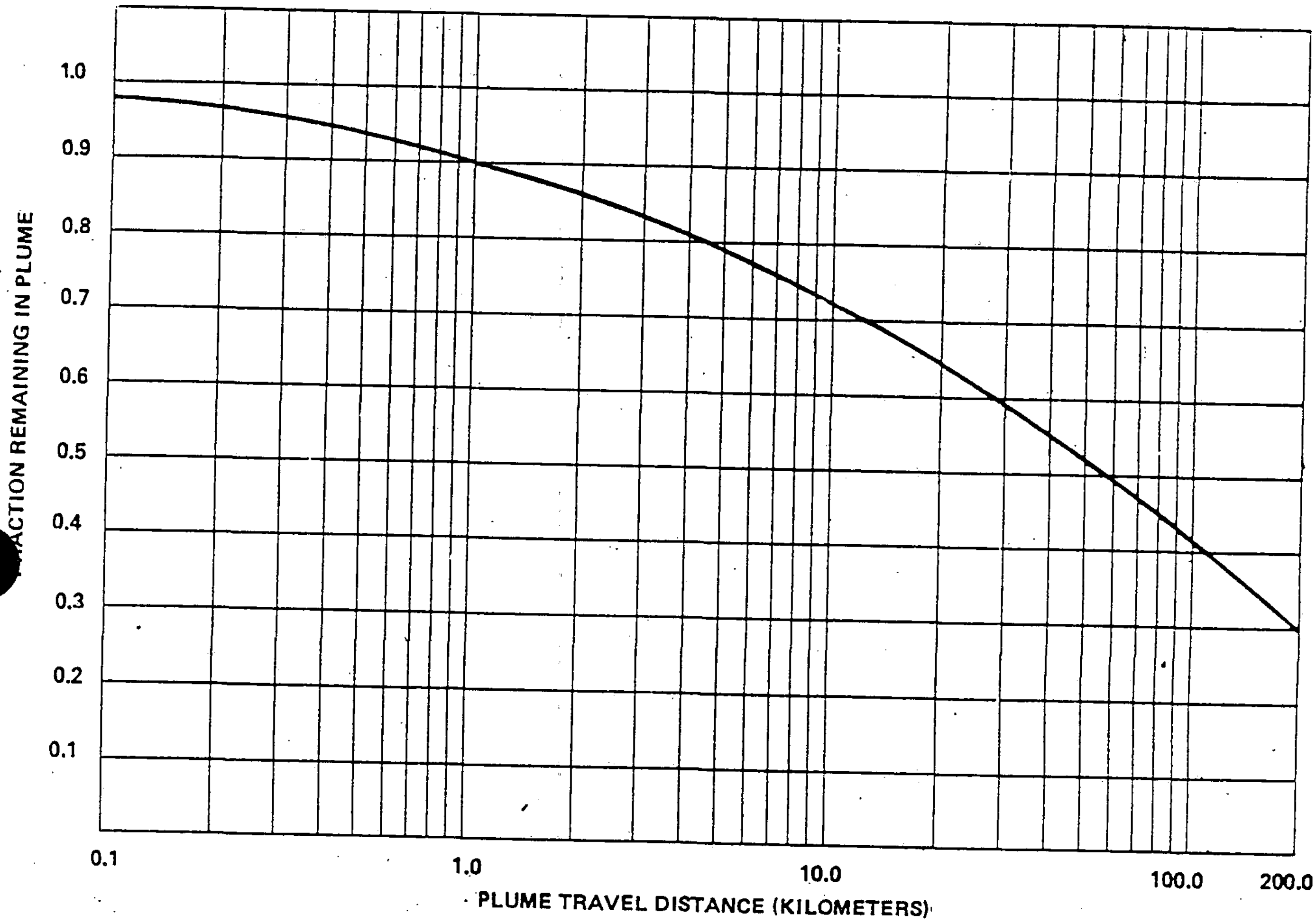


Figure 7.4
VERTICAL STANDARD DEVIATION OF MATERIAL IN A PLUME

