Docket No. 50-245
50-336
50-423
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Attachment 2

Millstone Nuclear Power Station, Unit Nos. 1, 2, and 3

Radiological Effluent Monitoring and Offsite Dose Calculation Manual
(REMODCM) - 1999

April 2000

SECTION I

RADIOLOGICAL EFFLUENT

MONITORING MANUAL

FOR THE
MILLSTONE NUCLEAR POWER STATION
UNIT NOs. 1, 2, & 3

DOCKET NOs. 50-245, 50-336, 50-423

November 18, 1999
Revision 17

MILLSTONE STATION

RADIOLOGICAL EFFLUENT MONITORING MANUAL

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A. INTRODUCTION

The purpose of this manual is to provide the sampling and analysis programs which provide input to the ODCM for calculating liquid and gaseous effluent concentrations and offsite doses. Guidelines are provided for operating radioactive waste treatment systems in order that offsite doses are kept As-Low-As-Reasonably-Achievable (ALARA).

The *Radiological Environmental Monitoring Program* outlined within this manual provides confirmation that the measurable concentrations of radioactive material released as a result of operations at the Millstone Site are not higher than expected.

In addition, this manual outlines the information required to be submitted to the NRC in both the *Annual Radiological Environmental Operating Report* and the *Annual Radioactive Effluent Report.*

B. RESPONSIBILITIES

All changes to this manual shall be reviewed and approved by the Site Operations Review Committee prior to implementation.

All changes and their rationale shall be documented in the *Annual Radioactive Effluent Report.*

It shall be the responsibility of the Senior Vice President and CNO - Millstone to ensure that this manual is used in performance of the applicable surveillance requirements and administrative controls of the *Technical Specifications for Millstone Units 2 and 3.*

C. LIQUID EFFLUENTS

C.1 Liquid Effluent Sampling and Analysis Program

Radioactive liquid wastes shall be sampled and analyzed in accordance with the program specified in **Table C-1** for Millstone Unit No. 1, **Table C-2** for Millstone Unit No. 2, and **Table C-3** for Millstone Unit No. 3. The results of the radioactive analyses shall be input to the methodology of the ODCM to assure that the concentrations at the point of release are maintained within the limits of *Radiological Effluent Control (Section III) D.1.1* for Millstone Unit No. 1 and within *Technical Specification 3.11.1* for Millstone Unit Nos. 2 and 3.

Table C-1

MILLSTONE 1

RADIOACTIVE LIQUID WASTE SAMPLING AND ANALYSIS PROGRAM

Liquid Release Type	Sampling Frequency	Minimum Analysis Frequency	Type of Activity Analysis	Lower Limit of Detection (LLD)[A] (μCi/ml)
A. Batch Release[B] Waste Sample Tanks, Floor Drain Sample Tank and Decontamination Solution Tank	Prior to Each Batch	Prior to Each Batch	Principal Gamma Emitters[C]	5×10^{-7}
			I-131	1×10^{-6}
			Ce-144	5×10^{-6}
	Prior to Each Batch	Monthly Composite[E]	H-3	1×10^{-5}
			Gross alpha	1×10^{-7}
	Prior to Each Batch	Quarterly Composite[E]	Sr-89, Sr-90	5×10^{-8}
			Fe-55	1×10^{-6}
B. Continuous Release Reactor Building Service Water	Weekly Grab Sample[D]	Weekly Composite[E]	Principal Gamma Emitters[C]	5×10^{-7}
			I-131	1×10^{-6}
			Ce-144	5×10^{-6}
	Weekly Grab or Composite[E]	Monthly Composite[E]	H-3	1×10^{-5}
			Gross alpha[F]	1×10^{-7}
	Weekly Composite[E,F]	Quarterly Composite[E,F]	Sr-89[F], Sr-90[F]	5×10^{-8}
			Fe-55[F]	1×10^{-6}

TABLE C-1 (Cont'd.)

TABLE NOTATIONS

A. The LLD is the smallest concentration of radioactive material in a sample that will be detected with 95% probability with 5% probability of falsely concluding that a blank observation represents a "real" signal.

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

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

where:

LLD is the lower limit of detection as defined above (as μCi per unit mass or volume)

S_b is the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (as counts per minute)

E is the counting efficiency (as counts per transformation)

V is the sample size (in units of mass or volume)

2.22×10^6 is the number of transformations per minute per microcurie

Y is the fractional radiochemical yield (when applicable)

λ is the radioactive decay constant for the particular radionuclide

Δt is the elapsed time between midoint of sample collection and midpoint of counting time

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 an a posteriori (after the fact) limit for a particular measurement.

Analyses shall be performed in such a manner that the stated LLDs will be achieved under routine conditions. Occasionally background fluctuations, unavoidably small sample sizes, the presence of interfering nuclides, or other uncontrollable circumstances may render these LLDs unachievable. In such cases, the contributing factors will be identified and recorded on the analysis sheet for the particular sample.

B. A batch release is the discharge of liquid wastes of a discrete volume from the tanks listed in this table. Prior to the sampling, each batch shall be isolated and at least two tank/sump volumes shall be recirculated or equivalent mixing provided.

C. The LLD will be 5×10^{-7} μCi/ml. The principal gamma emitters for which this LLD applies are exclusively the following radionuclides: Mn-54, Fe-59, Co-58, Co-60, Zn-65, Mo-99, Cs-134, Cs-137, and Ce-141. Ce-144 shall be measured, but with an LLD of 5×10^{-6} uCi/ml.

This list does not mean that only these nuclides are to be detected and reported. Other peaks which are measurable and identifiable, together with the above nuclides, shall also be identified

TABLE C-1 (Cont'd.)

and reported. Nuclides which are below the LLD for the analyses should not be reported as being present at the LLD level. When unusual circumstances result in a priori LLDs higher than required, the reasons shall be documented in the *Annual Radioactive Effluent Report.*

D. If a weekly sample identifies the presence of gamma activity greater than or equal to 5×10^{-7} uCi/ml, sample frequency shall be increased to daily until the gamma activity is less than 5×10^{-7} uCi/ml. Daily grab samples shall be taken at least five days per week.

E. A composite sample is one in which the quantity of liquid sampled is proportional to the quantity of liquid waste discharged and in which the method of sampling employed results in a specimen which is representative of the liquids released.

Prior to analysis, all samples taken for the composite shall be thoroughly mixed in order for the composite sample to be representative of the effluents released.

F. These analyses are only required if a weekly gamma analysis indicates a gamma activity greater than 5×10^{-7} μCi/ml.

G. LLD applies exclusively to the following radionuclides: Kr-87, Kr-88, Xe-133, Xe-133m, Xe-135, and Xe-138. This list does not mean that only these nuclides are to be detected and reported. Other peaks which are measurable and identifiable, together with the above nuclides, shall also be identified and reported. Nuclides which are below the LLD for the analyses should not be reported as being present at the LLD level. When unusual circumstances result in a priori LLDs higher than required, the reasons shall be documented in the *Annual Radioactive Effluent Report.*

Table C-2

MILLSTONE 2

RADIOACTIVE LIQUID WASTE SAMPLING AND ANALYSIS PROGRAM

Liquid Release Type	Sampling Frequency	Minimum Analysis Frequency	Type of Activity Analysis	Lower Limit of Detection (LLD)[A] (µCi/ml)
A. Batch Release[B] 1. Coolant Waste Monitor Tank, Aerated Waste Monitor Tank and Steam Generator Bulk 2. Condensate Polishing Facility - Waste Neutralization Sump[E]	Prior to Each Batch	Prior to Each Batch	Principal Gamma Emitters[C]	5×10^{-7}
			I-131	1×10^{-6}
			Ce-144	5×10^{-6}
			Dissolved and Entrained Gases[K]	1×10^{-5}
	Prior to Each Batch	Monthly Composite[F,G]	H-3	1×10^{-5}
			Gross alpha[D]	1×10^{-7}
	Prior to Each Batch	Quarterly Composite[F,G]	Sr-89[D], Sr-90[D]	5×10^{-8}
			Fe-55[D]	1×10^{-6}
B. Continuous Release 1. Steam Generator Blowdown[H] 2. Service Water Effluent 3. Turbine Building Sumps[H]	Daily Grab Sample[I]	Weekly Composite[F,G]	Principal Gamma Emitters[C]	5×10^{-7}
			I-131[L]	1×10^{-6}
			Ce-144	5×10^{-6}
	Monthly Grab Sample	Monthly	Dissolved and Entrained Gases[K]	1×10^{-5}
	Weekly Grab or Composite	Monthly Composite[F,G]	H-3	1×10^{-5}
			Gross alpha[J,L]	1×10^{-7}
	Weekly Composite	Quarterly Composite[F,G]	Sr-89[J], Sr-90[J]	5×10^{-8}
			Fe-55[J]	1×10^{-6}

TABLE C-2 (Cont'd.)

TABLE NOTATIONS

A. The LLD is the smallest concentration of radioactive material in a sample that will be detected with 95% probability with 5% probability of falsely concluding that a blank observation represents a "real" signal.

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

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

where:

LLD is the lower limit of detection as defined above (as µCi per unit mass or volume)

S_b is the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (as counts per minute)

E is the counting efficiency (as counts per transformation)

V is the sample size (in units of mass or volume)

2.22×10^6 is the number of transformations per minute per microcurie

Y is the fractional radiochemical yield (when applicable)

λ is the radioactive decay constant for the particular radionuclide

Δt is the elapsed time between midpoint of sample collection and midpoint of counting time

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 an a posteriori (after the fact) limit for a particular measurement.

Analyses shall be performed in such a manner that the stated LLDs will be achieved under routine conditions. Occasionally background fluctuations, unavoidably small sample sizes, the presence of interfering nuclides, or other uncontrollable circumstances may render these LLDs unachievable. In such cases, the contributing factors will be identified and recorded on the analysis sheet for the particular sample.

B. A batch release is the discharge of liquid wastes of a discrete volume from the tanks listed in this table. Prior to the sampling, each batch shall be isolated and at least two tank/sump volumes shall be recirculated or equivalent mixing provided. If the steam generator bulk can not be recirculated prior to batch discharge, samples will be obtained by representative compositing during discharge.

C. The LLD will be 5×10^{-7} µCi/ml. The principal gamma emitters for which this LLD applies are exclusively the following radionuclides: Mn-54, Fe-59, Co-58, Co-60, Zn-65, Mo-99, Cs-134, Cs-137, and Ce-141. Ce-144 shall also be measured, but with an LLD of 5×10^{-6} uCi/ml.

TABLE C-2 (Cont'd.)

TABLE NOTATIONS

This list does not mean that only these nuclides are to be detected and reported. Other peaks which are measurable and identifiable, together with the above nuclides, shall also be identified and reported. Nuclides which are below the LLD for the analyses should not be reported as being present at the LLD level. When unusual circumstances result in a priori LLDs higher than required, the reasons shall be documented in the *Annual Radioactive Effluent Report.*

D. For the Condensate Polishing Facility (CPF) - Waste Neutralization Sump and steam generator bulk, these analyses are only required if the applicable batch gamma activity is greater than 5×10^{-7} μCi/ml.

E. For the Condensate Polishing Facility (CPF) - Waste Neutralization Sump: tritium sampling and analyses is only required if there is detectable tritium in the steam generators. Remaining sampling and analysis is required if the steam generator gross gamma activity (sampled and analyzed three times per week per *Table 4.7-2* of the *Technical Specifications*) exceeds 1×10^{-5} μCi/ml.

F. For Batch Releases and Steam Generator Blowdown only, a composite sample is one in which the quantity of liquid sampled is proportional to the quantity of liquid waste discharged and in which the method of sampling employed results in a specimen which is representative of the liquids released.

G. Prior to analysis, all samples taken for the composite shall be thoroughly mixed in order for the composite sample to be representative of the effluents released.

H. For the Steam Generator Blowdown and the Turbine Building Sump: tritium sampling and analyses is only required if there is detectable tritium in the steam generators. Remaining sampling and analysis is required when the steam generator gross gamma activity (sampled and analyzed three times per week as per *Table 4.7-2* of the *Safety Technical Specifications*) exceeds 5×10^{-7} μCi/ml.

I. Daily grab samples shall be taken at least five days per week. For service water, daily grabs shall include each train that is in-service.

J. For the Service Water, these analyses are only required if a weekly gamma analysis indicates a gamma activity greater than 5×10^{-7} μCi/ml.

K. LLD applies exclusively to the following radionuclides: Kr-87, Kr-88, Xe-133, Xe-133m, Xe-135, and Xe-138. This list does not mean that only these nuclides are to be detected and reported. Other peaks which are measurable and identifiable, together with the above nuclides, shall also be identified and reported. Nuclides which are below the LLD for the analyses should not be reported as being present at the LLD level. When unusual circumstances result in a priori LLDs higher than required, the reasons shall be documented in the *Annual Radioactive Effluent Report.*

L. When the Turbine Building sump release pathway is directed to yard drains, the LLD for I-131 shall be 1.5×10^{-7} uCi/ml and for gross alpha 1×10^{-8} uCi/ml.

Table C-3

MILLSTONE 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)[A] (µCi/ml)
A. Batch Release[B]				
1. Condensate Polishing Facility - Waste Neutralization Sump[E]	Prior to Each Batch	Prior to Each Batch	Principal Gamma Emitters[C]	5×10^{-7}
			I-131	1×10^{-6}
			Ce-144	5×10^{-6}
			Dissolved and Entrained Gases[K]	1×10^{-5}
2. Waste Test Tanks, Low Level Waste Drain Tank, Boron Test Tanks and Steam Generator Bulk	Prior to Each Batch	Monthly Composite[F,G]	H-3	1×10^{-5}
			Gross alpha[D]	1×10^{-7}
	Prior to Each Batch	Quarterly Composite[F,G]	Sr-89[D], Sr-90[D]	5×10^{-8}
			Fe-55[D]	1×10^{-6}
B. Continuous Release				
1. Steam Generator Blowdown[H]	Daily Grab Sample[I]	Weekly Composite[F,G]	Principal Gamma Emitters[C]	5×10^{-7}
			I-131[L]	1×10^{-6}
			Ce-144	5×10^{-6}
	Monthly Grab Sample	Monthly	Dissolved and Entrained Gases[K]	1×10^{-5}
2. Service Water Effluent	Weekly Grab or Composite	Monthly Composite[F,G]	H-3	1×10^{-5}
			Gross alpha[J,L]	1×10^{-7}
3. Turbine Building Sumps[H]	Weekly Composite	Quarterly Composite[F,G]	Sr-89[J], Sr-90[J]	5×10^{-8}
			Fe-55[J]	1×10^{-6}

TABLE C-3 (Cont'd.)

TABLE NOTATIONS

A. The LLD is the smallest concentration of radioactive material in a sample that will be detected with 95% probability with 5% probability of falsely concluding that a blank observation represents a "real" signal. For a particular measurement system (which may include radiochemical separation):

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

where:

LLD is the lower limit of detection as defined above (as µCi per unit mass or volume)

S_b is the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (as counts per minute)

E is the counting efficiency (as counts per transformation)

V is the sample size (in units of mass or volume)

2.22×10^6 is the number of transformations per minute per microcurie

Y is the fractional radiochemical yield (when applicable)

λ is the radioactive decay constant for the particular radionuclide

Δt is the elapsed time between midpoint of sample collection and midpoint of counting time

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 an a posteriori (after the fact) limit for a particular measurement.

Analyses shall be performed in such a manner that the stated LLDs will be achieved under routine conditions. Occasionally background fluctuations, unavoidably small sample sizes, the presence of interfering nuclides, or other uncontrollable circumstances may render these LLDs unachievable. In such cases, the contributing factors will be identified and recorded on the analysis sheet for the particular sample.

B. A batch release is the discharge of liquid wastes of a discrete volume from the tanks listed in this table. Prior to the sampling, each batch shall be isolated and at least two tank/sump volumes shall be recirculated or equivalent mixing provided. If the steam generator bulk can not be recirculated prior to batch discharge, samples will be obtained by representative compositing during discharge.

C. The LLD will be 5×10^{-7} µCi/ml. The principal gamma emitters for which this LLD applies are exclusively the following radionuclides: Mn-54, Fe-59, Co-58, Co-60, Zn-65, Mo-99, Cs-134, Cs-137, and Ce-141. Ce-144 shall also be measured, but with an LLD of 5×10^{-6} µCi/ml. This list does not mean that only these nuclides are to be detected.

TABLE C-3 (Cont'd.)

TABLE NOTATIONS

and reported. Other peaks which are measurable and identifiable, together with the above nuclides, shall also be identified and reported. Nuclides which are below the LLD for the analyses should not be reported as being present at the LLD level. When unusual circumstances result in a priori LLDs higher than required, the reasons shall be documented in the *Annual Radioactive Effluent Report.*

D. For the Condensate Polishing Facility (CPF) - Waste Neutralization Sump and steam generator bulk, these analyses are only required if the applicable batch gamma activity is greater than 5×10^{-7} μCi/ml.

E. For the Condensate Polishing Facility (CPF) - Waste Neutralization Sump: tritium sampling and analyses is only required if there is detectable tritium in the steam generators. Remaining sampling and analysis is required when the steam generator gross gamma activity (sampled and analyzed three times per week as per *Table 4.7-1* of the *Safety Technical Specifications*) exceeds 1×10^{-5} μCi/ml.

F. For Batch Releases and Steam Generator Blowdown only, a composite sample is one in which the quantity of liquid sampled is proportional to the quantity of liquid waste discharged and in which the method of sampling employed results in a specimen which is representative of the liquids released.

G. Prior to analysis, all samples taken for the composite shall be thoroughly mixed in order for the composite sample to be representative of the effluents released.

H. For the Steam Generator Blowdown and the Turbine Building Sump: tritium sampling and analyses is only required if there is detectable tritium in the steam generators. Remaining sampling and analysis is required when the steam generator gross gamma activity (sampled and analyzed three times per week as per *Table 4.7-1* of the *Safety Technical* Specifications) exceeds 5×10^{-7} μCi/ml. Steam Generator Blowdown samples are not required when blowdown is being recovered.

I. Daily grab samples shall be taken at least five days per week. For service water, daily grabs shall include each train that is in-service.

J. For the Service Water, these analyses are only required if a weekly gamma analysis indicates a gamma activity greater than 5×10^{-7} μCi/ml.

K. LLD applies exclusively to the following radionuclides: Kr-87, Kr-88, Xe-133, Xe-133m, Xe-135, and Xe-138. This list does not mean that only these nuclides are to be detected and reported. Other peaks which are measurable and identifiable, together with the above nuclides, shall also be identified and reported. Nuclides which are below the LLD for the analyses should not be reported as being present at the LLD level. When unusual circumstances result in a priori LLDs higher than required, the reasons shall be documented in the *Annual Radioactive Effluent Report.*

L. When the Turbine Building sump release pathway is directed to yard drains, the LLD for I-131 shall be 1.5×10^{-7} uCi/ml and for gross alpha 1×10^{-8} uCi/ml.

C.2 Liquid Radioactive Waste Treatment

a. Dose Criteria for Equipment Operability Applicable to All Millstone Units

The following dose criteria shall be applied separately to each Millstone unit.

1. **IF** the radioactivity concentration criteria for the Unit 3 steam generator blowdown is exceeded with blowdown recovery not available to maintain releases to as low as reasonabley achievable; or,
   IF any of the other radioactive waste processing equipment listed in Section b are not routinely operating,
   THEN doses due to liquid effluents from the applicable waste stream to unrestricted areas shall be projected at least once per 31 days in accordance with the methodology and parameters in Section C.5 of the ODCM.
2. **IF** any of these dose projections exceeds 0.006 mrem to the total body or 0.02 mrem to any organ,
   THEN best efforts shall be made to return the inoperable equipment to service, or to limit discharges via the applicable waste stream.
3. **IF** an actual dose due to liquid effluents exceeds 0.06 mrem to the total body or 0.2 mrem to any organ,
   AND the dose from the applicable waste stream exceeds 10% of one of these limits,
   THEN prepare and submit to the Commission a Special Report within 30 days as specified in Section c.

b. Required Equipment for Each Millstone Unit

Best efforts shall be made to return the applicable liquid radioactive waste treatment system equipment specified below for each unit to service or to limit discharge via the applicable waste stream if the projected doses exceed any of the doses specified above.

1. Millstone Unit No. 1

Waste Stream	Processing Equipment
Waste collector	Filtration
	Waste demineralizer A or B
Floor drains	Filtration/ion exchanger OR Waste collector equipment (filtration and demineralizer)

2. Millstone Unit No. 2

Waste Stream	Processing Equipment
Clean liquid	Deborating ion exchanger (T11) OR Purification ion exchanger (T10A or T10B)
	Primary demineralizer (T22 A or B)
	Secondary demineralizer (T23)
Aerated liquid	Demineralizer (T24) OR Equivalent demineralizer

3. Millstone Unit No. 3

Waste Stream	Processing Equipment or Radioactivity Concentration
High level	Demineralizer filter (LWS-FLT3) and Demineralizer (LWS-DEMIN2) OR Demineralizer (LWS-DEMIN1) and Demineralizer filter (LWS-FLT1)
Boron recovery	Cesium ion exchanger (DEMIN A or B)
	Boron evaporator (EV-1)
Low level	High level processing equipment
Steam generator blowdown	Blowdown recovery when total gamma activity exceeds 5E-7 uCi/ml or tritium activity exceeds 0.02 uCi/ml.

c. Report Requirement For All Three Millstone Units

If required by Section a(3), prepare and submit to the Commission a Special Report within 30 days with the following content:

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

GASEOUS EFFLUENTS

D.1 Gaseous Effluent Sampling and Analysis Program

Radioactive gaseous wastes shall be sampled and analyzed in accordance with the program specified in **Table D-1** for Millstone Unit No. 1, **Table D-2** for Millstone Unit No. 2, and **Table D-3** for Millstone Unit No. 3. The results of the radioactive analyses shall be input to the methodology of the ODCM to assure that offsite dose rates are maintained within the limits of *Radiological Effluent Control (Section III) D.2.1* for Millstone Unit No. 1 and within *Technical Specification 3.11.2.1* for Millstone Unit Nos. 2 and 3.

Table D-1

MILLSTONE 1

RADIOACTIVE GASEOUS WASTE SAMPLING AND ANALYSIS PROGRAM

Gaseous Release Type	Sampling Frequency	Minimum Analysis Frequency	Type of Activity Analysis	Lower Limit of Detection (LLD)[A] (μCi/cc)
A. Steam Jet Air Ejector Discharge	Monthly - Gaseous Grab Sample[C]	Monthly	Principal Gamma Emitters[B]	1×10^{-4}
B. Main Stack	Monthly - Gaseous Grab Sample	Monthly	Principal Gamma Emitters[B]	1×10^{-4}
			H-3	1×10^{-6}
	Continuous[D]	Weekly Charcoal Sample[F]	I-131	1×10^{-12}
			I-133[E]	1×10^{-10}
	Continuous[D]	Weekly Particulate Sample[F]	Principal Particulate Gamma Emitters[B] - (I-131, Others with half lives greater than 8 Days)	1×10^{-11}
	Continuous[D]	Monthly Composite Particulate Sample	Gross alpha	1×10^{-11}
	Continuous[D]	Quarterly Composite Particulate Sample	Sr-89, Sr-90	1×10^{-11}
	Continuous[D]	Noble Gas Monitor	Noble Gases - Gross Activity	1×10^{-6}

TABLE D-1 (Cont'd.)

TABLE NOTATIONS

A. The lower limit of detection (LLD) is defined in *Table Notations, Item a*, of *Tables C-1, C-2, or C-3*.

B. For gaseous samples, the LLD will be 1×10^{-4} μCi/cc and for particulate samples, the LLD will be 1×10^{-11} μCi/cc. The principal gamma emitters for which these LLDs apply are exclusively the following radionuclides: Kr-87, Kr-88, Xe-133, Xe-133m, Xe-135, and Xe-138 for gaseous emission and Mn-54, Fe-59, Co-58, Co-60, Zn-65, Mo-99, I-131, Cs-134, Cs-137, Ce-141, and Ce-144 for particulate emissions. The list does not mean that only these nuclides are to be detected and reported. Other peaks which are measurable and identifiable, together with the above nuclides, shall also be identified and reported. Nuclides which are below the LLD for the analyses should not be reported as being present at the LLD level for that nuclide. When unusual circumstances result in a priori LLDs higher than required, the reasons shall be documented in the *Annual Radioactive Effluent Report*.

C. Sampling and analysis shall also be performed within 24 hours following an increase, as indicated by the steam jet air ejector off-gas monitor, of greater than 50%, after factoring out increases due to changes in THERMAL POWER level.

D. The ratio of the sample flow rate to the sampled stream flow rate shall be known.

E. Analyses for I-133 will not be performed on each charcoal sample. Instead, at least once per month, the ratio of I-133 to I-131 will be determined from a charcoal sample changed after 24 hours of sampling. This ratio, along with the routine I-131 activity determination will be used to determine the release rate of I-133.

F. Samples shall be changed at least once per seven days and analyses shall be completed within 48 hours after changing. Special sampling and analysis of iodine and particulate filters shall also be performed whenever subsequent reactor coolant I-131 samples show an increase of greater than a factor of 5 after factoring out increases due to changes in thermal power level. These filters shall be changed following such a five-fold increase in coolant activity and every 24 hours thereafter until the reactor coolant I-131 levels are less than a factor of 5 greater than the original coolant levels or until seven days have passed, whichever is shorter. Sample analyses shall be completed within 48 hours of changing. The LLDs may be increased by a factor of 10 for these samples.

Table D-2

MILLSTONE 2

RADIOACTIVE GASEOUS WASTE SAMPLING AND ANALYSIS PROGRAM

Gaseous Release Type	Sampling Frequency	Minimum Analysis Frequency	Type of Activity Analysis	Lower Limit of Detection (LLD)[A] (μCi/cc)
A. Batch Release 1. Waste Gas Storage Tank[H] 2. Containment Purge	Prior to Each Tank Discharge	Each Tank Discharge	Principal Gamma Emitters[B]	1×10^{-4}
			H-3	1×10^{-6}
B. Continuous Release	Monthly - Gaseous Grab Sample[C]	Monthly[C]	Principal Gamma Emitters[B]	1×10^{-4}
			H-3[G]	1×10^{-6}
	Continuous[D]	Weekly Charcoal Sample[F]	I-131	1×10^{-12}
			I-133[E]	1×10^{-10}
	Continuous[D]	Weekly Particulate Sample[F]	Principal Particulate Gamma Emitters[B] - (I-131, others with half lives greater than 8 days)	1×10^{-11}
1. Vent	Continuous[D]	Monthly Composite Particulate Sample	Gross alpha	1×10^{-11}
	Continuous[D]	Quarterly Composite Particulate Sample	Sr-89, Sr-90	1×10^{-11}
	Continuous[D]	Noble Gas Monitor	Noble Gases - Gross Activity	1×10^{-6}
2. Containment Venting	Weekly Grab, if venting[I]	Weekly	Principal Gamma Emitters[B]	1×10^{-4}
			H-3	1×10^{-6}

TABLE D-2 (Cont'd.)

