DOCKET NOS. 50-245
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ENCLOSURE 4

MILLSTONE NUCLEAR POWER STATION, UNIT NOS. 1 AND 2

OFFSITE DOSE CALCULATION MANUAL

1022 003

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OFFSITE DOSE CALCULATION MANUAL

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A. INTRODUCTION

The purpose of this manual is to provide the parameters and methodology 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 Technical Specifications. The manual also includes the methods used for determining quarterly individual and population doses for inclusion in the Semiannual Radioactive Effluents Release Report.

Another section of this manual discusses the methodology to be used in determining effluent monitor alarm/trip setpoints to be used to ensure compliance with the instantaneous release rate limits in the Technical Specifications.

Additional sections provide supplemental information on environmental sample locations and effluent flow paths.

The bases for some of the factors used in this manual are included as appendices to this manual.

This manual does not include the surveillance procedures and forms required to document compliance with the surveillance requirements in the Technical Specifications. All that is included here is the methodology to be used in performance of the surveillance requirements.

Most of the calculations in this manual have two or three 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.

This manual is written common to both Units 1 and 2 since some release pathways are shared and there are also site release limits involved. These facts make it impossible to completely separate the two unit calculations.

B. RESPONSIBILITIES

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

All changes and their rationale shall be documented in a monthly operating report within 90 days of the date of SORC review.

It shall be the responsibility of th Station Superintendent to ensure that this manual is used in performance of the surveillance requirements specified in the Technical Specifications.

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C. LIQUID DOSE CALCULATIONS

C.1.a Quarterly - Total Body Dose - Method 1 - Either Unit

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

Step 2 - Determine C_T = total curies of tritium released during the calendar quarter.

Step 3 - Determine D_{QT} = quarterly dose to the total body in mrem.

$$D_{QT} = 1.4 \times 10^{-2} * C_F + 4.9 \times 10^{-7} * C_T \text{ (See Note 1)}$$

Step 4 - If $D_{QT} > 0.5$ mrem, go to Method 2.

(Note 1) - See Appendix A for derivation of these factors.

C.1.b Quarterly - Total Body Dose - Method 2 - Either Unit

Step 1 - Determine the following curie release totals for the calendar quarter:

C_{134} = Curies of Cs-134

C_{137} = Curies of Cs-137

C_{58} = Curies of Co-58

C_{60} = Curies of Co-60

C_{59} = Curies of Fe-59

C_T = Curies of H-3

Step 2 - Determine V = total volume of dilution water discharged during the calendar quarter, in gallons. This should include all dilution flow and not just that during periods of discharge.

Step 3 - Determine D_{QT} = quarterly total body dose, in mrem:

$$D_{QT} = 1/V\,(1.9 \times 10^9\ C_{134} + 1.5 \times 10^9\ C_{137} + 1.8 \times 10^8\ C_{58} + 1.6 \times 10^9\ C_{60} + 8.3 \times 10^9\ C_{59} + 3.2 \times 10^4 \times C_T)$$

(See Appendix A for derivation of these factors)

Step 4 - If $D_{QT} > 1.0$ mrem, go to Method 3.

C.1.c Quarterly - Total Body Dose - Method 3 - Either Unit

If the calculated dose using Method 2 is greater than 1 mrem, use the NRC computer code LADTAP to calculate the liquid doses. The use of this code, and the input parameters are given in Environmental Programs Branch Procedure #EPB-IV-5-8, Liquid Dose Calculations - LADTAP. This procedure is attached as Appendix C to the manual.

C.2.a Quarterly - Maximum Organ Dose - Method 1 - Either Unit

Step 1 - Determine C_F - 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} = quarterly dose to the maximum organ in mrem.

$D_{QO} = 0.2\ C_F$ (See Appendix B for derivation of factor)

Step 3 - If $D_{QO} > 2$ mrem, go to Method 2.

C.2.b Quarterly - Maximum Organ Dose - Method 2 - Either 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 Environmental Programs Branch Procedure #EPB-IV-5-8, Liquid Dose Calculations - LADTAP. This procedure is attached as Appendix C to the manual.

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C.3 Annual - Total Body Dose - Either Unit

Determine D_{YT} = dose to the total body for the calendar year as follows:

$D_{YT} = \sum D_{QT}$ where the sum is over the first quarter through the present quarter total body doses.

The following should be used as D_{QT}:

(1) If the detailed quarterly dose calculations required per Section C.6 for the semiannual effluent report are complete 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 $D_{YT} > 3$ mrem and any D_{QT} determined as in Section C.1 was not calculated using method 3 of that section, recalculate D_{QT} using Method 3 if this could reduce D_{YT} to less than 3 mrem.

C.4 Annual - Maximum Organ Dose - Either Unit

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

$D_{YO} = \sum D_{QO}$ 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 semiannual effluent report are complete 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 $D_{YO} > 10$ 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.a **Monthly Dose Projections - Total Body & Maximum Organ - Unit 1**

Step 1 - Determine D'_{MT} = total body dose from the last typical* previously completed month as calculated per the methods in Section C.1.

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

Step 3 - Estimate R_1 = 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 = ratio of estimated primary coolant activity for the present month to that for the past month.

Step 5 - Determine F = factor to be applied to estimate ratio of final curie release 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-16 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_{MT} = estimated montly total body dose as follows:

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

Step 7 - Determine D^E_{MO} = 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.

C.5.b Monthly Dose Projections - Total Body + Maximum Organ - Unit 2

Step 1 - Determine D'_{MT} = total body dose from the last typical* previously completed month as calculated per the method in Section C.1.

Step 2 - Determine D'_{MO} = 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 = 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 = ratio of the total estimated volume of steam generator blowdown to be released in present month to the volume released in the past month.

Step 5 - Estimate F_1 = fraction of curies released last month coming from steam generator blowdown.

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

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

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

Step 8 - Determine F_2 = factor to be applied to estimate ratio of final curie release 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-17 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_{MT} = estimated monthly total body dose as follows:

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

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

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

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C.6 Quarterly Dose Calculations for Semi-Annual Radioactive Effluent Report

Detailed quarterly dose calculations required for the semi-annual Radioactive Effluent Report shall be done using the NRC computer code LAD P. The use of this code, and the input parameters are given in Environmental Programs Branch Procedure #EPB-IV-5-8, Liquid Dose Calculations - LADTAP. This procedure is attached as Appendix C to this manual.

D. GASEOUS DOSE CALCULATIONS

D.1.a Instantaneous Noble Gas Release Rate Limits - Both Units

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

$$\frac{Q_1}{830,000} + \frac{Q_2}{260,000} \leq 1$$

where

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

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

See Appendix D for derivation of this limit.

As long as the above is $\leq$ 1, the doses will be $\leq$ 500 mrem to the total body and $\leq$ 3000 mrem to the skin.

D.1.b **Release Rate Limit - I-131, Particulates With Half Lives Greater Than 8 Days, and Radionuclides Other Than Noble Gases With Half Lives Greater Than 8 Days - Both Units**

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

$$\frac{Q_1}{10.8} + \frac{Q_2}{0.58} \leq 1 \text{ where,}$$

Q_1 = Release rate of I-131 from MP1 Stack - (μCi/sec)

Q_2 = Release rate of I-131 from MP2 Stack - (μCi/sec)

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

$$\frac{Q_1}{122} + \frac{Q_2}{3.5} \leq 1 \text{ where,}$$

Q_1 = Release rate of total particulates with half lives greater than 8 days from the MP1 Stack (μCi/sec).

Q_2 = Release rate of total particulates with half lives greater than 8 days from the MP2 Stack (μCi/sec).

(3) The release rate limit of H-3 from the site shall be:

$$\frac{Q_1}{4.3 \times 10^6} + \frac{Q_2}{4.0 \times 10^4} \leq 1 \text{ where,}$$

Q_1 = release rate of tritium from MP1 stack (μCi/sec)

Q_2 = release rate of tritium from MP2 stack (μCi/sec)

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

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D.2 Appendix I Noble Gas Limits

D.2.a Quarterly Air Dose - Method 1 - Both Units

Step 1 - Determine C_{N1} = Total curies of noble gas released from Unit 1 during the calendar quarter.

Step 2 - Determine C_{N2} = Total curies of noble gas released from Unit 2 during the calendar quarter. Include all sources - ventilation, containment purges and waste gas tanks.

Step 3 - Determine D_{QG1} = Quarterl gamma air dose from Unit 1 (mrad).

$$D_{QG1} = 4.8 \times 10^{-5} C_{N1} *$$

Step 4 - Determine D_{QB1} = quarterly beta air dose from Unit 1 (mrad).

$$D_{QB1} \quad 4.8 \times 10^{-7} C_{N1} *$$

Step 5 - Determine D_{QG2} = quarterly gamma air dose from Unit 2 (mrad).

$$D_{QG2} = 1.8 \times 10^{-4} C_{N2} *$$

Step 6 - Determine D_{QB2} = quarterly beta air dose from Unit 2 (mrad).

$$D_{QB2} = 5.9 \times 10^{-4} C_{N2} *$$

Step 7 - If D_{QG1} or $D_{QG2} > 2.5$ mrad; or D_{QB1} or $D_{QB2} > 5$ mrad, go to Method 2.

*See Appendix D for derivation of factors.

D.2.b Quarterly Air Dose - Method 2 - Both Units

MP2 - For MP2 dose calculations use the GASPAR computer code to determine the critical site boundary air doses. The procedure to use this code is given in Appendix E.

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

X/Q's - 0.13×10^{-4} sec/m^3

D/Q - 0.15×10^{-6} m^{-2}

(See Appendix D)

If the calculated air dose exceeds the Tech Spec limit use real time meterology.

MP1 - For MP1 dose calculations use the AIREM computer code to determine the critical location air doses. The procedure to use this code is given in Appendix F.

The 3rd quarter 1978 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 the Tech Spec limit, use real time meteorology.

D.2.c **Annual Air Dose Limit Due to Noble Gases - Both Units**

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

$$D_{YG1} = \sum D_{QG1}, \; D_{YB1} = \sum D_{QB1} \text{ and } D_{YG2} = \sum D_{QG2}, \; D_{YB2} = \sum D_{QB2}$$

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 the section for the semi-annual 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 $D_{YG1 \text{ or } 2} > 10$ mrad or $D_{YB1 \text{ or } 2} > 20$ mrad and any corresponding quarterly dose was not calculated using Section D.2.b - real time meteorology, recalculate the quarterly dose using real time meteorology.

1022 025

D.3 Appendix I - Iodine and Particulate Doses

D.3.a Quarterly Doses - Unit 1

(1) Method 1 - Unit 1

Step 1 - Determine C_I = total curies of I-131 released in gaseous effluents from Unit 1 during the quarter.

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

Step 3 - Determine D_{QT} = quarterly thyroid dose as follows:

$D_{QT} = 8.4\ C_I$ (See Appendix D)

Step 4 - Determine D_{QO} = quarterly dose to the maximum organ other than the thyroid:

$D_{QO} = 1.1\ C_P$ (See Appendix D)

Step 5 - The maximum organ dose is the greater of D_{QT} or D_{QO}. If it is greater than 5 mrem, go to Method 2.

(2) Method 2 - Unit 1

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

$X/Q's = 7.1 \times 10^{-8}$ SEC/M^3

$D/Q = 7.9 \times 10^{-9}$ M^{-2}

Use the goat milk, vegetation and inhalation pathway in totaling the dose. If the maximum organ dose is greater than 7.5 mrem, go to Method 3.

(3) Method 3 - Unit 1

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

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D.3.b Quarterly Doses - Unit 2

(1) Method 1

Step 1 - Determine C_I = total curies of I-131 released in gaseous effluents from Unit 2 during the quarter.

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

Step 3 - Determine C_T = total curies of tritium released in gaseous effluents from Unit 2 during the calendar quarter.

Step 4 - Determine D_{QT} = quarterly thyroid dose as follows:

$$D_{QT} = 250\ C_I + 1.8 \times 10^{-3}\ C_T \text{ (See Appendix D)}$$

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

$$D_{QO} = 55\ C_P + 1.8 \times 10^{-3}\ C_T \text{ (See Appendix D)}$$

Step 6 - The maximum organ dose is the greater of D_{QT} or D_{QO}. If greater than 5 mrem, go to Method 2.

(2) Method 2

Use the GASPAR code, as given in Appendix E, 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's = 0.13×10^{-4} sec/M^3

D/Q = 0.15×10^{-6} M^{-2}

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.

The procedure to use the GASPAR code is given in Appendix E.

Use the goat milk, vegetation and inhalation pathways in totaling the dose. If the maximum organ dose is greater than 7.5 mrem, go to Method 3.

(3) Method 3 - Unit 2

Use the C..PAR code with actual locations, real-time meteorlogy and the pathways which actually exist at the time at these locations. The code should be run separately for ventilation releases, containment purges and waste gas tank releases.

D.3.c Maximum Organ - Annual Doses - Both Units

Determine D_{YO1} and D_{YO2} = maximum organ dose for the calendar year for units 1 and 2 respectively as follows:

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

The following guidelines should be used for use of D_{QO}:

(1) If the detailed quarterly dose calculations required per the section for the semi-annual 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_{YO} is greater than 15 mrem and any 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.

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D.4 Gaseous Effluent Monthly Dose Projections

D.4.a Unit 1

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

Step 1 - If it is expected that the augmented offgas treatment system will be out of service during the month, go to Step 7. Otherwise, continue with Steps 2 through 6.

Step 2 - Determine C'_N = number of curies of noble gas released during the most recent month of operation from the augmented offgas system.