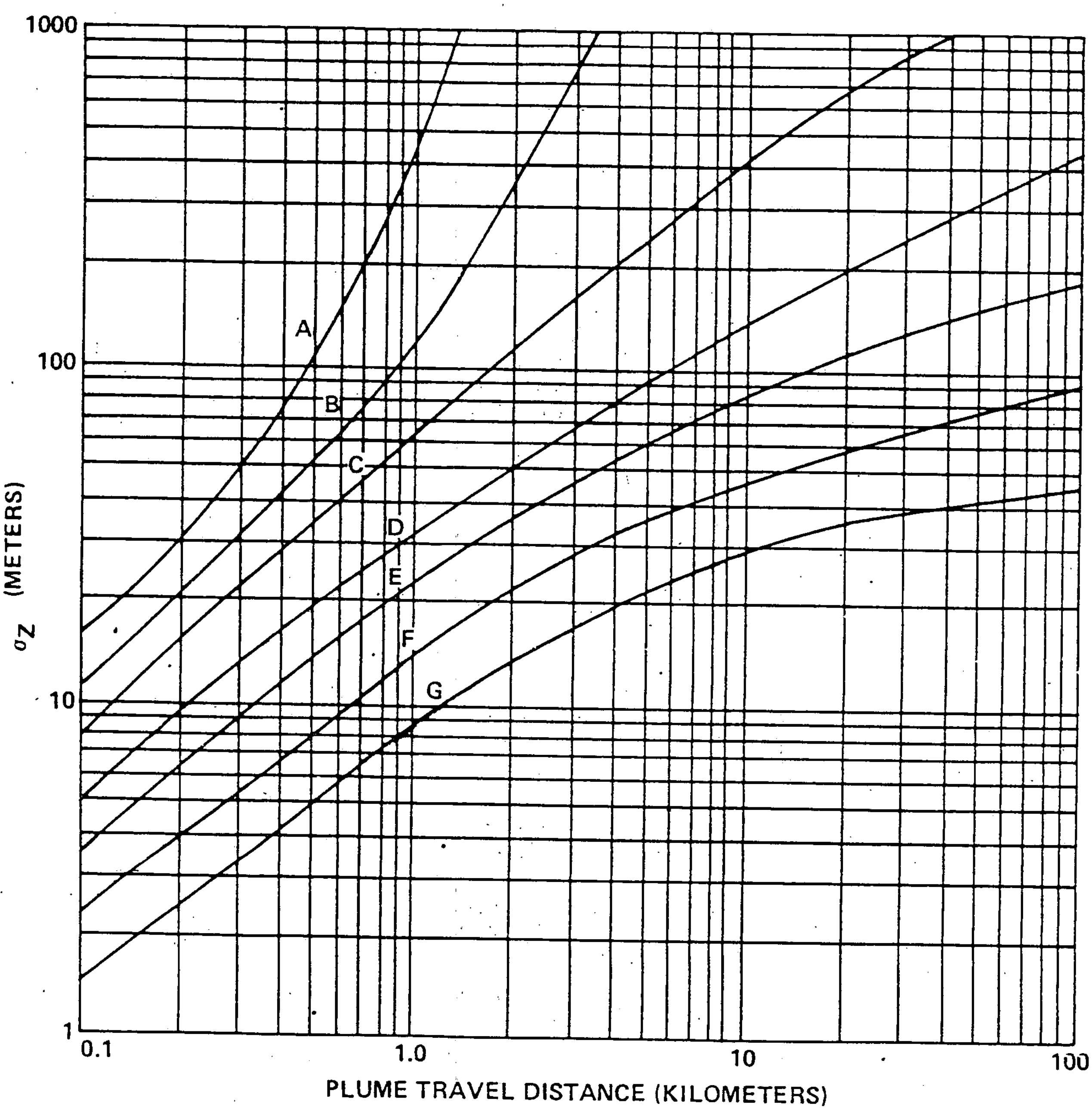
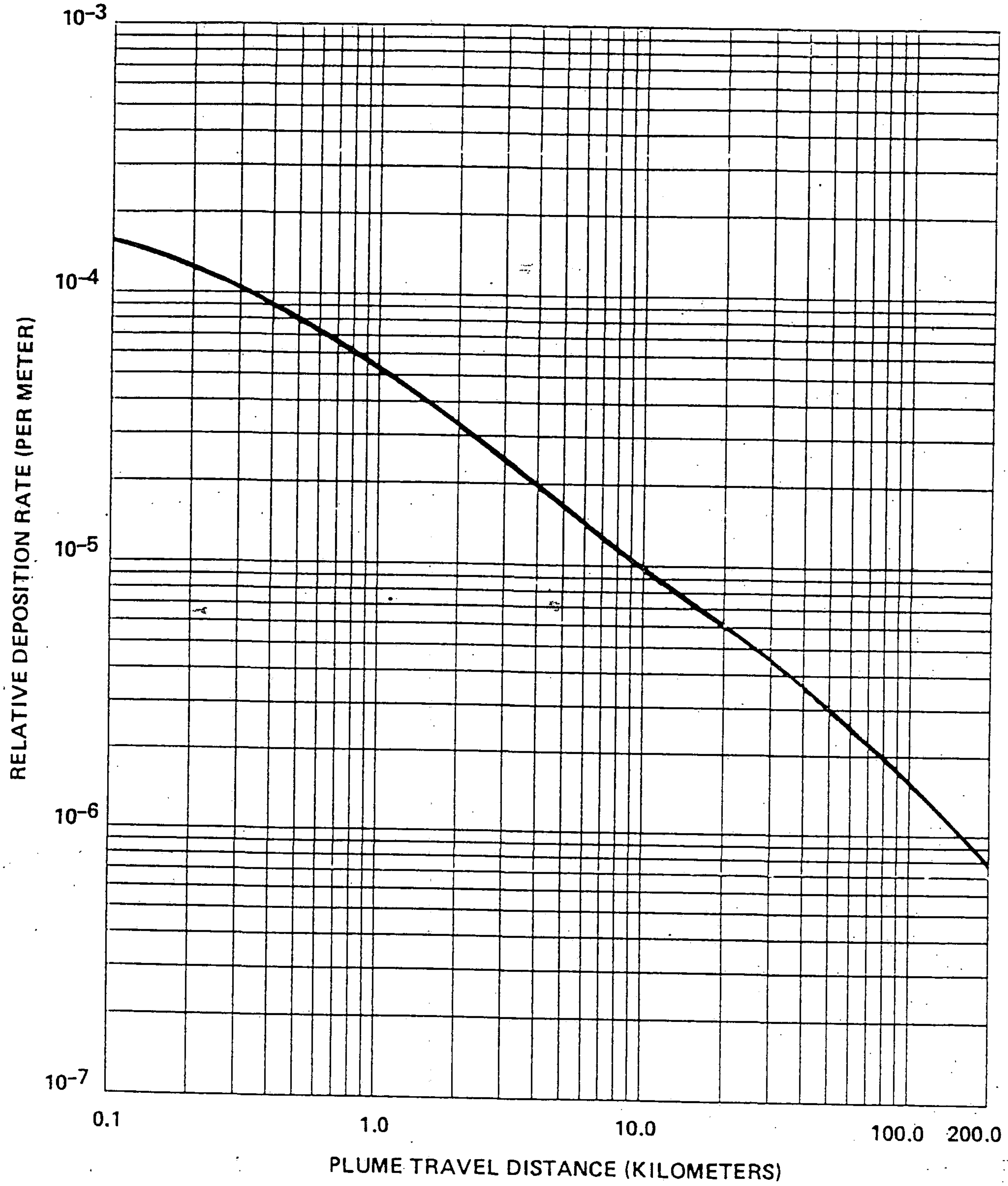