TABLE NOTATIONS

A. The lower limit of detection (LLD) is defined in *Table Notations, Item a*, of *Tables C-1, C-2, or C*-3.

B. For gaseous samples, the LLD will be 1 x 10^{-4} µCi/cc and for particulate samples, the LLD will be 1 x 10^{-11} µCi/cc. The principal gamma emitters for which these LLDs apply are exclusively the following radionuclides: Kr-87, Kr-88, Xe-133, Xe-133m, Xe-135, and XE-138 for gaseous emission and Mn-54, Fe-59, Co-58, Co-60, Zn-65, Mo-99, I-131, Cs-134, Cs-137, Ce-141, and Ce-144 for particulate emissions. The list does not mean that only these nuclides are to be detected and reported. Other peaks which are measurable and identifiable, together with the above nuclides, shall also be identified and reported. Nuclides which are below the LLD for the analyses should not be reported as being present at the LLD level for that nuclide. When unusual circumstances result in a priori LLDs higher than required, the reasons shall be documented in the *Annual Radioactive Effluent Report.*

C. Sampling and analysis shall also be performed within 24 hours following an unexplained increase, as indicated by the Unit 2 stack noble gas monitor, of greater than 50%, after factoring out increases due to changes in THERMAL POWER levels, containment purges, or other explainable increases.

D. The ratio of the sample flow rate to the sampled stream flow rate shall be known.

E. Analyses for I-133 will not be performed on each charcoal sample. Instead, at least once per month, the ratio of I-133 to I-131 will be determined from a charcoal sample changed after 24 hours of sampling. This ratio, along with the routine I-131 activity determination will be used to determine the release rate of I-133.

F. Samples shall be changed at least once per seven days and analyses shall be completed within 48 hours after changing. Special sampling and analysis of iodine and particulate filters shall also be performed whenever subsequent reactor coolant Dose Equivalent I-131 samples, which are taken two to six hours following a THERMAL POWER change exceeding 15% of RATED THERMAL POWER in one hour, show an increase of greater than a factor of 5. These filters shall be changed following such a five-fold increase in coolant activity and every 24 hours thereafter until the reactor coolant Dose Equivalent I-131 levels are less than a factor of 5 greater than the original coolant levels or until seven days have passed, whichever is shorter. Sample analyses shall be completed within 48 hours of changing. The LLDs may be increased by a factor of 10 for these samples.

G. Grab samples for tritium shall be taken weekly whenever the refueling cavity is flooded and there is fuel in the cavity. The grab sample shall be taken from the stack (Units 1 and 2) where the containment ventilation is being discharged at the time of sampling.

H. Waste Gas Storage Tanks are normally released on a batch basis. However, for the purpose of tank maintenance, inspection, or reduction of oxygen concentration, a waste gas tank may be continuously purged with nitrogen provided the following conditions are met:

(1) The previous batch of radioactive waste gas has been discharged to a final tank pressure of less than 5 PSIG.

TABLE D-2 (Cont'd.)

TABLE NOTATIONS

(2) No radioactive gases have been added to the tank since the previous discharge.

(3) Valve lineups are verified to ensure that no radioactive waste gases will be added to the tank.

(3) After pressurizing the tank with nitrogen, a sample of the gas in the tank will be taken and analyzed for any residual gamma emitters and tritium prior to initiation of the nitrogen purge. The measured activity will be used to calculate the amount of activity released during the purge.

I. If the containment air radioactivity increases or decreases by a factor of two compared to the radioactivity at the time of the weekly air sample based on a trend of Radiation Monitors RM8123 and RM8262 gas channels, a new containment air sample shall be taken.

Table D-3

MILLSTONE 3

RADIOACTIVE GASEOUS WASTE SAMPLING AND ANALYSIS PROGRAM

Gaseous Release Type	Sampling Frequency	Minimum Analysis Frequency	Type of Activity Analysis	Lower Limit of Detection (LLD)[A] (μCi/cc)
A. Batch Release 1. Containment Drawdown 2. Containment Purge	Prior to Each Purge or Drawdown[H]	Each Purge or Drawdown	Principal Gamma Emitters[B]	1×10^{-4}
			H-3	1×10^{-6}
B. Continuous Release	Monthly - Gaseous Grab[C]	Monthly[C]	Principal Gamma Emitters[B]	1×10^{-4}
			H-3[G]	1×10^{-6}
1. Unit 3 Ventilation Vent 2. Engineered Safeguards Building 3. Containment Vacuum System and Gaseous Radwaste[I]	Continuous[D]	Weekly Charcoal Sample[F]	I-131	1×10^{-12}
			I-133[E]	1×10^{-10}
	Continuous[D]	Weekly Particulate Sample[f]	Principal Particulate Gamma Emitters[B] - (I-131, others with half lives greater than 8 days)	1×10^{-11}
	Continuous[D]	Monthly Composite Particulate Sample	Gross alpha	1×10^{-11}
	Continuous[D]	Quarterly Composite Particulate Sample	Sr-89, Sr-90	1×10^{-11}
	Continuous[D]	Noble Gas Monitor	Noble Gases - Gross Activity	1×10^{-6}

TABLE D-3 (Cont'd.)

TABLE NOTATIONS

A. The lower limit of detection (LLD) is defined in *Table Notations, Item a*, of *Tables C-1, C-2, or C-3*.

B. For gaseous samples, the LLD will be 1×10^{-4} μCi/cc and for particulate samples, the LLD will be 1×10^{-11} μCi/cc. The principal gamma emitters for which these LLDs apply are exclusively the following radionuclides: Kr-87, Kr-88, Xe-133, Xe-133m, Xe-135, and XE-138 for gaseous emission and Mn-54, Fe-59, Co-58, Co-60, Zn-65, Mo-99, I-131, Cs-134, Cs-137, Ce-141, and Ce-144 for particulate emissions. The list does not mean that only these nuclides are to be detected and reported. Other peaks which are measurable and identifiable, together with the above nuclides, shall also be identified and reported. Nuclides which are below the LLD for the analyses should not be reported as being present at the LLD level for that nuclide. When unusual circumstances result in a priori LLDs higher than required, the reasons shall be documented in the *Annual Radioactive Effluent Report.*

C. Appropriate sampling and analysis shall also be performed within 24 hours following an unexplained increase, as indicated by the Unit 3 ventilation vent noble gas monitor or gaseous radioactive waste monitor, of greater than 50%, after factoring out increases due to changes in THERMAL POWER levels, containment purges, or other explainable increases. (Only applicable to gaseous radioactive waste monitor when gaseous dose exceeds 20% of limit - see Footnote I.)

D. The ratio of the sample flow rate to the sampled stream flow rate shall be known.

E. Analyses for I-133 will not be performed on each charcoal sample. Instead, at least once per month, the ratio of I-133 to I-131 will be determined from a charcoal sample changed after 24 hours of sampling. This ratio, along with the routine I-131 activity determination will be used to determine the release rate of I-133.

F. Samples shall be changed at least once per seven days and analyses shall be completed within 48 hours after changing. Special sampling and analysis of iodine and particulate filters shall also be performed whenever reactor coolant Dose Equivalent I-131 samples (which are taken two to six hours following a THERMAL POWER change exceeding 15% of RATED THERMAL POWER in one hour per *Table 4.4-4* of the *Safety Technical Specifications)* show an increase of greater than a factor of 5. These filters shall be changed following such a five-fold increase in coolant activity and every 24 hours thereafter until the reactor coolant Dose Equivalent I-131 levels are less than a factor of 5 greater than the original coolant levels or until seven days have passed, whichever is shorter. Sample analyses shall be completed within 48 hours of changing. The LLDs may be increased by a factor of 10 for these samples.

G. Grab samples for tritium shall be taken weekly from the ventilation vent whenever the refueling cavity is flooded and there is fuel in the cavity.

H. Subsequent to medical emergencies, for initial determination of isotopic content of the containment air, a Health Physics sample may be used in place of the normal chemistry sample.

I. Only required if Unit 1 or 3 gaseous doses exceed 20% of their limits.

D.2 Gaseous Radioactive Waste Treatment

a. Dose Criteria for Equipment Operability Applicable to All Millstone Units

The following dose criteria shall be applied separately to each Millstone unit.

1. **IF** any of the radioactive waste processing equipment listed in Section b are not routinely operating, **THEN** doses due to gaseous effluents from the untreated waste stream to unrestricted areas shall be projected at least once per 31 days in accordance with the methodology and parameters in Section D.4 of the ODCM. For each waste stream, only those doses specified in Section D.4 of the ODCM need to be determined for compliance with this section.
2. **IF** any of these dose projections exceed 0.02 mrad for gamma radiation, 0.04 mrad for beta radiation or 0.03 mrem to any organ due to gaseous effluents,
   THEN best efforts shall be made to return the inoperable equipment to service.
3. **IF** actual doses exceed 0.2 mrad for gamma radiation, 0.4 mrad for beta radiation or 0.3 mrem to any organ
   AND the dose from a waste stream with equipment not continuously operating exceed 10% any of these limits,
   THEN prepare and submit to the Commission a report as specified in Section c.

b. Required Equipment for Each Millstone Unit

Best efforts shall be made to return the gaseous radioactive waste treatment system equipment specified below for each unit to service if the projected doses exceed any of doses specified above. For the Unit 2 gas decay tanks, the tanks shall be operated to allow enough decay time of radioactive gases to ensure that the dose limits are not exceeded.

1. Millstone Unit No. 1

Waste Stream	Processing Equipment
Radwaste Vent Exhaust	Radwaste ventilation HEPA filters

2. Millstone Unit No. 2

Waste Stream	Processing Equipment
Gaseous Radwaste Treatment System	Five (5) gas decay tanks
	One waste gas compressor
Ventilation Exhaust Treatment System	Auxiliary building ventilation HEPA filter (L26 or L27)
	Containment purge HEPA filter (L25)
	Containment vent HEPA/charcoal filter (L29 A or B)

3. Millstone Unit No. 3

Waste Stream	Processing Equipment
Gaseous Radwaste Treatment System	Charcoal bed adsorbers
	One HEPA filter
Building Ventilation	Fuel building ventilation filter

c. Report Requirement For All Three Millstone Units

If required by Section a(3), prepare and submit to the Commission a Special Report within 30 days with the following content:

- Explanation of why gaseous radwaste was being discharged without treatment, identification of any inoperable equipment or subsystems, and the reason for the inoperability,
- Action(s) taken to restore the inoperable equipment to OPERABLE status, and
- Summary description of action(s) taken to prevent a recurrence.

RADIOLOGICAL ENVIRONMENTAL MONITORING

E.1 Sampling and Analysis

The radiological sampling and analyses provide measurements of radiation and of radioactive materials in those exposure pathways and for those radionuclides which lead to the highest potential radiation exposures of individuals resulting from plant operation. This monitoring program thereby supplements the radiological effluent monitoring program by verifying that the measurable concentrations 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. Program changes may be made based on operational experience.

The sampling and analyses shall be conducted as specified in *Table E-1* for the locations shown in *Appendix G* of the ODCM. Deviations are permitted from the required sampling schedule if specimens are unobtainable due to hazardous conditions, seasonal unavailability, malfunction of automatic sampling equipment or 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 *Section F.1*. It is recognized that, at times, it may not be possible or practicable to continue to obtain samples of the media of choice (excluding milk) at the most desired location or time. In these instances suitable alternative media and locations may be chosen for the particular pathways in questions and appropriate substitutions made within 30 days in the radiological environmental monitoring program.

If milk samples are temporarily unavailable from any one or more of the milk sample locations required by Table E-1, a grass sample shall be substituted during the growing season (Apr. - Dec.) and analyzed for gamma isotopes until milk is again available. Upon notification that milk samples will be unavailable for a prolonged period (>9 months) from any one or more of the milk sample locations required by Table E-1, a suitable replacement milk location shall be evaluated and appropriate changes made in the radiological environmental monitoring program. Reasonable attempts shall be made to sample the replacement milk location prior to the end of the next sampling period. Any of the above occurrences shall be documented in the Annual Radiological Environmental Operating Report which is submitted to the U. S. Nuclear Regulatory Commission prior to May 1 of each year.

Changes to sampling locations shall be identified in a revised table and figure(s) in Appendix G of the ODCM.

If the level of radioactivity in an environmental sampling medium at one or more of the locations specified in *Table E-1* exceeds the report levels of *Table E-2* when averaged over any calendar quarter, prepare and submit to the Commission within 30 days from the end of the affected calendar quarter, a Special Report which includes an evaluation of any release conditions, environmental factors or other aspects which caused the limits of *Table E-2* to be exceeded. When more than one of the radionuclides in *Table E-2* are detected in the sampling medium, this report shall be submitted if:

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

When radionuclides other than those in *Table E-2* are detected and are the result of plant effluents, this report shall be submitted if the potential annual dose to an individual is equal to or greater than the appropriate calendar year limit of the *Radiological Effluent Controls (Section III) D.1.1, D.2.2, or D.2.3* for Millstone Unit No. 1 or *Technical Specifications 3.11.1.2, 3.11.2.2 or 3.11.2.3* for Millstone Unit Nos. 2 and 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.*

The detection capabilities required by *Table E-3* are state-of-the-art 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 an a posteriori (after the fact) limit for a particular measurement. All analyses shall be performed in such a manner that the stated LLDs will be achieved under routine conditions. Occasionally background fluctuations, unavoidably small sample sizes, the presence of interfering nuclides, or other uncontrollable circumstances may render these LLDs unachievable. In such cases, the contributing factors will be identified and described in the *Annual Radiological Environmental Operating Report.*

TABLE E-1

MILLSTONE RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway and/or Sample	Number of Locations	Sampling and Collection Frequency	Type and Frequency of Analysis
1a. Gamma Dose - Environmental TLD	17	Monthly	Gamma Dose - Monthly
1b. Gamma Dose - Accident TLD	18	Quarterly[(a)]	N/A[(a)]
2. Airborne Particulate	8	Continuous sampler - weekly filter change	Gross Beta - Weekly Gamma Spectrum - Quarterly on composite (by location), and on individual sample if gross beta is greater than 10 times the mean of the weekly control station's gross beta results
3. Airborne Iodine	8	Continuous sampler - weekly canister change	I-131 - Weekly
4. Vegetation	5	One sample near middle and one near end of growing season	Gamma Isotopic on each sample
5. Milk	3	Monthly	Gamma Isotopic and I-131 on each sample; Sr-89 and Sr-90 on Quarterly Composite
5a. Pasture Grass	4	Sample as necessary to substitute for unavailable milk	Gamma Isotopic and I-131
6. Sea Water	2	Continuous sampler with a quarterly collection at indicator location. Quarterly at control location - Composite of 6 weekly grab samples	Gamma Isotopic and Tritium on each sample.
7. Bottom Sediment	5	Semiannual	Gamma Isotopic on each sample
8. Fin Fish-Flounder and one other type of edible fin fish (edible portion)	2	Quarterly	Gamma Isotopic on each sample
9. Mussels (edible portion)	2	Quarterly	Gamma Isotopic on each sample
10. Oysters (edible portion)	4	Quarterly	Gamma Isotopic on each sample
11. Clams (edible portion)	2	Quarterly	Gamma Isotopic on each sample
12. Lobsters (edible portion)	2	Quarterly	Gamma Isotopic on each sample

(a) Accident monitoring TLDs to be dedosed at least quarterly.

TABLE E-2

REPORTING LEVELS FOR RADIOACTIVITY CONCENTRATIONS IN ENVIRONMENTAL SAMPLES

Reporting Levels

Analysis	Water (pCi/l)	Airborne Particulate or Gases (pCi/m^3)	Fish (pCi/g, wet)	Shellfish[c] (pCi/g, wet)	Milk (pCi/l)	Vegetables (pCi/g, wet)
H-3	20,000[a]					
Mn-54	1,000		30	140		
Fe-59	400		10	60		
Co-58	1,000		30	130		
Co-60	300		10	50		
Zn-65	300		20	80		
Zr-95	400					
Nb-95	400					
Ag-110m			8	30		
I-131	20[b]	0.9	0.2	1	3	0.1
Cs-134	30	10	1	5	60	1
Cs-137	50	20	2	8	70	2
Ba-140	200				300	
La-140	200				300	

(a) 20,000 pCi/l for drinking water samples. (This is 40 CFR Part 141 value.) For non-drinking water pathways (i.e., seawater), a value of 30,000 pCi/l may be used.

(b) Reporting level for I-131 applies to non-drinking water pathways (i.e., seawater). If drinking water pathways are sampled, a value of 2 pCi/l is used.

(c) For on-site samples, these values can be multiplied by 3 to account for the near field dilution factor.

TABLE E-3

MAXIMUM VALUES FOR LOWER LIMITS OF DETECTION (LLD)[a]

Analysis	Water (pCi/l)	Airborne Particulate or Gas (pCi/m^3)	Fish, Shellfish (pCi/kg, wet)	Milk (pCi/l)	Food Products (pCi/kg, wet)	Sediment (pCi/kg, dry)
gross beta		1×10^{-2}				
H-3	2000[d]					
Mn-54	15		130			
Fe-59	30		260			
Co-58, 60	15		130			
Zn-65	30		260			
Zr-95	30					
Nb-95	15					
I-131	15[c]	7×10^{-2}		1	60[b]	
Cs-134	15	5×10^{-2}	130	15	60	150
Cs-137	18	6×10^{-2}	150	18	80	180
Ba-140	60[c]			70		
La-140	15[c]			25		

TABLE E-3 (Cont'd)

TABLE NOTATIONS

a. The LLD is the smallest concentration of radioactive material in a sample that will be detected with 95% probability with 5% probability of falsely concluding that a blank observation represents a "real" signal.

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

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

where:

LLD is the lower limit of detection as defined above (as pCi per unit mass or volume)

S_b is the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (as counts per minute)

E is the counting efficiency (as counts per transformation)

V is the sample size (in units of mass or volume)

2.22 is the number of transformations per minute per picocurie

Y is the fractional radiochemical yield (when applicable)

λ is the radioactive decay constant for the particular radionuclide

Δ**t** is the elapsed time between midpoint of sample collection (or end of the sample collection period) and time of counting.

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 an a posteriori (after the fact) limit for a particular measurement.

Analyses shall be performed in such a manner that the stated LLDs will be achieved under routine conditions. Occasionally background fluctuations, unavoidably small sample sizes, the presence of interfering nuclides, or other uncontrollable circumstances may render these LLDs unachievable. In such cases, the contributing factors will be identified in the Annual Radiological Environmental Operating Report.

E.2 Land Use Census

The land use census ensures that changes in the use of unrestricted areas are identified and that modifications to the monitoring program are made if required by the results of this census. This census satisfies the requirements of *Section IV.B.3* of *Appendix I* to *10 CFR Part 50.* The land use census shall be maintained and shall identify the location of the nearest resident, nearest garden*, and milk animals in each of the 16 meteorological sectors within a distance of five miles.

The validity of the land use census shall be verified within the last half of every year by either a door-to-door survey, aerial survey, consulting local agriculture authorities, or any combination of these methods.

With a land use census identifying a location(s) which yields a calculated dose or dose commitment greater than the doses currently being calculated in the off-site dose models, make the appropriate changes in the sample locations used.

With a land use census identifying a location(s) which has a higher D/Q than a current indicator location the following shall apply:

(1) If the D/Q is at least 20% greater than the previously highest D/Q, replace one of the present sample locations with the new one within 30 days if milk is available.

(2) If the D/Q is not 20% greater than the previously highest D/Q, consider direction, distance, availability of milk, and D/Q in deciding whether to replace one of the existing sample locations. If applicable, replacement should be within 30 days. If no replacement is made, sufficient justification should be given in the annual report.

Sample location changes shall be noted in the *Annual Radiological Environmental Operating Report.*

*Broad leaf vegetation (a composite of at least 3 different kinds of vegetation) may be sampled at the site boundary in each of 2 different direction sectors with high D/Qs in lieu of a garden census.

E.3 Interlaboratory Comparison Program

The 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 a quality assurance program for environmental monitoring in order to demonstrate that the results are reasonably valid.

Analyses shall be performed on radioactive materials supplied as part of an Interlaboratory Comparison Program. A summary of the results obtained as part of the above required Interlaboratory Comparison Program shall be included in the Annual Radiological Environmental Operating Report.

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

F. REPORT CONTENT

F.1 Annual Radiological Environmental Operating Report

The *Annual Radiological Environmental Operating Report* shall include summaries, interpretations, and statistical evaluation of the results of the radiological environmental surveillance activities for the report period, including a comparison with previous environmental surveillance reports and an assessment of the observed impacts of the plant operation on the environment. The report shall also include the results of the land use census required by *Section E.2* of this manual. If levels of radioactivity are detected that result in calculated doses greater than 10CFR50 Appendix I Guidelines, the report shall provide an analysis of the cause and a planned course of action to alleviate the cause.

The report shall include a summary table of all radiological environmental samples which shall include the following information for each pathway sampled and each type of analysis:

(1) Total number of analyses performed at indicator locations.

(2) Total number of analyses performed at control locations.

(3) Lower limit of detection (LLD).

(4) Mean and range of all indicator locations together.

(5) Mean and range of all control locations together.

(6) Name, distance and direction from discharge, mean and range for the location with the highest annual mean (indicator or control).

(7) Number of nonroutine reported measurements as defined in these specifications.

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 in the next annual report.

This report shall include a comparison of dose assessments of the measured environmental results to the calculated effluent results to confirm the relative accuracy or conservatism of effluent monitoring dose calculations.

The report shall also include a map of sampling locations keyed to a table giving distances and directions from the discharge; the report shall also include a summary of the Interlaboratory Comparison Data required by *Section E.3* of this manual.

F.2 Annual Radioactive Effluent Operating Report

The *Annual Radioactive Effluent Report (ARER)* shall include quarterly quantities of and an annual summary of radioactive liquid and gaseous effluents released from the unit in the *Regulatory Guide 1.21 (Rev. 1, June 1974)* format. Radiation dose assessments for these effluents shall be provided in accordance with 10 CFR 50.36a and the *Radiological Effluent Technical Specifications.* An annual assessment of the radiation doses from the site to the most likely exposed REAL MEMBER OF THE PUBLIC shall be included to demonstrate conformance with 40 CFR 190. Gaseous pathway doses shall use meteorological conditions concurrent with the time of radioactive gaseous effluent releases. Doses shall be calculated in accordance with the *Offsite Dose Calculation Manual.* The licensee shall maintain an annual summary of the hourly meteorological data (i.e., wind speed, wind direction and atmospheric stability) either in the form of an hour-by-hour listing on a magnetic medium or in the form of a joint frequency distribution. The licensee has the option of submitting this annual meteorological summary with the ARER or retaining it and providing it to the NRC upon request. The ARER shall be submitted by May 1 of each year for the period covering the previous calendar year.

The ARER shall include a summary of each type of solid radioactive waste shipped offsite for burial or final disposal during the report period and shall include the following information for each type:

- type of waste (e.g., spent resin, compacted dry waste, irradiated components, etc.)
- solidification agent (e.g., cement)
- total curies
- total volume and typical container volumes
- principal radionuclides (those greater than 10% of total activity)
- types of containers used (e.g., LSA, Type A, etc.)

The ARER shall include the following information for all abnormal releases of radioactive gaseous and liquid effluents (i.e., all unplanned or uncontrolled radioactivity releases, including reportable quantities) from the site to unrestricted areas:

- total number of and curie content of releases (liquid and gas)
- a description of the event and equipment involved
- cause(s) for the abnormal release
- actions taken to prevent recurrence
- consequences of the abnormal release

Changes to the *RADIOLOGICAL EFFLUENT MONITORING* and *OFFSITE DOSE CALCULATION MANUAL (REMODCM)* shall be submitted to the NRC as appropriate, as a part of or concurrent with the ARER for the period in which the changes were made.

SECTION II

OFFSITE DOSE

CALCULATION MANUAL

FOR THE
MILLSTONE NUCLEAR POWER STATION
UNIT NOs. 1, 2, & 3

DOCKET NOs. 50-245, 50-336, 50-423

November 18, 1999
Revision 17

MILLSTONE STATION

OFFSITE DOSE CALCULATION MANUAL

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APPENDICES

A. INTRODUCTION

The purpose of this manual is to provide the parameters and methods to be used in calculating offsite doses and effluent monitor setpoints at the Millstone Nuclear Power Station. Included are methods for determining maximum individual whole body and organ doses due to liquid and gaseous effluents to assure compliance with the dose limitations in the Technical Specifications. Also included are methods for performing dose projections to assure compliance with the liquid and gaseous treatment system operability sections of the *Radiological Effluent Monitoring Manual.* The manual also includes the methods used for determining quarterly individual and population doses for inclusion in the *Annual Radioactive Effluent Report.*

Another section of this manual discusses the methods to be used in determining effluent monitor alarm/trip setpoints to be used to ensure compliance with the instantaneous release rate limits in the *Radiological Effluent Controls (Section III)* for Unit 1 and the *Technical Specifications* for Units 2 and 3.

The basis for some of the factors in this manual are included as appendices to this manual. Supplemental information on environmental sample locations is provided in an additional appendix.

This manual does not include the surveillance procedures and forms required to document compliance with the surveillance requirements in the *Radiological Effluent Controls (Section III)* for Unit 1 and the *Technical Specifications* for Units 2 and 3. All that is included here are the methods to be used in performance of the surveillance requirements.

Most of the calculations in this manual have several methods given for the calculation of the same parameter. These methods are arranged in order of simplicity and conservatism, Method 1 being the easiest and most conservative. As long as releases remain low, one should be able to use Method 1 as a simple estimate of the dose. If release calculations approach the limit, however, more detailed yet less conservative calculations may be used At any time a more detailed calculation may be used in lieu of a simple calculation. The Radiological Engineering Section of the Safety Analysis Branch may perform these more detailed calculations.

This manual is written common to all three units since some release pathways are shared and there are also site release limits involved. These facts make it impossible to completely separate the three units.

B. RESPONSIBILITIES

All changes to this manual shall be reviewed and approved by the Site Operations Review Committee prior to implementation.

All changes and their rationale shall be documented in the *Annual Radioactive Effluent Report*.

It shall be the responsibility of the Senior Vice President and CNO - Millstone to ensure that this manual is used in performance of the surveillance requirements and administrative controls of the applicable *Technical Specifications* for Units 2 and 3.

C. LIQUID DOSE CALCULATIONS

C.1 Quarterly - Whole Body Dose

a. Method 1 - Any Unit

Step 1 Determine C_F which is total gross curies of fission and activation products, excluding tritium and dissolved noble gases, released during the calendar quarter.

Step 2 Determine C_H which is total curies of tritium released during the calendar quarter.

Step 3 Determine D_{QW} which is the quarterly dose to the whole body in mrem.

For Unit 1:

$$D_{QW} = 2.5\ C_F + 5.6 \times 10^{-7}\ C_H$$

For Units 2 and 3:

$$D_{QW} = 2 \times 10^{-2}\ C_F + 5.6 \times 10^{-7}\ C_H$$

Step 4 If D_{QW} is greater than 0.5 mrem, go to Method 2.