Step 3 - Estimate R_1 = ratio of expected full power offgas rate at the air ejector for the upcoming month compared to the reference month of Step 2.

Step 4 - Estimate R_2 = ratio of expected unit production capacity for the upcoming month compared to the reference month of Step 2.

Step 5 - Determine D^E_{MG} = estimated monthly gamma air dose.

D^E_{MG} (mrad) = $4.8 \times 10^{-5}\ C'_N\ R_1\ R_2$ (Factor is from Appendix D)

Step 6 - Determine D^E_{MB} = estimated monthly beta air dose.

$D^E_{MB} = 4.8 \times 10^{-7}\ C'_N\ R_1\ R_2$ (Factor is from Appendix D)

Step 7 - 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 expected maximum power for the month.

r = estimated curie reduction factor from air ejector to stack via 30 minute holdup line (in decimal fraction).

d = estimated number of days 30 minute holdup pipe will be used.

D^E_{MG} = estimated monthly gamma air dose.

= 4.8×10^{-5} mrad/Ci x Q Ci/sec x rx d (day) x 8.6×10^4 sec/day.

D^E_{MG} = 4.Q.r.d

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D_{MB}^{E} = estimated monthly beta air dose.

D_{MB}^{E} = $0.04 \times Q \times r \times d$

(2) Due to Ventilation System Releases

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

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

Step 3 - Estimate R_2 = expected ratio of primary leakage rate for the coming month as compared with the average leakage rate during the quarter used in Step 1.

Step 4 - Determine D_{MO}^{E} = estimated monthly dose to the maximum organ.

$$D_{MO}^{E} = 1/3\ R_1\ R_2\ D_{QO}\ (\text{or } D_{QT})^*$$

* - Whichever was greater

** - Section D.3.b for Unit 2

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D.4.b Unit 2

(1) Due to Gaseous Radwaste Treatment System

Step 1 - Estimate C_N^E = the number of curies of noble gas to be released from the waste gas storage tanks during the next month.

Step 2 - Determine D_{MG}^E = estimated monthly gamma air dose.

$$D_{MG}^E \text{ (mrad)} = 4.8 \times 10^{-5}\ C_N^E$$

(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_{MB}^E = estimated monthly beta air dose.

$$D_{MB}^E \text{ (mrad)} = 4.8 \times 10^{-7}\ C_N^E$$

(2) Due to Ventilation Releases

Use the same method as given in Section D.4.2.(2) for Unit 1.

1022 032

D.5 Quarterly Dose Calculations for Semi-Annual Report

Detailed quarterly dose calculations required for the Semi-Annual Radioactive Effluent Report shall be done using the computer codes GASPAR and AIREM. The use of these codes and required input parameters are attached as Appendices E and F.

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 and 2

b) Liquid Releases from Units 1 and 2

c) Direct Radiation from the Site

d) Since all other uranium fuel cycle sources are greater than 20 miles away, they need not be considered.

E. LIQUID MONITOR SETPOINTS

E.1 M1 Liquid Radwaste Effluent Line

The trip/alarm setting on the 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 these parameters, an alarm/trip setpoint will be determined prior to the release of each batch. The following methodology 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.:

$$R = \text{Reduction Factor} = 1 \Big/ \sum_i \frac{\text{Ci/ml of nuclide } i}{\text{MPC of nuclide } i}$$

Step 2 - Determine the existing dilution flow = D = #CIRC pumps x 100,000 gpm + # service water pumps x 10,000 gpm.

Step 3 - Determine the allowable discharge flow = F

F = 0.1 x R x D

Note that discharging at this flow rate would yield a discharge concentration 10% of the Tech Spec Limit due to the safety factor of 0.1.

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

Step 5 - Using the latest monitor calibration curve, determine the "cps" corresponding to two times the total μCi/ml determined in Step 4. This will be the trip setpoint.

Note: If discharging at the allowable discharge rate as determined in Step 3, this would yield a discharge concentration 20% of the Tech Spec limit.

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.

E.2 M1 Service Water Effluent Line

The M1 Service Water Monitor Hi alarm setting is approximately 1.5 times the ambient background and the Hi-Hi Alarm is approximately 2 times the ambient background reading on the monitor in counts per second.

E.3 M2 Clean Liquid Radwaste Effluent Line

Same as Section E.1 for the M1 Liquid Radwaste Monitor except for Step 2 where:

Dilution Flow = D - #CIRC Pumps x 135,000 gpm + # Service Water Pumps x 4,000 gpm.

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E.4 M2 Aerated Liquid Radwaste Effluent Line and Condensate Polishing Facility Waste Neut. Sump

Same as E.3 for Clean Liquid Monitor, except that for the Condensate Polishing Facility Waste Neut. Sump the monitor has a digital readout of μCi/ml and the alarm setpoint is set directly on μCi/ml and not the corresponding count rate.

E.5 M2 Steam Generator Blowdown Monitor

Maximum possible total S.G. blowdown flow rate = 250 gpm

Minimum possible circ water dilution flow during periods of blowdown = 270,000 gpm (2 pumps)

Unidentified MPC for unrestricted area = 1×10^{-7} μCi/ml

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

$$\text{Alarm } (\mu\text{Ci/ml}) = \frac{270{,}000}{250} \times 1 \times 10^{-7} = 1.1 \times 10^{-4}\ \mu\text{Ci/ml}$$

The latest monitor calibration curve should be used to determine the alarm setpoint in cpm corresponding to 1.1×10^{-4} μCi/ml.

This setpoint may be increased through proper administrative controls if the steam generator blowdown rate is maintained less than 250 gpm and/or more than 2 circulating water pumps are available. The percent increase would correspond to the ratio of the flows to those assumed above.

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.

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E.6 M2 Condenser Air Ejector Monitor

This monitor is included as a liquid monitor since the reason it's in the Technical Specifications is for control of the Steam Generator Blowdown liquid activity. It can be used in conjunction with or in place of the blowdown monitor to ensure that the blowdown concentration is within 10CFR20 limits.

Gaseous release limits are not controlled by this monitor but rather by the monitor at the final discharge point.

A detailed study was performed to determine the equilibrium steam generator blowdown activity as a function of blowdown rate and primary to secondary leakage rate. It turns out that in order to reach 10CFR20 limits as determined in Section E-5 the minimum primary to secondary leakage rate required is 0.4 gpm. The air ejector monitor is set to alarm at a level corresponding to approximately 0.2 gpm leakage. Thus it ensures adequate control of blowdown. The above values are for the primary coolant activity level used at the time of the study. However, if the coolant activity increased such that the leakage rate required to reach 10CFR20 limits was less, there would be an equal increase in the sensitivity of the air ejector monitor.

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E.7 M2 Reactor Bldg. Closed Cooling Water Monitor and Turbine Building Sump Monitor

The alarm setting is approximately 2 times the ambient background reading of the monitor.

1022 041

E.8 M2 RWST and Condensate Surge Tank Level Indicators

Tank level alarms are set as follows:

Refueling Water Storage Tank:

High Level Alarm - Approximately 97 Percent of Tank Capacity

Condensate Surge Tank:

High Level Alarm - Approximately 90 Percent of Tank Capacity

F. GASEOUS MONITOR SETPOINTS

F.1 M1 Hydrogen Monitor

Per Section 3.8.D.6 of the Technical Specifications, the alarm setpoint shall be $\leq$ 4% hydrogen by volume.

F.2 M1 Steam Jet Air Ejector Offgas Monitor

Per Section 3.8.D.7 of the Technical Specifications, the maximum allowed noble gas in-process activity rate shall not exceed 1.47×10^6 μCi/sec. This value will be more limiting than the instantaneous stack release rate limit.

Using the latest offgas monitor calibration curve, determine the reading in mR/HR corresponding to 1.47×10^6 μCi/sec. The alarm setpoint should be set at less than or equal to this value.

1022 044

F.3 Ml Stack Noble Gas Monitor

Per Technical Specification 3.8.D.1 and ODCM Section D.1.a, the instantaneous release rate limit from the site shall be:

$$\frac{Q_1}{830,000} + \frac{Q_2}{260,000} \leq 1$$

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

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

Assume 50% of the limit is from MP1 stack.

Therefore Q_1 should be less than 415,000 μCi/sec.

The M1 stack noble gas monitor calibration curve (given as μCi/sec per cps) is determined by assuming a maximum ventilation flow of 170,000.

Therefore, the alarm setpoint should be set at or below the "cps" corresponding to 415,000 μCi/sec from the calibration curve.

The alarm setpoint may be increased if the Unit 2 stack setpoint is at a level corresponding to less than 50% of the site limit.

F.4 <u>M1 Main Stack Sampler Flow Rate Monitor</u>

The M1 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:

a) Pressure Switch #1 $<$ 2" Hg

or

b) Pressure Switch #1 $>$ 18" Hg and Pressure Switch #2 $<$ 20" Hg

1022 046

F.5 MP2 Vent - Noble Gas Monitor

Per Section D.1.a of this manual, the instantaneous release rate limit from the site shall be:

$$\frac{Q_1}{830{,}000} + \frac{Q_2}{260{,}000} \leq 1$$

Assuming 50% of the limit is from the Unit 2 vent, the release rate limit for Unit 2 is 130,000 μCi/sec.

The MP2 vent noble gas monitor calibration curve (given as μCi/sec per cpm) is determined by assuming the maximum possible ventilation flow for various fan combinations. Curves for 3 different fan combinations are normally given.

The "cpm" corresponding to 130,000 μCi/sec should be determined from the appropriate curve. The alarm setpoint should be set at less than or equal to this value.

The alarm setpoint may be increased if the Unit 1 stack setpoint is at a level corresponding to less than 50% of the site limit.

G. ENVIRONMENTAL MONITORING PROGRAM

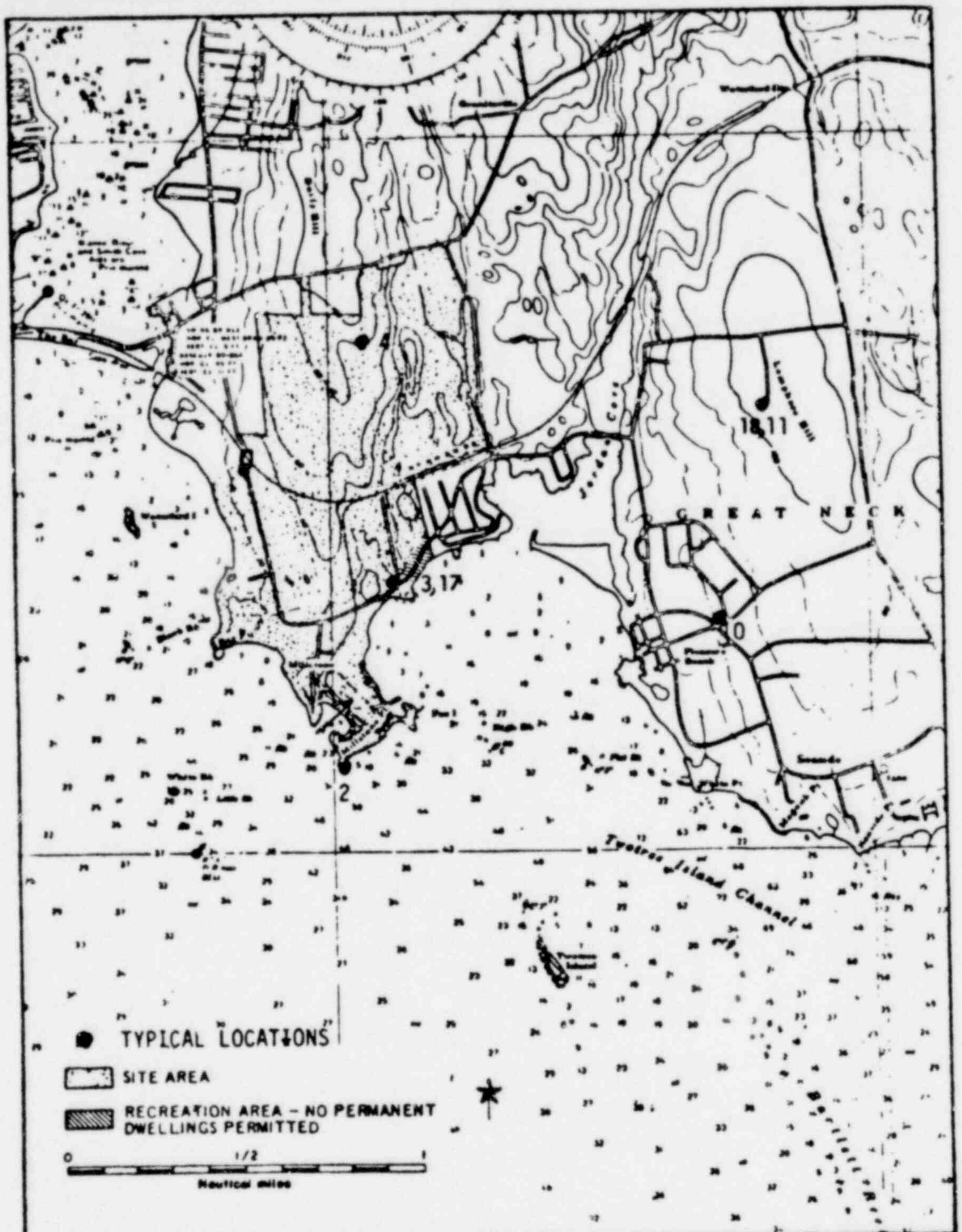
SAMPLING LOCATIONS

The following lists the environmental sampling locations and the types of samples obtained at each location. The distances given are to the nearest half mile. Sampling locations are also shown on Figures G-1, G-2 and G-3.