Figure 7.5
RELATIVE DEPOSITION FOR GROUND LEVEL RELEASES
(All Stability Classes)



SECTION 8.0

TOTAL DOSE

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

8.1 TOTAL MAXIMUM INDIVIDUAL DOSES

To determine compliance with 40 CFR 190 as required in ODCM Surveillance Requirement 2.2.3, the dose contributions to the maximum individual from WBN radioactive effluents and all other nearby uranium fuel cycle sources will be considered. The annual dose to the maximum individual will be conservatively estimated by first, summing the quarterly total body air submersion dose, the quarterly critical organ dose from gaseous effluents, the quarterly total body dose from liquid effluents, the quarterly critical organ dose from liquid effluents, and the direct radiation monitoring program, and then taking the sum for each quarter and summing over the four quarters.

SECTION 9.0

ENVIRONMENTAL MONITORING PROGRAM

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

9.1 MONITORING PROGRAM DESCRIPTION

An environmental radiological monitoring program shall be conducted in accordance with the above requirement. The monitoring program described in Tables 9.1, 9.2, and 9.3, and in Figures 9.1, 9.2 and 9.3 shall be conducted. Results of this program shall be reported in accordance with ODCM Administrative Control 5.1.

The atmospheric environmental radiological monitoring program shall consist of monitoring stations from which samples of air particulates and atmospheric radioiodine shall be collected.

The terrestrial monitoring program shall consist of the collection of milk, soil, ground water, drinking water, and food crops. In addition, direct gamma radiation levels will be measured in the vicinity of the plant.

The reservoir sampling program shall consist of the collection of samples of surface water, sediment, clams (if available), and fish.

Deviations are permitted from the required sampling schedule if specimens are unobtainable due to hazardous conditions, sample unavailability, or to malfunction of sampling equipment. If the latter, every effort shall be made to complete corrective action prior to the end of the next sampling period.

9.2 DETECTION CAPABILITIES

Analytical techniques shall be such that the detection capabilities listed in Table 2.3-3 are achieved.

9.3 LAND USE CENSUS

A land use survey shall be conducted in accordance with the requirements above. The results of the survey shall be reported in the Annual Radiological Environmental Operating Report.

9.4 INTERLABORATORY COMPARISON PROGRAM

Analyses shall be performed on radioactive materials supplied as part of an Interlaboratory Comparison Program which has been approved by the NRC. A summary of the results obtained in the intercomparison shall be included in the Annual Radiological Environmental Operating Report (or the EPA program code designation may be provided).

If analyses are not performed as required corrective actions taken to prevent a recurrence shall be reported in the Annual Radiological Environmental Operating Report.

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

Table 9.1 (1 of 4)
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway and/or Sample	Sample Locations*	Sampling and Collection Frequency	Type and Frequency of Analysis
AIRBORNE			
Particulates	4 samples from locations (in different sectors) at or near the site boundary (LM-1,2,3,and 4) 4 samples from communities approximately 6-10 miles distance from the plant. (PM-2,3,4,and 5) 2 samples from control locations greater than 10 miles from the plant (RM-2 and 3)	Continuous sampler operation with sample collection once per 7 days (more frequently if required by dust loading)	Analyze for gross beta radioactivity ≥ 24 hours following filter change. Perform gamma isotopic analysis on each sample if gross beta > 10 times that of control sample. Composite at least once per 31 days (by location) for gamma scan.
Radioiodine	Samples from same location as air particulates.	Continuous sampler operation with filter collection once per 7 days	I-131 at least once per 7 days
Soil	Samples from same locations as air particulates	Once per year	Gamma scan, Sr-89, Sr-90 once per year
DIRECT RADIATION	2 or more dosimeters placed at locations (in different sectors) at or near the site boundary in each of the 16 sectors. 2 or more dosimeters placed at stations located approximately 5 miles from the plant in each of the 16 sectors	Once per 92 days	Gamma dose at least once per 92 days

* Sample locations are listed in Tables 9.2 and 9.3 and shown on Figures 9.1, 9.2 and 9.3

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

Table 9.1 (2 of 4)
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway and/or Sample	Sample Locations*	Sampling and Collection Frequency	Type and Frequency of Analysis
DIRECT RADIATION (continued)	2 or more dosimeters in at least 8 additional locations of special interest, including at least 2 control stations.		
WATERBORNE			
Surface	TRM 529.3 TRM 523.1 TRM 517.9	Collected by automatic sequential-type sampler** with composite samples collected at least once per 31 days	Gamma scan of each composite sample. Composite for H-3 analysis at least once per 92 days
Ground	1 sample adjacent to plant (location W-1) 1 sample from ground water source up-gradient	At least once per 92 days	Gross beta and gamma scan, Sr-89 Sr-90 and H-3 an-analysis at least once per 92 days
Drinking	1 sample at the first potable surface water supply downstream from the plant (TRM 503.8) 1 sample at the next downstream potable surface water supplier (greater than 10 miles downstream) (TRM 473.0) 1 sample at control location (TRM 529.3)***	Collected by automatic sequential type sampler** with composite sample collected at least once per 31 days	Gross beta and gamma scan of each composite sample. Composite for H-3 Sr-89, Sr-90 at least once per 92 days.