Note: See *Appendix A* for derivation of these factors. For Unit 1, the dose contribution from tritium can be neglected since it has never contributed to more than 2% of the whole body doses.

b. Method 2 - Any Unit

If the calculated dose using Method 1 is greater than 0.5 mrem, use the NRC computer code LADTAP II to calculate the liquid doses. The use of this code and the input parameters are given in Radiological Assessment Branch Procedure, *Liquid Dose Calculations - LADTAP II.*

C.2 Quarterly - Maximum Organ Dose

a. Method 1 - Any Unit

Step 1 Determine C_F which is total gross curies of fission and activation products, excluding tritium and dissolved noble gases, released during the calendar quarter - same as *Step C.1.a.*

Step 2 Determine D_{QO} which equals the quarterly dose to the maximum organ in mrem.

For Unit 1:

$$D_{QO} = 2.1\ C_F$$

For Units 2 and 3:

$$D_{QO} = 0.2\ C_F$$

(See *Appendix B* for derivation of these factors)

Step 3 If D_{QO} is greater than 2 mrem, go to *Method 2*.

b. Method 2 - Any Unit

If the calculated dose using Method 1 is greater than 2 mrem, use the NRC computer code LADTAP to calculate the liquid doses. The use of this code and the input parameters are given in Radiological Assessment Branch Procedure, *Liquid Dose Calculations - LADTAP II.*

C.3 Annual - Whole Body Dose - Any Unit

Determine D_{YW} which equals dose to the whole body for the calendar year as follows:

$D_{YW} = \Sigma\ D_{QW}$, where the sum is over the first quarter through the present quarter whole body doses.

The following should be used as D_{QW}:

(1) If the detailed quarterly dose calculations required per *Section C.6* for the *Annual Radioactive Effluent Report* are completed for any calendar quarter, use that result.

(2) If the detailed calculations are not complete for a particular quarter, use the results as determined in *Section C.1*.

(3) If D_{YW} is greater than 3 mrem and any D_{QW} determined as in *Section C.1* was not calculated using *Method 2* of that section, recalculate D_{QW} using *Method 2* if this could reduce D_{YW} to less than 3 mrem.

C.4 Annual - Maximum Organ Dose - Any Unit

Determine D_{YO} which is the dose to the maximum organ for the calendar year as follows:

$D_{YO} = \Sigma\ D_{QO}$, where the sum is over the first quarter through the present quarter maximum organ doses.

The following guidelines should be used:

(1) If the detailed quarterly dose calculations required per *Section C.6* for the *Annual Radioactive Effluent Report* are completed for any calendar quarter, use that result.

(2) If the detailed calculations are not complete for a particular quarter, use the results as determined in *Section C.2*.

(3) If different organs are the maximum for different quarters, they may be summed together and D_{YO} can be recorded as a less than value as long as the value is less than 10 mrem.

(4) If D_{YO} is greater than 10 mrem and any value used in its determination was calculated as in *Section C.2*, but not with *Method 2*, recalculate that value using *Method 2* if this could reduce D_{YO} to less than 10 mrem.

C.5 Monthly Dose Projections

a. Whole Body and Maximum Organ - Unit 1

Step 1 Determine D'_{MW} which is the whole body dose from the last typical* previously completed month as calculated per the methods in *Section C.1*.

Step 2 Determine D'_{MO} which is the maximum organ dose from the last typical* previously completed month as calculated per the methods in *Section C.2*.

Step 3 Estimate R_1 which is the ratio of the total estimated volume of liquid batches to be released in the present month to the volume released in the past month.

Step 4 Estimate R_2 which is the ratio of estimated primary coolant activity for the present month to that for the past month.

Step 5 Determine F which is the factor to be applied to the estimated ratio of final curies released if there are expected differences in treatment of liquid waste for the present month as opposed to the past month (e.g., bypass of filters or demineralizers). NUREG-0016 or past experience should be used to determine the effect of each form of treatment which will vary. F = 1 if there are no expected differences.

Step 6 Determine D^E_{MW} which is the estimated monthly whole body dose as follows:

$$D^E_{MW} = D'_{MW} * R_1 * R_2 * F$$

Step 7 Determine D^E_{MO} which is the estimated monthly maximum organ dose as follows:

$$D^E_{MO} = D'_{MO} * R_1 * R_2 * F$$

* - The last typical month should be one without significant operational differences from the projected month.

For example, if the plant was down for refueling the entire month of February and startup is scheduled for March 3, use the last month of operation as the base month to estimate March's dose.

Or, if there were no releases during September, do not use September as the base month for October if it is estimated that there will be releases in October.

If the last typical month's doses were calculated using LADTAP II (or similar methodology), also multiply the LADTAP doses by R_5 where R_5 = total dilution flow from LADTAP run divided by estimated total dilution flow.

b. **Whole Body and Maximum Organ - Unit 2 and Unit 3**

Step 1 Determine D'_{MW} which is the whole body dose from the last typical* previously completed month as calculated per the methods in *Section C.1.*

Step 2 Determine D'_{MO} which is the maximum organ dose from the last typical* previously completed month as calculated per the methods in *Section C.2.*

* - See footnote in Section C.5.a.

Step 3 Estimate R_1 which is the ratio of the total estimated volume of liquid batches to be released in the present month to the volume released in the past month.

Step 4 Estimate R_2 which is the ratio of estimated volume of steam generator blowdown to be released in present month to the volume released in the past month.

Step 5 Determine F_1 which is the fraction of curies released last month coming from steam generator blowdown.

i.e. $F_1 = \dfrac{\text{curies from blowdown}}{\text{curies from blowdown + curies from batch tanks}}$

Step 6 Estimate R_3 which is the ratio of estimated secondary coolant activity for the present month to that for the past month.

Step 7 Estimate R_4 which is the ratio of estimated primary coolant activity for the present month to that for the past month.

Step 8 Determine F_2 which is the factor to be applied to the estimated ratio of final curies released if there are expected differences in treatment of liquid waste for the present month as opposed to the past month (e.g., bypass of filters or demineralizers). NUREG-0017 or past experience should be used to determine the effect of each form of treatment which will vary. $F_2 = 1$ if there are no expected differences.

Step 9 Determine D^E_{MW} which equals estimated monthly total body dose as follows:

$$D^E_{MW} = D'_{MW}\ [(1 - F_1)\, R_1\, R_4\, F_2 + F_1\, R_2\, R_3]$$

Step 10 Determine D^E_{MO} which equals estimated monthly maximum organ dose as follows:

$$D^E_{MO} = D'_{MO}\ [(1 - F_1)\, R_1\, R_4\, F_2 + F_1\, R_2\, R_3]$$

C.6 Quarterly Dose Calculations for Annual Radioactive Effluent Report

Detailed quarterly dose calculations required for the *Annual Radioactive Effluent Report* shall be done using the NRC computer code LADTAP II. The use of this code, and the input parameters are given in Radiological Assessment Branch *Procedure Liquid Dose Calculations - LADTAP II.*

D. GASEOUS DOSE CALCULATIONS

D.1 10CFR20 Limits ("Instantaneous")

a. Instantaneous Noble Gas Release Rate Limits - All Units

The instantaneous noble gas release rate limit from the site shall be:

$$\frac{Q_1}{1,100,000} + \frac{Q_2}{290,000} + \frac{Q_3}{290,000} \leq 1$$

Where:

Q_1 = Noble gas release rate from MP1 Stack (μCi/sec)
Q_2 = Noble gas release rate from MP2 Vent (μCi/sec)
Q_3 = Noble gas release rate from MP3 Vent (μCi/sec)

See *Appendix D* for derivation of this limit.

As long as the above is less than or equal to 1, the doses will be less than or equal to 500 mrem to the total body and less than 3000 mrem to the skin.

b. Release Rate Limit - I-131, I-133, Particulates With Half Lives Greater Than 8 Days and Radionuclides Other Than Noble Gases With Half Lives Greater Than 8 Days - All Units

$_{131}Q_{I1}$ = Release rate of I-131 from MP1 Stack - (μCi/sec)

$_{133}Q_{I1}$ = Release rate of I-133 from MP1 Stack - (μCi/sec)

$_{131}Q_{I2}$ = Release rate of I-131 from MP2 Vent - (μCi/sec)*

$_{133}Q_{I2}$ = Release rate of I-133 from MP2 Vent - (μCi/sec)*

$_{131}Q_{I3}$ = Release rate of I-131 from MP3 Vent - (μCi/sec)*

$_{133}Q_{I3}$ = Release rate of I-133 from MP3 Vent - (μCi/sec)*

Q_{H1} = Release rate of tritium from MP1 Stack - (μCi/sec)

Q_{H2} = Release rate of tritium from MP2 Vent - (μCi/sec)*

Q_{H3} = Release rate of tritium from MP3 Vent - (μCi/sec)*

Q_{P1} = Release rate of total particulates with half-lives greater than 8 days from the MP1 Stack - (μCi/sec)

Q_{P2} = Release rate of total particulates with half-lives greater than 8 days from the MP2 Vent - (μCi/sec)

Q_{P3} = Release rate of total particulates with half-lives greater than 8 days from the MP3 Vent - (μCi/sec)

* includes releases via the steam generator blowdown tank vent.

(1) The release rate limit of I-131, I-133, and tritium from the site shall be:

$$5.5 \times 10^{-4}\ {}_{131}Q_{I1} + 5.1 \times 10^{-2}\ {}_{131}Q_{I2} + 5.1 \times 10^{-2}\ {}_{131}Q_{I3} + 1.33 \times 10^{-4}\ {}_{133}Q_{I1} + 1.25 \times 10^{-2}\ {}_{133}Q_{I2} + 1.25 \times 10^{-2}\ {}_{133}Q_{I3} + 4.4 \times 10^{-8}\ Q_{H1} + 4.2 \times 10^{-6}\ Q_{H2} + 4.2 \times 10^{-6}\ Q_{H3} \leq 1$$

(2) The release rate limit of particulates with half-lives greater than 8 days and tritium from the site shall be:

$$5.5 \times 10^{-4}\ Q_{P1} + 5.1 \times 10^{-2}\ Q_{P2} + 5.1 \times 10^{-2}\ Q_{P3} + 4.4 \times 10^{-8}\ Q_{H1} + 4.2 \times 10^{-6}\ Q_{H2} + 4.2 \times 10^{-6}\ Q_{H3} \leq 1$$

Method 2

Above methods assume a conservative nuclide mix. If necessary, utilize the GASPAR code to estimate the dose rate limit.

With releases within the above limits, the dose rate to the maximum organ will be less than 1500 mrem/year from the inhalation pathway.

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D.2. 10 CFR50 Appendix I - Noble Gas Limits

a. Quarterly Air Dose - Method 1 - All Units

Step 1 Determine C_{N1} which equals the total curies of noble gas released from Unit 1 Stack* during the calendar quarter.

Step 2 Determine C_{N2} which equals the total curies of noble gas released from Unit 2 during the calendar quarter. Include all sources - Unit 2 Vent, containment purges and waste gas decay tanks.

Step 3 Determine C_{N3} which equals the total curies of noble gas released from Unit 3 during the calendar quarter. Include all sources - Unit 3 Vent, ESF Building Vent, and containment purges and drawdowns.

Step 4 Determine D_{QG1} which equals the quarterly gamma air dose from Unit 1 (mrad).

$$D_{QG1} = 9.3 \times 10^{-5}\ C_{N1}{**}$$

Step 5 Determine D_{QB1} which equals the quarterly beta air dose from Unit 1 (mrad).

$$D_{QB1} < 9.3 \times 10^{-7}\ C_{N1}{**}$$

Step 6 Determine D_{QG2} which equals the quarterly gamma air dose from Unit 2 (mrad).

$$D_{QG2} = 6.3 \times 10^{-4}\ C_{N2}{**}$$

Step 7 Determine D_{QB2} which equals the quarterly beta air dose from Unit 2 (mrad).

$$D_{QB2} = 1.7 \times 10^{-3}\ C_{N2}{**}$$

Step 8 Determine D_{QG3} which equals the quarterly gamma air dose from Unit 3 (mrad).

$$D_{QG3} = 6.3 \times 10^{-4}\ C_{N3}{**}$$

Step 9 Determine D_{QB3} which equals the quarterly beta air dose from Unit 3 (mrad).

$$D_{QB3} = 1.7 \times 10^{-3}\ C_{N3}{**}$$

Step 10 If D_{QG1}, D_{QG2}, or D_{QG3} are greater than 1.6 mrad; or D_{QB1}, D_{QB2}, or D_{QB3} are greater than 3.3 mrad, go to *Method 2*.

* - Includes contributions from Units 2 and 3. If 20% of the airborne dose limits are exceeded, a Special Assessment will be performed to determine the dose attributable to each unit individually. The intent is to prevent double accounting of normal routine releases since Unit 1 accounts for some Unit 2 and 3 releases. Special sampling for batch releases is not required at the Unit 1 Stack.

** - See *Appendix D* for derivation of factors.

b. **Quarterly Air Dose - Method 2 - All Units**

Unit 1 For MP1 dose calculations, use the AIREM computer code to determine the critical location air doses.

The 3rd quarter 1980 joint frequency data should be used as input for the AIREM code. The reason for this is given in *Appendix D.*

If the calculated air dose exceeds one-half the Radiological Effluent Controls limit, use meteorology concurrent with time of release.

Units 2, 3 For MP2 and MP3 dose calculations use the GASPAR computer code to determine the critical site boundary air doses.

For the Special Location, enter the following worst case quarterly average meteorology:

$X/Q = 0.81 \times 10^{-5}$ sec/m^3

(See *Appendix D*)

$D/Q = 0.15 \times 10^{-6}$ m^{-2}

If the calculated air dose exceeds one-half the quarterly Technical Specification limit, use meteorology concurrent with time of release.

c. **Annual Air Dose Limit Due to Noble Gases - All Units**

Determine D_{YG1}, D_{YG2}, D_{YG3}, D_{YB1}, D_{YB2} and D_{YB3} = gamma air dose and beta air dose for the calendar year for Unit 1, 2, or 3 as follows:

$D_{YG1} = \Sigma D_{QG1}$; $D_{YB1} = \Sigma D_{QB1}$; $D_{YG2} = \Sigma D_{QG2}$; $D_{YB2} = \Sigma D_{QB2}$; $D_{YG3} = \Sigma D_{QG3}$; $D_{YB3} = \Sigma D_{QB3}$

where the sum is over the first quarter through the present quarter doses.

The following should be used as the quarterly doses:

(1) If the detailed quarterly dose calculations required per *Section D.5* for the *Annual Radioactive Effluent Report* are complete for any calendar quarter, use those results.
(2) If the detailed calculations are not complete for a particular quarter, use the results as determined above in *Section D.2.a or D.2.b.*
(3) If $D_{YG1,\ YG2\ or\ YG3}$ are greater than 10 mrad or $D_{YB1,\ YB2\ or\ YB3}$ are greater than 20 mrad and any corresponding quarterly dose was not calculated using *Section D.2.b*, recalculate the quarterly dose using meteorology concurrent with time of release.

D.3. 10 CFR50 Appendix I - Iodine and Particulate Doses

Doses from tritium (for Methods 1-4 only) for Unit 1 may be neglected if the total tritium curies from the quarter are less than 500.

a. Quarterly Doses - Unit 1

(1) Method I - Unit 1

Step 1 - Determine ${}_{131}C_I$ which is the total curies of I-131 and ${}_{133}C_I$ which is the total curies of I-133 released in gaseous effluents from Unit 1 Stack* during the quarter.

Step 2 - Determine C_P which is the total curies of particulates with half-lives greater than 8 days released in gaseous effluents from Unit 1 Stack* during the calendar quarter.

Step 3 - Determine C_H which is the total curies of tritium released in gaseous effluents from Unit 1 Stack* during the quarter.

Step 4 - Determine D_{QT} which equals the quarterly thyroid dose as follows:

$$D_{QT} = 1.22 \times 10^{2}\,{}_{131}C_I + 1.13\,{}_{133}C_I + 2.0 \times 10^{-5} C_H$$

Step 5 - Determine D_{QO} which equals the quarterly dose to the maximum organ other than the thyroid:

$$D_{QO} = 42.3 C_P + 2.0 \times 10^{-5} C_H$$

Step 6 - The maximum organ dose is the greater of D_{QT} or D_{QO}. If it is greater than 2.5 mrem, go to *Method 2.*

* **Note** - Unit 1 Stack samples include releases from Units 2 and 3. The activity from Units 2 and 3 released via the Unit 1 Stack will normally be included here. However, if 20% of any airborne limits are exceeded, a Special Assessment will be required to determine the dose attributable to each unit individually. The intent is to prevent double accounting of normal routine releases since Unit 1 accounts for some Unit 2 and 3 releases. Special sampling for batch releases is not required at the Unit 1 Stack.

(2) Method 2 - Unit 1

Doses from vegetation consumption can be neglected during the 1st and 4th quarters and doses from milk consumption can be neglected during the 1st quarter. These time frames can be extended for short term releases (batch releases and weekly continuous, if necessary) if it can be verified that the milk animals were not on pasture and/or vegetation is not available for harvest. Therefore, calculate doses to the thyroid and maximum organ for pathways that actually exist. Sum pathways if necessary.

Perform Steps *1 through 3* as in *Method* 1, above. Then:

Step 4 -

i. Inhalation Pathway

$$D_{QT} = 3.2 \times 10^{-2}\,{}_{131}C_I + 7.8 \times 10^{-3}\,{}_{133}C_I + 2.6 \times 10^{-6} C_H$$

$$D_{QO} = 3.2 \times 10^{-2} C_P + 2.6 \times 10^{-6} C_H$$

ii. Vegetation Pathway

$D_{QT} = 4.1\,{}_{131}C_I + 7.48 \times 10^{-2}\,{}_{133}C_I + 8.0 \times 10^{-6} C_H$
$D_{QO} = 4.9\, C_P + 8.0 \times 10^{-6} C_H$

iii. Milk Pathway

$D_{QT} = 118\,{}_{131}C_I + 1.05\,{}_{133}C_I + 9.8 \times 10^{-6} C_H$
$D_{QO} = 38\, C_P + 9.8 \times 10^{-6} C_H$

Sum above pathways, as appropriate (Note: sum of all three pathways is *Method 1)*

Step 5 - The maximum organ dose is the greater D_{QT} or D_{QO}. If it is greater than 2.5 mrem, go to the next method.

(3) Method 3 - Unit 1

After reviewing the existing cow and goat farms, if it can be determined that the 1983 -1987 D/Q data is acceptable (Note: If not, see guidance in *Appendix D),* then follow *Method 2* above, except for *iii.* where milk pathway dose is:

$D_{QT} = 28\,{}_{131}C_I + 0.249\,{}_{133}C_I + 9.8 \times 10^{-6} C_H$
$D_{QO} = 8.9\, C_P + 9.8 \times 10^{-6} C_H$

Note: During the 2nd and 3rd quarters also add (to the above) the Inhalation and Vegetation Pathways from *Step 4 of Method 2;* during the 4th quarter add Inhalation and Milk (above) only.

(4) Method 4 - Unit 1

Use the GASPAR code to determine the maximum organ dose. For the Special Location, enter the following worst case quarterly average meteorology as taken from *Appendix D:*

$X/Q = 6.1 \times 10^{-8}$ sec/ m^3
$D/Q = 5.9 \times 10^{-9}\ m^{-2}$ (Milk and Vegetation) and/or
$D/Q = 1.4 \times 10^{-9}\ m^{-2}$ (If 1983-1987 D/Q data is acceptable for existing milk locations. If not, see guidance in *Appendix D.)*

Use the Inhalation, Milk and Vegetation pathways (if applicable) in totaling the dose. If the maximum organ dose is greater than 3.8 mrem, go to *Method 5.*

(5) Method 5 - Unit 1

Use the GASPAR code with actual locations, real-time meteorology and the pathways which actually exist at the time at those locations.

b. Quarterly Doses - Unit 2 and Unit 3

(1) Method 1 - Unit 2 and Unit 3

Step 1 Determine ${}_{131}C_I$, which is the total curies of I-131, and ${}_{133}C_I$, which is the total curies of I-133 in gaseous effluents from Unit 2 (Unit 2 Vent and Steam Generator Blowdown Tank Vent*) or Unit 3 (Unit 3 Vent, ESF Building Vent, Steam Generator Blowdown Tank Vent*, and Containment Drawdown**) during the quarter.***

Step 2 Determine C_P, which is the total curies of particulates with half-lives greater than eight days released in gaseous effluents from the Unit 2 Vent or Unit 3 (Unit 3 Vent, ESF Building Vent, and Containment Drawdown**) during the calendar quarter.***

Step 3 Determine C_H, which is the total curies of tritium released in gaseous effluents from the Unit 2 Vent or Unit 3 (Unit 3 Vent, ESF Building Vent and Containment Drawdown**) during the calendar quarter.***

Step 4 Determine D_{QT} which equals the quarterly thyroid dose as follows:

$$D_{QT} = 3.1 \times 10^3 \, {}_{131}C_I + 29.53 \, {}_{133}C_I + 2.6 \times 10^{-3} \, C_H$$

Step 5 Determine D_{QO} which equals the quarterly dose to the maximum organ other than the thyroid:

$$D_{QO} = 1.1 \times 10^3 \, C_P + 2.6 \times 10^{-3} \, C_H$$

Step 6 The maximum organ dose is the greater of D_{QT} or D_{QO}. If greater than 2.5 mrem, go to *Method 2.*

* Results from SAI studies in 1982 and 1983 and guidance provided in the R. A. Crandall / E. R. Brezinski memo to E. J. Mroczka, Millstone Unit 2 Steam Generator Blowdown Tank Releases, NE-83-RA-879, June 15, 1983, indicate that the steam generator blowdown tank vent releases can be estimated by use of a factor of 1/6,000 (a DF of 2000 and a partitioning factor of 1/3). Although Unit 3 normally recycles blowdown, periodically blowdown is released for short periods of time. These releases should be similar to Unit 2 and until studies can be performed at Unit 3 the same calculation should be performed. Based upon the above, the formula to be used is:

S/G blowdown concentration x S/G blowdown flow rate x 1/6000 x time = integrated activity

** This pathway does not have a effluent monitor.

*** Unit 2 and 3 also have releases via the Unit 1 Stack. This activity will be included in the Unit 1 calculations unless 20% of any airborne limit is exceeded and/or a Special Evaluation is performed.

(2) Method 2 - Unit 2 and Unit 3

Doses from vegetation consumption can be neglected during the 1st and 4th quarters and doses from milk consumption can be neglected during the 1st quarter. These time frames can be extended for short term releases (batch releases and weekly continuous, if necessary) if it can be verified that the milk animals were not on pasture and/or vegetation was not available for harvest. Therefore, calculate doses to the thyroid and maximum organ for pathways that actually exist. Sum pathways, if necessary.

Perform *Steps 1 through 3* as in *Method 1*, then:

<u>Step 4</u>

i. **Inhalation Pathway** (1st, 2nd, 3rd and 4th Quarters)

$D_{QT} = 4.1\ {}_{131}C_I + 1.0\ {}_{133}C_I + 3.3 \times 10^{-4}\ C_H$

$D_{QO} = 4.1\ C_P + 3.3 \times 10^{-4}\ C_H$

ii. **Vegetation Pathway** (2nd and 3rd Quarters)

$D_{QT} = 105\ {}_{131}C_I + 1.9\ {}_{133}C_I + 1.0 \times 10^{-3}\ C_H$

$D_{QO} = 124\ C_P + 1.0 \times 10^{-3}\ C_H$

iii. **Milk Pathway** (2nd, 3rd and 4th Quarters)

$D_{QT} = 3000\ {}_{131}C_I + 26.6\ {}_{133}C_I + 1.3 \times 10^{-3}\ C_H$

$D_{QO} = 951\ C_P + 1.3 \times 10^{-3}\ C_H$

Sum above pathways, as appropriate (<u>Note</u>: sum of all three pathways is *Method 1)*

<u>Step 5</u> - The maximum organ dose is the greater of D_{QT} or D_{QO}. If it is greater than 2.5 mrem, go to the next method.

(3) **<u>Method 3 - Unit 2 and Unit 3</u>**

After reviewing the existing cow and goat farms, if it can be determined that the 1983-1987 D/Q data is acceptable (Note: If not, see guidance in Appendix D) then follow *Method 2*, above, except for *iii* where the milk pathway dose is:

$D_{QT} = 122_{131}C_I + 1.08_{133}C_I + 1.3 \times 10^{-3}\ C_H$

$D_{QO} = 40\ C_P + 1.3 \times 10^{-3}\ C_H$

<u>Note:</u> During the 2nd and 3rd quarters also add (to the above) the Inhalation and Vegetation Pathways from *Step 4 of Method 2;* during the 4th quarter add Inhalation and Milk (above) only.

(4) **<u>Method 4 - Unit 2 and Unit 3</u>**

Use the GASPAR code to determine the maximum organ dose. For the Special Location, enter the following worst case quarterly average meteorology as taken from *Appendix D:*

$X/Q = 8.1 \times 10^{-6}$ sec/ m^3

$D/Q = 1.5 \times 10^{-7}\ m^{-2}$ (Milk and Vegetation) and/or

$D/Q = 6.1 \times 10^{-9}\ m^{-2}$ (If 1983-1987 D/Q data is acceptable for existing milk locations. If not, see guidance in *Appendix D.)*

As shown in *Appendix D,* the same meteorology can be used for both continuous and batch releases. Therefore, the program need only be run once using the total curies from all releases from Unit 2 or 3.

Use the Inhalation, Milk and Vegetation pathways (if applicable) in totaling the dose. If the maximum organ dose is greater than 3.8 mrem, go to *Method 5.*

(5) **Method 5 - Unit 2**

Use the GASPAR code with the actual locations, real-time meteorology and the pathways which actually exist at the time at these locations. The code should be run separately for steam generator blowdown tank vents and ventilation releases, containment purges and waste gas tank releases.

(5) **Method 5 - Unit 3**

Use the GASPAR code with the actual locations, real-time meteorology and the pathways which actually exist at these locations. The code should be run separately for ventilation, process gas, containment vacuum system, aerated ventilation and containment purges.

c. **Annual Doses - All Units**

Determine D_{YT1}, D_{YT2}, D_{YT3}, D_{YO1}, D_{YO2}, and D_{YO3} which are the thyroid and maximum organ doses for the calendar year for Units 1, 2, and 3 respectively, as follows:

$D_{YT1,\ 2,\ or\ 3} = \Sigma D_{QT} =$ sum of the quarterly thyroid doses where the sum is over the first quarter through the present quarter.

$D_{YO1,\ 2,\ or\ 3} = \Sigma D_{QO} =$ sum of the quarterly maximum organ doses where the sum is over the first quarter through the present quarter.

The following guidelines should be used for D_{QT} and D_{QO}:

(1) If the detailed quarterly dose calculations required per *Section D.5* for the *Annual Radioactive Effluent Report* are complete for any calendar quarter, use those results.

(2) If the detailed calculations are not complete for a particular quarter, use the results as determined above in *Section D.3.a* or *D.3.b*.