Location Number	Name	Direction & Distance	Sample Types
1-I*	Onsite - Old Millstone Rd.	0.5 Mi. - NW	TLD, Air Particulate
2-I	Onsite - Weather Shack	0.5 Mi. - S	TLD, Air Particulate
3-I	Onsite - Bird Sanctuary	0.5 Mi. - NE	TLD, Air Particulate, Iodine
4-I	Onsite - Albacore Drive	1.0 Mi. - N	TLD, Air Particulate, Iodine
10-I	Pleasure Beach	1.0 Mi. - E	TLD, Air Particulate
11-I	New London Country Club	1.5 Mi. - NE	TLD, Air Particulate, Iodine
13-C	Mystic, CT	11.5 Mi. - ENE	TLD, Air Particulate
14-C	Ledyard, CT	11.5 Mi. - NE	TLD, Air Particulate, Iodine
15-C	Montville, CT	14.0 Mi. - N	TLD, Air Particulate
16-C	Old Lyme, CT	9.0 Mi. - W	TLD, Air Particulate
17-I	Site Boundary	0.5 Mi. - NE	Vegetation
18-I	New London Country Club	1.5 Mi. - NE	Vegetation
19-I	Cow Location #1	4.5 Mi. - NW	Milk
20-I	Cow Location #2	7.0 Mi. - W	Milk
21-I	Cow Location #3	11.0 Mi. - NE	Milk
22-C	Cow Location #4	15.0 Mi. - NNW	Milk
23-I	Goat Location #1	2.0 Mi. - ENE	Milk
24-C	Goat Location #2	15.0 Mi. - NE	Milk
25-I	Fruits & Vegetables	Within 10 Miles	Vegetation
26-C	Fruits & Vegetables	Beyond 10 Miles	Vegetation
30-C	Golden Spur	4.5 Mi. - NNW	Bottom Sediment, Mussels, Oysters
31-I	Niantic Shoals	2.5 Mi. - NNW	Bottom Sediments, Oysters
32-I	Vicinity of Discharge	Within 2 Miles	Bottom Sediments, Mussels, Lobster, Fish, Seawater
33-I	Seaside Point	2.0 Mi. - ESE	Bottom Sediment
35-I	Niantic Bay	1.0 Mi. - W	Lobster, Fish
36-I	Black Point	2.5 Mi. - SW	Bottom Sediment, Oysters
37-C	Giant's Neck	3.5 Mi. - WSW	Bottom Sed., Oysters, Lobster, Water
38-I	Waterford Shellfish Bed #1	0.5 Mi. - NNW	Clams

* I = Indicator C = Control

1022 048



POOR ORIGINAL

FIGURE G-1
Inner Terrestrial Monitoring Stations
Millstone Nuclear Power Station

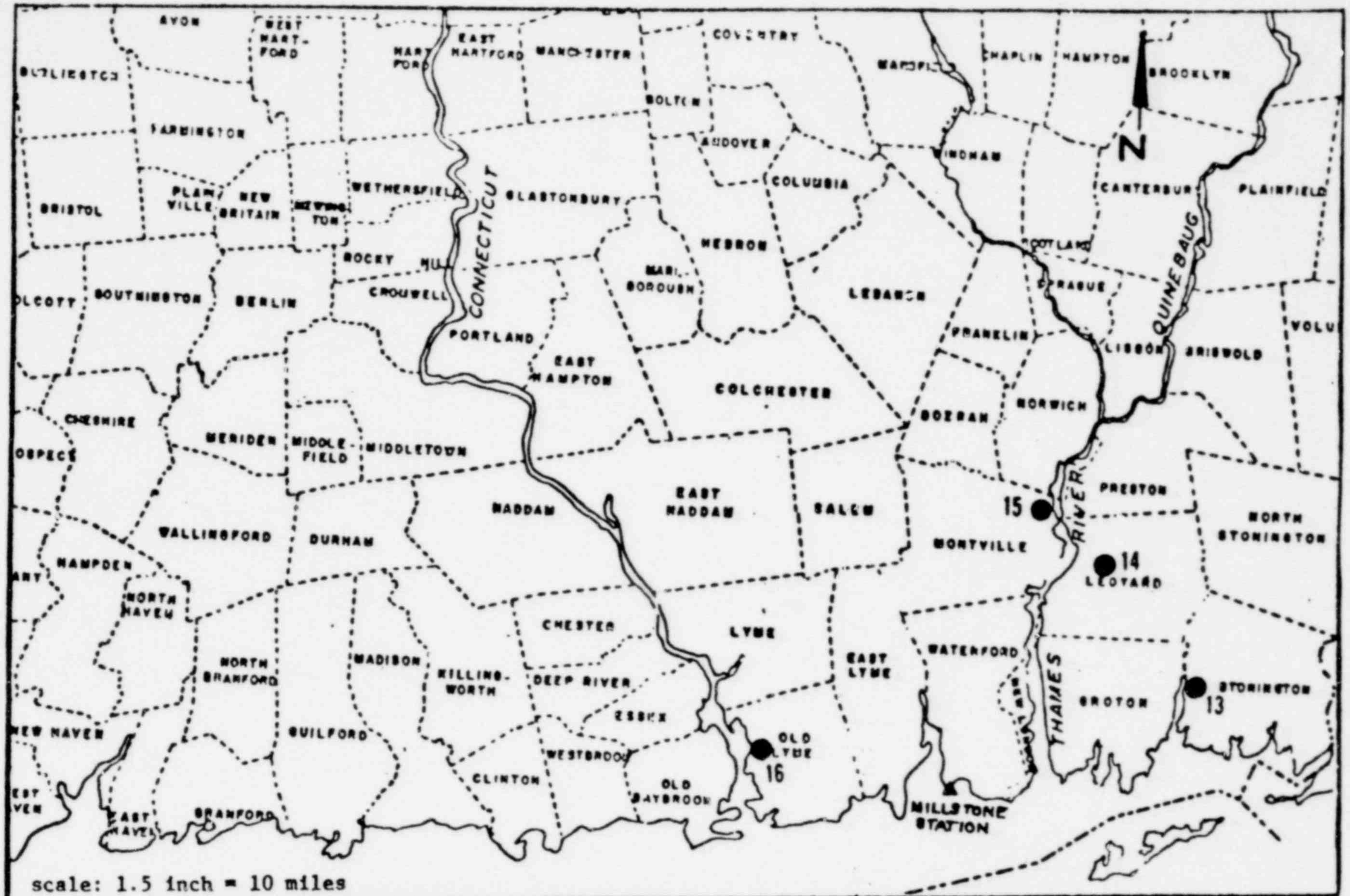


FIGURE G-2
Outer Terrestrial Monitoring Stations
Millstone Nuclear Power Station

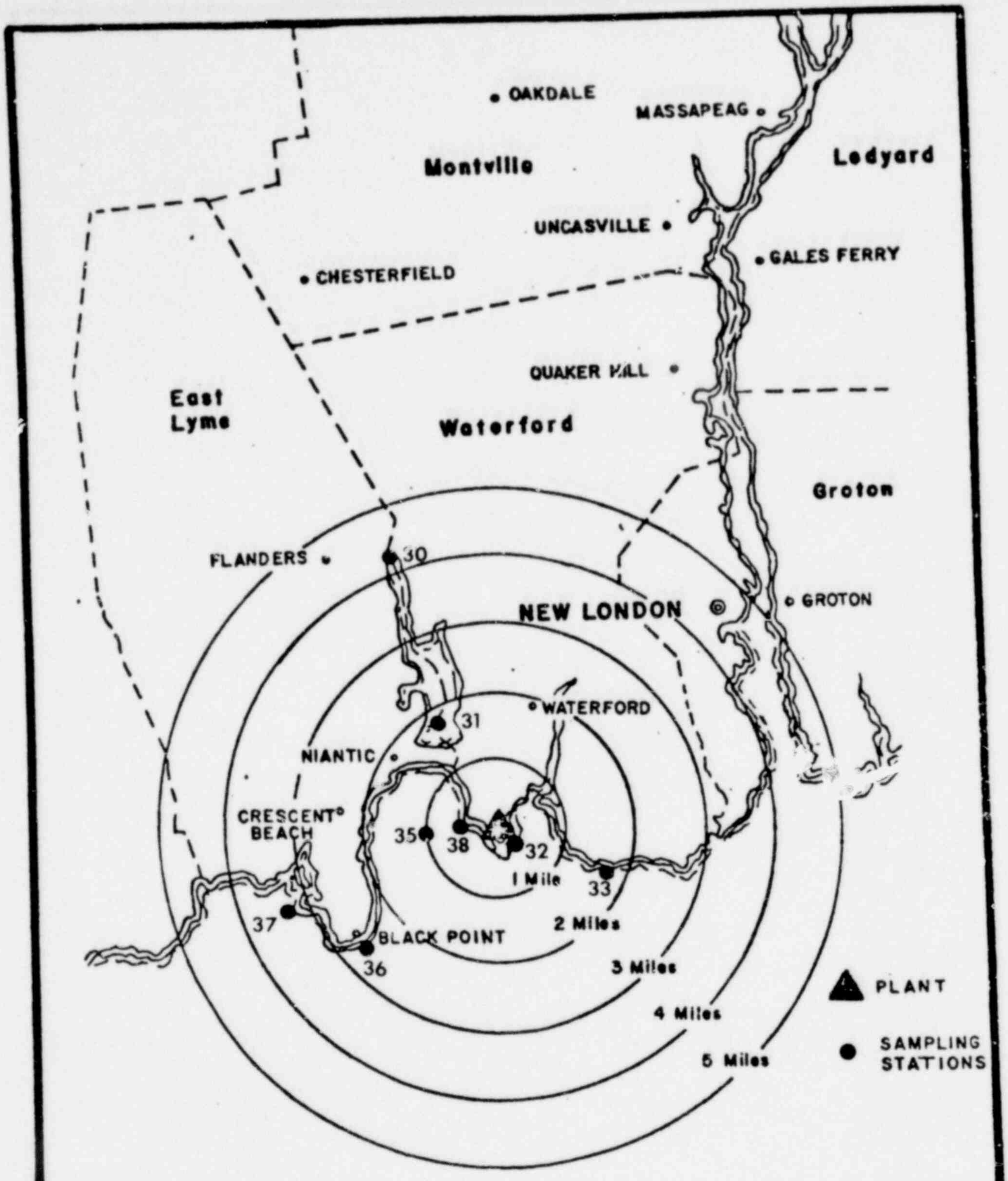


Figure G-3

AQUATIC SAMPLING STATIONS
Millstone Nuclear Power Station

POOR ORIGINAL

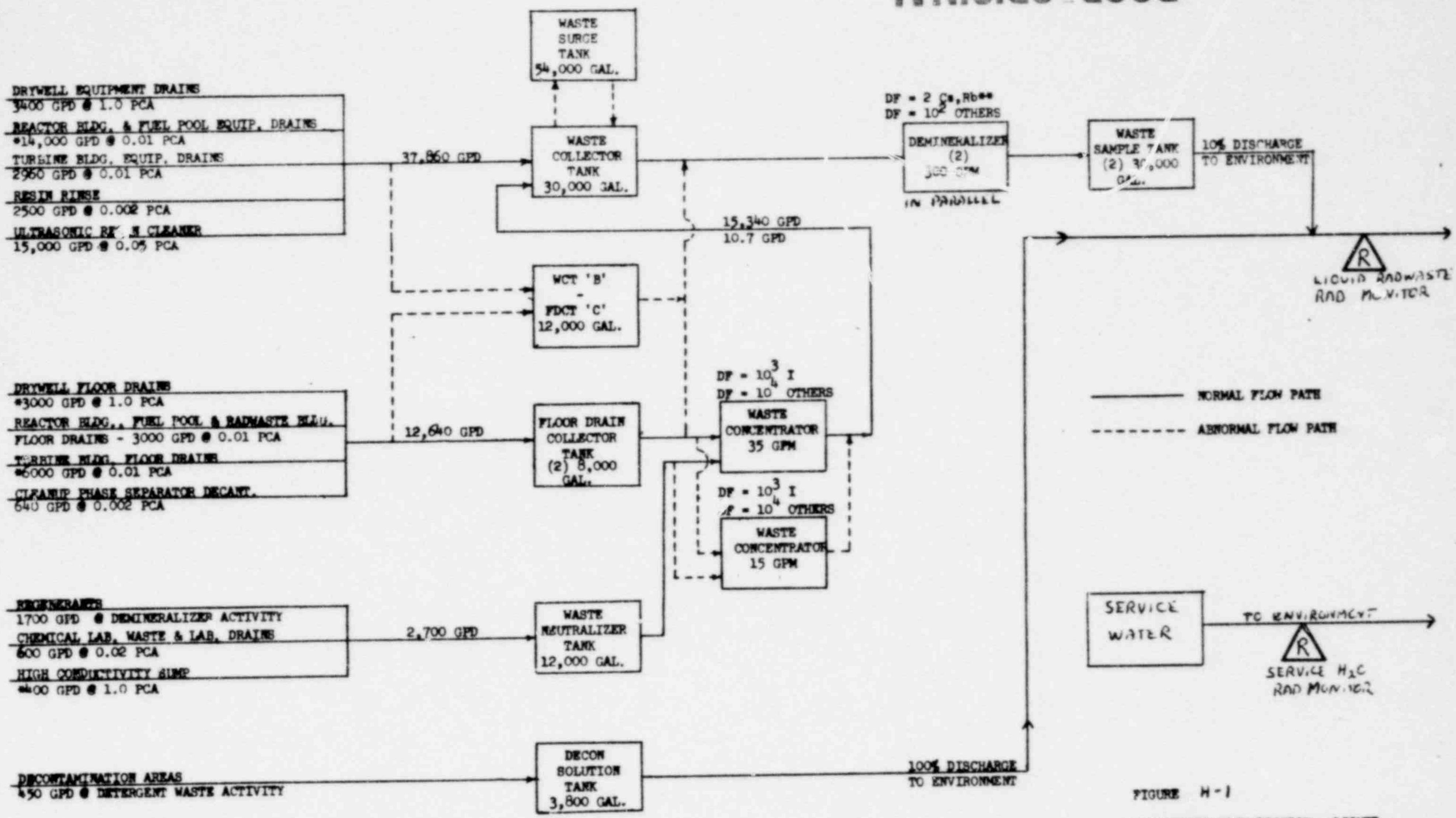
H. EFFLUENT FLOW DIAGRAMS

Figures H-1, H-2, H-3 and H-4 present simplified flow diagrams for the liquid and gaseous radwaste systems for both Units 1 and 2. They also indicate the location of the radiation monitors listed in the Technical Specifications.