* Sample locations are listed in Tables 9.2 and 9.3 and shown on Figures 9.1, 9.2 and 9.3

** Samples shall be collected by collecting an aliquot at intervals not exceeding 2 hours.

*** The surface water sample collected at TRM 529.3 is considered a control for the raw drinking water sample.

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

Table 9.1 (3 of 4)
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway and/or Sample	Sample Locations*	Sampling and Collection Frequency	Type and Frequency of Analysis
WATERBORNE (continued)			
Sediment	TRM 532.1, TRM 527.4 TRM 518.0, TRM 496.5	At least once per 184 days	Gamma scan of each sample.
Shoreline	TRM 513, TRM 530.2	At least once per 184 days	Gamma scan of each sample.
INGESTION			
Milk	1 sample from milk producing animals in each of 1-3 areas indicated by the cow census where doses are calculated to be highest. If samples are not available from a milk animal location, doses to that area may be estimated by projecting the doses from concentrations detected in milk from other sectors or samples of vegetation may be taken monthly where milk is not available At least 1 sample from a control location	At least once per 15 days	Gamma isotopic and I-131 analysis of each sample. Sr-89 Sr-90 once per quarter
Fish	1 sample each from Chickamauga and Watts Bar Reservoirs	At least once per 184 days. One sample of each of the following species: Channel Catfish Crappie Smallmouth Buffalo	Gamma scan on edible portion

* Sample locations are listed in Tables 9.2 and 9.3 and shown on Figures 9.1, 9.2 and 9.3

Table 9.1 (4 of 4)
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway and/or Sample	Sample Locations*	Sampling and Collection Frequency	Type and Frequency of Analysis
INGESTION (continued)			
Invertebrates (Asiatic Clams)	1 sample downstream from plant discharge** 1 sample upstream from the plant**	At least once per 184 days	Gamma scan on edible portion
Food Products	1 sample each of principal food products grown at private gardens and/or farms in the immediate vicinity of the plant	At least once per 365 days at time of harvest. The types of foods available for sampling will vary. Following is a list of typical foods which may be available: Cabbage and/or Lettuce Corn Green Beans Potatoes Tomatoes	Gamma scan on edible portion
Vegetation	Samples from farms producing milk but not providing a milk sample or from 1 to 2 farms (Farms L, S)	At least once per 31 days	I-131 and gamma scan at least once per 31 days. Sr-89, Sr-90 analysis at least once per 92 days.

* Sample locations are listed in Tables 9.2 and 9.3 and shown on Figures 9.1, 9.2 and 9.3

** No permanent stations established. Locations depend on availability of clams.

OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

Table 9.2 (1 of 2)
ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM SAMPLING LOCATIONS

Map Location Number [a]	Station	Sector	Approximate Distance (Miles)	Indicator (I) or Control (C)	Samples Collected[b]
2	PM-2	NW	7.0	I	AP,CF,S
3	PM-3	NNE	10.4	I	AP,CF,S
4	PM-4	NE/ENE[c]	7.6	I	AP,CF,S
5	PM-5	S	6.2	I	AP,CF,S
6	RM-2	SW	15.0	C	AP,CF,S
7	RM-3	NNW	15.0	C	AP,CF,S
8	LM-1	SSW	0.5	I	AP,CF,S
9	LM-2	N	0.5	I	AP,CF,S
10	LM-3	NNE	1.9	I	AP,CF,S
11	LM-4	SE	0.9	I	AP,CF,S
12	Farm L	SSW	1.3	I[d]	M,V,W
15	Farm B	E	15.0	C	M
16	Farm C	SSW	16.0	C	M
17	Farm S	SW	19.5	C	M,V
18	Well #1	S	0.6	I	W
19	Farm Mu	ESE	3.7	I	M
25	TRM 517.9	-	9.9[e]	I	SW
25a	TRM 518.0	-	9.8[e]	I	SD
26	TRM 523.1	-	4.7[e]	I	SW
27	TRM 529.3	-	1.5[e]	C	SW, PW[f]
28	TRM 532.1	-	4.3[e]	C	SD
29	TRM 527.4	-	0.4[e]	I	SD
31	TRM 473.0 (C.F. Industries)	-	54.8[e]	I	PW
32	TRM 513.0	-	14.8[e]	I	SS
33	TRM 530.2	-	2.4[e]	I	SS
35	TRM 503.8 (Dayton)	-	24.0[e]	I	PW
36	TRM 496.5	-	31.3[e]	I	SD
38	TRM 471-530 (Chickamauga Lake)	-	-	I	F,CL
39	TRM 530-602 (Watts Bar Lake)	-	-	C	F
40	Watts Bar Reservation	N	1-2	C	PW
74	Piney River Mile 5.7	-	7.6[e]	C	PW

Table 9.2 (2 of 2)
ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM SAMPLING LOCATIONS
TABLE NOTATION

a See Figures 9.1, 9.2, and 9.3

b Sample codes:
AP = Air particulate filter
CF = Charcoal Filter
CL = Clams
F = Fish
S = Soil
M = Milk
PW = Public Water
SD = Sediment
SS = Shoreline Sediment
SW = Surface Water
V = Vegetation
W = Well Water

c Station located on boundary between these sectors

d A control for well water

e Distance from plant discharge (TRM 527.8)

f The surface water sample collected at TRM 529.3 is considered a control for the raw drinking water sample.