(3) If D_{YT} and/or D_{YO} are greater than 15 mrem and quarterly dose was not calculated using *Method 3* of *Section D.3.a* or *D.3.b*, recalculate the quarterly dose using *Method 3*.

(4) If different organs are the maximum organ for different quarters, they can be summed together and D_{YO} recorded as a less-than value as long as the value is less than 15 mrem. If it is not, the sum for each organ involved should be determined.

D.4. Gaseous Effluent Monthly Dose Projections

a. Unit 1

(1) Due to Gaseous Radwaste Treatment System (Offgas)

If the augmented offgas system is expected to be out of service during the month, determine the following:

Q = Estimated curies/sec at the air ejector at the expected maximum power for the month.
R = Estimated curie reduction factor from air ejector to stack via the 30 minute (actual time is approximately 55 minutes) holdup line (in decimal fraction).
d = Estimated number of days the 30 minute holdup pipe will be used.

D^E_{MG} = Estimated monthly gamma air dose.
= 9.3×10^{-5} mrad/Ci* x Q Ci/sec x R x d (day) x 8.6×10^4 sec/day
D^E_{MG} (mrad)= 8.0 x Q x R x d

D^E_{MB} = Estimated monthly beta air dose.
D^E_{MB} (mrad)< 0.08 x Q x R x d

** See Appendix D for dose factor*

(2) Due to Ventilation System Releases**

i. Method 1

Step 1 - For the last quarter of operation, determine D_{QO} as determined per *Section D.3.a.*

Step 2 - Estimate R_1 which is the expected reduction factor for the HEPA filter. Typically this should be 100 *(see NUREG-0016 or 0017 for additional guidance).*

Step 3 - Estimate R_2 which is the fraction of the time which the equipment was inoperable during the last quarter.

Step 4 - Estimate R_3 which is the fraction of the time which the equipment is expected to be inoperable during the next month.

Step 5 - Determine D^E_{MO} which is the estimated monthly dose to the maximum organ.

$$D^E_{MO} = 1/3\ R_1\ (1.01 - R_2)\ (R_3 + 0.01)\ D_{QO}$$

ii. **Method 2**

If necessary, estimate the curies expected to be released for the next month and applicable method for dose calculation from Section *D.3.a.*

b. **Unit 2**

(1) **Due to Gaseous Radwaste Treatment System**

Step 1 - Estimate C^E_N which equals the number of curies of noble gas to be released from the waste gas storage tanks during the next month.

Step 2 - Determine D^E_{MG} which is the estimated monthly gamma air dose.

$$D^E_{MG} \text{ (mrad)} = 9.3 \times 10^{-5} C^E_N$$

(Factor is from *Appendix D* for the Unit 1 stack releases since the Unit 2 waste gas tanks are discharged via the Unit 1 stack. This factor should be conservative as the isotopic mix would only be the longer-lived noble gases which would have lower dose conversion factors than the typical mix from Unit 1.)

Step 3 - Determine D^E_{MB} which is the estimated monthly beta air dose.

$$D^E_{MB} \text{ (mrad)} < 9.3 \times 10^{-7} C^E_N$$

(2) **Due to Steam Generator Blowdown Tank Vent**

i. **Method 1**

Step 1 - For the last quarter of operation, determine D_{QT} as determined per *Section D.3.b.*

Step 2 - Estimate R_I which is the expected ratio of secondary coolant iodine level for the coming month as compared with the average level during the quarter used in Step *1.*

Step 3 - Determine D^E_{MO} which is the estimated monthly dose to the maximum organ.

$$D^E_{MO} = 1/3\ R_I \times D_{QT}$$

ii. **Method 2**

If necessary, estimate the curies expected to be released for the next month and applicable method for dose calculation from *Section D.3.b.*

(3) **Due to Ventilation Releases****

i. **Method 1**

Step 1 - For the last quarter of operation, determine D_{QO} as determined per *Section D.3-b.*

Step 2 - Estimate R_1 which is the expected reduction factor for the HEPA filter. Typically this should be 100 *(see NUREG-0016 or 0017 for additional guidance).*

Step 3 - Estimate R_2 which is the fraction of the time which the equipment was inoperable during the last quarter.

Step 4 - Estimate R_3 which is the fraction of the time which the equipment is expected to be inoperable during the next month.

Step 5 - Determine D^E_{MO} which is the estimated monthly dose to the maximum organ.

$$D^E_{MO} = 1/3\ R_1\ (1.01 - R_2)\ (R_3 + 0.01)\ D_{QO}$$

ii. **Method 2**

If necessary, estimate the curies expected to be released for the next month and applicable method for dose calculation from Section *D.3.b.*

c. **Unit 3**

(1) **Due to Radioactive Gaseous Waste System**

Step 1 - Estimate C^E_N which equals the number of curies of noble gas to be released from the reactor plant gaseous vents (The activity from this pathway increases when the process waste gas system is out of service.) during the next month.

Step 2 - Determine D^E_{MG} which is the estimated monthly gamma air dose.

$$D^E_{MG}\ (\text{mrad}) = 9.3 \times 10^{-5}\ C^E_N$$

(Factor is from *Appendix D* for the Unit 1 stack releases since the Unit 3 reactor plant gaseous vents are discharged via the Unit 1 stack)

Step 3 - Determine D^E_{MB} which is the estimated monthly beta air dose.

$$D^E_{MB}\ (\text{mrad}) < 9.3 \times 10^{-7}\ C^E_N$$

(2) **Due to Steam Generator Blowdown Tank Vent**

i. **Method 1**

Step 1 - For the last quarter of operation, determine D_{QT} as determined per *Section D.3.b*

Step 2 - Estimate R_1 which is the expected ratio of secondary coolant iodine level for the coming month as compared with the average level during the quarter used in Step *1*.

Step 3 - Determine D^E_{MO} which is the estimated monthly dose to the maximum organ.

$$D^E_{MO} = 1/3\ R_1 \times D_{QT}$$

ii. **Method 2**

If necessary, estimate the curies expected to be released for the next month and applicable method for dose calculation from Section *D.3.b.*

(3) **Due to Ventilation Releases****

i. **Method 1**

Step 1 - For the last quarter of operation, determine D_{QO} as determined per *Section D.3-b.*

Step 2 - Estimate R_1 which is the expected reduction factor for the HEPA filter. Typically this should be 100 *(see NUREG-0016 or 0017 for additional guidance)*.

Step 3 - Estimate R_2 which is the fraction of the time which the equipment was inoperable during the last quarter.

Step 4 - Estimate R_3 which is the fraction of the time which the equipment is expected to be inoperable during the next month.

Step 5 - Determine D^E_{MO} which is the estimated monthly dose to the maximum organ.

$$D^E_{MO} = 1/3\ R_1\ (1.01 - R_2)\ (R_3 + 0.01)\ D_{QO}$$

ii. **Method 2**

If necessary, estimate the curies expected to be released for the next month and applicable method for dose calculation from Section *D.3.b.*

** Since dose projections are only required if the treatment specified in *Section D* of the Radiological Effluent Monitoring Manual are not operating, the monthly gamma and beta air dose projections are not required for ventilation releases.

D.5. Quarterly Dose Calculations for Annual Radioactive Effluent Report

Detailed quarterly dose calculations required for the *Annual Radioactive Effluent Report* shall be done using the computer codes GASPAR and AIREM.

D.6. Compliance with 40CFR190

The following sources should be considered in determining the total dose to a real individual from uranium fuel cycle sources:

a. **Gaseous Releases** from Units 1, 2, and 3.
b. **Liquid Releases** from Units 1, 2, and 3.
c. **Direct and Scattered Radiation** from Unit 1 Turbine Shine.
d. **Direct and Scattered Radiation** from Radioactive Material Stored on Site.
e. Since all other uranium fuel cycle sources are greater than 5 miles away, they need not be considered.

The Radiological Effluent Control D.3 for Unit 1 and the Radioactive Effluents Technical Specifications (RETS) in Technical Specification 3.11.3 for Units 2 and 3 contain specific requirements for ensuring compliance with 40CFR190 based on gaseous and liquid doses (sources **a** and **b**).
Calculations and detailed surveys* were used to characterize off-site exposure from "Skyshine" (source **c**) from the Unit 1 Turbine Building. The location of maximum dose is that of the critical fisherman. Listed below are the assumptions used for the calculation of this dose:

CALCULATION OF SKYSHINE CONTRIBUTION TO CRITICAL FISHERMAN**

(1) Based upon data obtained by Don Landers (MP Env. Lab) from the State of CT Department of Environmental Protection (DEP) records on lobster catches:
Annual average of 3.5-4.5 days between trips to each lobster basket.
(2) Therefore, there are 104 trips per year.
(3) Conservatively, assuming it takes one hour in the area to check all the baskets, this results in 104 hours around the intake structures areas.
(4) Maximum dose rate in the area is normally 65 μR/hr.
(5) Average dose rate is approximately one-half of the maximum.
(6) Therefore, annual dose to critical lobsterman is approximately 104 hours/year x 65 μR/h x 1/2 = 3.4 mrem.
(7) Multiplication to account for increase due to hydrogen water chemistry (HWC)
(8) Therefore, dose/month =

$$3.4\ \frac{\text{mrem}}{\text{year}} \times \frac{\text{year}}{12\text{ months}} \times \text{Unit 1 Capacity Factor} = 0.3\ \frac{\text{mrem}}{\text{month}} \times \text{Unit 1 Capacity Factor} \times \text{HWC Factor*}$$

* For operation without hydrogen injection, HWC = 1.

There are three things that could increase the Skyshine doses. First, would be an increase in the percent of N-16 in main steam. This occurs at plants implementing hydrogen water chemistry (HWC) and was observed at the Unit 1 mini test. Based on this test and data from other HWC plants an HWC factor increase in the range of 1.5 to 4 for feedwater hydrogen of 0.4 to 0.8 ppm and a factor increase from 4 to 5 for 0.8 to 2.0 ppm would be expected. Hence, any process that could increase N-16 main steam concentrations would require a detailed Radiological Environmental Review to ensure limits are met. Second, would be removal of shielding within the Unit 1 Turbine Building. This is not expected, but would definitely receive a radiological review if it occurred. Third, would be an increased occupancy time by a member of the public off site such that the combined occupancy and dose rate exceeded that assumed for the fisherman. Since the dose rate decreases rapidly with distance, this would only be expected to be an activity very near the Unit 1 intake structure. The RAB should be informed by anyone who becomes aware of any activity by a member of the public that could be expected to exceed 50 hours per year in this location.

Doses to source **d** are controlled by design and operations to ensure the off-site dose from each radwaste storage facility is less than one mrem per year. Potential doses from each facility are evaluated in Radiological Environmental Reviews (RER's) where total off-site doses from all four sources are considered to ensure compliance with 40CFR190.

* Memo to P. L. Tirinzoni from J. W. Doroski and C. A. Flory, Skyshine Evaluation at Millstone Unit #1, NE-87-RA-1033, December 8, 1987

** This should be the most limiting individual since it is expected that even though fishermen may spend more time near the area, they normally fish in an area of ~1 μR/hr.

E. LIQUID MONITOR SETPOINTS

E.1 Unit 1 Liquid Radwaste Effluent Line

The trip/alarm setting on the Unit 1 liquid radwaste discharge line depends on dilution water flow, radwaste discharge flow, the isotopic composition of the liquid, the background count rate of the monitor and the efficiency of the monitor. Due to the variability of these parameters, an alarm/trip setpoint will be determined prior to the release of each batch. The following method will be used:

Step 1 From the tank isotopic analysis and the MPC values for each identified nuclide (including noble gases*) determine the required reduction factor, i.e.:

$$R_1 = \text{Required Reduction Factor} = 1/\Sigma \frac{\mu\text{Ci/ml of nuclide i}}{\text{MPC of nuclide i}}$$

Step 2 Determine the existing dilution flow which is D *
D = # service water pumps x 8,000 gpm + # emergency service water pumps x 2,500 gpm

Step 3 Determine the allowable discharge flow which is F

$$F = 0.1 \times R \times D$$

Note that discharging at this flow rate would yield a discharge concentration corresponding to 10% of the *Technical Specification Limit* due to the safety factor of 0.1.

Step 4 Determine the total μCi/ml in the tank.

Step 5 Using the current calibration response factor, determine the "cps" corresponding to two times the total μCi/ml determined in Step 4. This value or that corresponding to 2.1×10^{-5} μCi/ml**, whichever is greater, plus background is the trip setpoint. For the latter setpoint, independent valve verification shall be performed and a minimum dilution flow of 2,500 gpm shall be verified and if necessary, appropriately adjusted.

Step 6 This allowable discharge flow rate calculated in *Step* 3 may be increased by up to a factor of 5 with appropriate administrative controls (e.g., insure other release points may not cause MPC's to be exceeded).

* If necessary, credit for other unit dilution flow can be taken as long as administrative controls are in place to assure MPC's are not exceeded. When using other unit dilution flow, at least one circulating water pump from the other unit shall be operating and the setpoint shall be equal to 8.5×10^{-4} uCi/ml. The value of 8.5×10^{-4} is based on a maximum discharge flow of 350 gpm, a minimum dilution flow of 100,000 gpm, and an effective maximum permissible concentration of 3×10^{-6}. The concentration assumes that Sr-90 is present at 10% of total activity.

** The value of 2.1×10^{-5} is based on the same parameters as the previous note except minimum dilution flow is 2,500 gpm.

E.2a Unit 1 Reactor Building Service Water Effluent Line

The MP1 Reactor Building Service Water Monitor is approximately two times the ambient background reading on the monitor in counts per second.

E.2b Unit 1 Reactor Building Service Water Effluent Concentration Limitation

Results of analysis of service water sample taken in accordance with Table C-1 of Part I of the REMODCM shall be used to limit radioactivity concentrations in the service water to less than the limits in 10CFR20, Appendix B (version prior to January 1, 1994).

E.3 Unit 2 Clean Liquid Radwaste Effluent Line

Similar to the Unit 1 liquid discharge line, the setpoints on the Unit 2 liquid waste effluent line depend on dilution water flow, radwaste discharge flow, the isotopic composition of the liquid, the background count rate of the monitor and the efficiency of the monitor. Due to the variability of these parameters, an alarm/trip setpoint will be determined prior to the release of each batch. The following method will be used:

Step 1 From the tank isotopic analysis and the MPC values for each identified nuclide (including noble gases*) determine the required reduction factor, i.e.:

For Nuclides Other Than Noble Gases*:

R_1 = Required Reduction Factor = $1/\Sigma \frac{\mu Ci/ml \text{ of nuclide } i}{MPC \text{ of nuclide } i}$

For Noble Gases:

R_2 = Required Reduction Factor = $1/\Sigma \frac{\mu Ci/ml \text{ of noble gases}}{2 \times 10^{-4}\ \mu Ci/ml}$

$= 2 \times 10^{-4}/\Sigma\ \mu Ci/ml$ of noble gases

R = the smaller of R_1 or R_2

* In lieu of determining the required reduction factor for noble gases, conservatism is allowed. For example, calculate the maximum concentration of noble gases that can be discharged from any tank.

Assuming:

Maximum discharge rate = 350 gpm

Normal Minimum dilution flow = 200,000 gpm (2 *circulating pumps, less than rated due to biotic fouling)*

Maximum noble gas Concentration x $\frac{350 \text{ gpm}}{200,000 \text{ gpm}}$ = $2 \times 10^{-4}\ \mu Ci/ml$

Therefore,

Maximum concentration = 0.11 μCi/ml

Step 2 Determine the existing dilution flow which is D

D = # circulating water pumps x 100,000 gpm + # service water pumps x 4,000 gpm

Step 3 Determine the allowable discharge flow which is F

F = 0.1 x R x D

Note that discharging at this flow rate would yield a discharge concentration corresponding to 10% of the *Technical Specification Limit* due to the safety factor of 0.1.

Step 4 Determine the total μCi/ml in the tank.

Step 5 Using the current calibration response factor, determine the "cpm" corresponding to two times the total μCi/ml determined in *Step 4* (*Note 1*). This value or that corresponding to $1.7 \times 10^{-4}\ \mu Ci/ml$ *(Note 2)*, whichever is greater, plus background is the trip setpoint. For the latter setpoint, independent valve verification shall be performed and minimum dilution flow in Note 2 shall be verified and if necessary, appropriately adjusted.

Note 1: If discharging at the allowable discharge rate as determined in *Step 3*, this would yield a discharge concentration corresponding to 20% of the Technical Specification limit.

Note 2: This value is based upon worst case conditions, assuming maximum discharge flow (350 gpm), normal minimum dilution water flow (200,000 gpm for MP2) and an assumed worst case mix of nuclides (3×10^{-7} - I-131 MPC). This will assure that low level releases are not terminated due to small fluctuations in activity. However, to verify that the correct tank is being discharged when using this value, independent valve verification shall be performed. This value may be adjusted (increased or decreased) by factors to account for the actual discharge flow and actual dilution flow; however, controls shall be established to ensure that the allowable discharge flow is not exceeded and the dilution flow is maintained.

Step 6 This allowable discharge flow rate calculated in *Step* 3 may be increased by up to a factor of 5 with appropriate administrative controls (e.g., insure other release points may not cause MPC's to be exceeded).

E.4 Unit 2 Aerated Liquid Radwaste Effluent Line and Condensate Polishing Facility Waste Neutralization Sump Effluent Line

Same as E.3 for Clean Liquid Monitor and the Condensate Polishing Facility (CPF) Waste Neutralization Sump monitor except the CPF monitor has the capability to readout in CPM or µCi/ml. For the CPF Waste Neutralization Sump monitor, use a default setpoint if no chemistry grab samples are required. This default shall be the lower of: two times background or the value as specified in E.3.

E.5a Unit 2 Steam Generator Blowdown

Assumptions used in determining the Alarm setpoint for this monitor are:

a. Total S.G. blowdown flow rate = 700 gpm.

b. Normal minimum possible circulating water dilution flow during periods of blowdown = 200,000 gpm (2 circulating water pumps) = 200,000 gpm.

c. The release rate limit is conservatively set at 10% of the *10CFR Part 20* limit for I-131 ($0.1 \times 3 \times 10^{-7}$ µCi/ml = 3×10^{-8} µCi/ml)*.

d. Background can be added after above calculations are performed.

Therefore, the alarm setpoint should correspond to a concentration of:

$$\text{Alarm } (\mu\text{Ci/ml}) = \frac{200{,}000}{700} \times 3 \times 10^{-8} + \text{background}^{**} = 8.5 \times 10^{-6}\ \mu\text{Ci/ml} + \text{background}$$

The latest monitor calibration curve should be used to determine the alarm setpoint in cpm corresponding to 8.5×10^{-6} µCi/ml.

This setpoint may be adjusted (increased or decreased) through proper administrative controls if the steam generator blowdown rate is maintained other than 700 gpm and/or other than 2 circulating water pumps are available. The adjustment would correspond to the ratio of flows to those assumed above or:

$$\text{Alarm } (\mu Ci/ml) = 8.5 \times 10^{-6}\ \mu Ci/ml \times \frac{\text{circulating \& service water flow (gpm)}}{200{,}000} \times \frac{700}{\text{S/G Blowdown (gpm)}}$$

$$+ \text{Background} = \frac{3 \times 10^{-8}\ \mu Ci/ml \times \text{circulating \& service water flow (gpm)}}{\text{total S/G Blowdown (gpm)}} + \text{Background}$$

Note: The Steam Generator Blowdown alarm criteria is in practice based on setpoints required to detect allowable levels of primary to secondary leakage. This alarm criteria is typically more restrictive than that required to meet discharge limits. This fact should be verified, however, whenever the alarm setpoint is recalculated.

* In lieu of using the I-131 MPC value, the identified MPC values for unrestricted area may be used.

** Background of monitor at monitor location (i.e., indication provided by system monitor with no activity present in the monitored system)

E.5b Unit 2 Steam Generator Blowdown Effluent Concentration Limitation

The results of analysis of blowdown samples required by Table C-2 of Part I of the REMODCM shall be used to ensure that blowdown effluent releases do not exceed the concentration limits in 10CFR20, Appendix B (version prior to January 1, 1994).

E.6 Unit 2 Condenser Air Ejector

N/A since this monitor is no longer a final liquid effluent monitor.

E.7a **Unit 2 Reactor Building Closed Cooling Water**

The purpose of the Reactor Building Closed Cooling Water (RBCCW) radiation monitor is to give warning of abnormal radioactivity in the RBCCW system and to prevent releases to the Service Water system which, upon release to the environment, would exceed allowable limits in 10CFR20. According to Calculation RERM-02665-R2, radioactivity in RBCCW water which causes a monitor response of greater than the setpoint prescribed below could exceed 10CFR20 limits upon release to the Service Water system.

SETPOINT DURING POWER OPERATIONS:
To give adequate warning of abnormal radioactivity, the setpoint shall be two times the radiation monitor background reading, provided that the background reading does not exceed 2,000 cpm. The monitor background reading shall be the normal monitor reading. If the monitor background reading exceeds 2,000 cpm, the setpoint shall be set at the background reading plus 2,000 cpm and provisions shall be made to adjust the setpoint if the background decreases.

SETPOINT DURING SHUTDOWN:
1. During outages not exceeding three months the setpoint shall be two times the radiation monitor background reading, provided that the background reading does not exceed 415 cpm. If the monitor background reading exceeds 415 cpm, the setpoint shall be set at the background reading plus 415 cpm and provisions shall be made to adjust the setpoint if the background decreases.
2. During extended outages exceeding three months, but not exceeding three years, the setpoint shall be two times the radiation monitor background reading, provided that the background reading does not exceed 80 cpm. If the monitor background reading exceeds 80 cpm, the setpoint shall be set at the background reading plus 80 cpm and provisions shall be made to adjust the setpoint if the background decreases.

PROVISIONS FOR ALTERNATE DILUTION FLOWS
These setpoints are based on a dilution flow of 4,000 gpm from one service water train. If additional dilution flow is credited, the setpoint may be adjusted proportionately. For example, the addition of a circulating water pump dilution flow of 100,000 gpm would allow the setpoint to be increased by a factor of 25.

E.7b Unit 2 Service Water and Turbine Building Sump Effluent Concentration Limitation

Results of analyses of service water and turbine building sump samples taken in accordance with Table C-2 of Part I of the REMODCM shall be used to limit radioactivity concentrations in the service water and turbine building sump effluents to less than the limits in 10CFR20, Appendix B (version prior to January 1, 1994).

E.8 Unit 3 Liquid Waste Monitor

Similar to the Unit 1 liquid discharge line, the setpoints on the Unit 3 liquid waste monitor depend on dilution water flow, radwaste discharge flow, the isotopic composition of the liquid, the background count rate of the monitor and the efficiency of the monitor. Due to the variability of these parameters, the alert and alarm setpoints will be determined prior to the release of each batch. The following method will be used:

Step 1 From the tank isotopic analysis and the MPC values for each identified nuclide (including noble gases*) determine the required reduction factor, i.e.:

For Nuclides Other Than Noble Gases*:

$$R_1 = \text{Required Reduction Factor} = 1/\Sigma \frac{\mu\text{Ci/ml of nuclide i}}{\text{MPC of nuclide i}}$$

For Noble Gases*:

$$R_2 = \text{Required Reduction Factor} = 1/\Sigma \frac{\mu\text{Ci/ml of noble gases}}{2 \times 10^{-4}\ \mu\text{Ci/ml}}$$

$$= 2 \times 10^{-4}/\Sigma\ \mu\text{Ci/ml of noble gases}$$

R = the smaller of R_1 or R_2

* In lieu of determining the required reduction factor for noble gases, conservatism is allowed. For example, calculate the maximum concentration of noble gases that can be discharged from any tank.

Assuming:

Maximum discharge rate = 150 gpm

Normal minimum dilution flow = 300,000 gpm (*2 circulating pumps)*

$$\text{Maximum "allowable" Concentration} \times \frac{150\ \text{gpm}}{300{,}000\ \text{gpm}} = 2 \times 10^{-4}\ \mu\text{Ci/ml}$$

Therefore,

Maximum "allowable" concentration = 0.4 μCi/ml

Step 2 Determine the existing dilution flow which is D

D = # circ water pumps x 150,000 gpm + # service water pumps x 15,000 gpm

Step 3 Determine the allowable discharge flow which is F

F = 0.1 x R x D

Note that discharging at this flow rate would yield a discharge concentration corresponding to 10% of the *Technical Specification Limit* due to the safety factor of 0.1.

Step 4 Determine the total μCi/ml in the tank.

Step 5 The alarm setpoint will be two times the total μCi/ml determined in *Step 4* (*Note 1*) or

2×10^{-4} µCi/ml *(Note 2)*, whichever is greater, plus background. For the latter setpoint, independent valve verification shall be performed and minimum dilution flow in Note 2 shall be verified and if necessary, appropriately adjusted.

Note 1: If discharging at the allowable discharge rate as determined in *Step 3*, this Alarm setpoint would yield a discharge concentration corresponding to 20% of the Technical Specification limit.

Note 2: This value is based upon worst case conditions, assuming maximum discharge flow (150 gpm), minimum dilution water flow (2 circulating pumps = 300,000 gpm), and an assumed mix of nuclides as specified for an unidentified liquid release in *10CFR20* (1×10^{-7} µCi/ml). This will assure that low level releases are not terminated due to small fluctuations in activity. However, to verify that the correct tank is being discharged when using this value, independent valve verification shall be performed. This value may be adjusted (increased or decreased) by factors to account for the actual discharge flow and actual dilution flow; however, controls shall be established to ensure that the allowable discharge flow is not exceeded and the dilution flow is maintained.

Step 6 The allowable discharge flow rate calculated in *Step* 3 may be increased by up to a factor of 5 with appropriate administrative controls (to ensure other release points do not cause MPC's to be exceeded).

E.9 Unit 3 Regenerant Evaporator Effluent Line

The MP3 Regenerant Evaporator has been removed from service with DCR M3-97-041. Therefore a radiation monitor alarm is not needed.

E.10 Unit 3 Waste Neutralization Sump Effluent Line

Same as *Section E.8*. Note that for this monitor, even though grab samples may not be required, setpoints still have to be utilized. In such cases, the default shall be the lower of: two times background or the value as specified in E.8.

E.11a Unit 3 Steam Generator Blowdown

The alarm setpoint for this monitor assumes:

a. Steam generator blowdown rate of 400 gpm (maximum blowdown total including weekly cleaning of generators - per 3-Part Memo from MP3 Reactor Engineering).

b. The release rate limit is conservatively set at 10% of the *10CFR Part* 20 limit (0.1 times the I-131 MPC* for unrestricted areas which equals $0.1 \times 3 \times 10^{-7}$ µCi/ml).

c. Minimum possible circulating and service water dilution flow during periods of blowdown = 300,000 gpm (2 circulating water pumps) + 30,000 gpm (2 service water pumps) = 330,000 gpm.

d. Background can be added after above calculations are performed.