1022 052

Rev. 0

POOR ORIGINAL

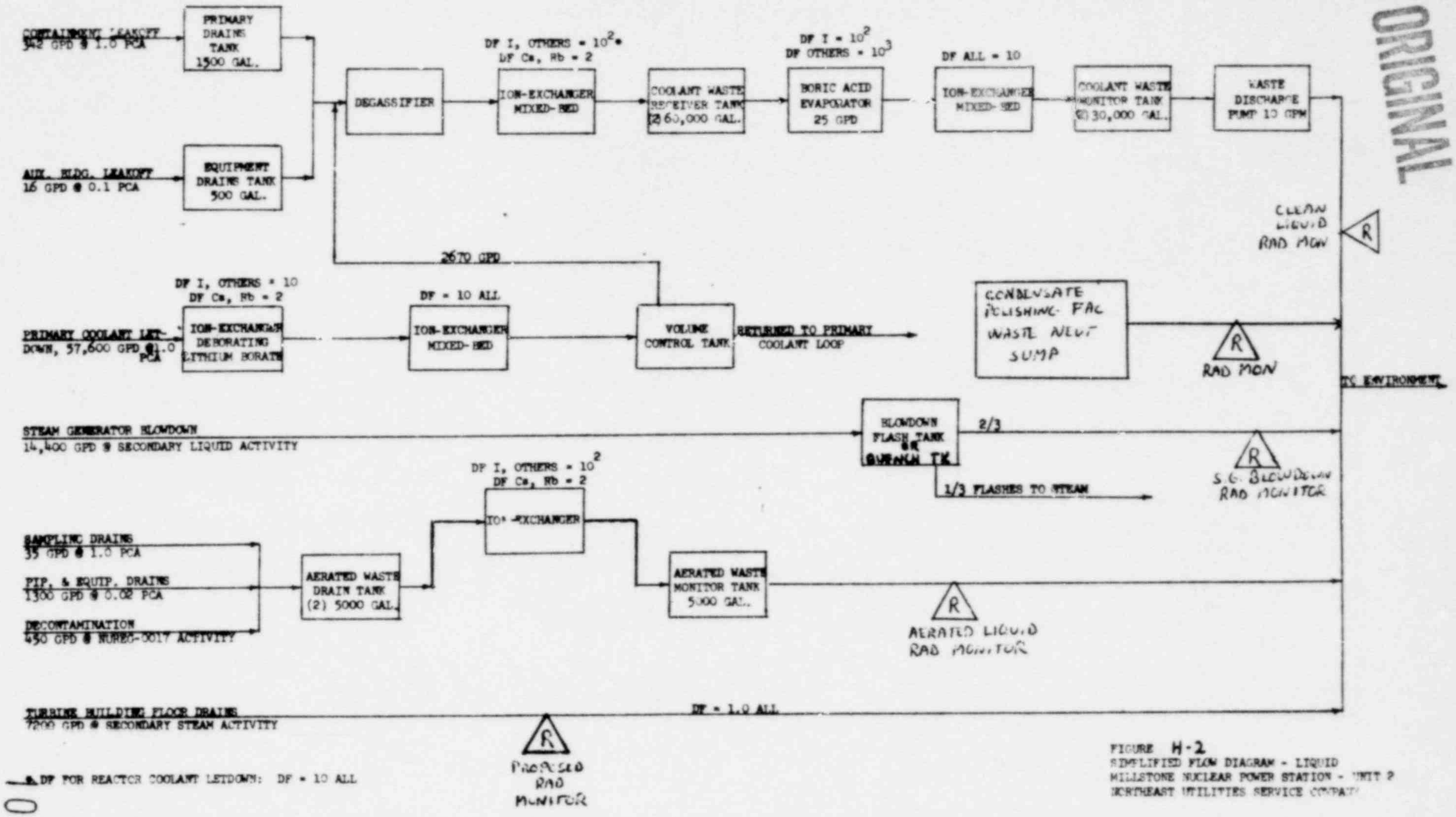


* - Flow rate based on operating experience.
** - DF's for an evaporator polishing demineralizer are 10 for all isotopes (Pg. C-94, Reg. Guide 1.CC)

FIGURE H-1

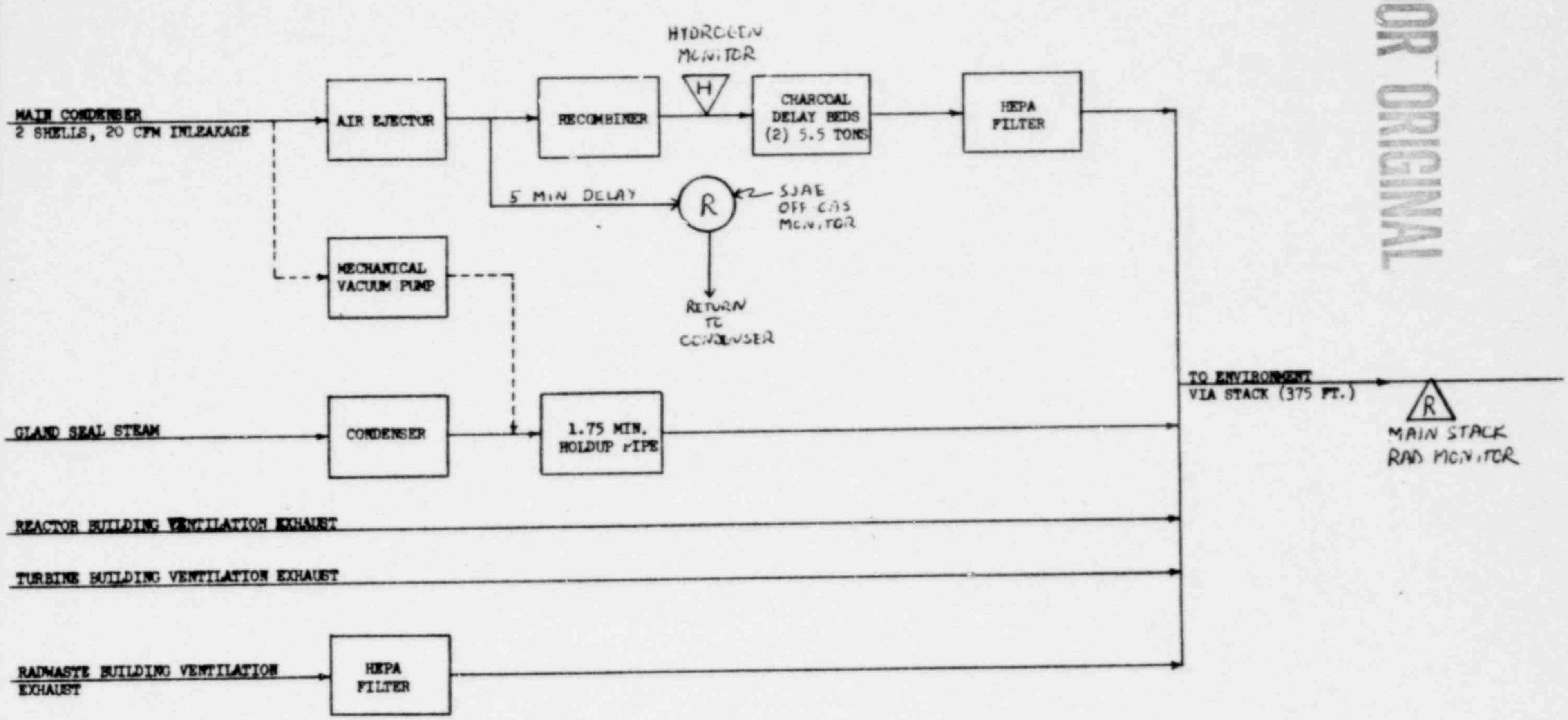
SIMPLIFIED FLOW DIAGRAM - LIQUID
MILLSTONE NUCLEAR POWER STATION - UNIT 1
NORTHEAST UTILITIES SERVICE COMPANY

1022 053



* DF FOR REACTOR COOLANT LETDOWN: DF = 10 ALL

FIGURE H-2
SIMPLIFIED FLOW DIAGRAM - LIQUID
MILLSTONE NUCLEAR POWER STATION - UNIT 2
NORTHEAST UTILITIES SERVICE COMPANY



The offgas system is based on the proposed augment which replaces a 100 minute holdup pipe with a recombiner & charcoal delay beds.

The mechanical vacuum pump is not a normal flow path (intermittent operation).

FIGURE H-3
SIMPLIFIED FLOW DIAGRAM - GASEOUS
MILLSTONE NUCLEAR POWER STATION - UNIT 1
NORTHEAST UTILITIES SERVICE COMPANY

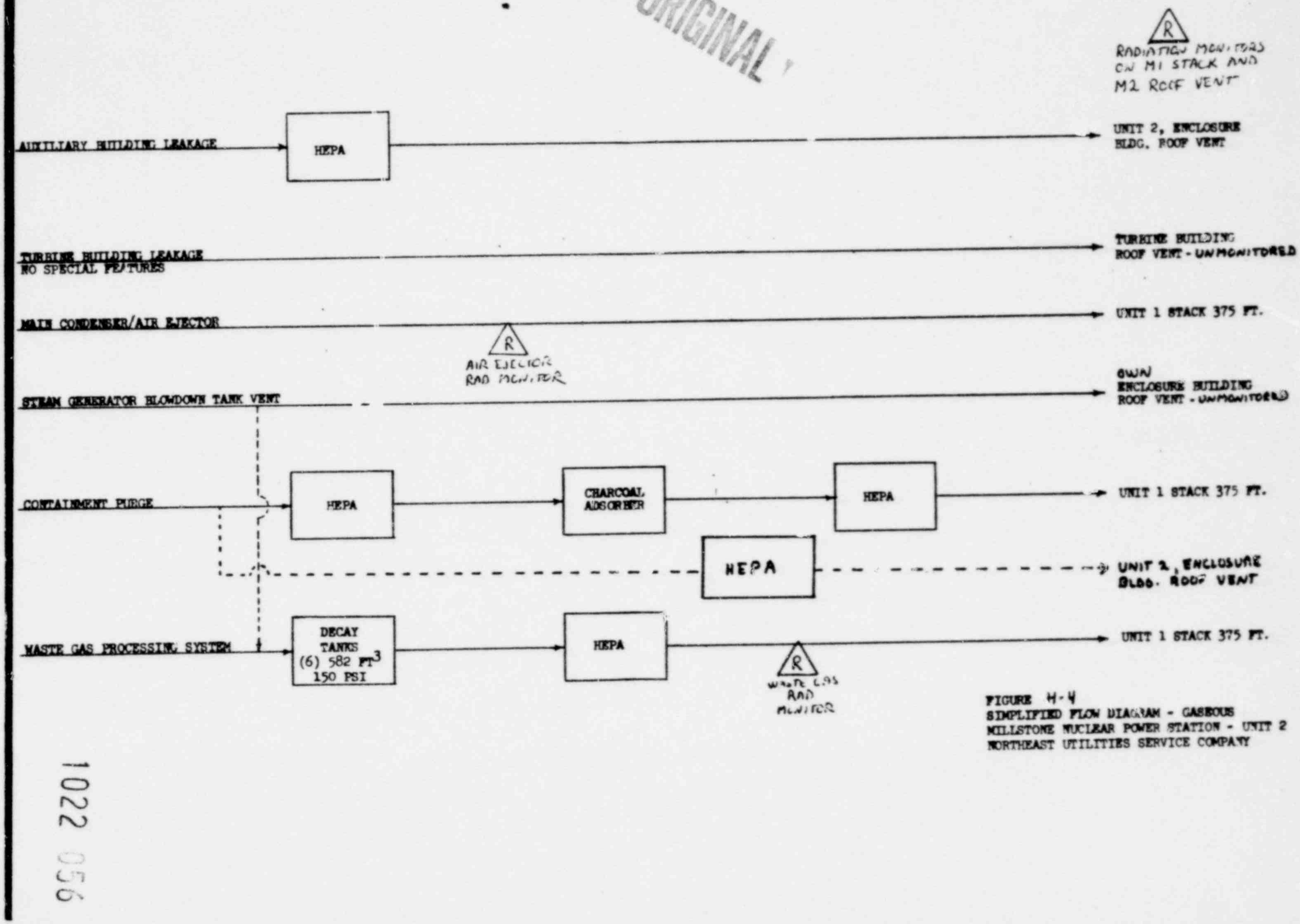


FIGURE H-4
SIMPLIFIED FLOW DIAGRAM - GASEOUS
MILLSTONE NUCLEAR POWER STATION - UNIT 2
NORTHEAST UTILITIES SERVICE COMPANY