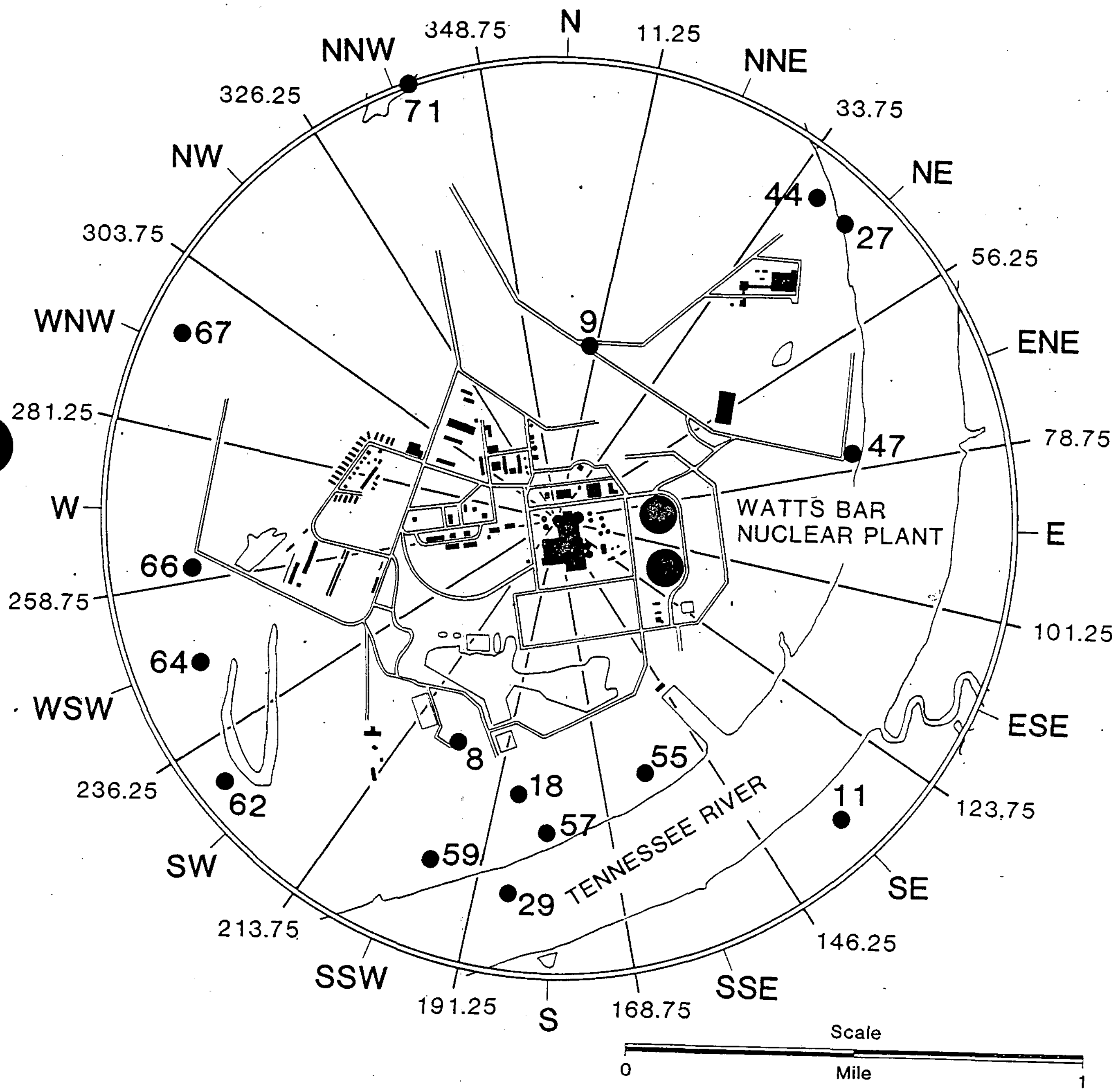
OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

Table 9.3
THERMOLUMINESCENT DOSIMETRY LOCATIONS

Map Location Number	Station	Sector	Approximate Distance (Miles)	Onsite (On)[a] or Offsite (Off)
2	NW-3	NW	7.0	Off
3	NNE-3	NNE	10.4	Off
4	ENE-3	ENE	7.6	Off
5	S-3	S	6.2	Off
6	SW-3	SW	15.0	Off
7	NNW-4	NNW	15.0	Off
10	NNE-1A	NNE	1.9	On
11	SE-1A	SE	0.9	On
12	SSW-2	SSW	1.3	On
14	W-2	W	4.8	Off
15	E-3	E	15.0	Off
40	N-1	N	1.2	On
41	N-2	N	4.7	Off
42	NNE-1	NNE	1.2	On
43	NNE-2	NNE	4.1	Off
44	NE-1	NE	0.9	On
45	NE-2	NE	2.9	Off
46	NE-3	NE	6.1	Off
47	ENE-1	ENE	0.7	On
48	ENE-2	ENE	5.8	Off
49	E-1	E	1.3	On
50	E-2	E	5.0	Off
51	ESE-1	ESE	1.2	On
52	ESE-2	ESE	4.4	Off
54	SE-2	SE	5.3	Off
55	SSE-1	SSE	0.6	On
56	SSE-2	SSE	5.8	Off
57	S-1	S	0.7	On
58	S-2	S	4.8	Off
59	SSW-1	SSW	0.8	On
60	SSW-3	SSW	5.0	Off
62	SW-1	SW	0.8	On
63	SW-2	SW	5.3	Off
64	WSW-1	WSW	0.9	On
65	WSW-2	WSW	3.9	Off
66	W-1	W	0.9	On
67	WNW-1	WNW	0.9	On
68	WNW-2	WNW	4.9	Off
69	NW-1	NW	1.1	On
70	NW-2	NW	4.7	Off
71	NNW-1	NNW	1.0	On
72	NNW-2	NNW	4.5	Off
73	NNW-3	NNW	7.0	Off

[a]TLDs designated onsite are those located two miles or less from the plant. TLDs designated offsite are those located more than two miles from the plant.