Therefore, the alarm setpoint should correspond to a concentration of:

$$\text{Alarm } (\mu\text{Ci/ml}) = \frac{330{,}000}{400} \times 3 \times 10^{-8} + \text{background} = 2.47 \times 10^{-5}\ \mu\text{Ci/ml} + \text{background}$$

This setpoint may be increased through proper administrative controls if the steam generator blowdown rate is maintained less than 400 gpm and/or more than 2 circulating and 2 service water pumps are available. The amount of the increase would correspond to the ratio of flows to those assumed above or:

$$\text{Alarm } (\mu\text{Ci/ml}) = 2.47 \times 10^{-5}\ \mu\text{Ci/ml} \times \frac{\text{circulating \& service water flow (gpm)}}{330{,}000 \text{ gpm}} \times \frac{400}{\text{S/G Blowdown (gpm)}}$$

$$+ \text{Background} = 3 \times 10^{-8}\ \mu\text{Ci/ml} \times \frac{\text{circulating \& service water flow (gpm)}}{\text{total S/G Blowdown (gpm)}} + \text{Background}$$

Note: The Steam Generator Blowdown alarm criteria is in practice based on setpoints required to detect allowable levels of primary to secondary leakage. This alarm criteria is typically more restrictive than that required to meet discharge limits. This fact should be verified, however, whenever the alarm setpoint is recalculated.

* In lieu of using the I-131 MPC value, the identified MPC values for unrestricted area may be used.

E.11b Unit 3 Steam Generator Blowdown Effluent Concentration Limitation

The results of analysis of blowdown samples required by Table C-3 of Part I of the REMODCM shall be used to ensure that blowdown effluent releases do not exceed the concentration limits in 10CFR20, Appendix B (version prior to January 1, 1994).

E.12a Unit 3 Turbine Building Floor Drains Effluent Line

The alarm setpoint for this monitor assumes:

a. Drinking water is not a real pathway at this site. Therefore, the NRC code, LADTAP, is used to calculate the dose to the maximum individual.

b. The average annual discharge flow is 1.11 x 10^{-2} ft^3/sec (process flow during sump pump operation is 50 gpm and pump normally operates less than 10% of the time for a conservative average flow of 5 gpm). There is no continuous additional dilution, therefore, there is no dilution prior to discharge.

c. Near field dilution factor = 13,000.
Far field dilution factor = 32,000.
(Reference: Millstone 3 FSAR, Section 2.4.13)

d. Isotopic concentrations were taken from the *Millstone 3 FSAR, Table 11.2-4 (See column under Turbine Building).*

e. Each concentration above was multiplied by the total annual flow (9.95 x 10^9 cm^3, conservatively assuming 5 gpm continuous as discussed in item b).

f. The maximum individual organ dose is set equal to 1% of 75 mrem (40CFR190 limit). The limiting individual is the child; maximum organ is the thyroid. This value is approximately one quarter of the value

The setpoint corresponding to 0.75 mrem to the child's thyroid is 3.8 x 10^{-5} µCi/ml.

E.12b Unit 3 Service Water and Turbine Building Sump Effluent Concentration Limitation

Results of analyses of service water and turbine building sump samples taken in accordance with Table C-3 of Part I of the REMODCM shall be used to limit radioactivity concentrations in the service water and turbine buidling sump effluents to less than the limits in 10CFR20, Appendix B (version prior to January 1, 1994).

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F. GASEOUS MONITOR SETPOINTS

F.1 Unit I Hydrogen Monitor

Per *Radiological Effluent Controls C.2 and C.3 (Section III)* , the alarm setpoint shall be less than or equal to 4% hydrogen by volume. [Note: This parameter is pertinent only during the operational period of the plant. Power operations has permanently ceased.]

F.2 Unit I Steam Jet Air Ejector Offgas Monitor

[Note: This parameter is pertinent only during the operational period of the plant.
Power operations has permanently ceased.]

Radiological Effluent Control C.2 (Section III) requires the alarm setpoint to be set up to ensure that the instantaneous noble gas release rate limits from the stack are not exceeded.

Radiological Effluent Control C.4 (Section III) specifies the maximum allowed noble gas in-process activity to be 1.47×10^6 μCi/sec. The value of 1.47×10^6 μCi/sec is based on an assumed release of the entire inventory in the off gas treatment system with 95% worst-case meteorology. At that level, the dose would still be less than 10CFR20 limits.

Based on *Section F.3 (below),* the stack instantaneous release rate limit for MP-1 (assuming 1/3 of the site limit) is 363,000 μCi/sec. Assuming an approximate two factor decay from the air ejector monitor to the stack when using the 50 minute hold-up pipe, the corresponding activity at the air ejector is 700,000 μCi/sec and, hence, is more limiting than the 1.47×10^6 μCi/sec. When using the off gas treatment system, the decay factor is greater than 40, and hence, the 1.47×10^6 μCi/sec is more limiting.

The trip setpoint should be established by Station Chemistry to ensure Technical Specification Limits are met based on latest conversion factor from mR/hr to μCi/sec. Chemistry should specify the mR/hr corresponding to the following noble gas activity rates at the air ejector monitor:

With of gas treatment system out of service: ≤ 700,000 μCi/sec
With all flow thru off gas treatment system: ≤ 1,470,000 μCi/sec

To avoid having to re-adjust the setpoint with a change in off gas treatment, it is recommended that the alarm correspond to ≤ 700,000 μCi/sec unless a higher value is necessary to continue operations.

F.3 Unit I Stack Noble Gas Monitor

The instantaneous release rate limit from the site shall be set in accordance with the conditions given in ODCM Section D.1.a in order to satisfy *Radiological Effluent Control D.2.1 (Section III).*

The alarm setpoint should be set at or below the "cps" corresponding to 363,000 μCi/sec from the MP1 stack noble gas monitor calibration curve. The calibration curve (given as μCi/sec per cps) is determined by assuming a maximum ventilation flow of 180,000 CFM.

[Note: The release rate value of 363,000 μCi/sec assumes that 33% of the site limit is assigned to the MP1 stack. If effluent conditions from the MP1 stack approach the alarm setpoint, it may be increased if the MP2 or MP3 vent setpoints are also changed to ensure that the sum of the allowed individual unit noble gas release rates do not exceed the site limit as dictated in ODCM Section D.1.a, and described in Appendix D.]

F.4 Unit 1 Main Stack Sampler Flow Rate Monitor

The MP1 main stack sampler flow control alarms on low pressure indicating loss of flow, or on high pressure indicating restricted flow.

The alarm will occur with either (per GEK-27681A):

a. Pressure Switch #1 less than 2" Hg (Low Flow, i.e., damaged filter, filter inadvertently left out)

or

b. Pressure Switch #1 greater than 18" Hg (Restricted Flow, i.e., plugged filter)

or

c. Pressure Switch #2 less than 20" Hg (Restricted Flow, i.e., pump abnormalities)

F.5 Unit 2 Vent - Noble Gas Monitor

The instantaneous release rate limit from the site shall be set in accordance with the conditions given in ODCM Section D.1.a in order to satisfy *Technical Specifications 3.3.3.10 and 3.11.2.1.*

The alarm setpoint should be set at or below the "cpm" corresponding to 95,000 μCi/sec from the MP2 vent noble gas monitor calibration curve. The calibration curve (given as μCi/sec per cpm) is determined by assuming the maximum possible ventilation flow for various fan combinations. Curves for three different fan combinations are normally given.

[Note: The release rate value of 95,000 μCi/sec assumes that 33% of the site limit is assigned to the MP2 vent. If effluent conditions from the MP2 vent approach the alarm setpoint, it may be increased if the MP1 stack or MP3 vent setpoints are also changed to ensure that the sum of the allowed individual unit noble gas release rates do not exceed the site limit as dictated in ODCM Section D.1.a, and described in Appendix D. Prior to decreasing the MP1 stack setpoint, evaluate if the MP1 steam jet air ejector setpoint needs to be changed, to comply with *Technical Specification 3.8.B.1 (see Section F.2).]*

F.6 Unit 2 Waste Gas Decay Tank Monitor

Administratively all waste gas decay tank releases are via the MP1 stack which has a release rate limit typically set at 363,000 μCi/sec (see Appendix D for bases). Assuming 33% of the limit is from the MP1 stack, the release rate limit for MP1 is 363,000 μCi/sec.

Releases from waste gas decay tanks are much lower than this limit and are based upon a dilution factor of 1000 (dilution less than 1% of the worst case quarter X/Q; 210,000 ft^3/min x 6.3 x 10^{-8} sec/m^3 x 0.028317 m^3/ft^3 x 1/60 min/sec = 1/160,000, which is equivalent to 0.6245% of a dilution factor of 1000) and release rates to maintain offsite concentration below MPC values.

The MP2 waste gas decay tank monitor (given μCi/cc per cpm) calibration curve is used to assure that the concentration of gaseous activity being released from a waste gas decay tank is not greater than the concentration used in discharge permit calculations.

F.7 Unit 3 Vent Noble Gas Monitor

The instantaneous release rate limit from the site shall be set in accordance with the conditions given in ODCM Section D.1.a in order to satisfy *Technical Specification 3.3.3.10 and 3.11.2.1.*

The alarm setpoint should be set at or below a value of 9.5 x 10^{-4} μCi/cc for the MP3 vent.

[Note: The release rate value of 9.5 x 10^{-4} μCi/cc assumes that 33% of the site limit is assigned to the MP3 vent. This value corresponds to a release rate of 95,000 μCi/sec and a maximum ventilation flow rate of 210,000 CFM (per memo from G. C. Knight to R. A. Crandall, MP-3-1885, July 19, 1989). If effluent conditions from the MP3 vent approach the alarm setpoint, it may be increased if the MP1 stack or MP2 vent setpoints are also changed to ensure that the sum of the allowed individual unit noble gas release rates do not exceed the site limit as dictated in ODCM Section D.1.a, and described in Appendix D.]

F.8 Unit 3 Engineering Safeguards Building Monitor

Assuming releases less than 10% of the MP3 FSAR design releases of noble gases *(Table 11.3-11,* 1.4 x 10^4 Ci/year which is equal to 450 μCi/sec) assures that less than 1% of the above instantaneous release rate is added by this intermittent pathway (450/290,000 = 0.16%). Assuming a flow rate of 6,500 CFM (3.05 x 10^6 cc/sec) for this pathway translates this limit to:

$$0.1 \times 450/3.05 \times 10^6 = 1.5 \times 10^{-5}\ \mu Ci/cc$$

The Alarm setpoint should be set at or below this value.

APPENDIX A

DERIVATION OF FACTORS FOR SECTION C.1. - LIQUID DOSES

1. Section C.1.a - Step 3

C_F = Curies of fission and activation products released during calendar quarter.

$D_{QW(F)}$ = Calculated whole body dose to the maximum individual (mrem) due to fission and activation products. Dose calculated using computer code LADTAP.

C_H = Curies of tritium released during calendar quarter.

$D_{QW(H)}$ = Calculated whole body dose to the maximum individual (mrem) due to tritium releases. Dose calculated using computer code LADTAP.

UNIT 1 - LIQUID - WHOLE BODY DOSES

Year	Quarter	C_F	$D_{QW(F)}$	$D_{QW(F)}/C_F$ (mrem/Ci)	C_H	$D_{DQW(H)}$	$D_{QW(H)}/C_H$ (mrem/Ci)
1980	1	0.013	6.2 (-5)	4.8 (-3)	2.40	3.04 (-7)	1,27 (-7)
	2	0.014	1.6 (-4)	1.1 (-2)	4.96	1.54 (-6)	3.10 (-7)
	3	0.011	1.2 (-4)	1.1 (-2)	6.45	1.67 (-6)	2.59 (-7)
	4	0.686	1.2 (-2)	1.8 (-2)	13.50		
1981	1	0.314	5.8 (-3)	1.9 (-2)	1.42		
	2	0.042	7.6 (-4)	1.8 (-2)	0.88		
	3	0.029	3.5 (-4)	1.2 (-2)	0.31		
	4	0.009	1.2 (-4)	1.3 (-2)	0.006		
1982	1	0.008	1.2 (-4)	1.5 (-2)	0.12		
	2	0.030	1.8 (-4)	6.0 (-3)	0.12		
	3	0.577	7.4 (-3)	1.3 (-2)	3.88		
	4	0.538	6.1 (-3)	1.1 (-2)	2.08		
1983	1	0.777	3.9 (-3)	5.0 (-3)	1.61		
	2	0.007	7.3 (-5)	1.0 (-2)	1.87	3.96 (-7)	2.12 (-7)
	3	0.007	1.0 (-4)	1.4 (-2)	3.64	1.16 (-6)	3.19 (-7)
	4	0.016	2.0 (-4)	1.3 (-2)	1.26		
1984	1	0.017	1.6 (-4)	9.4 (-3)	0.77		
	2	0.016	2.3 (-4)	1.4 (-2)	5.56	1.5 (-6)	2.7 (-7)
	3	0.003	3.1 (-5)	1.0 (-2)	1.06	1.5 (-7)	1.4 (-7)
	4	0.002	2.0 (-5)	1.0 (-2)	1.19	2.4 (-7)	2.0 (-7)
1985	1	0.038	4.5 (-4)	1.2 (-2)	2.61		

UNIT 1 - LIQUID - WHOLE BODY DOSES

Year	Quarter	C_F	$D_{QW(F)}$	$D_{QW(F)}/C_F$ (mrem/Ci)	C_H	$D_{DQW(H)}$	$D_{QW(H)}/C_H$ (mrem/Ci)
	2	0.025	3.3 (-4)	1.3 (-2)	2.43		
	3	0.354	3.1 (-3)	8.8 (-3)	5.26		
	4	0.049	6.7 (-4)	1.4 (-2)	7.56		
1986	1	0.019	2.2 (-4)	1.2 (-2)	1.73	4.9 (-7)	2.8 (-7)
	2	0.511	5.2 (-3)	1.0 (-2)	1.78	4.6 (-7)	2.6 (-7)
	3	0.239	2.2 (-3)	9.2 (-3)	1.01	2.4 (-7)	2.4 (-7)
	4	0.004	4.0 (-5)	1.0 (-2)	0.81	2.4 (-7)	3.0 (-7)
1987	1	0.012	1.1 (-4)	9.2 (-3)	1.65	4.0 (-7)	2.4 (-7)
	2	0.142	1.5 (-3)	1.1 (-2)	9.93	2.4 (-6)	2.4 (-7)
	3	0.413	6.6 (-3)	1.6 (-2)	2.66	6.6 (-7)	2.5 (-7)
	4	0.577	5.9 (-3)	1.0 (-2)	3.57	9.5 (-7)	2.7 (-7)
1988	1	0.598	6.2 (-3)	1.0 (-2)	2.88	8.3 (-7)	2.9 (-7)
	2	0.280	1.3 (-2)	4.6 (-2)	8.42	2.0 (-6)	2.4 (-7)
	3	0.145	7.5 (-3)	5.2 (-2)	11.8	2.6 (-6)	2.2 (-7)
	4	0.059	1.1 (-2)	1.9 (-1)	14.7	3.6 (-6)	2.4 (-7)
1989	1	0.087	1.1 (-2)	1.3 (-1)	11.4	3.0 (-6)	2.6 (-7)
	2	0.344	3.3 (-1)	9.6 (-1)	11.5	3.8 (-6)	3.3 (-7)
	3	0.353	2.8 (-1)	7.9 (-1)	3.86	8.8 (-7)	2.3 (-7)
	4	0.110	3.1 (-2)	2.8 (-1)	19.0	4.6 (-6)	2.4 (-7)
1990	1	0.042	1.51E-02	3.57E-01			
	2	0.027	1.80E-02	6.74E-01			
	3	0.012	4.77E-03	4.08E-01			
	4	0.060	7.17E-03	1.19E-01			
1991	1	0.061	4.40E-03	7.18E-02			
	2	0.598	5.92E-01	9.90E-01			
	3	0.340	6.66E-01	1.96E+00			
	4	0.354	3.27E-01	9.24E-01			
1992	1	0.224	1.58E-01	7.05E-01			
	2	0.071	2.26E-02	3.17E-01			
	3	0.110	2.87E-02	2.61E-01			
	4	0.058	2.56E-02	4.43E-01			
1993	1	0.057	2.38E-02	4.18E-01			
	2	0.035	3.61E-02	1.03E+00			
	3	0.026	4.64E-02	1.78E+00			
	4	0.011	1.20E-02	1.09E+00			

UNIT 1 - LIQUID - WHOLE BODY DOSES

Year	Quarter	C_F	$D_{QW(F)}$	$D_{QW(F)}/C_F$ (mrem/Ci)	C_H	$D_{DQW(H)}$	$D_{QW(H)}/C_H$ (mrem/Ci)
1994	1	0.006	1.26E-02	2.10E+00			
	2	0.036	6.18E-02	1.72E+00			
	3	0.006	1.50E-02	2.50E+00			
	4	0.012	3.02E-02	2.50E+00			

UNIT 2 - LIQUID - WHOLEBODY DOSES

Year	Quarter	C_F	$D_{QW(F)}$	$D_{QW(F)}/C_F$ (mrem/Ci)	C_H	$D_{DQW(H)}$	$D_{QW(H)}/C_H$ (mrem/Ci)
1980	1	0.635	4.0 (-3)	6.3 (-3)	97.7		
	2	0.285	1.6 (-3)	6.0 (-3)	57.0	1.09 (-5)	1.91 (-7)
	3	1.17	1.2 (-2)	6.8 (-3)	48.8		
	4	0.723	1.2 (-2)	1.7 (-2)	64.8	2.28 (-5)	3.52 (-7)
1981	1	0.435	6.8 (-3)	1.6 (-2)	55.3		
	2	0.343	5.8 (-3)	1.7 (-2)	149.0	5.41 (-5)	3.63 (-7)
	3	0.265	1.6 (-3)	6.0 (-3)	87.2	1.77 (-5)	2.03 (-7)
	4	3.14	1.0 (-2)	3.2 (-3)	79.9		
1982	1	1.65	1.0 (-2)	6.1 (-3)	7.4		
	2	9.94	8.4 (-3)	8.5 (-4)	88.3	4.91 (-5)	5.56 (-7)
	3	1.14	8.1 (-3)	7.1 (-3)	113.0		
	4	1.14	1.3 (-2)	1.1 (-2)	82.6		
1983	1	1.48	1.1 (-2)	7.4 (-3)	70.7		
	2	0.685	7.2 (-3)	1.1 (-2)	36.7		
	3	2.42	3.6 (-2)	1.5 (-2)	6.5		
	4	3.22	4.5 (-2)	1.4 (-2)	6.8		
1984	1	1.49	9.4 (-3)	6.3 (-3)	47.4		
	2	0.86	1.4 (-2)	1.6 (-2)	77.1	2.2 (-5)	2.9 (-7)
	3	0.41	3.9 (-3)	9.5 (-3)	136	2.6 (-5)	1.9 (-7)
	4	0.80	4.7 (-3)	5.9 (-3)	137	2.5 (-5)	1.8 (-7)
1985	1	1.17	8.4 (-3)	7.2 (-3)	34.9		
	2	2.29	3.0 (-2)	1.3 (-2)	5.7	1.5 (-6)	2.6 (-7)
	3	0.83	8.5 (-3)	1.0 (-2)	25.1	3.3 (-6)	1.3 (-7)
	4	0.30	4.9 (-3)	1.6 (-2)	100.0	2.9 (-5)	2.9 (-7)
1986	1	0.40	4.2 (-3)	1.1 (-2)	50.9	1.5 (-5)	2.9 (-7)
	2	0.36	4.0 (-3)	1.1 (-2)	134.0	3.5 (-5)	2.6 (-7)
	3	1.55	1.1 (-2)	7.1 (-3)	81.8	2.1 (-5)	2.6 (-7)
	4	2.18	1.1 (-2)	5.0 (-3)	12.9	3.8 (-6)	2.9 (-7)
1987	1	1.58	4.1 (-3)	2.6 (-3)	55.7	1.3 (-5)	2.3 (-7)
	2	1.08	5.7 (-3)	5.3 (-3)	53.7	1.3 (-5)	2.4 (-7)
	3	0.11	7.4 (-4)	6.7 (-3)	108	2.7 (-5)	2.5 (-7)
	4	1.30	9.8 (-3)	7.5 (-3)	68.6	1.8 (-5)	2.6 (-7)
1988	1	4.56	1.9 (-2)	4.2 (-3)	20.5	5.9 (-6)	2.9 (-7)
	2	2.84	1.2 (-2)	4.2 (-3)	96.4	2.3 (-5)	2.4 (-7)
	3	0.241	1.4 (-3)	5.8 (-3)	42.3	9.1 (-6)	2.2 (-7)
	4	1.25	1.1 (-2)	8.8 (-3)	99.9	2.4 (-5)	2.4 (-7)
1989	1	7.01	1.9 (-2)	2.7 (-3)	88.5	2.4 (-5)	2.7 (-7)

UNIT 2 - LIQUID - WHOLEBODY DOSES

Year	Quarter	C_F	$D_{QW(F)}$	$D_{QW(F)}/C_F$ (mrem/Ci)	C_H	$D_{DQW(H)}$	$D_{QW(H)}/C_H$ (mrem/Ci)
	2	3.07	1.9 (-2)	6.2 (-3)	21.4	7.0 (-6)	3.3 (-7)
	3	0.139	8.6 (-4)	6.2 (-3)	76.7	1.7 (-5)	2.2 (-7)
	4	0.448	3.1 (-3)	6.9 (-3)	179.	4.4 (-5)	2.5 (-7)

*For data prior to 1986, tritium doses not listed when doses from tritium were less than ½% of the whole body doses.

UNIT 3 - LIQUID - WHOLE BODY DOSES

Year	Quarter	C_F	$D_{QW(F)}$	$D_{QW(F)}/C_F$ (mrem/Ci)	C_H	$D_{DQW(H)}$	$D_{QW(H)}/C_H$ (mrem/Ci)
1986	1	0.06	9.1 (-6)	1.5 (-4)	4.0	1.1 (-6)	2.8 (-7)
	2	0.88	2.5 (-4)	2.8 (-4)	99.6	2.6 (-5)	2.6 (-7)
	3	1.96	1.3 (-3)	6.6 (-4)	286	6.8 (-5)	2.5 (-7)
	4	0.11	2.7 (-4)	2.5 (-3)	169	5.0 (-5)	3.0 (-7)
1987	1	1.99	3.3 (-3)	1.7 (-3)	243	5.9 (-5)	2.4 (-7)
	2	1.76	3.4 (-3)	1.9 (-3)	171	4.2 (-5)	2.5 (-7)
	3	0.43	1.4 (-3)	3.3 (-3)	98.3	2.4 (-5)	2.4 (-7)
	4	1.22	1.4 (-2)	1.1 (-2)	77.4	2.1 (-5)	2.7 (-7)
1988	1	1.46	1.5 (-2)	1.0 (-2)	52.0	1.5 (-5)	2.9 (-7)
	2	0.72	3.3 (-3)	4.6 (-3)	124	2.9 (-5)	2.3 (-7)
	3	0.30	1.5 (-3)	5.0 (-3)	95.1	2.1 (-5)	2.2 (-7)
	4	0.66	3.8 (-3)	5.8 (-3)	276	6.7 (-5)	2.4 (-7)
1989	1	1.28	6.2 (-3)	4.8 (-3)	187	4.9 (-5)	2.6 (-7)
	2	1.13	6.9 (-3)	6.1 (-3)	194	6.3 (-5)	3.2 (-7)
	3	2.47	2.8 (-2)	1.1 (-2)	72.5	1.6 (-5)	2.2 (-7)
	4	1.05	1.3 (-2)	1.2 (-2)	244	5.9 (-5)	2.4 (-7)

Projected Releases*	**Ci/yr**	**Dose (mrem/year)**	**Dose/Ci**
Total Fission and Activation (excl. H-3)	0.18	8.8 (-4)	4.9 (-3)
H-3	730	1.6 (-4)	2.2 (-7)

*From Unit 3 EROLS Table 5.2-4

Maximum Value of $D_{QW(F)}/C_F$ = Unit 1 = 2.5×10^{0} mrem/Ci
Unit 2 = 1.7×10^{-2} mrem/Ci
Unit 3 = 1.2×10^{-2} mrem/Ci (From 1986-1989 data)

Maximum Value of $D_{QW(H)}/C_H$ = Unit 1 = 4.3×10^{-7} mrem/Ci
Unit 2 = 5.6×10^{-7} mrem/Ci
Unit 3 = 3.2×10^{-7} mrem/Ci (From 1986-1989 data)

The maximum value of $D_{QW(F)}/C_F$ is much higher for Unit 1 than for Units 2 and 3. This difference in dose/curie values was caused by the change in the isotopic mixture resulting from operation of the zinc injection system at Unit 1; therefore, a separate value for Unit 1 is necessary. The values for Units 2 and 3 are within a factor of 2 and can be conservatively applied to both units.

Since the maximum value $D_{QW(H)}/C_H$ is not much different for Units 1, 2 and 3, the same factor can be used for all three units (for simplicity).

*Dose factor values for Unit 1 have increased significantly because of the zinc injection process.

Thus, for Unit 1:	$D_{QW(F)}/C_F$	=	2.5×10^{0} mrem/Ci
	$D_{QW(H)}/C_H$	=	5.6×10^{-7} mrem/Ci
for Units 2 and 3:	$D_{QW(F)}/C_F$	=	2.0×10^{-2} mrem/Ci
	$D_{QW(H)}/C_H$	=	5.6×10^{-7} mrem/Ci

Note: Although operation of Unit 3 increases the dilution flow, the near field dilution factor is reduced from 5 to 3. Therefore, the net effect is to reduce the doses by only a factor of 0.86. As can be seen in the 1986-1989 data, this has a negligible effect on the doses.

APPENDIX B

DERIVATION OF FACTORS FOR SECTION C.2. — LIQUID DOSES

1. Section C.2.a — Step 2

C_F = Curies of fission and activation products released during calendar quarter.

GI (LLI) = Gastro-intestinal Tract — Lower Large Intestine.

D_{QO} = Calculated critical organ dose to the maximum individual (mrem) for the calendar quarter. Dose was calculated using the computer code LADTAP.

Note: Tritium has never contributed more than 1% to the maximum organ dose and thus it is not included in the calculation.