APPENDIX A

DERIVATION OF FACTORS FOR SECTION C.1 - LIQUID DOSES

1. Section C.1.a - Step 3

Millstone 1 - Liquid Doses

Year	Qtr.	C_F	$D_{QT(F)}$	$D_{QT(F)}/C_F$ (mrem/Ci)	C_H	$D_{QT(H)}$	$D_{QT(H)}/C_H$ (mrem/Ci)
1976	1	8.60	7.6(-2)	8.8(-3)	5.12	ND	-
	2	0.053	1.3(-4)	2.5(-3)	9.19	2.1(-6)	2.3(-7)
	3	0.48	6.8(-3)	1.4(-2)	1.33	ND	-
	4	0.15	1.3(-3)	8.7(-3)	4.42	1.9(-6)	4.3(-7)
1977	1	0.12	1.1(-3)	9.2(-3)	3.11	7.3(-7)	2.3(-7)
	2	0.36	4.6(-3)	1.3(-2)	0.64	1.3(-7)	2.0(-7)
	3	0.012	1.1(-4)	9.2(-3)	0.002	8.0(-10)	4.0(-7)
	4	0.028	1.5(-4)	5.4(-3)	0.66	2.3(-7)	3.5(-7)
1978	1	0.119	1.3(-3)	1.1(-2)	0.98	3.9(-7)	3.9(-7)
	2	0.049	5.2(-4)	1.1(-2)	1.29	2.9(-7)	2.2(-7)

Millstone 2 - Liquid Doses

Year	Qtr.	C_F	$D_{QT(F)}$	$D_{QT(F)}/C_F$ (mrem/Ci)	C_H	$D_{QT(H)}$	$D_{QT(H)}/C_H$ (mrem/Ci)
1976	1	0.102	1.8(-4)	1.8(-3)	34.7	1.2(-5)	3.4(-7)
	2	0.179	2.4(-4)	1.3(-3)	87.3	2.7(-5)	3.1(-7)
	3	0.037	0.9(-4)	2.4(-3)	70.0	2.0(-5)	2.8(-7)
	4	0.025	1.0(-4)	4.0(-3)	85.4	3.7(-5)	4.3(-7)
1977	1	0.217	7.0(-4)	3.2(-3)	60.1	2.1(-5)	3.4(-7)
	2	0.802	6.1(-3)	7.6(-3)	73.3	3.0(-5)	4.1(-7)
	3	0.035	1.6(-4)	1.6(-4)	42.1	1.5(-5)	3.5(-7)
	4	0.509	1.9(-3)	3.7(-3)	35.0	1.1(-5)	3.3(-7)
1978	1	0.432	5.2(-3)	1.2(-2)	1.8	8.9(-7)	4.9(-7)
	2	1.27	6.6(-3)	5.2(-3)	43.6	1.2(-5)	2.7(-7)

where,

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

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

1022 057

C_H = Curies of tritium released during calendar quarter.

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

Maximum Value of $D_{QT(F)}/C_F$ - Unit 1 = 1.4×10^{-2} mrem/Ci

Unit 2 = 1.2×10^{-2} mrem/Ci

Average Value of $D_{QT(F)}/C_F$ - Unit 1 = 9.3×10^{-3} mrem/Ci

Unit 2 = 4.6×10^{-3} mrem/Ci

Maximum Value of $D_{QT(H)}/C_H$ - Unit 1 = 4.3×10^{-7} mrem/Ci

Unit 2 = 4.9×10^{-7} mrem/Ci

Average Value of $D_{QT(H)}/C_H$ - Unit 1 = 3.1×10^{-7} mrem/Ci

Unit 2 = 3.6×10^{-7} mrem/Ci

Since the maximum values observed of $D_{QT(F)}/C_F$ and $D_{QT(H)}/C_H$ are not much different for the two units, the same factor can be used for both units for simplicity. Also, since the maximum values are less than 3 times the average values, this says that the dose per total curie does not fluctuate greatly, hence this method is not over-conversative.

$$D_{QT(F)}/C_F = \boxed{1.4 \times 10^{-2}} \text{ mrem/Ci}$$

$$D_{QT(H)}/C_H = \boxed{4.9 \times 10^{-7}} \text{ mrem/Ci}$$

1022 058

2. Section C.1.b - Justification for Only Using Only Particular Nuclide

Millstone 1 Liquid Doses - Nuclide Breakdown
Percent of Dose

Year	Qtr.	Cs-134	Cs-137	Co-60	Mn-54	Ba-140	Co-58	Fe-59
1976	1	48	46	1	1	1	1	1
	2	29	41	14	1	2	5	2
	3	1	1	10	3	1	1	84
	4	1	1	45	7	1	1	39
1977	1	26	30	33	4	1	1	1
	2	42	47	9	1	1	1	1
	3	38	48	9	1	1	1	1
	4	24	35	18	1	1	19	1
1978	1	5	12	64	2	1	13	1
	2	2	1	77	2	1	3	11
	Avg.	22	26	28	2	1	4	14

Millstone 2 Liquid Doses - Nuclide Breakdown
Percent of Dose

Year	Qtr.	Cs-134	Cs-137	Co-60	Co-58	H-3	Fe-59	Mn-54	Zn-65
1976	1	1	4	7	35	8	38	3	1
	2	1	30	5	17	11	30	1	1
	3	1	5	10	38	28	3	1	9
	4	2	7	4	31	37	16	1	1
1977	1	1	1	11	39	3	43	1	1
	2	1	1	60	25	1	10	1	1
	3	1	2	43	33	15	1	1	1
	4	13	12	30	36	1	1	3	1
1978	1	3	3	68	20	1	1	4	1
	2	5	5	56	21	1	3	5	1
	Avg.	3	7	29	30	10	14	2	1

Listed above, are all of the nuclides which have contributed more than 1% to the quarterly total body dose during the past 2-1/2 years. The only nuclides which have ever contributed more than 10% of the total body dose are:

For Unit 1: Cs-134, Cs-137, Co-58, Co-60, and Fe-59

For Unit 2: Cs-134, Cs-137, Co-58, Co-60, Fe-59, and H-3

The average percent of the total body dose accounted for by these few nuclides is:

For Unit 1: 94%

For Unit 2: 93%

The minimum percent of the total body dose accounted for by these few nuclides in any one quarter is:

For Unit 1: 86%

For Unit 2: 84%

Therefore, using only these few nuclides for Method 2, the real dose should not exceed (1.0)/0.84=1.2 mrem.

1022 060

3. Section C.1.b - Step 3

Dose due to Cs-134 = $\frac{C134\ (Ci)}{V\ (gal)}$ x 10^{12} pCi/Ci x 0.26 gal/liter x 1/5 x

x [21/4 kg x 4.0 x 10^{1} pCi/kg per p Ci/liter x 1.2 x 10^{-4} mrem/pC +

5/4 kg x 2.5 x 10^{1} PCi/kg per pC/liter x 1.2 x 10^{-4} mrem/pCi

+ 100 $1/m^2$ day x 67/4 hr x 0.5 x 748 day x 1.2 x 10^{-8} mrem/hr per pCi/m^2]

= 5.2 x 10^{10} $\frac{C134}{V}$ [2.5 x 10^{-2} + 0.37 x 10^{-2} + 0.75 x 10^{-2}]

= $\boxed{1.9 \times 10^{9}}$ * C134/V

where,

1/5	=	Near field dilution factor (LADTAP)
21/4	=	Quarterly usage factor - Adult fish (Reg. Guide 1.109)
5/4	=	Quarterly usage factor - Adult shellfish (Reg. Guide 1.109)
67/4	=	Quarterly shoreline usage - teen (Reg. Guide 1.109)
4.0 x 10^{1}	=	Cs bioaccumulation factor - saltwater fish (Reg. Guide 1.109)
2.5 x 10^{1}	=	Cs bioaccumulation factor - saltwater shellfish (Reg. Guide 1.109)
1.2 x 10^{-4}	=	Cs-134 ingestion dose conversion factor - adult total body (Reg. Guide 1.109)
100	=	Proportionality factor from Reg. Guide 1.109
0.5	=	Shore width factor (Reg. Guide 1.109)
748 days	=	Half life of Cs-134
1.2 x 10^{-8}	=	External dose factor for shoreline pathway for Cs-134 - total body - (Reg. Guide 1.109)

1022 061

Likewise, dose due to Cs-137

$$= 5.2 \times 10^{10} \frac{C137}{V} [21/4 \times 4.0 \times 10^{1} \times 7.1 \times 10^{-5} + 5/4 \times 2.5 \times 10^{1}$$

$$\times 7.1 \times 10^{-5} + 100 \times 67/4 \times 0.5 \times 1.1 \times 10^{4} \times 4.2 \times 10^{-9} \times (1-e^{-\frac{.692 \times 15}{30}})]$$

$$= \boxed{1.5 \times 10^{9}} * C_{137}/V$$

where,

7.1×10^{-5}	=	Cs-137 ingestion dose conversion factor - adult total body (Reg. Guide 1.109)
1.1×10^{4}	=	Half life of Cs-137 in days
4.2×10^{-9}	=	External dose factor for shoreline pathway for Cs-137 - total body (Reg. Guide 1.109)
15	=	Period of time sediment is exposed to the contaminated water, in years - from Reg. Guide 1.109.
30	=	Half life of Cs-137 in years all other terms are defined above.

Likewise, dose due to Co-58

$$= 5.2 \times 10^{10} \frac{C58}{V} [21/4 \times 1.0 \times 10^{2} \times 1.67 \times 10^{-6} + 5/4 \times 1.0 \times$$

$$10^{3} \times 1.67 \times 10^{-6} + 100 \times 67/4 \times 0.5 \times 71 \times 7.0 \times 10^{-9}]$$

$= \boxed{1.8 \times 10^{8}} * C_{58}/V$, where

1.0×10^{2}	=	Co bioaccumulation factor - saltwater fish (Reg. Guide 1.109)
1.0×10^{3}	=	Co bioaccumulation factor - saltwater shellfish - (Reg. Guide 1.109)
1.67×10^{-6}	=	Co-58 ingestion dose conversion factor - adult total body - (Reg. Guide 1.109)
71	=	Half life of Co-58 in days.
7.0×10^{-9}	=	External dose factor for shoreline pathway for Co-58 - total body (Reg. Guide 1.109)

1022 062

All other terms are defined above.

Likewise, dose due to Co-60

$= 5.2 \times 10^{10} \frac{C60}{V} [21/4 \times 1.0 \times 10^{2} \times 4.7 \times 10^{-6} + 5/4 \times 1.0 \times$

$\times 10^{3} \times 4.7 \times 10^{-6} + 100 \times 67/4 \times 0.5 \times 1.9 \times 10^{3} \times 1.7 \times 10^{-8}$

$\times (1 - e \frac{-.693 \times 15}{5.2})]$

$= \boxed{1.6 \times 10^{9}} * C_{60}/V$

where,

4.7×10^{-6}	=	Co-60 ingestion dose conversion factor - adult total body (Reg. Guide 1.109)
1.9×10^{3}	=	Half life of Co-60 in days
1.7×10^{-8}	=	External dose factor for shoreline pathway for Co-60 - total body (Reg. Guide 1.109)
5.2	=	Half life of Co-60 in years.

All other terms are defined above.

Likewise, dose due to Fe-59

$= 5.2 \times 10^{10}$ C59/V $[21/4 \times 3.0 \times 10^{3} \times 3.9 \times 10^{-6} + 5/4 \times 2.0 \times 10^{4}$

$\times 3.9 \times 10^{-6} + 100 \times 67/4 \times 0.5 \quad 45 \times 8.0 \times 10^{-9}]$

$= \boxed{8.3 \times 10^{9}} * C_{59}/V$

where

3.0×10^{3}	=	Fe bioaccumulation factor - saltwater fish (Reg. Guide 1.109)
2.0×10^{4}	=	Fe bioaccumulation factor - saltwater shellfish (Reg. Guide 1.109)
3.9×10^{-6}	=	Fe-59 ingestion dose conversion factor - adult total body (Reg. Guide 1.109)
45	=	Half life of Fe-59 in days.
8.0×10^{-9}	=	External dose factor for shoreline pathway for Fe-59 - total body (Reg. Guide 1.109)

Likewise, dose due to H-3,

$= 5.2 \times 10^{10}$ CT/V $[21/4 \times 9.0 \times 10^{-1} \times 1.05 \times 10^{-7} + 5/4 \times 9.3$
$\times 10^{-1} \times 1.05 \times 10^{-7}]$
$= \boxed{3.2 \times 10^{4}} *$ CT/V

where,

9.0×10^{-1}	=	H-3 bioaccumulation factor - saltwater fish (Reg. Guide 1.109)
9.3×10^{-1}	=	H-3 bioaccumulation factor - saltwater shellfish (Reg. Guide 1.109)
1.05×10^{-7}	=	H-3 ingestion dose conversion factor - adult total body (Reg. Guide 1.109)

APPENDIX B

DERIVATION OF FACTORS FOR SECTION C2 - LIQUID DOSES

1. Section C.2.a - Step 2

Millstone 1 - Liquid Doses

Year	Qtr.	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	GI (LLI)	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

Millstone 2 - Liquid Doses

Year	Qtr.	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	0.120

where,

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

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

1022 065

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 is not included in the calculation.