Figure 9.1
ENVIRONMENTAL MONITORING LOCATIONS
WITHIN ONE MILE OF THE PLANT



OFFSITE DOSE CALCULATION/ENVIRONMENTAL MONITORING METHODOLOGIES

Figure 9.2
ENVIRONMENTAL MONITORING LOCATIONS
FROM ONE TO FIVE MILES FROM THE PLANT

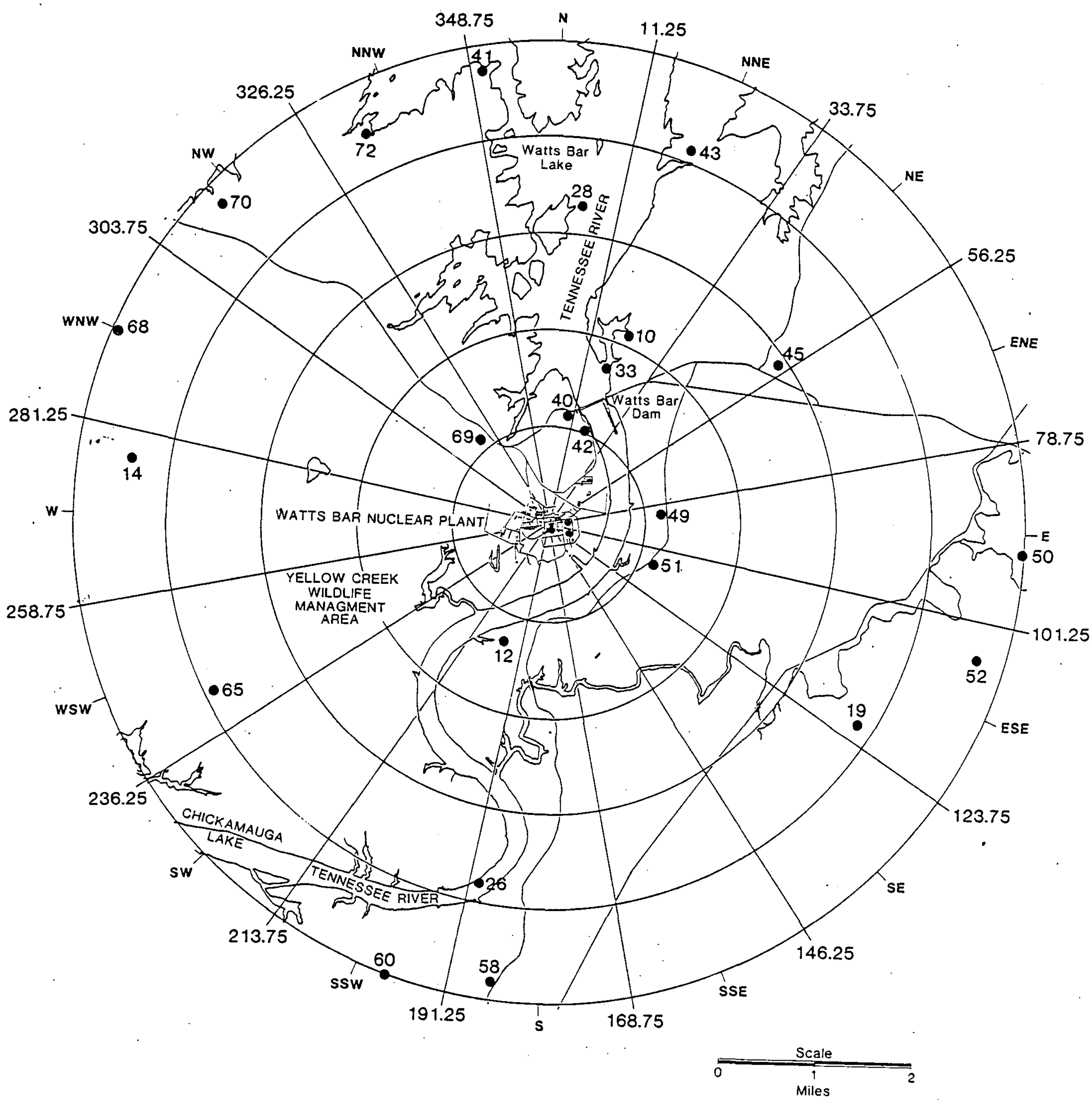
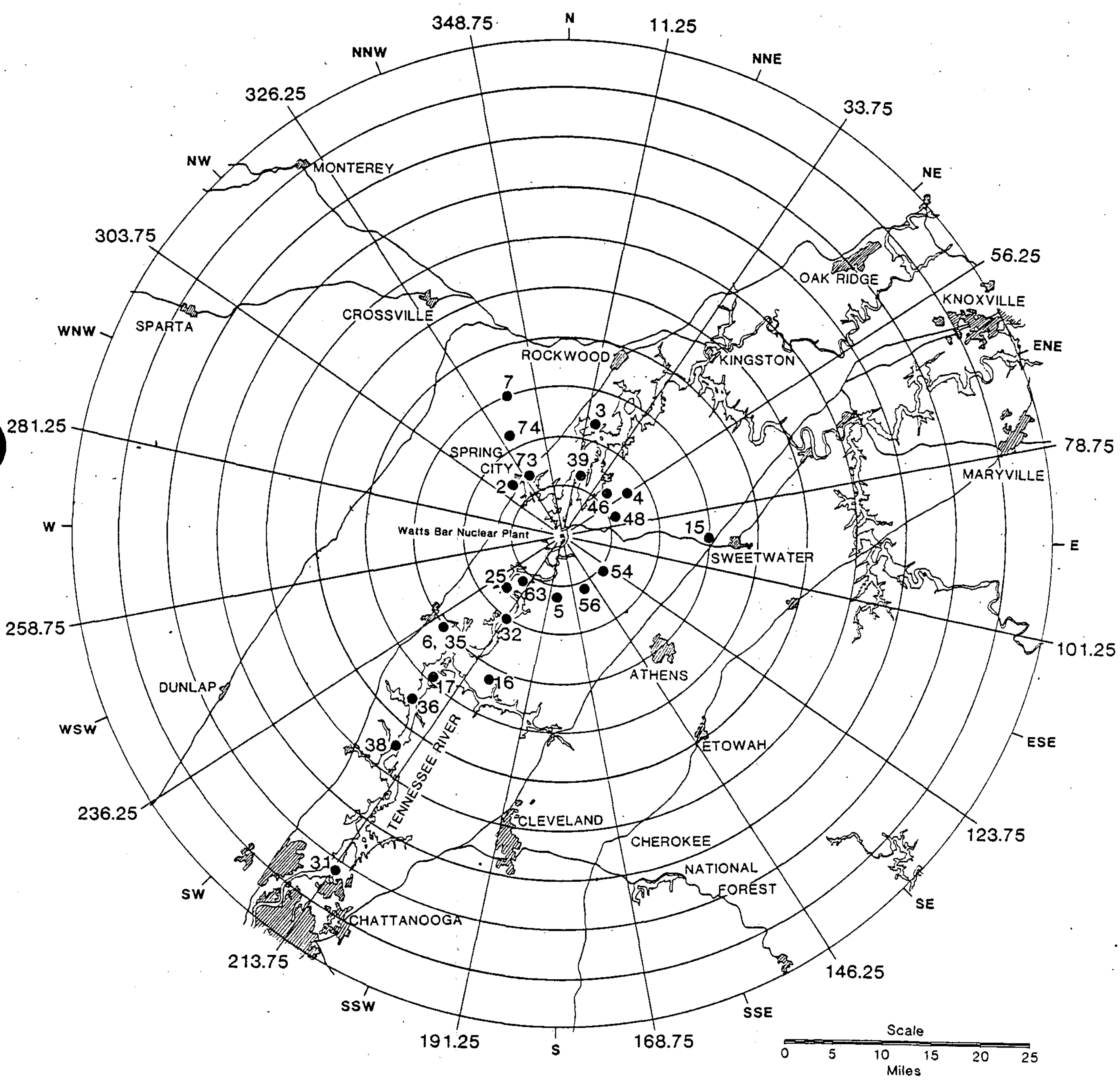