UNIT 1 — LIQUID DOSES — MAXIMUM ORGAN

Year	Quarter	C_F	Max. Organ	D_{QO}	D_{QO}/C_F
1976	1	8.60	GI (LLI)	0.054	0.0062
	2	0.053	GI (LLI)	0.0003	0.0056
	3	0.48	GI (LLI)	0.059	0.123
	4	0.15	GI (LLI)	0.0057	0.038
1977	1	0.12	GI (LLI)	0.0021	0.018
	2	0.36	GI (LLI)	0.0041	0.011
	3	0.012	Liver	0.00017	0.014
	4	0.028	GI (LLI)	0.00086	0.031
1978	1	0.119	GI (LLI)	0.024	0.202
	2	0.049	GI (LLI)	0.0031	0.063
	3	0.002	GI (LLI)	4.0(-5)	0.02
	4	0.005	GI (LLI)	1.3(-4)	0.026
1979	1	0.045	GI (LLI)	1.8(-3)	0.04
	2	0.146	GI (LLI)	9.3(-3)	0.064
	3	0.009	GI (LLI)	9.0(-4)	0.10
	4	0.01	GI (LLI)	2.1(-4)	0.021
1980	1	0.013	GI (LLI)	1.7(-4)	0.013
	2	0.014	GI (LLI)	5.5(-4)	0.039
	3	0.011	GI (LLI)	3.0(-4)	0.027
	4	0.686	Liver	1.7(-2)	0.025
1981	1	0.314	GI (LLI)	9.75(-3)	0.031
	2	0.042	GI (LLI)	1.88(-3)	0.045
	3	0.029	GI (LLI)	7.94(-4)	0.027
	4	0.009	GI (LLI)	2.58(-4)	0.029

UNIT 1 — LIQUID DOSES — MAXIMUM ORGAN

Year	Quarter	C_F	Max. Organ	D_{QO}	D_{QO}/C_F
1982	1	0.008	GI (LLI)	2.58(-4)	0.032
	2	0.030	GI (LLI)	3.09(-4)	0.010
	3	0.577	Liver	1.24(-2)	0.021
			Thyroid	1.42(-2)	0.025
	4	0.538	GI (LLI)	1.17(-2)	0.022
1983	1	0.777	GI (LLI)	1.26(-2)	0.016
	2	0.007	GI (LLI)	1.73(-4)	0.025
	3	0.007	GI(LLI)	2.15(-4)	0.031
	4	0.016	GI (LLI)	4.12(-4)	0.026
1984	1	0.017	GI (LLI)	3.1(-4)	1.8(-2)
	2	0.016	GI (LLI)	6.0(-4)	3.8(-2)
	3	0.003	GI (LLI)	6.1(-5)	2.0(-2)
	4	0.002	GI (LLI)	3.7(-5)	1.9(-2)
1985	1	0.038	GI (LLI)	7.7(-4)	2.0(-2)
	2	0.025	GI (LLI)	5.1(-4)	2.0(-2)
	3	0.354	Liver	5.4(-3)	1.5(-2)
	4	0.049	Liver	1.0(-3)	2.0(-2)
1986	1	0.019	GI (LLI)	1.1(-3)	5.8(-2)
	2	0.511	Liver	7.2(-3)	1.4(-2)
	3	0.239	Liver	3.0(-3)	1.3(-2)
	4	0.004	Bone	1.5(-4)	3.8(-2)
1987	1	0.012	Bone	1.6(-4)	1.3(-2)
	2	0.142	GI (LLI)	3.0(-3)	2.1(-2)
	3	0.413	GI (LLI)	1.2(-2)	2.9(-2)
	4	0.577	GI (LLI)	2.0(-2)	3.5(-2)
1988	1	0.598	GI (LLI)	2.4(-2)	3.9(-2)
	2	0.280	Liver	2.7(-2)	9.6(-2)
	3	0.145	Liver	1.6(-2)	1.1(-1)
	4	0.059	Liver	2.4(-2)	4.1(-1)
1989	1	0.087	Liver	2.3(-2)	2.6(-1)
	2	0.344	Liver	7.3(-1)	2.1(0)
	3	0.353	Liver	6.2(-1)	1.8(0)
	4	0.110	Liver	6.9(-2)	6.3(-1)

UNIT 2 — LIQUID DOSES — MAXIMUM ORGAN

Year	Quarter	C_F	Max. Organ	D_{QO}	D_{QO}/C_F
1976	1	0.102	GI (LLI)	0.0017	0.016
	2	0.179	GI (LLI)	0.0051	0.028
	3	0.037	GI(LLI)	0.0024	0.065
	4	0.025	GI (LLI)	0.00075	0.030
1977	1	0.217	GI (LLI)	0.012	0.055
	2	0.802	GI (LLI)	0.036	0.045
	3	0.035	GI(LLI)	0.0014	0.040
	4	0.509	GI (LLI)	0.012	0.024
1978	1	0.432	GI (LLI)	0.039	0.090
	2	1.27	GI (LLI)	0.13	0.102
	3	0.715	GI (LLI)	4.2(-2)	0.059
	4	0.372	GI (LLI)	9.0(-3)	0.024
1979	1	1.65	GI (LLI)	4.1(-2)	0.025
	2	2.48	GI (LLI)	2.4(-1)	0.097
	3	0.331	GI (LLI)	1.8(-2)	0.054
	4	0.411	GI (LLI)	1.6(-2)	0.039
1980	1	0.635	GI (LLI)	1.1(-2)	0.017
	2	0.285	GI (LLI)	3.9(-3)	0.014
	3	1.17	GI (LLI)	1.0(-1)	0.085
	4	0.723	GI (LLI)	7.4(-2)	0.102
1981	1	0.435	GI (LLI)	2.91(-2)	0.067
	2	0.343	GI (LLI)	2.91(-2)	0.085
	3	0.265	GI (LLI)	7.47(-3)	0.028
	4	3.14	Liver	1.67(-2)	0.005
1982	1	1.65	GI (LLI)	9.6(-2)	0.058
	2	9.94	GI (LLI)	5.76(-2)	0.006
			Thyroid	3.59(-1)	0.036
	3	1.14	GI (LLI)	2.43(-2)	0.021
			Thyroid	2.84(-2)	0.025
	4	1.14	Liver	1.09(-2)	0.010
1983	1	1.48	Liver	1.66(-2)	0.011
	2	0.685	Liver	1.14(-2)	0.017
	3	2.42	GI (LLI)	6.36(-2)	0.026
	4	3.22	GI (LLI)	7.74(-2)	0.024
1984	1	1.49	GI (LLI)	1.7(-2)	1.1(-2)
	2	0.86	GI (LLI)	2.3(-2)	2.7(-2)
	3	0.41	Liver	6.1(-3)	1.5(-2)
	4	0.80	Thyroid	1.6(-2)	2.0(-2)
1985	1	1.17	Thyroid	2.5(-2)	2.1(-2)
	2	2.29	GI (LLI)	8.0(-2)	3.5(-2)
	3	0.83	GI (LLI)	4.3(-2)	5.2(-2)
	4	0.30	GI (LLI)	2.5(-2)	8.3(-2)
1986	1	0.40	GI (LLI)	1.5(-2)	3.8(-2)
	2	0.36	GI (LLI)	6.6(-3)	1.8(-2)
	3	1.55	GI (LLI)	4.1(-2)	2.6(-2)
	4	2.18	GI (LLI)	1.1(-1)	5.0(-2)

UNIT 2 — LIQUID DOSES — MAXIMUM ORGAN

Year	Quarter	C_F	Max. Organ	D_{QO}	D_{QO}/C_F
1987	1	1.58	GI (LLI)	2.9(-2)	1.8(-2)
	2	1.08	GI (LLI)	2.1(-2)	1.9(-2)
	3	0.11	GI (LLI)	3.8(-3)	3.5(-2)
	4	1.30	GI (LLI)	5.4(-2)	4.2(-2)
					4.2(-1)
1988	1	4.56	GI (LLI)	9.9(-2)	2.2(-2)
	2	2.84	GI (LLI)	9.7(-2)	3.4(-2)
	3	0.241	GI(LLI)	8.3(-3)	3.4(-2)
	4	1.25	GI (LLI)	5.2(-2)	4.2(-2)
1989	1	7.01	GI (LLI)	1.3(-1)	1.9(-2)
	2	3.07	GI (LLI)	3.6(-1)	1.2(-1)
	3	0.139	GI(LLI)	1.6(-2)	1.2(-1)
	4	0.448	GI (LLI)	4.6(-2)	1.0(-1)
					4.2(-1)

UNIT 3 — LIQUID DOSES — MAXIMUM ORGAN

Year	Quarter	C_F	Max. Organ	D_{QO}	D_{QO}/C_F
1986	1	0.06	GI (LLI)	4.6(-5)	7.7(-4)
	2	0.88	GI (LLI)	3.1(-3)	3.5(-3)
	3	1.96	GI(LLI)	2.2(-2)	1.1(-2)
	4	0.11	GI (LLI)	1.2(-2)	1.1(-1)
1987	1	1.99	GI (LLI)	3.7(-2)	1.9(-2)
	2	1.76	GI (LLI)	4.2(-2)	2.4(-2)
	3	0.43	GI(LLI)	7.9(-3)	1.8(-2)
	4	1.22	GI (LLI)	6.9(-2)	5.7(-2)
1988	1	1.46	GI (LLI)	1.1(-1)	7.5(-2)
	2	0.72	GI (LLI)	3.6(-2)	5.0(-2)
	3	0.30	GI (LLI)	7.3(-3)	2.4(-2)
	4	0.66	GI (LLI)	3.2(-2)	4.8(-2)
1989	1	1.28	GI (LLI)	7.1(-2)	5.5(-2)
	2	1.13	GI (LLI)	3.5(-2)	3.1(-2)
	3	2.47	GI (LLI)	3.0(-1)	1.2(-1)
	4	1.05	GI (LLI)	1.5(-1)	1.4(-1)

Projected Releases From ER Ci/yr	Max. Organ	Dose (mrem/year)	Dose/Ci
0.18	Thyroid	6.3(-3)	0.035

Maximum Value of D_{QO}/C_F

Unit 1 — 2.1 mrem/Ci
Unit 2 — 0.12 mrem/Ci
Unit 3 — 0.14 mrem/Ci (From 1986-1989 data)

Average Value of D_{QO}/C_F

Unit 1 — 0.68 mrem/Ci (From 1988-1989 data*)
Unit 2 — 0.043 mrem/Ci
Unit 3 — 0.068 mrem/Ci (From 1988-1989 data)

The maximum value of $D_{QO(F)}/C_F$ is much higher for Unit 1 than for Units 2 and 3. This difference in dose/curie values was caused by the change in isotopic mixture resulting from operation of the zinc injection system at Unit 1; therefore, a separate value for Unit 1 is necessary. The values for Units 2 and 3 are within a factor of 2 and can be conservatively applied to both units.

The maximum value for all three units is less than three times the average values; therefore , this is not over-conservative.

Thus, for Unit 1: $D_{QO(F)}/C_F = 2.1$

for Units 2 and 3: $D_{QO(F)}/C_F = 0.2$

* Dose factor values for Unit 1 have increased significantly because of the change in isotopic mixture caused by the zinc injection process; therefore, only the last two years were averaged.

APPENDIX C

LIQUID DOSE CALCULATIONS — LADTAP

The LADTAP code was written by the NRC to compute doses from liquid releases. The actual model used is LADTAP II which performs calculations in accordance with *Regulatory Guide 1.109, Revision 1.*

For calculating the maximum individual dose at Millstone, the following options and parameters are used:

1. Real time, measured dilution flow
2. Salt water site
3. Reconcentration — cycle time — 12 hrs. (*MP1 and 2 FES*)
   Recycle fraction = 0.025 (*Final Environmental Statements for MP1 and 2*)
4. Shorewidth factor = 0.5 (*Table A-9, Regulatory Guide 1.109*)
5. Dilution for maximum individual pathways = 3 (*Page 5.2-5 of MP3 Environmental Report)*
6. Thirty-minute Discharge Transit Time — time to transit quarry; estimated from chloride study (*MP3 Environmental Report*)
7. *Regulatory Guide 1.109* usage factors for maximum individual for fish, shellfish, shoreline, swimming and boating pathways
8. Zero usage for algae, drinking water, and irrigated food pathways

APPENDIX D

DERIVATION OF FACTORS FOR SECTION D — GASEOUS DOSES

1. X/Q's, D/Q's

Unit 1 Stack
Elevated X/Q's, D/Q's
Quarterly Averages — Maximum Values

Year	Quarter	Land Maximum X/Q	Residence Maximum D/Q	Cow or Goat Maximum D/Q
1980	1	5.3(-8)	----------*	----------**
	2	4.0(-8)	1.7(-9)	3.6(-10)
	3	5.6(-8)	1.8(-9)	2.7(-10)
	4	6.3(-8)	4.0(-9)	1.4(-9)
1981	1	4.5(-8)	----------	----------
	2	3.9(-8)	9.1(-10)	1.7(-10)
	3	6.3(-8)	1.6(-9)	6.2(-10)
	4	5.6(-8)	5.9(-9)	7.1(-10)
1982	1	5.9(-8)	----------	----------
	2	3.8(-8)	2.4(-9)	4.4(-10)
	3	4.8(-8)	2.2(-9)	7.2(-10)
	4	5.1(-8)	3.2(-9)	9.8(-10)
1983	1	3.7(-8)	----------	----------
	2	6.0(-8)	1.3(-9)	3.8(-10)
	3	4.4(-8)	1.8(-9)	5.4(-10)
	4	6.0(-8)	5.4(-9)	1.2(-9)
1984	1	4.8(-8)	----------	----------
	2	5.4(-8)	6.8(-10)	4.7(-10)
	3	5.0(-8)	1.7(-9)	5.3(-10)
	4	5.3(-8)	3.4(-9)	1.0(-9)
1985	1	4.8(-8)	----------	----------
	2	4.5(-8)	2.3(-9)	3.0(-10)
	3	6.1(-8)	1.5(-9)	5.6(-10)
	4	5.6(-8)	4.7(-9)	1.1(-9)
1986	1	5.0(-8)	----------	----------
	2	4.9(-8)	2.3(-9)	2.4(-10)
	3	5.8(-8)	2.4(-9)	6.3(-10)
	4	6.3(-8)	5.0(-9)	1.2(-9)
1987	1	4.3(-8)	----------	----------
	2	3.4(-8)	1.2(-9)	3.4(-10)
	3	5.8(-8)	1.6(-9)	5.9(-10)
	4	5.0(-8)	5.9(-9)	8.9(-10)

* Not listed since fruits and vegetables are only harvested during the second and third quarters, fourth quarter listed in case milk animals are at maximum residence.

** Not listed since milk animals are not on pasture during the first quarter.

Highest Land Maximum X/Q	=	6.3×10^{-8} sec/m^3
Highest Residence Maximum D/Q	=	5.9×10^{-9} m^{-2}
Highest Milk Animal D/Q	=	1.4×10^{-9} m^{-2}
Average Land Maximum X/Q	=	5.1×10^{-8}
Average Residence Maximum D/Q	=	2.7×10^{-9}
Average Milk Animal Maximum D/Q	=	6.5×10^{-10}

Unit 2 - Vents
Quarterly Averages X/Q's - D/Q's

Year/Qtr.	Land Maximum X/Q		Residence Maximum D/Q		Cow or Goat Maximum D/Q	
	Continuous	Batch	Continuous	Batch	Continuous	Batch
1980 — 1	2.3(-6)	9.5(-7)	----------	----------	----------	----------
2	6.9(-6)	6.8(-6)	1.1(-7)	1.3(-7)	3.8(-9)	3.6(-9)
3	7.3(-6)	3.4(-8)	1.2(-7)	3.3(-9)	4.9(-9)	1.7(-10)
4	3.2(-6)	7.5(-7)	7.6(-8)	8.2(-9)	2.7(-9)	3.0(-9)
1981 — 1	3.9(-6)	1.3(-7)	----------	----------	----------	----------
2	7.9(-6)	1.9(-7)	1.0(-7)	7.0(-10)	3.6(-9)	1.6(-10)
3	4.9(-6)	1.4(-7)	9.6(-8)	4.9(-9)	3.7(-9)	7.7(-10)
4	1.7(-6)	6.2(-8)	4.1(-8)	5.1(-9)	1.8(-9)	9.4(-10)
1982 — 1	2.9(-6)	2.4(-7)	----------	----------	----------	----------
2	6.5(-6)	9.3(-8)	9.2(-8)	----------	3.4(-9)	----------
3	6.7(-6)	1.4(-7)	1.2(-7)	2.1(-9)	4.8(-9)	9.3(-10)
4	4.2(-6)	1.8(-7)	1.0(-7)	2.6(-9)	2.9(-9)	9.3(-10)
1983 — 1	1.3(-6)	1.0(-7)	----------	----------	----------	----------
2	5.4(-6)	1.9(-7)	1.1(-7)	5.2(-9)	5.5(-9)	2.0(-9)
3	8.1(-6)	2.4(-7)	1.5(-7)	4.4(-9)	5.4(-9)	1.5(-9)
4	2.3(-6)	1.2(-7)	6.2(-8)	8.4(-9)	3.3(-9)	----------
1984 — 1	2.3(-6)	1.1(-7)	----------	----------	----------	----------
2	5.4(-6)	3.4(-7)	8.0(-8)	4.2(-9)	4.4(-9)	1.5(-9)
3	7.2(-6)	1.5(-7)	1.4(-7)	5.4(-9)	6.1(-9)	6.2(-10)
4	2.8(-6)	8.3(-8)	9.4(-8)	5.6(-9)	3.3(-9)	2.0(-9)
1985 — 1	4.0(-6)	1.3(-7)	----------	----------	----------	----------
2	7.6(-6)	3.4(-7)	1.3(-7)	9.0(-9)	4.8(-9)	2.4(-9)
3	7.8(-6)	1.3(-7)	1.3(-7)	3.4(-9)	5.4(-9)	7.1(-10)
4	3.8(-6)	2.1(-7)	9.5(-8)	4.8(-8)	2.5(-9)	1.6(-9)
1986 — 1	4.0(-6)	ND	----------	----------	----------	----------
2	5.5(-6)	3.6(-7)	9.7(-8)	0	3.5(-9)	0
3	5.5(-6)	1.6(-7)	1.5(-7)	1.4(-8)	4.4(-9)	9.2(-10)
4	3.0(-6)	1.9(-7)	8.8(-8)	2.6(-8)	2.9(-9)	5.5(-9)
1987 — 1	1.9(-6)	1.4(-7)	----------	----------	----------	----------
2	6.8(-6)	5.6(-8)	3.4(-8)	1.7(-9)	5.0(-9)	3.1(-10)
3	4.8(-6)	---------	1.1(-7)	----------	3.3(-9)	----------
4	4.1(-6)	1.3(-7)	9.8(-8)	5.2(-9)	3.1(-9)	3.3(-9)

Average Maximum Quarterly X/Q — Continuous Release = 4.8×10^{-6}
Maximum Quarterly X/Q — Continuous Release = 8.1×10^{-6}

Average Maximum Quarterly X/Q — Batch Release = 4.3×10^{-7}
Maximum Quarterly X/Q — Batch Release = 6.8×10^{-6}

Average Maximum Quarterly D/Q — Residence - Continuous Release = 1.0×10^{-7}
Maximum Quarterly D/Q — Residence - Continuous Release = 1.5×10^{-7}

Average Maximum Quarterly D/Q — Residence - Batch Release = 1.4×10^{-8}
Maximum Quarterly D/Q — Residence - Batch Release = 1.3×10^{-7}

Average Maximum Quarterly D/Q — Milk Animal - Continuous Release = 3.9×10^{-9}
Maximum Quarterly D/Q — Milk Animal - Continuous Release = 6.1×10^{-9}

Average Maximum Quarterly D/Q — Milk Animal - Batch Release = 1.6×10^{-9}
Maximum Quarterly D/Q — Milk Animal - Batch Release = 5.5×10^{-9}

Beginning in 1982, purges are released through the Unit 1 stack. Therefore, the batch releases should have lower X/Q's and D/Q's.

This is shown in the above data, however, at much lesser extent in the maximum values versus the average values.

Unit 3 — Vents						
Year/Qtr.	**Land Maximum X/Q**		**Residence Maximum D/Q**		**Cow or Goat Maximum D/Q**	
	Continuous	**Batch**	**Continuous**	**Batch**	**Continuous**	**Batch**
1986 — 1	1.7(-6)	1.4(-6)	----------	----------	----------	----------
2	2.2(-6)	7.8(-6)	8.4(-8)	5.1(-7)	3.3(-9)	2.1(-9)
3	1.7(-6)	1.2(-5)	8.6(-8)	2.5(-7)	4.2(-9)	2.8(-8)
4	1.3(-6)	----------	7.2(-8)	----------	2.8(-9)	----------
1987 — 1	1.7(-6)	2.1(-6)	----------		----------	
2	6.5(-6)		1.3(-7)		4.9(-9)	
3	3.3(-6)		8.0(-8)		3.1(-9)	
4	2.4(-6)		7.9(-8)		3.1(-9)	

Average Maximum Quarterly X/Q — Continuous Release = 2.6×10^{-6}
Maximum Quarterly X/Q — Continuous Release = 6.5×10^{-6}

Average Maximum Quarterly X/Q — Batch Release = 5.8×10^{-6}
Maximum Quarterly X/Q — Batch Release = 1.2×10^{-5}

Average Maximum Quarterly D/Q — Residence - Continuous Release = 8.9×10^{-8}
Maximum Quarterly D/Q — Residence - Continuous Release = 1.3×10^{-7}

Average Maximum Quarterly D/Q — Residence - Batch Release = 3.8×10^{-7}
Maximum Quarterly D/Q — Residence - Batch Release = 5.1×10^{-7}

Average Maximum Quarterly D/Q — Milk Animal - Continuous Release = 3.6×10^{-9}
Maximum Quarterly D/Q — Milk Animal - Continuous Release = 4.9×10^{-9}

Average Maximum Quarterly D/Q — Milk Animal - Batch Release = 1.5×10^{-8}
Maximum Quarterly D/Q — Milk Animal - Batch Release = 2.8×10^{-8}

2. **Section D.1.a — Instantaneous Noble Gas Release Rate Limits**

Unit 1 Stack Gaseous Releases — Curies vs. Dose					
Year	Quarter	Avg. Noble Gas Release Rate (mCi/Sec)	Max. Individual Dose (mrem) W.B.	Skin	mrem per µCi/Sec W.B. and Skin
1976	1	17,400	1.9	1.9	1.1(-4)
	2	25,600	4.2	4.3	1.6(-4)
	3	20,100	3.4	3.4	1.7(-4)
	4	2,600	0.3	0.3	1.0(-4)
	1-4	16,400	9.8	9.9	6.0(-4)
1977	1	11,600	1.1	1.1	9.5(-5)
	2	13,000	1.9	1.9	1.5(-4)
	3	24,000	4.6	4.6	1.9(-4)
	4	29,700	2.2	2.2	7.4(-5)
	1-4	19,600	9.8	9.8	5.0(-4)
1978	1	50,800	4.4	4.4	8.7(-5)
	2	20,800	3.1	3.1	1.5(-4)
	3	350	0.044	0.044	1.3(-4)
	4	530	0.034	0.034	6.5(-5)
	1-4	18,100	7.6	7.6	4.2(-4)
1979	1	1,180	0.032	0.032	2.7(-5)
	2	380	0.024	0.024	6.3(-5)
	3	640	0.061	0.061	9.5(-5)
	4	420	0.024	0.024	5.7(-5)
	1-4	655	0.14	0.14	2.1(-4)
1980	1	360	0.018	0.020	5.0(-5)
	2	230	0.019	0.019	8.2(-5)
	3	880	0.20	0.20	2.3(-4)
	4	40	6.4(-4)	6.4(-4)	1.6(-5)
	1-4	380	0.24	0.24	6.3(-4)
1981	1	1.2	6.0(-6)	6.0(-6)	5.0(-6)
	2	25	0.004	0.004	1.6(-4)
	3	1,580	0.19	0.19	1.2(-4)
	4	220	0.015	0.016	6.8(-5)
	1-4	460	0.21	0.21	4.6(-4)
1982	1	160	0.004	0.004	2.5(-5)
	2	140	0.042	0.042	3.0(-4)
	3	490	0.051	0.052	1.0(-4)
	4	240	0.002	0.002	8.3(-6)
	1-4	260	0.10	0.10	3.8(-4)
1983	1	560	0.002	0.002	3.6(-6)
	2	120	0.014	0.014	1.2(-4)
	3	74	0.012	0.012	1.6(-4)
	4	56	0.003	0.003	5.4(-5)
	1-4	200	0.031	0.031	1.6(-4)

Unit 1 Stack Gaseous Releases — Curies vs. Dose					
Year	Quarter	Avg. Noble Gas Release Rate (mCi/Sec)	Max. Individual Dose (mrem) W.B.	Skin	mrem per μCi/Sec W.B. and Skin
1984	1	119	0.0091	0.0091	7.6 (-5)
	2	352	0.0029	0.0029	8.2 (-6)
	3	197	0.037	0.037	1.9 (-4)
	4	46	0.0002	0.0002	4.8 (-6)
	1-4	179	0.049	0.049	2.7 (-4)
1985	1	86	0.010	0.013	1.2 (-4)
	2	33	0.0058	0.0058	1.8 (-4)
	3	9.5	0.0004	0.0004	4.2 (-5)
	4	14	0.0009	0.0009	6.4 (-5)
	1-4	35.6	0.017	0.020	4.8 (-4)
1986	1	7.6	0.0028	0.0034	3.7 (-4)
	2	84	0.021	0.021	2.5 (-4)
	3	199	0.046	0.046	2.3 (-4)
	4	131	0.014	0.018	1.1 (-4)
	1-4	105	0.085	0.088	8.1 (-4)
1987	1	419	0.037	0.041	8.8 (-5)
	2	285	0.043	0.043	1.5 (-4)
	3	21	0.0022	0.0028	1.0 (-4)
	4	19	9.7 (-4)	0.0014	5.1 (-5)
	1-4	186	0.083	0.088	4.5 (-4)

Unit 2 Vent Gaseous Releases - Curies vs. Dose*

Year	Quarter	Avg. Noble Gas Release Rate (μCi/Sec)	Max. Individual Dose (mrem) W.B.	Max. Individual Dose (mrem) Skin	mrem per μCi/Sec W.B.	Ratio Skin/W.B.
1976	1	0.63	0.00016	0.00047	2.5 (-4)	2.9
	2	83	0.058	0.16	7.0 (-4)	2.8
	3	54	0.015	0.055	2.8 (-4)	3.7
	4	63	0.022	0.035	3.5 (-4)	1.6
	1-4	50	0.095	0.25	1.9 (-3)	2.6
1977	1	134	0.023	0.058	1.7 (-4)	2.5
	2	70	0.007	0.018	1.0 (-4)	2.8
	3	39	0.019	0.056	4.9 (-4)	2.9
	4	69	0.010	0.030	1.4 (-4)	3.0
	1-4	78	0.059	0.162	7.6 (-4)	2.7
1978	1	10	0.0068	0.012	6.8 (-4)	1.8
	2	91	0.019	0.058	2.1 (-4)	3.1
	3	313	0.13	0.37	4.2 (-4)	2.8
	4	21	0.0054	0.011	2.6 (-4)	2.0
	1-4	109	0.16	0.45	1.5 (-3)	2.8
1979	1	7.1**	0.0081	0.019	1.1 (-3)	2.3
	2	2.6	0.0007	0.0021	2.5 (-4)	3.2
	3	38	0.013	0.037	3.4 (-4)	2.8
	4	23	0.0052	0.015	2.3 (-4)	2.9
	1-4	18	0.027	0.073	1.5 (-3)	2.7
1980	1	54	0.0086	0.022	1.6 (-4)	2.6
	2	47	0.020	0.056	4.3 (-4)	2.8
	3	67	0.066	0.13	9.9 (-4)	2.0
	4	2.5	0.00028	0.0043	1.1 (-3)	1.5
	1-4	42	0.097	0.212	2.3 (-3)	2.2
1981	1	16	0.0061	0.014	3.8 (-4)	2.3
	2	124	0.075	0.20	6.0 (-4)	2.7
	3	64	0.030	0.078	4.7 (-4)	2.6
	4	79	0.013	0.033	1.6 (-4)	2.5
	1-4	71	0.124	0.325	1.7 (-3)	2.6
1982	1	5.3***	0.013	0.022	2.5 (-3)	1.7
	2	322	0.18	0.49	5.6 (-4)	2.7
	3	205	0.13	0.34	6.3 (-4)	2.6
	4	191	0.074	0.18	3.9 (-4)	2.4
	1-4	180	0.397	1.03	2.2 (-3)	2.6
1983	1	464	0.041	0.11	8.8 (-5)	2.7
	2	659	0.22	0.62	3.3 (-4)	2.8
	3	0	0.0045	0.0053	—	1.2
	4	0	0.0020	0.0023	—	1.2
	1-4	280	0.268	0.737	9.6 (-4)	2.8

Unit 2 Vent Gaseous Releases - Curies vs. Dose*

Year	Quarter	Avg. Noble Gas Release Rate (μCi/Sec)	Max. Individual Dose (mrem) W.B.	Max. Individual Dose (mrem) Skin	mrem per μCi/Sec W.B.	Ratio Skin/W.B.
1984	1	320	0.046	0.13	1.4 (-4)	2.8
	2	68	0.018	0.048	2.6 (-4)	2.7
	3	111	0.044	0.12	4.0 (-4)	2.7
	4	42	0.014	0.041	3.3 (-4)	2.9
	1-4	135	0.12	0.34	9.0 (-4)	2.8
1985	1	45	0.020	0.038	4.4 (-4)	1.9
	2	1.0	0.0012	0.0014	1.2 (-3)	1.2
	3	3.1	0.0051	0.012	1.6 (-3)	2.4
	4	2.6	0.0027	0.0048	1.1 (-3)	1.8
	1-4	12.9	0.029	0.056	2.2 (-3)	1.9
1986	1	2.7	0.0020	0.0048	7.4 (-4)	2.4
	2	1.6	0.0019	0.0039	1.2 (-3)	2.1
	3	8.6	0.0055	0.012	6.4 (-4)	2.2
	4	0.03	7.7 (-4)	9.1 (-4)	2.6 (-2)†	1.2
	1-4	3.2	0.010	0.022	3.2 (-3)	2.2
1987	1	16	0.0018	0.0051	1.1 (-4)	2.8
	2	5.6	0.0031	0.0084	5.5 (-4)	2.7
	3	17	0.0053	0.015	3.1 (-4)	2.8
	4	12	0.0029	0.0078	2.4 (-4)	2.7
	1-4	12.7	0.013	0.036	1.0 (-3)	2.8

* Dose conservatively assumes contributions from both plume and ground shine.