Maximum Value of D_{QO}/C_F - Unit 1 - 0.202 mrem/Ci
Unit 2 - 0.120 mrem/Ci

Average Value of D_{QO}/C_F - Unit 1 - 0.055 mrem/Ci
Unit 2 - 0.050 mrem/Ci

Since the maximum value of D_{QO}/C_F is within a factor of two for both units, the same factor can be used for both units for simplicity. Also, since the maximum value is within a factor of 4 of the average value, this says that the dose per total curies does not fluctuate greatly, hence this method is not over-conservative.

Thus, D_{QO}/C_F = **0.2 mrem/Ci**

1022 066

APPENDIX C

LADTAP - LIQUID DOSE CALCULATIONS

The LADTAP code was written by the NRC to compute doses from liquid releases using the models given in Regulatory Guide 1.109. There is no revision date on the copy of the code which was obtained, but it was purchased in March 1976. The only change made to the code since that time was a change in the ingestion dose factors from those given in Rev. 0 of Reg. Guide 1.109 to those in Rev. 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.

   Recycle fraction = 0.025
4. Shorewidth factor = 0.5
5. Dilution for Max. Individual Pathways = 5-Surface-High Velocity Discharge
6. 1 Hour Discharge Transit Time - time to transit quarry
7. Reg. Guide 1.109 usage factors for Max. Individual for fish, shellfish, shoreline, swimming and boating pathways
8. Zero usage for algae, drinking water, and irrigated food pathways

The following pages of Appendix C present the in-house procedure written for running this code. It is written for running the quarterly dose calculations but can easily be used to perform monthly calculations.

APPENDIX C

LIQUID DOSE CALCULATIONS - LADTAP

A. PURPOSE

This procedure may be used to calculate the quarterly (or any other time period) doses to both the maximum individual and the 50 mile population due to radionuclides released in liquid effluents from either Connecticut Yankee or Millstone Units 1 or 2. The procedure involves the use of the computer code LADTAP which was developed by the NRC in order to perform dose calculations in accordance with Regulatory Guide 1.109.

B. REFERENCES

1. User's Manual for the LADTAP Program - 8 page printout.
2. U.S. N.R.C. Regulatory Guide 1.109.
3. U.S. N.R.C. Regulatory Guide 1.113.
4. Millstone 3 - Demonstration of Compliance with 10CFR50, Appendix I - Part 2B - Nov. 76.
5. Final Environmental Statements - CY and Millstone 1 and 2.

C. PREREQUISITES

The plant must supply the total number of Curies released for each radionuclide during the time period involved.

D. PRECAUTIONS

None.

E. LIMITATIONS AND ACTIONS

None.

F. PROCEDURE

1. Review the plant curie tables for accuracy and completeness. If the strontium results are not yet available, but the calculations must be performed in order to meet the semiannual effluent report schedule, the code may be run without the strontium values and the doses due to strontium ratioed by hand by comparison with the previous quarter's results.
2. Obtain the computer deck for the proper site - there is one deck for Connecticut Yankee and one deck for Millstone. The Millstone deck may be used for both Units 1 and 2, however the quarterly doses must be calculated for each plant separately.

3. The following control cards are required for either deck:

```
// 082), 'CRANDALL', MSGLEVEL = 1, CLASS = B
//STEP1 EXEC PGM = PFLADTAP
//FT10F001 DD DSN=FANG.DOSE.FACTOR.FOR.PFLADTAP, DISP=OLD
//FTØ6FØØ1 DD SYSOUT = A
//FTØ5FØØ1 DD *

            INPUT CARDS

/*
```

4. The deck should be in the order as used during the previous quarter. If not, refer to reference 1 to ensure the proper input cards are used. Pay particular attention to the number of blank cards required.

5. The following values are incorporated in the input cards and need not be revised routinely. Check the basis as given below used to generate these values. If there has not been a change in the basis, proceed to step 6 - if there has been a change, revise the appropriate card (and the procedure if the change is permanent).

<u>Card 2</u>

a. Site type - CY = 0 = fresh MP = 1 = salt

b. Release multiplier - CY & MP = 1 - calculation done for 1 unit at a time.

c. Percentage dose printout - CY & MP = 1 - prints nuclide breakdown of dose.

<u>Card 3</u>

a. 50 mile population - CY = 3.83E+06 - 1980 population estimate-ER
MP = 3.03E+06 - 1980 population estimate-ER

b. Change the standard population distribution - CY & MP = 0 = NO

Assumes population around CY & MP is typical as far as fraction which is adult, teenage and child.

<u>Card 6</u>

a. CY = no reconcentration - river site - blank card.

b. MP = Model #2 - ocean site.
Cycle Time = 12 hr. - total cycle.
Recycle Fraction = 0.025 - from MP 1&2 FES.

Card 7

a. Change the standard usage factors CY & MP = 1 - factors must be changed.

b. Shorewidth factor -

CY = 0.1 - canal shorewidth factor from reference 1 - using for max individual dose.
MP = 0.5 - ocean site from reference 1.

c. Dilution for aquatic foods -

CY = 1 - From table A-1 of Reg Guide 1.109 - Surface - Low Velocity discharge.
MP = 5 - From table A-1 of Reg Guide 1.109 - Surface - High Velocity discharge.

d. Dilution for shoreline -

CY = 1 - Same as 7c.
MP = 5 - Same as 7c.

e. Dilution for drinking water -

CY = 5 - Arbitrary number since usage factor is zero.
MP = 5 - Arbitrary number since usage factor is zero.

f. Discharge transit time.

CY = 1 hr - From FES canal transit time is 50-100 min.
MP = 1 hr - Estimated quarry transit time from chlorine study.

g. Transit time to drinking water intake.

CY = 5 hr - arbitrary number since usage factor is zero.
MP = 5 hr - arbitrary number since usage factor is zero.

Card 7a - Adult usage factor - max individual

a. Fish consumption - CY & MP = 21 kg/yr - from reference 1.

b. Invertebrate consumption -

CY = 0 - river site.
MP = 5 kg/yr - from reference 1.

c. Algae consumption - CY & MP = 0 - no body eats algae.

d. Water - CY & MP = 0 - no drinking water source for either plant.

e. Shoreline - CY & MP - 12 hr/yr - from reference 1.

f. Swimming - CY & MP - 12 hr/yr - assume the same as shoreline recreation.

g. Boating - CY & MP - 52 hr/yr - from Reg Guide 1.109.

Card 7b Teenager usage factors - max individual (basis are the same as 7a).

a. Fish consumption - CY & MP = 16 kg/yr.

b. Invertebrate consumption - CY = 0
MP = 3.8 kg/yr

c. Algae consumption - CY & MP = 0

d. Water - CY & MP = 0

e. Shoreline - CY & MP = 67 hr/yr

f. Swimming CY & MP - 67 hr/yr

g. Boating CY & MP - 52 hr/yr

Card 7c - Child usage factors - max individual (basis are the same as 7a).

a. Fish consumption - CY & MP = 6.9 kg/yr

b. Invertebrate consumption - CY = 0
MP = 1.7 kg/yr

c. Algae consumption - CY & MP = 0

d. Water - CY & MP = 0

e. Shoreline - CY & MP = 14 hr/yr

f. Swimming - CY & MP = 14 hr/yr

g. Boating - CY & MP = 29 hr/yr

Card 7d - Infant usage factors - max individual.

a. Fish consumption - CY & MP = 0 - infants don't eat fish.

b. Invertebrates consumption - CY & MP = 0 - infants don't eat invertebrates.

c. Algae consumption - CY & MP = 0 - infants don't eat algae.

d. Water - CY & MP = 0 - no drinking water supply.

e. Shoreline - CY & MP = 14 hr/yr - assume same as child.

f. Swimming - CY & MP = 0

g. Boating - CY & MP = 29 hr/yr - assume same as child.

Card 8 - Leave blank unless special calculation is desired.

Card 9 - Sport fish harvest.

a. Fish harvest.

CY - 83,000 kg/yr

Based on pg. 109 - The Connecticut River Ecological Study - Merriman & Thorpe Jan.-Jun. 1973 - 16,000 fish caught in discharge canal. Add 30% for July-Dec. = 16,000 x 1.3 = 20,800 fish.

Assume 4 kg/fish = 83,000 kg/yr.

MP = 1.54 E + 05 kg/yr.

Based on U.S. Dept. of Interior - Commercial Landing Record for New London County 1971-1973. Used 1973 data (highest of 3 years). Commercial fish (excluding menhaden) = 1.54×10^5 kg/yr.

Assume an equal amount of sport fish.

b. Dilution.

CY = 1 - dilution factor for discharge canal.

MP = Based on Section 1.3 of reference 4.

Assume 50% caught - near field dilution = 5
50% caught - far field dilution = 18.6

Average dilution factor = 11.8.

c. Transit Time.

CY = 0.5 hrs. - half way through canal.

MP = 1 hr. = quarry transit time.

Card 10 - Commercial fish harvest.

a. Fish harvest.

CY - 470,000 kg/yr

Based on U.S. Dept. of Interior Commercial Fish Landing Records for 1972 and 1973 @ Middlesex County.

Avg. of 2 years = 470,000 kg/yr.

MP - 1.54 E + 0.5 - See card 9 for basis.

b. Dilution.

CY = 5 - assumed dilution for Conn. River.

MP = 11.8 - See card 9.

c. Transit Time.

CY = 1 hr. - canal transit time.

MP - 1 hr. - quarry transit time.

Card 11 - Sport Invertebrate harvest.

a. CY - Blank card - no significant invertebrate catch.

b. MP - harvest 8.6 x 10^4 kg/yr.

Based on U.S. Dept. of Interior Commercial Shellfish catch for New London County for 1973.

Commercial catch = 5.72 x 10^5 kg/yr.
Assume sport catch = 15% of commercial catch.

Dilution = 11.8 - see card 9.
Transit Time = 1 hr.

Card 12 - Commercial Invertebrate Harvest.

a. CY - Blank card - see card 11.

b. MP - Harvest = 5.72 x 10^5 kg/yr. See card 11.
Dilution = 11.8 - See card 9.
Transit Time = 1 hr.

Card 13 - Population Drinking Water.

CY & MP - Blank card - no drinking water source for either site.

Card 14 - Population Shoreline.

a. Usage (manhours).

CY = 100,000 manhours.

Based on 2 Parks - Gilette Castle State Park and Selden Neck State Park 26 weeks x 1000 persons/wk x 4 hours/person = 104,000 manhours.

Millstone = 1.5×10^6 manhours.

Based on table 1.1.2-5 of reference 4.

b. Dilution.

CY = 5 - Assumed river dilution.

MP = 11.6 - Average dilution factor for 7 beaches - See Table 1.3.2-1 of reference 4.

c. Transit Time-Hrs.

CY = 10 hrs. - assumed river transit time to 2 beaches.

MP = 1 hr. - quarry transit time.

d. Shorewidth factor.

CY = 0.2 - river shorewidth factor.

MP = 0.5 - ocean shorewidth factor.

e. Location Identification

CY & MP - Parks - rather than doing each park separately, this card combines them all and uses average dilution factor.

<u>Card 15</u> - Population Swimming

a. CY - blank card - no swimming in Connecticut River.

b. MP - Usage - 1.4×10^6 manhours - Table 1.1.2-4 of reference 4.
Dilution = 11.6 - See card 14.
Transit Time = 1 hr. - See card 14.
Location ID = Beaches.

<u>Card 16</u> - Population Boating

a. Usage

CY - 100,000 manhours = from Environmental Statement.

MP - 5.8×10^5 manhours = from Table 1.1.2-3 of reference 4.

b. Dilution

CY = 5 - See card 13.

MP = 11.8 - See card 9.

c. Transit Time

CY = 10 hrs. - See card 13.

MP = 1 hr. - quarry transit time.

d. Location ID

CY = river
MP = ocean

Cards 17 & 18 - Irrigated Foods

CY & MP - blank card - no irrigation pathway.

Card 19 - Biota

a. Dilution

CY = 5
MP = 11.8

b. Transit time

CY = 1 hr.
MP = 1 hr.

6. The following input cards must be changed routinely for each quarterly run of the program:

Card 1 - Title card - Format - 2X, A78

Enter the plant name, "Liquid Dose Calculation", and the time period of the dose calculation.

Card 2 - Columns 11-20 - Format E10 - Dilution Flow.

Determine the average dilution flow rate (ft 3/sec) for the quarter by:

a. Determine the total dilution volume for the quarter.

This should be the total dilution volume for the entire quarter and not just for the periods of discharge. It should be on the order of 1 x 10" liters.

b. Divide by the number of seconds in the quarter.

c. Convert liters/sec to ft^3/sec by dividing by 28.32.

For CY the normal full power flow is 882 ft^3/sec.

For M1 plus M2 the normal full power flow is 2265 ft^3 /sec.

Card 4 - Source term identification - Format 2X, A78.

Identify the time period of the releases.

Cards 5.1, 5.2 - Source terms - Format 2X, A2, A5, 1X, E10

One card is required for each nuclide.

Enter the nuclides chemical symbol beginning in column 3 -left justified.

Enter the isotopes number beginning in column 5 - left justified.

Enter the number of curies released in scientific notation beginning in column 11 and ending in column 20. Be sure to sum the totals from all continuous and batch release tables.

Examples:

										1										2
Column No:	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0
			H		3						2	.	6	2			E	+	Ø	3
			I		1	3	1				6	.	9	9			E	-	Ø	4
			C	0	6	Ø					1	.	8	Ø			E	-	Ø	2

There is no need to enter the dissolved noble gases as they will not be included in the calculation. The last nuclide is followed by a blank card.

7. Save the old cards for approximately 1 year in case doses must be recalculated.

8. Submit the cards in order to run the program on the IBM-370.

G. ACCEPTANCE CRITERIA

None.