Figure 9.3
ENVIRONMENTAL MONITORING LOCATIONS
GREATER THAN FIVE MILES FROM THE PLANT



Review of WBN ODCM vs. NUREG-1301 "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors," Generic Letter 89-01, Supplement 1, April 1991.

1. NUREG-1301 includes Controls 3.0.3 and 3.0.4 in the Applicability Section. These Controls have not been included in the WBN ODCM because the requirements relocated from TS included statements taking exception to LCOs 3.0.3 and 3.0.4. Since all of the relocated TS had this statement, the Controls have been deleted along with the statements taking exception to Controls 3.0.3 and 3.0.4.

   Controls 1.0.1 and 1.0.2 and Surveillance Requirements 2.0.1-2.0.4 have been replaced by a the most recent WBN LCOs 3.0.1 and 3.0.2 and SRs 3.0.1-3.0.4. This has been done to ensure consistency between the WBN TS and the WBN ODCM.

2. Control 1/2.1.1 NUREG-1301 lists the applicability for liquid monitoring instrumentation operability as "At all times". Applicability for WBN liquid effluent instrumentation is defined in Table 1.1-1. WBN is asking for the flexibility to only require that only the discharge monitors (those monitors which are the last to monitor the liquid effluents prior to discharge to the river) always be operable. Other monitors will need to be operable only when releases are being made through those systems.

   Tank Level Indication Devices are excluded from the WBN ODCM. They will be required by the Explosive Gas and Storage Tank Radioactivity Monitoring Program required by WBN TS.

3. Control 1/2.1.2 Tables 1.1-2 and 2.1-2 require that both Unit 1 and 2 Shield Building Exhaust monitors must meet operability requirements to operate either unit. This is because releases from the either unit may exit from either unit's Shield Building Vent.

4. Control 1/2.1.3 WBN is placing the meteorological monitoring requirements in the ODCM.

5. Control 1/2.2.1.1 Table 2.2-1, the requirements for sampling of continuous liquid release pathways (TBS and SGBD) are for daily grab samples rather than a continuous sampler. This is consistent with the requirements for SQN for the same points.

Review of WBN ODCM vs. NUREG-1301 "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors," Generic Letter 89-01, Supplement 1, April 1991.

5. Control 1/2.2.1.1 (continued) Table 2.2-1, the definition of a composite liquid effluent sample is somewhat different than that given in NUREG-1301 (WBN will be creating the composite in the lab from the grab samples, the NUREG is referring to a composite sample from a continuous sampler).

   Footnote 6 is added to Table 2.2-1 to require that the continuous liquid release points be sampled only if primary to secondary leakage is identified. This is consistent with requirements in the SQN effluent control program.