** Only continuous ventilation (purge data leads to an unconservative value).

***Beginning in 1982, purges are released through Unit 1 stack.

† Outlier caused by low noble gas releases. At such low releases, the doses are well below the limits.

Unit 3 Vent Gaseous Releases - Curies vs. Dose*

Year	Quarter	Avg. Noble Gas Release Rate (μCi/Sec)	Max. Individual Dose (mrem) W.B.	Max. Individual Dose (mrem) Skin	mrem per μCi/Sec W.B.	Ratio Skin/W.B.
1986	1	0.038	3.7 (-5)	8.7 (-5)	9.7 (-4)	2.4
	2	—	5.9 (-5)	1.7 (-4)	—	2.9
	3	2.1	3.4 (-4)	7.1 (-4)	1.6 (-4)	2.1
	4	0.81	8.3 (-5)	2.3 (-4)	1.0 (-4)	2.8
	1-4	0.74	5.2 (-4)	1.2 (-3)	7.0 (-4)	2.3
1987	1	0.94	6.3 (-4)	8.7 (-4)	6.7 (-4)	1.4
	2	6.6	2.3 (-3)	6.4 (-3)	3.5 (-4)	2.8
	3	0.002	1.4 (-6)	2.2 (-6)	7.0 (-4)	1.6
	4	6.3	1.4 (-2)	1.8 (-2)	2.2 (-3)	1.3
	1-4	3.5	1.7 (-2)	2.5 (-2)	4.8 (-3)	1.5

Release Projection	Noble Gas Release Rate (μCi/Sec)	Max. Individual Dose (mrem) W.B.	Max. Individual Dose (mrem) Skin	mrem per μCi/Sec W.B.	Ratio Skin/W.B.
Unit 3 FSAR* and ER	14.2	0.16	0.29	1.1 (-2)	1.8

* Expected releases from *Table 11.3-11*: 448 Ci/yr which equals 14.2 μCi/sec.

Design releases from Unit 3 *FSAR Table 11.3-11* and Unit 3 *ER Table 3.5-14*: 14, 141 Ci/yr. = 448 μCi/sec.

Since the average X/Qs are less for Unit 3 than for Unit 2, a conservative estimate for Unit 3 would be to assume its value would be the same as for Unit 2. The 1976-1987 average values for the whole body doses are:

Unit 1 = 4.5×10^{-4} mrem/yr. per μCi/sec

Unit 2 = 1.7×10^{-3} mrem/yr. per μCi/sec

Unit 3 = 1.7×10^{-3} mrem/yr. per μCi/sec

The *10CFR20* limit is 500 mrem to the whole body and 3000 mrem to the skin. Since the skin dose has never been as much as six times the whole body dose for Unit 1, Unit 2, or Unit 3 releases, we can use the 500 mrem as the limiting dose. Therefore, the release rate limits would be:

Unit 1: $500/4.5 \times 10^{-4}$ = 1,100,000

Unit 2: $500/1.7 \times 10^{-3} =$ 290,000

Unit 3: $500/1.7 \times 10^{-3} =$ 290,000

However, *10CFR20* is a site limit, therefore the limit is:

$$\frac{Q_1}{1{,}100{,}000} + \frac{Q_2}{290{,}000} + \frac{Q_3}{290{,}000} \leq 1$$

where:

Q_1 = noble gas release rate from MP1 stack (µCi/sec)

Q_2 = noble gas release rate from MP2 vent (µCi/sec)

Q_3 = noble gas release rate from MP3 vent (µCi/sec)

Justification for Above Method

The above method of determining instantaneous release rates will ensure compliance with *10CFR20* for the following reasons:

1. The doses presented for Unit 1 were calculated using the EPA AIREM code, which uses a finite cloud model similar to that in *Regulatory Guide 1.109*. This code has compared very favorably with data actually measured at the critical site boundary with a pressurized ion chamber. Plant related quarterly doses measured by the ion chamber were calculated using a model developed by ERDA's Health and Safety Lab. These doses have always been within 30% of those calculated by AIREM. The average difference has been 14% with the AIREM code calculating the higher dose. Thus, we are ensured that the AIREM code yields reasonable, if not slightly conservative, estimates of the maximum individual whole body dose.

2. The doses presented for Unit 2 and Unit 3 were calculated using the NRC GASPAR code which uses the methodology of *Regulatory Guide 1.109*.

3. The dose per curie release can be seen from the tables not to vary significantly from one quarter to the next.

Unit 1:	Minimum Value	-	3.6×10^{-6} mrem/qtr. per µCi/sec
	Average Value	-	1.1×10^{-4} mrem/qtr. per µCi/sec
	Maximum Value	-	3.7×10^{-4} mrem/qtr. per µCi/sec
Unit 2:	Minimum Value	-	8.8×10^{-5} mrem/qtr. per µCi/sec
	Average Value	-	5.3×10^{-4} mrem/qtr. per µCi/sec
	Maximum Value	-	2.5×10^{-3} mrem/qtr. per µCi/sec

It can be seen that the maximum value observed is only a factor of 5 greater than the average value even though there have been significant changes in the isotopic compositions of the releases and/or the meteorological frequencies. Also note that the maximum annual average is less than a factor of 2 greater than the average of the annual averages.

The isotopic changes include significant operational changes such as:

a. Operation with and without the recombiner-charcoal delay system on the Unit 1 off-gas.

b. Period when a unit was down the entire quarter for refueling.

c. Quarters with many MP2 containment purges and quarters with no purges.

d. Quarters with relatively high and relatively low fuel leakage from MP1.

Thus, the dose per curie released is not that sensitive to operational changes such that a gross curie release ratio can be used. Although *10CFR20.106* allows average aging concentrations of radioactive material over a period not greater than one year, this does not suggest that the worst-case year should be used for release rate determinations. *NUREG-0133* recommends that the STS consider historical annual average atmospheric dispersion conditions. Therefore, average values from above are adequate for release rate calculations. This is conservative since the maximum quarterly averages are not typically at the same location.

4. It should also be recognized that there is a conservatism between this method and the actual requirements of *10CFR20* for the following reasons:

   a. *10CFR20* states that release rates may be averaged over a year, however, we are using this as an instantaneous release rate limit.

   b. *10CFR20* limits are ground level concentration limits, which for elevated releases from the Unit 1 stack would be less restrictive than the use of the elevated finite cloud model as used here.

   c. *10CFR20* states that these limits are for noble gases only. However, we have included the ground shine dose from particulates.

5. It must also be recognized that the type of empirical method given above is a practical operational method. The use of a method similar to that given in *NUREG-0133* would be an operational nightmare, would be next to impossible to implement and could yield allowable release rates many times that given above.

   For example, releases from the Unit 1 stack could include any of the following releases:

   MP1 ventilation from radiological areas
   MP1 off-gas release from the off-gas treatment system
   MP1 off-gas releases via the 30 minute holdup pipe
   MP1 mechanical vacuum pump
   MP1 gland seal condenser
   MP2 waste gas tank discharge
   MP2 containment purges

MP2 ventilation from radiological areas
MP2 condenser air ejector
MP2 mechanical vacuum pump
MP3 ventilation from radiological areas
MP3 condenser air ejector
MP3 reactor plant gaseous vents
MP3 radioactive gaseous waste system
MP3 containment vacuum pump
MP3 reactor plant aerated vents
MP3 steam generator blowdown tank vent

These sources may exist in any possible combination and each has its own particular, but changing, nuclide mixtures. Thus, the ratio of nuclides being released is a constantly changing parameter.

It is impractical to recalculate a stack release rate based on isotope specific dose conversion factors each time a source stream is initiated or terminated or a new isotopic analysis is performed on any of the source streams. This could require 4 or 5 recalculations and monitor setpoint changes each day. The plant could not operate in this manner.

It would also be unnecessarily restrictive to assume the worst possible mixture and use that as the limit for all situations. Therefore, a practical solution is to use a conservatively determined empirical method as given above.

3. Section D.1.b - Release Rate Limit - Iodine and Particulates

Doses are calculated using the methods of *NUREG-0133* dated October 1978 and *NRC Regulatory Guide 1.109, Revision 1.* Note that the equation of page 27 of *NUREG-0133* (for all radionuclides, except tritium) has been corrected for the elemental iodine fraction, as in *Regulatory Guide 1.109, Revision 1.* For the instantaneous release rate limit, only the inhalation pathway needs to be considered.

Method 1

$$D_{T_H} = \left[X/Q \bullet P_i \bullet {}_{133}Q_I\right] + \left[X/Q \bullet P_i \bullet {}_{133}Q_I\right]$$

where: D_{T_I} = thyroid dose rate from inhalation due to iodine releases, mrem/yr

${}_{131}Q_1$ = release rate of I-131, μCi/sec
${}_{133}Q_1$ = release rate of I-133, μCi/sec
X/Q = meteorological dispersion factor, sec/m^3
P_i = values derived from *NUREG-0133* and *Regulatory Guide 1.109* (see Table 1).

Dose formula for tritium is:

$$D_{T_H} = \left[X/Q \bullet P_i \bullet Q_H\right]$$

where: D_{T_H} = thyroid (or any other organ) dose rate from inhalation due tritium releases, mrem/yr

Q_H = release rate of H-3, μCi/sec

Dose formula for particulates is:

$$D_{O_P} = \left[X/Q \bullet P_i \bullet Q_P\right]$$

where: D_{O_P} = maximum organ dose rate from inhalation due to particulate releases

Q_P = release rate of particulates, μCi/sec
other parameters as described for iodine, above.

a. Thyroid Doses

Release rate limit is 1500 mrem/year, using the average worst case X/Q's and P_i values from Table 1 results in:

UNIT 1

$D_T = .82_{131}Q_{I1} + .20\ _{133}Q_{I1} + 6.63 \text{ X } 10^{-5}\ Q_{H1}$

UNIT 2 AND UNIT 3

$D_T = 76.8_{131}Q_I + 18.72\ _{133}Q_I + 6.24 \times 10^{-3} Q_H$

Summing all three units, and setting $\leq$ 1500 mrem/year results in:

$0.82\ _{131}Q_{I1} + .20\ _{133}Q_{I1} + 6.63 \times 10^{-5}\ Q_{H1} + 76.8\ _{131}Q_{I2} +$
$18.72\ _{133}Q_{I2} + 6.24 \times 10^{-3}\ Q_{H2} + 76.8\ _{131}Q_{13} + 18.72\ _{133}Q_{I3} +$
$6.24 \times 10^{-3}\ Q_{H3} \leq 1500$ mrem/yr

dividing by 1500 gives:

$5.5 \times 10^{-4}\ _{131}Q_{I1} + 5.1 \times 10^{-2}\ _{131}Q_{I2} + 5.1 \times 10^{-2}\ _{131}Q_{I3} +$
$1.33 \times 10^{-4}\ _{133}Q_{I1} + 1.25 \times 10^{-2}\ _{133}Q_{I2} + 1.25 \times 10^{-2}\ _{133}Q_{I3} +$
$4.4 \times 10^{-8}\ Q_{H1} + 4.2 \times 10^{-6}\ Q_{H2} + 4.2 \times 10^{-6}\ Q_{H3} \leq 1$

b. Maximum Organ (other than thyroid) Doses

Release rate limit is 1500 mrem/year. Using the 1980-1987 worst case X/Q's and P_i values (conservative mix)* from *Table 1* results in:

UNIT 1

$D_O = (5.1 \times 10^{-8} \cdot 1.6 \times 10^7 \cdot Q_P) + (5.1 \times 10^{-8} \cdot 1.3 \times 10^3 \cdot Q_H)$

$D_O = (0.82\ Q_P) + (6.63 \times 10^{-5}\ Q_H)$

*Sr-90 values are too conservative. Review of the 1978-1988 effluent data shows Sr-90 has never contributed to greater than 2% of the total curies; use the next limiting nuclide (other than Sr-89). Comparison with ODCM Rev. 0, shows this results in a conservative calculation.

UNIT 2 and UNIT 3

$D_O = (4.8 \times 10^{-6} \cdot 1.6 \times 10^7 \cdot Q_P) + (4.8 \times 10^{-6} \cdot 1.3 \times 10^3 \cdot Q_H)$
$= 76.8\ Q_P + 6.24 \times 10^{-3}\ Q_H$

Summing all three units, and setting $\leq$ 1500 mrem/year results in:

$$0.82\ Q_{P1} + 76.8\ Q_{P2} + 76.8\ Q_{P3} + 6.63 \times 10^{-5}\ Q_{H1} +$$

$$6.24 \times 10^{-3}\ Q_{H2} + 6.24 \times 10^{-3}\ Q_{H3} \leq 1500 \text{ mrem/yr}$$

dividing by 1500 gives:

$$5.5 \times 10^{-4}\ Q_{P1} + 5.1 \times 10^{-2}\ Q_{P2} + 5.1 \times 10^{-2}\ Q_{P3} + 4.4 \times 10^{-8}\ Q_{H1} +$$

$$4.2 \times 10^{-6}\ Q_{H2} + 4.2 \times 10^{-6}\ Q_{H3} \leq 1$$

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4. Section D.2.a - Noble Gas - Quarterly Air Dose Method 1

(1) Unit 1

From the *Table* in *Section D.2* of this *Appendix*, the maximum quarterly value of mrem/qtr. per µCi/sec is 3.7×10^{-4}. This factor is for the whole body. To convert to mrad air dose we must multiply by 2. There is a factor of 0.7 to convert from mrad to whole body mrem (*The Distribution of Absorbed Dose Rates in Humans From Exposure to Environmental Gamma Rays*, Health Physics, January 1976) and also a factor of 0.7 for building shielding and occupancy (*Regulatory Guide 1.109, Rev. 1, Pg. 43*). These factors were used to originally calculate the whole body results. Therefore, the conversion factor for the air dose is:

$$7.4 \, x \, 10^{-4} \; mrad \,/\, qtr. \, per \; \mu Ci \,/\, \sec \; or$$

$$7.4 \, x \, 10^{-4} \, \frac{mrad - \sec}{qtr. - \mu Ci} \, x \, 10^{6} \; \mu Ci \,/\, Ci \, x \, 1.26 \, x \, 10^{-7} \; qtr./\sec$$
$$= 9.3 \, x \, 10^{-5} \; mrad \,/\, Ci$$

This is the gamma air dose at the critical location. Since the critical location is the site boundary and is only 0.5 miles from a 375 foot stack, the beta air dose at the critical location is near zero as the dose is from the overhead finite cloud (see earlier discussion in *Section D.1.a*). The beta air dose at the critical location has always been less than 0.01 times the gamma dose. Thus, the beta dose can be recorded as:

Less than 9.3×10^{-7} mrad/Ci

(2) Unit 2

Likewise for Unit 2 from *Section D.2*, the maximum quarterly value of mrem/qtr. per µCi/sec is 2.5×10^{-3}.

Converting to mrad/Ci we have:

$2.5 \times 10^{-3} \times 2 \times 10^{6} \times 1.26 \times 10^{-7} = 6.3 \times 10^{-4}$ mrad/Ci

This is the gamma air dose. The following is the ratio of the beta air dose to the gamma air dose at the critical location as calculated by the GASPAR code:

Ratio

	1976	1977	1978	1979	1980	1981	1982
1st qtr.	2.9	3.1	6.9	3.1	2.8	2.5	1.3
2nd qtr.	2.9	3.0	2.8	3.3	2.7	2.4	2.3
3rd qtr.	3.5	2.5	3.0	3.1	1.7	2.2	2.2
4th qtr.	3.0	3.0	3.0	3.0	1.8	2.2	2.4

	1983	1984	1985	1986	1987

1st qtr.	2.6	2.7	2.8	1.7	2.8
2nd qtr.	2.7	2.8	*	1.8	2.3
3rd qtr.	*	2.8	1.6	2.2	2.6
4th qtr.	*	2.9	2.1	*	2.8

The average ratio = 2.7

Beta air dose - 1.7 x 10^{-3} mrad/Ci

(3) **Unit 3**

Again, as mentioned in *Section D.2*, since the average X/Qs are less for Unit 3 than for Unit 2, a conservative estimate for Unit 3 would be to assume its values would be the same as for Unit 2. This is confirmed by the 1986-1987 data for Unit 3.

5. **Section D.2.b**

Year	Quarter	Unit 1 Finite Cloud Code Curies of Xe-138	Dose (mrem) due to Xe-138	Dose/Curie	Wind Freq. To NE, %
1976	1	2.4 (+4)	0.29	1.2 (-5)	
	2	3.9 (+4)	0.61	1.6 (-5)	
	3	3.3 (+4)	0.52	1.6 (-5)	
	4	7.5 (+3)	0.08	1.0 (-5)	
1977	1	2.1 (+4)	0.19	8.9 (-6)	
	2	1.9 (+4)	0.22	1.2 (-5)	
	3	3.4 (+4)	0.52	1.5 (-5)	
	4	3.4 (+4)	0.22	6.4 (-6)	
1978	1	6.5 (+4)	0.31	4.8 (-6)	
	2	4.7 (+4)	0.57	1.2 (-5)	
	3	9.0 (+2)	0.019	2.1 (-5)	
	4	1.6 (+3)	0.015	9.2 (-6)	
1979	1	1.98 (+3)	0.010	5.1 (-6)	
	2	8.42 (+2)	0.013	1.5 (-5)	
	3	1.05 (+3)	0.028	2.7 (-5)	
	4	1.06 (+3)	0.019	1.8 (-5)	
1980	1	1.09 (+3)	1.6 (-2)	1.5 (-5)	6.5
	2	5.42 (+2)	1.5 (-2)	2.9 (-5)	11.2
	3	2.43 (+3)	6.3 (-2)	2.6 (-5)	19.5
	4	3.54 (+1)	4.3 (-4)	1.2 (-5)	7.4
1981	1	—	—	—	9.2
	2	1.41 (+2)	3.4 (-3)	2.4 (-5)	14.9
	3	3.63 (+3)	4.8 (-2)	1.3 (-5)	9.6

Year	Quarter	Unit 1 Finite Cloud Code Curies of Xe-138	Dose (mrem) due to Xe-138	Dose/Curie	Wind Freq. To NE, %
	4	8.48 (+2)	7.7 (-3)	9.0 (-6)	4.5
1982	1	2.40 (+2)	2.9 (-3)	1.2 (-5)	7.3
	2	3.59 (+1)	6.5 (-4)	1.8 (-5)	11.2
	3	1.09 (+3)	0.019	1.8 (-5_	13.2
	4	—	—	—	13.0
1983	1	8.89 (+1)	3.0 (-4)	3.4 (-6)	3.3
	2	4.52 (+2)	1.1 (-2)	2.4 (-5)	12.0
	3	3.55 (+2)	1.1 (-2)	3.0 (-5)	14.4
	4	2.11 (+2)	2.3 (-3)	1.1 (-5)	5.6
1984	1	5.77 (+2)	7.6 (-3)	1.3 (-5)	5.3
	2	1.28 (+2)	2.9 (-3)	2.3 (-5)	10.6
	3	7.30 (+2)	2.4 (-2)	3.3 (-5)	16.1
	4	5.10 (0)	1.8 (-4)	3.6 (-5)*	8.7
1985	1	1.07 (+2)	1.3 (-3)	1.2 (-5)	7.5
	2	1.58 (+2)	4.1 (-3)	2.6 (-5)	13.5
	3	—	—	—	13.7
	4	3.46 (+1)	8.8 (-4)	2.5 (-5)	11.0
1986	1	5.76 (0)	2.8 (-4)	4.8 (-5)*	9.2
	2	3.70 (+2)	9.3 (-3)	2.5 (-5)	14.0
	3	6.40 (+2)	1.3 (-2)	2.0 (-5)	14.9
	4	3.36 (+2)	3.5 (-3)	1.1 (-5)	9.3
1987	1	1.83 (+3)	1.6 (-2)	8.5 (-6)	4.4
	2	1.21 (+3)	2.0 (-2)	1.6 (-5)	10.9
	3	—	—	—	12.3
	4	5.08 (0)	1.1 (-4)	2.2 (-5)	10.8

* High values caused by dose contribution of other isotopes. Low doses prevented breakdown by isotope. Therefore, discard these values. Review of wind frequencies for these quarters indicates that those are not critical quarters.

The above table attempts to normalize the dose at the maximum location from a particular radionuclide (Xe-138). However, the method for calculating the Xe-138 contribution is not exact; it is based upon % contribution to the population dose. In several cases, there is only a small contribution from Xe-138, causing much error in the calculations. Therefore, the wind frequencies should also be evaluated. Note that the worst case critical sector is towards the NE (nearest residence and high probability of wind direction). Therefore, using the last two columns from above indicates that the worst case quarters are either 3rd quarter 1980 or 3rd quarter 1984. Test runs of these two reveals that the worst is in 1980.

6. Section D.3

Doses are calculated using the methods of *NUREG-0133* dated October 1978 and *NRC Regulatory Guide 1.109, Revision 1*. Note that the equation on page 27 of *NUREG-0133* (for all radionuclides, except tritium) has been corrected for the elemental iodine fraction, as in *Regulatory Guide 1.109, Revision 1*. Since the locations of milk producing animals causes significant variations in the dose calculations (substantial variations in D/Qs), use 3 methods when performing these calculations.

Method 1

Assume worst case locations (i.e., milk animals located at maximum resident D/Q location), vegetables harvested throughout the year, and milk animals on pasture throughout the year.

Method 2

Assume worst case quarterly x/Q and D/Q as above, however:

i. If 1st quarter, neglect vegetation and milk doses.

ii. If 4th quarter, neglect vegetation doses.

iii. For batch releases (including weekly continuous releases, if necessary), evaluate other periods of time where the above may apply.

Method 3

Determine if the maximum quarterly D/Q data from *Appendix D.1* is acceptable to use (i.e., no milk animal likely to be more critical than the data for 1983-1987). If acceptable, use worst case year D/Q for milk locations. If not, an acceptable D/Q for use is the worst case quarter of at least the past three years.

Dose formula for iodine is:

$$D_{QT_I} = \underbrace{\left[X/Q \bullet O_i \bullet C_I\right]}_{\text{Inhalation}} + \underbrace{\left[D/Q \bullet O_i \bullet C_I\right]}_{\text{Vegetation}} + \underbrace{\left[D/Q \bullet O_i \bullet C_I\right]}_{\text{Milk}}$$

where:

D_{QT_I} = quarterly thyroid dose from iodine releases

${}_{131}C_I$ = curies of iodine-131 released

${}_{133}C_I$ = curies of iodine-133 released

X/Q = meteorological dispersion factor, sec/m3

D/Q = deposition factor, m^{-2}

O_i = $P_i \times 3.17 \times 10^{-2*}$, mrem • m^3/Ci • sec. for inhalation and mrem • m^2/Ci for food consumption

P_i = values derived from *NUREG-0133* and *Regulatory Guide 1.109* (see *Table 1*)

*µCi/sec per Ci/yr conversion factor

Dose formula for tritium is:

$$D_{QT_H} = \underbrace{[X/Q \bullet O_i \bullet C_H]}_{\text{Inhalation}} + \underbrace{[X/Q \bullet O_i \bullet C_H]}_{\text{Vegetation}} + \underbrace{[X/Q \bullet O_i \bullet C_H]}_{\text{Milk}}$$

where:

D_{QT_H} = quarterly thyroid (or any other organ) dose from tritium releases

C_H = curies of tritium released

Other parameters as described above, except units for O_i and P_i. Since milk and vegetable doses from tritium are related to X/Q and not D/Q, use the units for inhalation (see *NUREG-0133* and/or *Regulatory Guide 1.109, Revision 1* for details).