H. CHECKLISTS

None.

I. DEFINITIONS

LADTAP = Liquid Annual Doses to all Persons.

J. RESPONSIBILITY

Environmental Programs Branch.

APPENDIX D

DERIVATION OF FACTORS FOR SECTION D

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

Millstone - Unit 1 Stack
Elevated X/Q's, D/Q's

Quarterly Averages - Maximum Values

Year	Quarter	Maximum X/Q	Maximum D/Q
1976	1	2.7E-08	1.3E-09
	2	2.8E-08	2.1E-09
	3	4.7E-08	5.5E-09
	4	2.6E-08	7.9E-09
1977	1	2.3E-08	1.4E-09
	2	4.1E-08	4.2E-10
	3	4.8E-08	2.2E-09
	4	5.4E-08	4.8E-09
1978	1	4.7E-08	6.6E-09
	2	5.3E-08	1.2E-09
	3	4.0E-08	2.2E-09
	4	7.1E-08	4.3E-09

Maximum Quarterly Average X/Q = $\boxed{7.1 \times 10^{-8}}$ Sec/M^3

Maximum Quarterly Average D/Q = $\boxed{7.9 \times 10^{-9}}$ M^{-2}

1022 077

Millstone - Unit 2 - Vent

Quarterly Average X/Q's - D/Q's
Maximum Values

		Maximum X/Q		Maximum D/Q	
Year	Quarter	Continuous	Batch	Continuous	Batch
1976	1	5.0E-06	ND	4.3E-08	ND
	2	1.3E-05	ND	6.7E-08	ND
	3	4.4E-06	8.1E-06	4.5E-08	8.0E-08
	4	2.2E-06	5.9E-06	2.5E-08	6.5E-08
1977	1	2.8E-06	4.1E-06	3.2E-08	5.4E-08
	2	1.9E-06	1.4E-06	1.3E-08	1.3E-08
	3	8.2E-06	7.5E-06	1.5E-07	1.5E-07
	4	3.5E-06	2.6E-06	6.9E-08	5.2E-08
1978	1	2.5E-06	ND	4.3E-08	ND
	2	5.3E-06	1.6E-06	8.7E-08	2.9E-08
	3	9.1E-06	8.2E-06	1.4E-07	1.1E-07
	4	3.3E-06	4.2E-06	8.7E-08	8.0E-08

Maximum Quarterly Average X/Q = 1.3×10^{-5} Sec/M^3

Maximum Quarterly Average D/Q = 1.5×10^{-7} M^{-2}

From the above data we can also see that the batch releases are of a random enough nature such that the batch release meteorology approximates the continuous meteorology as shown by the average of the above values:

Average Max. Qtr. X/Q - Continuous Release - 5.1×10^{-6}

Average Max. Qtr. X/Q - Batch Releases - 4.8×10^{-6}

Average Max. Qtr. D/Q - Contiuous Releases - 6.7×10^{-8}

Average Max. Qtr. D/Q - Batch Releases - 7.0×10^{-8}

Therefore, the same X/Q's and D/Q's can be used for both batch and continuous releases.

1022 078

2. Section D.1.a - Noble Gas Release Rate Limits

M1 Gaseous Releases - Curies vs. Dose

Year	Quarter	Avg. Noble Gas Release Rate (μCi/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	8.6 (-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	0.04	0.04	1.3 (-4)
	4	530	0.03	0.03	6.4 (-5)
	1-4	18,100	7.6	7.6	4.2 (-4)

M2 Stack Gaseous Releases - Curies vs. Dose

Year	Quarter	Avg. Noble Gas Release Rate (μCi/Sec)	Max. Individual Dose (mrem) W. B.	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

1022 079

Maximum value of mrem/year per μCi/sec release rate is for 1976 for both units. These values are for whole body doses:

M1: 6.0×10^{-4} mrem/yr. per μCi/sec

M2: 1.9×10^{-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 or Unit 2 releases, we can use the 500 mrem as the limiting dose. Therefore, the release rate limits would be:

M1: $500/6.0 \times 10^{-4} = 830{,}000$ μCi/sec

M2: $500/1.9 \times 10^{-3} = 260{,}000$ μCi/sec

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

$$\frac{Q1}{830{,}000} + \frac{Q2}{260{,}000} \leq 1$$

where,

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

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

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 Millstone 1 were calculated using the EPA AIREM code, which uses a finite cloud model similar to that in Reg. 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 Millstone 2 were calculated using the NRC GASPAR code which uses the methodology of Reg. Guide 1.109.

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

M1: Minimum Value - 6.4×10^{-5} mrem/qtr. per μCi/sec

Average Value - 1.2×10^{-4} mrem/qtr. per μCi/sec

Maximum Value - 1.9×10^{-4} mrem/qtr. per μCi/sec

M2: Minimum Value - 1.0×10^{-4} mrem/qtr. per μCi/sec

Average Value - 3.4×10^{-4} mrem/qtr. per μCi/sec

Maximum Value - 7.0×10^{-4} mrem/qtr. per μCi/sec

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

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. Periods when a unit was down the entire quarter for refueling.

c. Quarters with many M2 containment purges and quarters with no purges.

d. Quarters with relatively high and relatively low fuel leakage from Unit 1.

Thus, the dose per curie released is not that sensitive to operational changes such that a gross curie release ratio can be used. We have been conservative in taking the worst annual ratio observed.

4. It should also be recognized that there is a great deal of 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.

1022 081

5. It must also be recognized that the type of empiracal method given above is the only 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 releases 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

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 recalculation and monitor set point 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. The only practical solution is to use a conservatively determined empirical method as given above.

1022 082

3. Section D.1.b - Iodine, Particulate and Other Limits

a. Iodine

Iodine Releases vs. Dose - M1

Year	Quarter	Curies I-131	Thyroid Dose mrem	mrem/Ci
1976	1	0.58	0.6	1.0
	2	0.75	3.8	5.1
	3	0.58	4.9	8.4
	4	0.29	0.6	2.1
	1-4	2.20	9.9	4.5
1977	1	0.38	0.3	0.8
	2	0.59	1.2	2.0
	3	1.57	5.4	3.4
	4	2.11	4.6	2.2
	1-4	4.65	11.5	2.5
1978	1	1.70	8.7	5.1
	2	1.15	3.1	2.7
	3	0.18	0.6	3.3
	4	0.16	0.3	1.9
	1-4	3.19	12.7	4.0

Iodine Release vs. Dose - M2

Year	Quarter	Curies I-131	Thyroid Dose mrem	mrem/Ci
1976	1	3.3 (-3)	0.015	4.5
	2	4.0 (-3)	0.076	19.0
	3	1.8 (-3)	0.077	43.7
	4	4.2 (-4)	0.023	54.8
	1-4	9.5 (-3)	0.191	20.1
1977	1	2.6 (-4)	0.010	38.5
	2	1.8 (-3)	0.047	26.1
	3	6.9 (-4)	0.037	53.6
	4	2.5 (-3)	0.064	25.6
	1-4	5.2 (-3)	0.158	30.4
1978	1	6.9 (-4)	0.024	34.8
	2	1.0 (-3)	0.051	51.0
	3	5.7 (-3)	0.52	91.2
	4	6.7 (-5)	0.017	253.8
	1-4	7.5 (-3)	0.612	81.6

Maximum Valu. for M1 is for 1976

= 4.4 mrem/Ci I-131

Maximum Value for M2 is for 1978

= 81.6 mrem/Ci I-131

Limit is 1500 mrem/yr. to the thyroid

M1 allowable release rate

$= 1500 \text{ mrem}/4.4 \text{ mrem} \times 10^{6}\ \mu\text{Ci/Ci} \times 3.17 \times 10^{-8} \text{ yr/sec} = 10.8\ \mu\text{Ci/sec}$

M2 allowable release rate

$= 1500 \text{ mrem}/81.6 \text{ mrem} \times 10^{6} \times 3.17 \times 10^{-8} = 0.58\ \mu\text{Ci/sec}$

Since this is a site limit, the allowable release rate is:

$$\frac{Q_1}{10.8} + \frac{Q_2}{0.58} \leq 1$$

b. Particulates with Half Lives Greater Than 8 Days

Particulate Releases vs Dose - M1

Year	Quarter	Total Curves Particulates	Max. Organ Ex. Thyroid	Max. Organ Dose	mrem/Ci
1976	1	0.040	Bone	7.9 (-3)	0.20
	2	0.043	Bone	2.1 (-2)	0.49
	3	0.051	Bone	1.7 (-2)	0.33
	4	0.014	Bone	1.1 (-2)	0.79
	1-4	0.148	-	5.7 (-2)	0.39
1977	1	0.009	Bone	3.2 (-3)	0.36
	2	0.014	Liver	4.3 (-3)	0.31
	3	0.075	Bone	1.8 (-2)	0.24
	4	0.103	Bone	5.0 (-2)	0.49
	1-4	0.201	-	7.6 (-2)	0.38
1978	1	0.156	Bone	1.6 (-1)	1.02
	2	0.963	Bone	9.5 (-2)	0.10
	3	0.131	Bone	2.7 (-2)	0.21
	4	0.105	Bone	2.8 (-2)	0.27
	1-4	1.355	-	3.1 (-1)	0.23

Particulate Releases vs Dose - M2

Year	Quarter	Total Part. Curies	Max. Organ Ex. Thyroid	Max. Organ Dose	mrem/Ci
1976	1	5.5 (-4)	GI (LLI)	1.7 (-3)	3.1
	2	7.0 (-5)	Liver	6.0 (-4)	8.6
	3	1.2 (-5)	Bone	6.7 (-4)	55.8
	4	4.6 (-4)	Bone	1.2 (-2)	26.1
	1-4	1.1 (-3)	-	1.5 (-2)	13.6
1977	1	2.5 (-4)	Bone	1.8 (-3)	7.2
	2	1.0 (-4)	Liver	2.1 (-4)	2.1
	3	1.5 (-5)	Bone	2.7 (-4)	18.0
	4	4.4 (-4)	Bone	1.2 (-3)	2.7
	1-4	8.1 (-4)	-	3.5 (-3)	4.3
1978	1	8.1 (-4)	GI (LLI)	1.1 (-3)	1.4
	2	2.7 (-4)	Bone	2.2 (-3)	8.1
	3	1.0 (-4)	Bone	2.8 (-3)	28.0
	4	3.9 (-4)	Bone	6.0 (-4)	0.4
	1-4	1.6 (-3)	-	6.7 (-3)	4.2

Maximum Value for M1 is for 1976

= 0.39 mrem/Ci

Maximum Value for M2 is for 1976

= 13.6 mrem/Ci

Limit is 1500 mrem/yr to the maximum organ

M1 allowable release rate

$= 1500 \text{ mrem}/0.39 \text{ mrem/Ci} \times 10^{6}\ \mu\text{Ci/Ci} \times 3.17 \times 10^{-8} \text{ yr/sec} = 122\ \mu\text{Ci/sec}$

M2 allowable release rate

$= 1500/13.6 \times 10^{6} \times 3.17 \times 10^{-8} = 3.5\ \mu\text{Ci/sec}$

Since this is a site limit, the allowable release rate is:

$$\frac{Q_1}{122} + \frac{Q_2}{3.5} \leq 1$$

1022 085

c. Tritium

M1 Tritium Releases - Curies vs. Dose

Year	Quarter	Tritium Curies	Dose (mrem) Due to Tritium	mrem/Ci
1976	1	3.71	2.5 (-5)	6.7 (-6)
	2	1.47	8.1 (-6)	5.5 (-6)
	3	11.4	8.2 (-5)	7.2 (-6)
	4	12.1	6.2 (-5)	5.1 (-6)
	1-4	28.7	1.8 (-4)	6.3 (-6)
1977	1	7.17	3.2 (-5)	4.5 (-6)
	2	9.24	7.5 (-5)	8.1 (-6)
	3	19.3	1.8 (-4)	9.4 (-6)
	4	29.5	1.9 (-4)	6.3 (-6)
	1-4	65.2	4.8 (-4)	7.4 (-6)
1978	1	16.8	1.7 (-4)	1.0 (-5)
	2	7.68	8.6 (-5)	1.1 (-5)
	3	13.1	1.1 (-4)	8.5 (-6)
	4	11.1	1.7 (-4)	1.5 (-5)
	1-4	48.7	5.4 (-4)	1.1 (-5)

M2 Tritium Releases - Curies vs. Dose

Year	Quarter	Tritium Curies	Dose (mrem) Due to Tritium	mrem/Ci
1976	1	0.2	1.7 (-4)	8.5 (-4)
	2	2.2	3.0 (-3)	1.4 (-3)
	3	5.6	3.2 (-3)	5.7 (-4)
	4	3.7	1.7 (-3)	4.5 (-4)
	1-4	11.7	8.1 (-3)	6.9 (-4)
1977	1	11.2	5.1 (-3)	4.5 (-4)
	2	2.9	7.3 (-4)	2.5 (-4)
	3	7.4	1.1 (-2)	1.5 (-3)
	4	2.7	1.3 (-3)	4.8 (-4)
	1-4	24.2	1.8 (-2)	7.4 (-4)
1978	1	0.0003	-	-
	2	2.2	8.5 (-4)	3.9 (-4)
	3	23.4	4.2 (-2)	1.8 (-3)
	4	23.2	1.6 (-2)	7.0 (-4)
	1-4	48.8	5.9 (-2)	1.2 (-3)

Maximum VAlue for M1 is for 1978

$= 1.1 \times 10^{-5}$ mrem/Curie H-3

1022 086

Maximum Value for M2 is for 1978

$= 1.2 \times 10^{-3}$ mrem/curie - H-3

Limit is 1500 mrem/yr to the maximum organ

M1 allowable release rate

$= (1500 \text{ mrem}/1.1 \times 10^{-5} \text{ mrem/Ci}) \times 10^{6}\ \mu\text{Ci/Ci} \times 3.17 \times 10^{-8} \text{ yr/sec} = 4.3 \times 10^{6}\ \mu\text{Ci/sec}$

M2 allowable release rate

$= (1500/1.2 \times 10^{-3}) \times 10^{6} \times 3.17 \times 10^{-8} = 4.0 \times 10^{4}\ \mu\text{Ci/sec}$

Since this is a site limit, the allowable release rate is:

$$\boxed{\frac{Q_1}{4.3 \times 10^{6}} + \frac{Q_2}{4.0 \times 10^{4}} \leq 1}$$

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

(1) Millstone Unit 1

From Table in Section 2 of this Appendix, the maximum quarterly value of mrem/qtr. per μCi/sec is 1.9×10^{-4}. This value is mrem to the whole body. To convert to mrad air dose we must multiply by 2 because there is a factor of 0.7 to go from mrad to whole body mrem and also a factor of 0.7 for building shielding and occupancy used to originally calculate the whole body results. Therefore, the conversion factor for the air dose is:

3.8×10^{-4} mrad/qtr. per μCi/sec or

$$3.8 \times 10^{-4} \frac{\text{mrad-sec}}{\text{qtr.- Ci}} \times 10^{6}\ \mu\text{Ci/Ci} \times 1.26 \times 10^{-7} \text{ qtr./sec}$$

$$\boxed{= 4.8 \times 10^{-5} \text{ mrad/Ci}}$$

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

1022 087

cloud. 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:

$\leq 4.8 \times 10^{-7}$ mrad/Ci

(2) Millstone Unit 2

Likewise, for Unit 2 the maximum quarterly value of mrem/qtr. per μCi/sec is 7.0×10^{-4}.