6. Control 1/2.2.2.1

   a. Table 2.2-2 requires sampling of containment purge and vent following shutdown, startup, or a thermal power change exceeding 15% of RATED THERMAL POWER within a 1 hour period. This is consistent with the NUREG, but WBN goes further to state that this does not need to be done if analysis shows that the DEI has not increased by a factor of 3 or more, AND if the containment noble gas monitor does not show an increase of a factor of 3 or more. This is consistent with the requirements in the SQN effluent control program.

   b. Table 2.2-2, Footnote 8 details applicability and timing requirements for sampling of the containment for purges. This note is consistent with one in the SQN ODCM, except that MODE requirements and times are different.

   c. Table 2.2-2, Footnote 9 details applicability requirements for sampling of the containment for venting. This note is consistent with one in the SQN ODCM, but details are different.

   d. Table 2.2-1, Footnote 10 excludes the Shield Building Exhaust from the monthly requirement for grab sampling to analyze for noble gas and tritium, since all releases through this point will have been quantified previously.

   e. Table 2.2-1, Footnote 11 excludes the Condenser Vacuum Exhaust from the requirements for sampling until a primary to secondary leak in identified.

   f. Table 2.2-1, Footnote 13 limits the principle gamma emitters for grab samples to the noble gas nuclides only to clarify that particulate releases are quantified from filter analyses.

Review of WBN ODCM vs. NUREG-1301 "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors," Generic Letter 89-01, Supplement 1, April 1991.

7. Control 1/2.3.1

a. Table 2.3-1 - the drinking water control sample location is defined in footnote 9 to be the upstream surface water sample.

b. Requirements for drinking water sample analysis differ from the NUREG. Due to the large downstream distance of the first public water supply (> 10 miles) and the volume of dilution water available, doses due to water ingestion will ve very low under normal circumstances. This situation applies at both SQN and BFN and is reflected in their Environmental Monitoring Programs.

c. Text is added to Table 2.3-1 footnote 8 to state that the hydraulic gradient of the groundwater at the WBN site is such that the groundwater will move from the site toward the river, therefore groundwater sampling is not required.

d. Table 2.3-1 footnote 3 is added to clarify identification of control samples for iodine and particulate airborne monitoring.

8.. BASES 1/2.1.2 Additional wording is added to state that the sensitivity of noble gas monitors used to satisfy Control 1.2.2.1 (dose rate) will be sufficient to ensure that concentrations of 1E-06 µCi/cc can be measured.

9. BASES 1/2.1.3 Bases for the meteorological monitoring instrumentation Control are included in the ODCM.

10. BASES 1/2.2.1.1 An additional reference is given for further LLD discussion (ARH-SA-215, June 1975).

Allocation of activity between the reactor units for dose calculation purposes is discussed in more detail.

Text is added to explain that the dose for composited nuclides will be calculated using the values from the previous compositing period.

11. BASES 1/2.2.1.4 Allocation of activity between the reactor units for dose calculation purposes is discussed in more detail.

Review of WBN ODCM vs. NUREG-1301 "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors," Generic Letter 89-01, Supplement 1, April 1991.

12. BASES 1/2.2.2.1 An additional reference is given for further LLD discussion (ARH-SA-215, June 1975).

    Allocation of activity between the reactor units for dose calculation purposes is discussed in more detail.

13. BASES 1/2.2.2.2 Allocation of activity between the reactor units for dose calculation purposes is discussed in more detail.

14. BASES 1/2.2.2.4 Allocation of activity between the reactor units for dose calculation purposes is discussed in more detail.

15. BASES 1/2.3.1 An additional reference is given for further LLD discussion (ARH-SA-215, June 1975).

16. The definitions of Controlled Area, Member of the Public, Restricted area, Unrestricted area, and Site Boundary are not consistent with those given in NUREG-1301. This is due to the revision to 10 CFR 20 due to be implemented by TVA on 1/1/94. The definitions are consistent with that regulation and the new CONTROLLED AREA concept is discussed here for clarification of radiation protection boundaries vs effluent boundaries. Similar changes are made to the BASES sections to clarify the wording where these definitions are used. Figure 3.1 shows the locations of these boundaries and areas. A calculation is given in Section 7.2.4 for a member of the public inside the site boundary which demonstrates that the location of the site boundary on the opposite side of the Tennessee River will meet the intent of the regulation.

17. The Source Check definition is changed to reflect changes made in the definition for SQN (revision 27). The new definition will allow the use of internal test circuits in lieu of a radioactive source (some monitors at SQN and WBN use an LED light source to provide the check signal to the photomultiplier tube).

18. The COT Frequency for items 3.a, 3.b, and 3.c of Table 2.1-1 and 1.b, 2.d, 2.e, and 4.e of Table 2.1-2 has been changed to N.A. These items do not have an associated alarm, interlock, and/or trip setpoint, therefore a COT cannot be performed for these items.

19. Footnote 1 has been deleted from Items 1.b and 1.c of Table 2.1-1. Item 1.b and 1.c generate an automatic isolation on level above the alarm/trip setpoint, not instrument malfunction.

Review of WBN ODCM vs. NUREG-1301 "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors," Generic Letter 89-01, Supplement 1, April 1991.

20. The Applicability for Items 2.a and 2.e have been changed to MODES 1, 2, 3, and 4 because the system does not operate in MODES 5 and 6.

21. Some existing plant gaseous effluent monitoring channels have been removed from this revision to the ODCM to reflect current design plans which do not require these monitoring channels to meet ODCM requirements. Should these design plans not be implemented, the ODCM will be revised to include appropriate additonal monitoring channels reuqired to support effluent monitoring.

22. The CHANNEL CALIBRATION Frequency for Table 2.1-1 Instrument 3.b, Table 2.1-2 Instrument 2.e., and 4.c. has been changed from refueling to 5 years. This change is consistent with site practice.