Dose formula for particulates is:

$$D_{QO_P} = \underbrace{[X/Q \bullet O_i \bullet C_P]}_{\text{Inhalation}} + \underbrace{[D/Q \bullet O_i \bullet C_P]}_{\text{Vegetation}} + \underbrace{[D/Q \bullet O_i \bullet C_P]}_{\text{Milk}}$$

where:

$D_{QO_{P_I}}$ = quarterly maximum organ dose from particulate releases

C_P = curies of particulates released and other parameters as described for iodine, above

a. **Unit 1**

i. **Method 1**

Using the worst case quarters as explained earlier and P_is* from *Table 1* results in:

* For particulates, Sr-90 P_i values are too conservative. Review of the 1978-1988 effluent data shows that Sr-90 has not contributed to greater than 2% of the total curies. Therefore, use the next most limiting nuclide

(other than Sr-89). Comparison with *ODCM Rev. 0* shows that this still results in a conservative calculation.

$$D_{QT_I} = [(0.032) + (4.1) + (118)]\ {}_{131}C_I + [(.0078) + (.0748) + (1.047)]\ {}_{133}C_I$$

Inhalation Veg Milk Inhalation Veg Milk

$$D_{QT_H} = [(2.60 \times 10^{-6}) + (7.99 \times 10^{-6}) + (9.79 \times 10^{-6})] C_{H_3}$$

Inhalation Vegetation Milk

$$D_{QO_P} = [(0.032) + (4.86) + (37.41)]\ C_{P_H}$$

Inhalation Vegetation Milk

$$D_{QT_I} = 122_{131}C_I + 1.13_{133}C_I$$

$$D_{QT_H} = 2.04 \text{ X } 10^{-5} C_H$$

$$D_{QO_P} = 42.3C_P$$

ii. Method 2

Use same formulas as for Method 1, however, delete vegetables and/or milk when applicable.

iii. Method 3

After review of existing cow and goat farms, if the 1983-1987 milk animal D/Q data is determined to be acceptable, then:

Milk Pathway Doses:

$$D_{QT_I} = 122_{131}C_I + 1.08_{133}C_I$$

$$D_{QT_H} = 1.3 \text{ X } 10^{-3} C_H$$

$$D_{QO_P} = 40C_P$$

TABLE 1

DOSE FACTORS FOR IODINES & PARTICULATES

Radionuclide	(mrem/yr per μCi/m³) Inhalation	P_i* (m^2 mrem/yr per μCi/sec) Vegetables	Goat Milk	Cow Milk
H-3	1.3 (3)	4.0 (3)**	4.9 (3)**	
Cr-51	2.1(4)	6.4 (6)		
Mn-54	2.0 (6)	3.0 (9)		
Fe-59	1.5 (6)	6.8 (8)		
Co-58	1.3 (6)	3.8 (8)		
Co-60	8.7 (6)	2.1 (9)		
Zn-65	1.2 (6)	2.2 (9)		1.9 (10)
Rb-86	2.0 (5)			
Sr-89	2.4 (6)	3.7 (10)	2.7 (10)	1.3 (10)
Sr-90	1.1 (8)	1.25 (12)	2.6 (11)	1.2 (11)
Y-91	2.9 (6)			
Zr-95	2.7 (6)			
Nb-95	7.5 (5)			
Ru-103	7.8 (5)			
Ru-106	1.6 (7)	1.2 (10)		
Ag-110m	6.8 (6)			
Te-127m	1.7 (6)			
Te-129m	2.0 (6)			
Cs-134	1.1 (6)	2.6 (10)	2.0 (11)	6.8 (10)
Cs-136	1.9 (5)			
Cs-137	9.1 (5)	2.4 (10)	1.8 (11)	6.0 (10)
BA-140	2.0 (6)			
Ce-141	6.1 (5)			
Ce-144	1.3 (7)	1.0 (10)		
I-131	1.6 (7)	2.2 (10)	6.3 (11)	5.3 (11)

TABLE 1

DOSE FACTORS FOR IODINES & PARTICULATES

		P_i* (m^2 mrem/yr per µCi/sec)		
	(mrem/yr per µCi/m^3)			
Radionuclide	**Inhalation**	**Vegetables**	**Goat Milk**	**Cow Milk**
I-133	3.9 (6)	4.0 (8)	5.6 (9)	4.7 (9)

* P_i are the inhalation and consumption factors derived from *NRC Regulatory Guide 1.109, Rev. 1*. For inhalation, the teen is the critical age group for all nuclides except Rb-86, Cs-137, I-131, and I-133, which are for the child. For vegetables, the child is critical; for milk, the infant. Maximum organs are: whole body for H-3, bone for Sr-90 and thyroid for I-131, 133.

** Same units as for Inhalation for H-3, based on *NUREG 0133* assumptions.

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DERIVATION OF FACTORS FOR TABLE 1*

1. **Vegetation Factors**

a. **H-3**

$$R_i = K^1 K^{11} \left[U_a^L f_l + U_a^S f_g\right] (DFL_i)_a \left[0.75\ (0.5/H)\right]$$

From page 36 of NUREG-0133

$K^1 = 10^6$ $\qquad$ $DFL_{H-3} = 2.03 \times 10^{-7}$

$K^{11} = 10^3$ $\qquad$ $f_l = 1.0$

$U_a^L = 26$ (for child) $\qquad$ $f_s = 0.76$

$U_a^S = 520$ (for child) $\qquad$ $H = 8\ g/m^3$

$$R_i = 10^6 \bullet 10^3 \left[26\ (1.0) + 520\ (.76)\right] 2.03 \times 10^{-7}\ (0.75 \times 0.5/8) = 4.01 \times 10^3$$

b. **Iodine - 131, 133**

$$R_i^V\ [D/Q] = K^1 \left[\frac{(r)}{Y_v(\lambda_i + \lambda_\omega)}\right] (DFL_i)a \left[U_a^L\ f_l\ e^{-\lambda_i t_l}\right] 0.5$$

From page 35 of *NUREG-0133*, except last term was deleted since it is negligible for iodine-131 and 133 and accounting for elemental iodine fraction.

$K1 = 10^6$ $\qquad$ $U_a = 26$ (child), 64 (adult)

$r = 1.0$ $\qquad$ $f_l = 1.0$

$Y_v = 2$ $\qquad$ $\lambda_i = 9.97 \times 10^{-7}$ (I-131)

$DFL = 5.72 \times 10^{-3}$ (1-131) $\qquad$ $\lambda_i = 9.35 \times 10^{-6}$ (I-133)

$DFL = 1.36 \times 10^{-3}$ (I-133) $\qquad$ $t_l = 8.6 \times 10^4$ sec

$\lambda_\omega = 5.73 \times 10^{-7}$

$$R_i = 10^6 \times \left[\frac{1}{2\,(\lambda_i + \lambda_\omega)}\right] DCF_i \left(26\ e^{-\lambda_i t_l}\right) (0.5)$$

for I-131:

$$R_i = 10^6 \frac{1}{2\,(1.57 \times 10^{-6})} \times 5.72 \times 10^{-3}\ (26 \times 0.9178)\,(0.5) = 2.17 \times 10^{10}$$

for I-133

$$R_i = 10^6 \frac{1}{2\,(9.92 \times 10^{-6})} \times 1.36 \times 10^{-3}\ (26 \times 0.4475)\,(0.5)$$

$$= 3.99 \times 10^8 \cong 4.0 \times 10^8$$

c. **Sr-90**

$$R_i^V [D/Q] = K^1 \left[\frac{(r)}{Y_v\ (\lambda_i + \lambda_\omega)}\right] (DFL_i)a \left[U_a^L\ f_l\ e^{-\lambda_i t_l} + U_a^S\ f_g\ e^{-\lambda_i t_h}\right]$$

From page 35 of NUREG-0133

$K^1 = 10^6$	$U_a^S = 26$ (child), 64 (adult)
$r = 0.2$	$U_a^S = 520$ (child), 520 (adult)
$Y_v = 2$	$f_l = 1.0$
$\lambda_i + \lambda_\omega = 5.738 \times 10^{-7}$	$f_g = 0.76$
$DFL_{Sr-90} = 1.70 \times 10^{-2}$ (child)	$\lambda_i = 7.85 \times 10^{-10}$
$= 7.85 \times 10^{-3}$ (adult)	$t_l = 8.6 \times 10^4$ sec
	$t_h = 5.16 \times 10_6$ sec

$$e^{-\lambda_i t_f} = 1 = e^{-\lambda_i t_h}$$

$$R_i^V[D/Q] = 106\left[\frac{0.2}{2\ (5.738\ x\ 10^{-7})}\right] 1.7 x 10^{-2}\ [(1\ x\ 26) + (.76\ x\ 520)]$$

$$= 2.96\ x\ 10^{9}\ (26 + 395.2) = 1.25\ x\ 10^{12}$$

2. Milk Factors

a. H-3

$$P_i = K^1\ K^{111}\ F_m\ Q_f\ U_{ap}\ DFL_i\ [0.75\ (0.5/H)]$$

From page 27 of NUREG-0133

$K^1 = 10^6$

$K^{111} = 10^3$ gm/Kg

$F_m = 0.17$ (for goat)

$Q_f = 6$ (for goat)

$U_{ap} = 330$ (for infant)

$DFL_i = 3.08\ x\ 10^{-7}$

$H = 8$

$$P_i = 10^6 \bullet 10^3\ (0.17)\ (6)\ (330)\ (3.08\ x\ 10^{-7})\ x\ \frac{.75\ x\ .5}{8}$$

$$= 4860 \text{ (for goat)}$$

$$= 2400 \text{ (for cow – see NUREG – 0133)}$$

b. Iodine - 131, 133

$$P_i = \frac{K^1\ Q_f\ U_{ap}}{Y_p}\ \frac{rF_m}{\lambda_i + \lambda_\omega}\ DFL_i\ \left(e^{-\lambda_i t_f}\right)$$

From page 26 of NUREG=0133, however, multiply this by 0.5 elemental iodine fraction per guidance in *NRC Regulatory Guide 1.109, page 26.*

$Y_p = 0.7$ $\quad$ $F_m = 0.06$

$r = 1.0$ for iodine $\quad$ $t_f = 1.73 \times 10_5$ sec

$\lambda_i = 9.97 \times 10^{-7}$ for I−131 $\quad$ $DFL_{I-131} = 1.39 \times 10^{-2}$

$\lambda_i = 9.35 \times 10^{-6}$ for I−133 $\quad$ $DFL_{I-133} = 3.31 \times 10^{-3}$

$\lambda_\omega = 5.73 \times 10^{-7}$ sec^{-1}

and other factors as shown above.

for I-131:

$$P_i = 7.5 \times 10^{11} \left(e^{-\lambda_i t_f}\right) = 7.5 \times 0.842 = 6.32 \times 10^{11}$$

for I-133

$$P_i = 2.83 \times 10^{10} \left(e^{-\lambda_i t_f}\right) = 2.83 \times 10^{10} \ (0.198) = 5.62 \times 10^{9}$$

c. **Sr-90**

Same equation as for iodines, except disregard elemental iodine fraction and:

$\lambda_i = 7.85 \times 10^{-10}$ $\quad$ $\lambda_i + \lambda_\omega = 5.738 \times 10^{-7}$

$r = 0.2$ $\quad$ $DFL_{Sr-90} = 1.85 \times 10^{-2}$

$F_m = 0.014$ (for goat)

$$P_i = 2.83 \times 10^{9} \frac{rF_m}{\lambda_i + \lambda_\omega} DFL_i \left(e^{-\lambda_i t_f}\right)$$

$$= 2.55 \times 10^{11} \times \left(e^{-\lambda_i t_f}\right) = 2.6 \times 10^{11}$$

* Comparisons of calculations performed using these values with calculations from GASPAR (NRC computer code) verify these factors.

APPENDIX E

GASEOUS DOSE CALCULATIONS - GASPAR

The GASPAR code was written by the NRC to compute doses from gaseous releases using the models given in *Regulatory Guide 1.109*. The revision date of the code which was purchased is February 20, 1976. The only changes made to the code were to change the dose factors and inhalation rates from those given in *Rev. 0* of *Regulatory Guide 1.109* to those in *Rev. 1*.

For calculating the maximum individual dose from Millstone, the following options and parameters are used:

1. Real-time meteorology using a X/Q, D/Q model which incorporates the methodology of *Regulatory Guide 1.111*. Meteorology is determined separately for continuous releases and batch releases.

2. 100% of vegetation grown locally, 76% of vegetation intake from garden, harvest season from April through September.

3. Animals on pasture April through December - 100% pasture intake.

4. Air water concentration equals 8 g/m^3.

5. Maximum individual dose calculations are performed at the nearest land site boundary with maximum decayed X/Q, and at the nearest vegetable garden (assumed to be nearest residence) and cow and goat farms with maximum D/Qs.

APPENDIX F

GASEOUS DOSE CALCULATIONS - AIREM

The AIAREM code was written by the EPA to compute doses from atmospheric emissions of radionuclides. The code is composed of two basic parts - a diffusion calculation and a dose calculation.

For the maximum individual dose at Millstone, cloud gamma doses are calculated using dose tables from a model which considers the finite extent of the cloud in the vertical direction. Beta doses are calculated assuming semi-infinite cloud concentrations which are based upon a standard sector averaged diffusion equation.

APPENDIX G

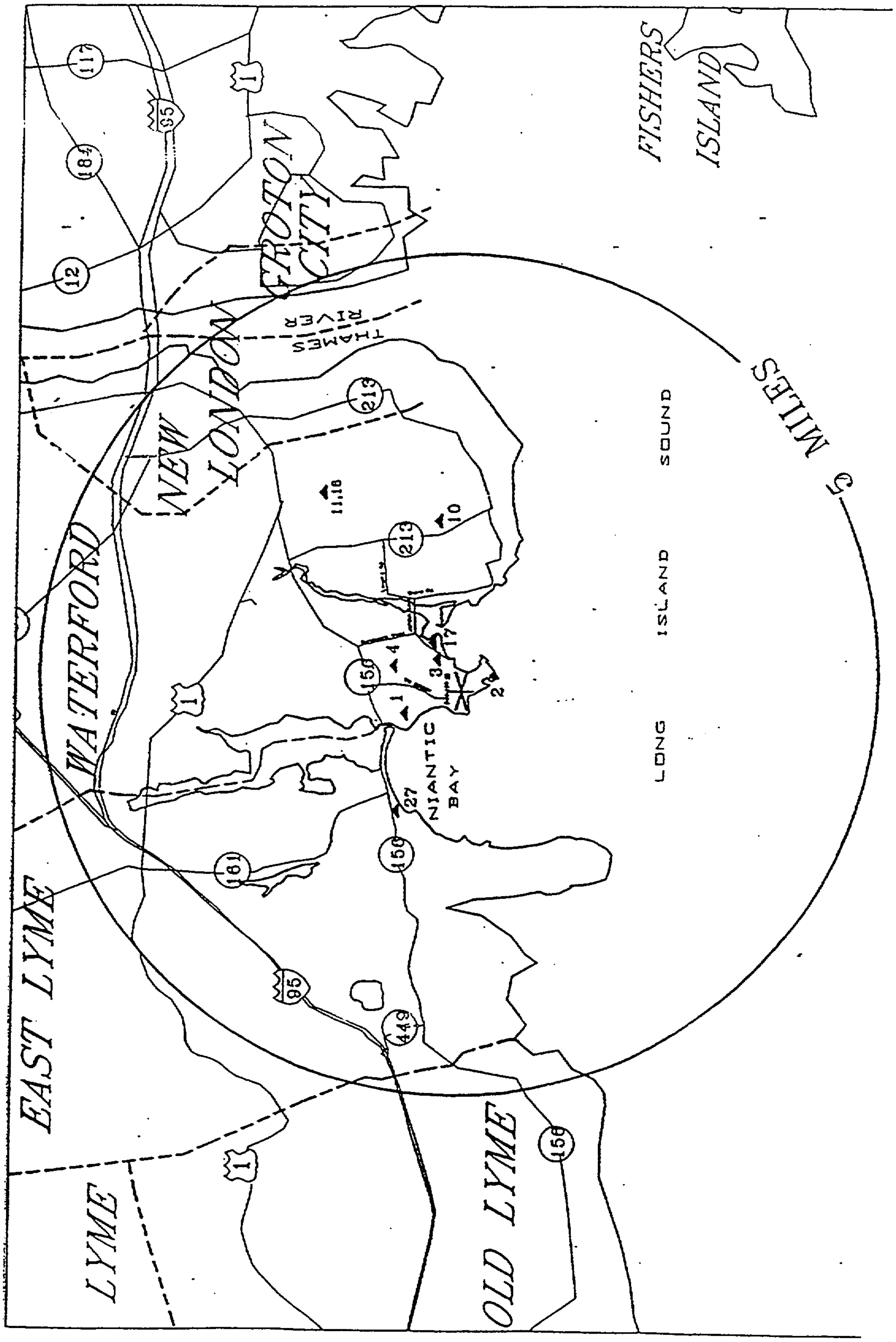
ENVIRONMENTAL MONITORING PROGRAM

Sampling Locations

The following lists the environmental sampling locations and the types of samples obtained at each location. Sampling locations are also shown on Figures G-1, G-2, and G-3.

Number	Location Name	Direction & Distance From Release Point***	Sample Types
1-I*	On-site - Old Millstone Road	0.6 Mi, NNW	TLD, Air Particulate, Iodine, Vegetation
2-1	On-site - Weather Shack	0.3 Mi, S	TLD, Air Particulate, Iodine
3-I	On-site - Bird Sanctuary	0.3 Mi, NE	TLD, Air Particulate, Iodine
4-I	On-site - Albacore Drive	1.0 Mi, N	TLD, Air Particulate, Iodine
5-I	MP3 Discharge	0.1 Mi, SSE	TLD
6-I	Quarry Discharge	0.3 Mi, SSE	TLD
7-I	Environmental Lab Dock	0.3 Mi, SE	TLD
8-I	Environmental Lab	0.3 Mi, SE	TLD
9-I	Bay Point Beach	0.4 Mi, W	TLD
10-I	Pleasure Beach	1.2 Mi, E	TLD, Air Particulate, Iodine
11-I	New London Country Club	1.6 Mi, ENE	TLD, Air Particulate, Iodine
12-C	Fisher's Island, NY	8.7 Mi, ESE	TLD
13-C	Mystic, CT	11.5 Mi, ENE	TLD
14-C	Ledyard, CT	12.0 Mi, NE	TLD
15-C	Norwich, CT	14.0 Mi, N	TLD, Air Particulate, Iodine
16-C	Old Lyme, CT	8.8 Mi, W	TLD
17-I	Site Boundary	0.5 Mi, NE	Vegetation
18-I	Pleasure Beach	1.2 Mi, E	Vegetation
21-I	Goat Location #1	2.0 Mi, N	Milk
22-I	Goat Location #2	5.2 Mi, NNE	Milk
23-I	Goat Location #3	2.0 Mi, ENE	Milk
24-C	Goat Location #4	29 Mi, NNW	Milk
25-I	Fruits & Vegetables	Within 10 Miles	Vegetation
26-C	Fruits & Vegetables	Beyond 10 Miles	Vegetation
27-I	Niantic	1.7 Mi, WNW	TLD, Air Particulate, Iodine
28-I	Two Tree Island	0.8 Mi, SSE	Mussels
29-I	West Jordan Cove	0.4 Mi, NNE	Clams
30-C	Golden Spur	4.7 Mi, NNW	--------------
31-I	Niantic Shoals	1.8 Mi, NW 1.5 Mi, NNW	Bottom Sediment, Oysters Mussels
32-I	Vicinity of Discharge		Bottom Sediment, Oysters, Lobster, Fish, Seawater
33-I	Seaside Point	1.8 Mi, ESE	Bottom Sediment
34-I	Thames River Yacht Club	4.0 Mi, ENE	Bottom Sediment
35-I	Niantic Bay	0.3 Mi, WNW	Lobster, Fish
36-I	Black Point	3.0 Mi, WSW	Oysters
37-C	Giant's Neck	3.5 Mi, WSW	Bottom Sediment, Oysters, Seawater
38-I	Waterford Shellfish Bed #1	1.0 Mi, NW	Clams

*I = Indicator **C = Control
***The release points are the MP1 stack for terrestrial locations and the end of the quarry for aquatic locations.



INNER AIR PARTICULATE AND VEGETATION MONITORING STATIONS

APP. G-2

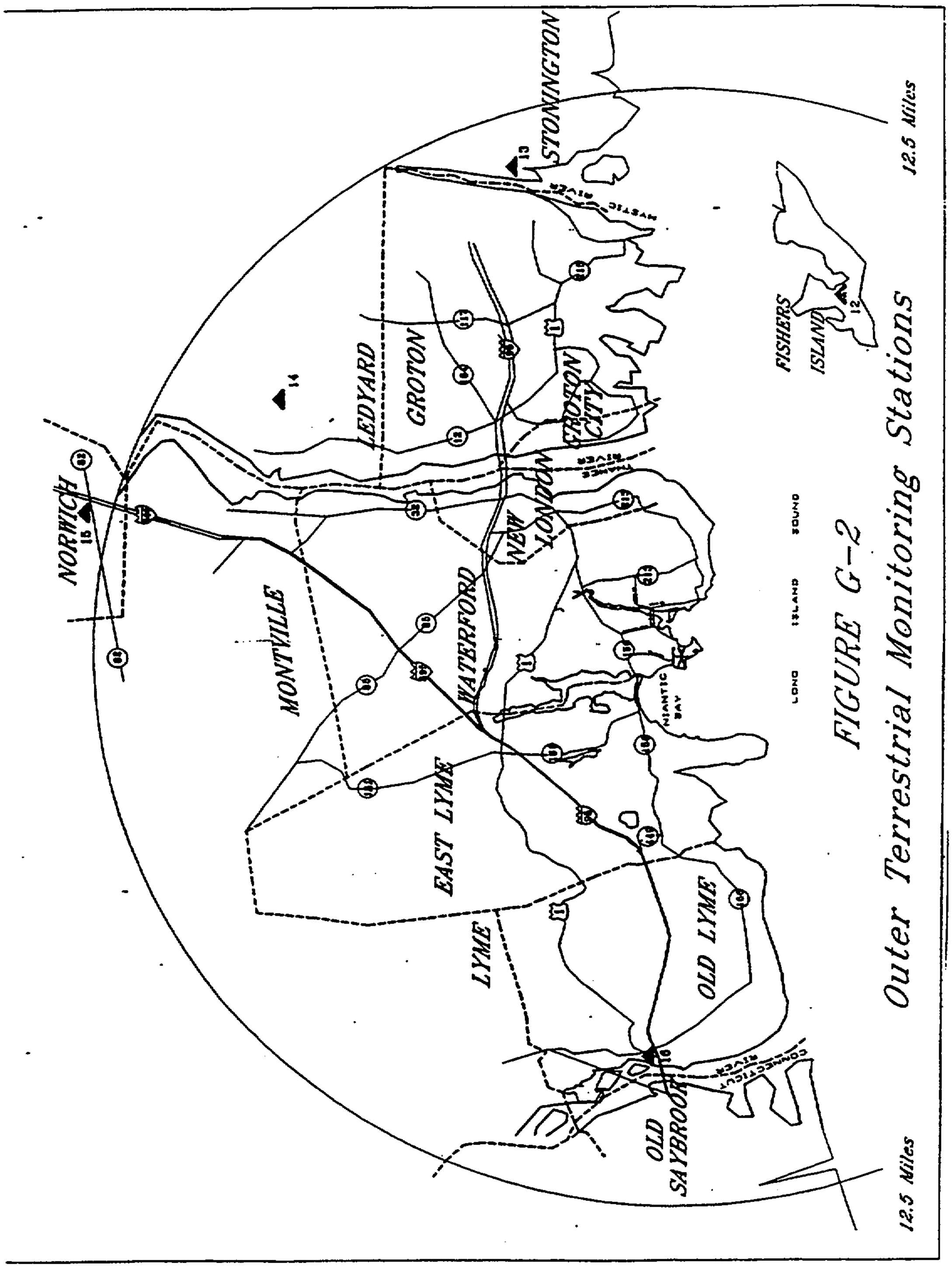


FIGURE G–2
Outer Terrestrial Monitoring Stations

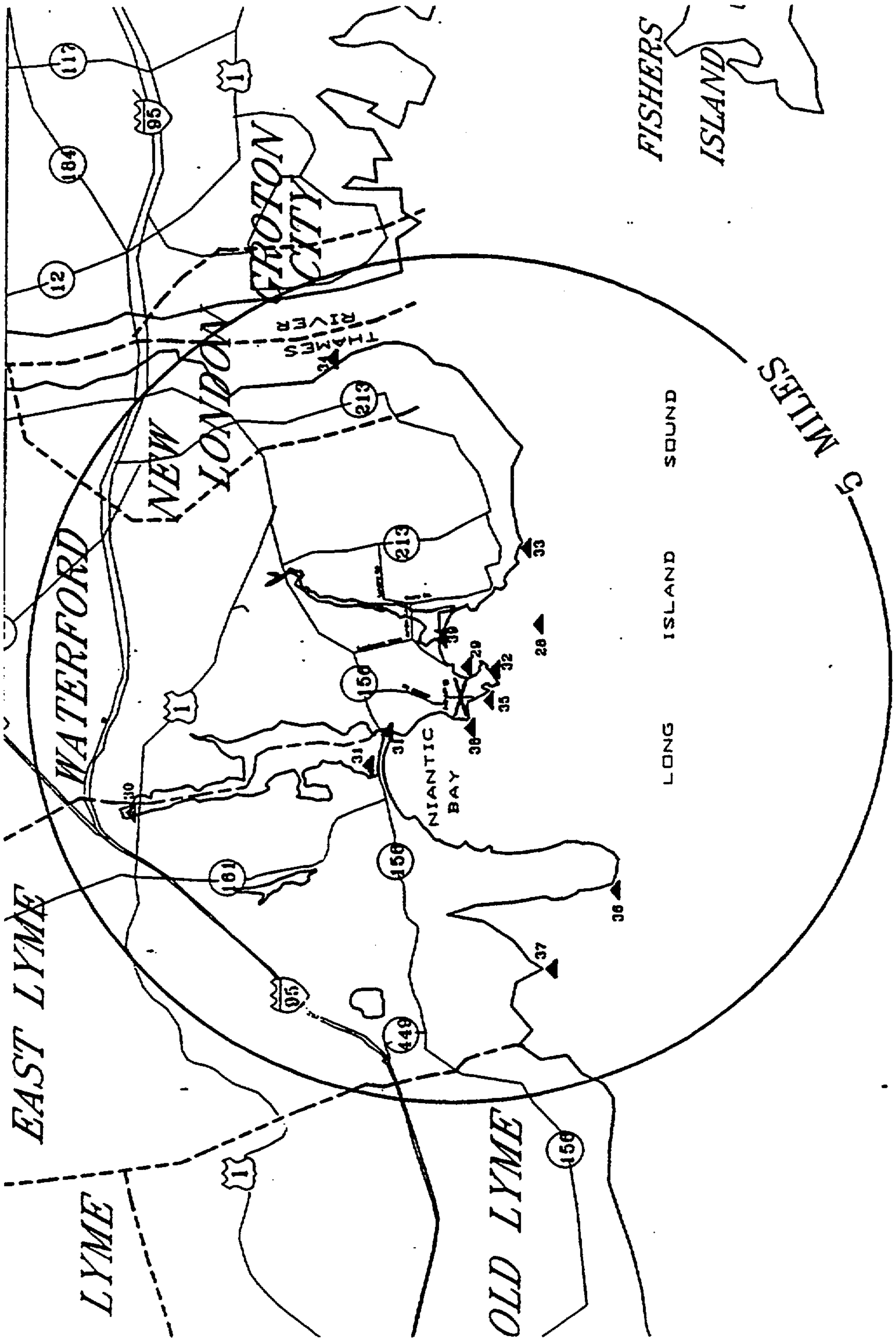


FIGURE G-3
Aquatic Sampling Stations