Converting to mrad/Ci we have

$$7.0 \times 10^{-4} \times 2 \times 10^{6} \times 1.26 \times 10^{-7} =$$

$$= 1.8 \times 10^{-4} \text{ mrad/Ci}$$

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
1st. qtr.	2.9	3.1	6.9
2nd. qtr.	2.9	3.0	2.8
3rd. qtr.	3.5	2.5	3.0
4th. qtr.	3.0	3.0	3.0

The average ratio = 3.3

Beta air dose = 5.9×10^{-4} mrad/Ci

1022 088

5. Section D.2.b

M1 Finite Cloud Code

Year	Quarter	Curies Xe-138	Dose @ 600m NE Due to Xe-138	Dose/Curie
1976	1	2.4×10^4	0.29	1.2 (-5)
	2	3.9×10^4	0.61	1.6 (-5)
	3	3.3×10^4	0.52	1.6 (-5)
	4	7.5×10^3	0.08	1.0 (-5)
1977	1	2.1×10^4	0.19	8.9 (-6)
	2	1.9×10^4	0.22	1.2 (-5)
	3	3.4×10^4	0.52	1.5 (-5)
	4	3.4×10^4	0.22	6.4 (-6)
1978	1	6.5×10^4	0.31	4.8 (-6)
	2	4.7×10^4	0.57	1.2 (-5)
	3	9.0×10^2	0.019	2.1 (-5)
	4	1.6×10^3	0.015	9.2 (-6)

The above table normalizes the dose for each quarter to the same location from a particular radionuclide. Thus, the only variance in dose per curie should be due to the quarterly meteorology. Using this method, we can determine that the worst case meteorology occurred during the 3rd quarter 1978. Thus, the 3rd quarter joint frequencies should be used as input for the AIREM code.

6. Section D.3

a. Millstone - Unit 1

The only significant contributor to the thyroid dose is I-131. If the particulates were significant a different organ would be limiting. Tritium releases have never contributed more than 1% of the doses from Unit 1.

Thus, to determine the quarterly thyroid dose we can use the maximum quarterly value observed of mrem/curie of I-131 as presented in Section 3 of this appendix.

This maximum value is:

8.4 mrem/curie - I-131

The critical organ dose due to particulates with half lives greater than 8 days can also be determined from the maximum quarterly dose per curie given in Section 3 of this appendix.

1022 089

This maximum value is:

1.1 mrem/curie of particulates

b. Millstone - Unit 2

For Unit 2, we must consider tritium in both the calculation of the thyroid and other organ doses. The dose factor for all organs for tritium is the same.

The maximum values of mrem per curie as presented in Section 3 of the appendix are as follows:

For I-131, 250 mrem/Ci - I-131

For Particulates 55 mrem/Ci - Particulates

For Tritium 1.8×10^{-3} mrem/Ci - H-3

1022 090

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. C of Reg. Guide 1.109 to those in Rev. 1.

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

1. Real time meteorology using a X/Q, D/Q model which incorporates the methodology of Reg. Guide 1.111 - see Appx. G. Meteorology is determined separately for continuous releases and batch releases and for elevated releases and vent releases.

2. 100% of vegetation grown locally, 76% of vegetation intake from garden.

3. Animals on pasture April through September - 100% pasture intake.

4. Air water concentration equals 8 g/m^3.

5. Maximum individual dose calculations are performed at the land location with maximum decayed X/Q, at the nearest vegetable garden (assumed to be nearest residence) with the maximum depleted X/Q, and at the cow and goat farms with maximum D/Q's.

The following pages of Appendix E present the in-house procedure written for running this code. It is written for running the quarterly dose calculations but can easily be used to perform monthly calculations.

APPENDIX E

GASEOUS DOSE CALCULATIONS · GASPAR

A. PURPOSE

This procedure is used to implement the NRC computer code GASPAR in order to calculate the maximum individual and population doses due to radionuclides released in gaseous effluents. The code implements the semi-infinite cloud model and the dose calculation models of Reg Guide 1.109 and is used to calculate the following:

1. All maximum individual and population doses from Connecticut Yankee.
2. All maximum individual and population doses from Millstone Unit 2.
3. Population doses from Millstone Unit 1.
4. Maximum individual organ doses from Millstone Unit 1.

The maximum individual whole body and skin doses due to elevated releases from Millstone 1 should be calculated using the finite cloud model as performed by the EPA code AIREM.

A more detailed description of the GASPAR code can be found in reference 1.

B. REFERENCES

1. GASPAR dose code manuals - dated 10/17/75 and 2/20/76.
2. U.S. NRC Regulatory Guide 1.109.
3. U.S. NRC Regulatory Guide 1.111.

C. PREREQUISITES

1. The plant must supply the total number of Curies released for each radionuclide during the time period involved.
2. The meteorological programs must be run to generate the required input cards for X/Q, decayed X/Q, depleted X/Q and D/Q.

D. PRECAUTIONS

None.

E. LIMITATIONS AND ACTIONS

None.

F PROCEDURE

1. Review the plant curie release tables for accuracy and completeness. If the strontium results are not yet available, but the calculations must be performed in order to meet the semi-annual effluent report schedule, the code may be run without the strontium values and the doses due to strontium ratioed by hand by comparison with the previous quarters results.

2. Obtain the computer deck for the GASPAR code for the nuclear site involved.

3. The deck should be in the following order:

```
// 082), 'CRANDALL', MSGLEVEL=1, CLASS=B
// STEP 1 EXEC PGM=PFGASPAR
// FT06F001 DD SYSOUT=A
// FT05F001 DD *
```

| Adult, teenager, child and infant dose factor cards. |

Blank Card.

| Input cards as discussed below. |

3 blank cards
/ *

4. Due to different meteorology calculations, the code must be run separately for each of the following cases:

   a. CY - continuous, semi-elevated releases - ventilation.

   b. CY - batch mode, semi-elevated releases - waste gas tanks.

   c. M1 - continuous, elevated releases - ventilation and off gas.

   d. M2 - continuous, semi-elevated releases - ventilation.

   e. M2 - batch mode, semi-elevated releases - containment purges.

   f. M2 - batch mode, elevated releases - waste gas tanks and some containment purges.

   The resulting doses must then be summed by hand for each unit.

5. The input cards are as follows. Those parameters which must be changed each quarter are enclosed in blocks /‾‾‾‾‾‾7.

   a. | CARD 1 | - Title card - Format - 2X, 78A1

   Millstone Unit One - Gaseous | Identify Release Type |
   | 1st | Quarter | 1976. |

b. CARD 2 - Job control card - Format 10I2.

Column 2=0 - will calculate population doses and maximum individual.
Column 4=1 - number of source terms - done for each unit separately.
Column 6=1 - arbitrary if number in column 4 is 1.

c. CARD 3 - Site parameters - Format 10E8.0 - Same for CY and Millstone.

Columns 1-5=500.0 - distance from site to NE corner of U.S.
Columns 14-16=1.0 - fraction of fresh leafy vegetation grown locally.
Columns 22-24=1.0 - fraction of year milk animals on pasture.
Columns 29-32=0.76 - fraction of veg. intake grown in garden - from Reg Guide 1.109.
Columns 38-40=1.0 - fraction of animals intake from pasture when on pasture.
Columns 46-48=8.0 - air water concentration (g/m^3).

Note: Do not add in milk or vegetation results during 1st or 4th quarter.

d. CARD 4 - Population title card - Format = 2X, 78A1.

Population Data

e. CARD 4.1 - Population data format - Format = 3I5.

Column 5=0 - Population data starts in north sector.
Column 10=5 - Number of radial locations for which data is supplied on first card.
Columns 14&15=10 - Total number of radial locations.

f. CARDS 4.2---4.33

32 cards of population data - based on 1980 population estimates from Conn. Yankee and Millstone Environmental Reports.

g. CARD 5 - Milk data title card - Format = 2X, 78A1.

Milk data - NRC Memo - 10-15-75 - State of CT.

h. CARD 5.1 - Milk data format.

Columns 9&10 = 16 - Dummy number since using default values.

i. CARD 5.2 - Milk data.

Columns 3-10=4.4E + 08 - 50 mile milk usage from reference 1.

j. CARDS 6-6.2 - Same as 5-5.2 except for meat instead of milk usage factor = 2.0E+07.

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k. CARDS 7-7.2 - Same as 5-5.2 except for vegetation instead of milk usage factor = 3.2E+07.

l. CARD 8 - Source term title card - Format - 2X, 78A1.

Source Terms - 1ST QUARTER 1976.

m. CARD 8.1 - Source description - Format = (E10, 2(9X,I1)).

Columns 8-10 = 1.0 - release point multiplier
Column 20 = 0 - see reference 1.
Column 30 = 0 - see reference 1.

n. CARDS 8.2 - 8.X - Source data - Format = 2X, A2, 5A1, 1X, E10.0.

Enter total curies released for each nuclide for the particular release mode as listed in step 4 of this procedure.

One card per nuclide. Isotope chemical symbol and atomic number and curies released are all left justified.

The following are examples of the input format:

Column No.:	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	20
			I		1	3	1				Ø	.	5	7	9					
			H		3						3	.	7	1						
			K	R	8	5	M				7	1	2	Ø	.	Ø				
			K	R	8	7					1	9	Ø	Ø	Ø	.	Ø			
			C	O	6	Ø					Ø	.	Ø	Ø	Ø	8	9			

o. CARD 8.n - blank card following source data.

p. CARD 9 - X/Q title card.

q. CARD 9.1 - X/Q format - Format = 3I5.

Column 5=0 - Data starts with north as the downwind sector (south wind).
Column 10=5 - There are 5 X/Q values on the first card for each sector.
Column 14&15=10 - There are a total of 10 X/Q values for each sector.

NOTE WELL - There are two possible computer codes used to generate the X/Q cards - one was written by the NRC (XOQDOQ) and one by NUSCO (PFAADRG). The NRC code punches cards such that they start with the south downwind sector and have 7 values on the first card and 3 on the second.

Changing 0 to 1 in column five will designate that south is the first sector, and changing 5 to 7 in column ten will indicate that there are 7 values on the first card, also change

1022 095

cards 10.1, 11.1 and 12.1. The NUSCO code should start with the north downwind sector and have five values per card.

r. CARDS 9.2 to 9.33 - X/Q Data - Format - Alternate (5X, 7E10.0) and (8E10.0) insert the 32 X/Q cards as generated by the meteorological program. Be certain the sectors are in the proper order as required by card 9.1.

s. CARD 10 - Decayed X/Q title card.

t. CARD 10.1 - Same as 9.1 except for decayed X/Q's.

u. CARDS 10.2 to 10.33 - Same as 9.2 to 9.33 expect for decayed X/Q's.

v. CARD 11 - Depleted X/Q title card.

w. CARD 11.1 - Same as 9.1 except for depleted X/Q's.

x. CARDS 11.2 to 11.33 - Same as 9.2 to 9.33 except for depleted X/Q's.

y. CARD 12 - D/Q title card.

z. CARD 12.1 - Same as 9.1 except for D/Q.

aa. CARDS 12.2 to 12.33 - Same as 9.2 to 9.33 except for D/Q.

bb. CARDS 13.1 to 13.n - Special locations for Maximum Individual.

These cards are submitted to calculate whole body and organ doses to the maximum individual. One card is required for each location at which these doses are to be calculated. A maximum of 5 is all that can be done.

The meteorological program outputs the X/Q, decayed X/Q, depleted X/Q, and D/Q for the site boundary, nearest land, nearest residence and vegetable garden, goat farms and cow farms in each sector.

The following locations should be entered:

1) The nearest land with highest decayed X/Q.

2) The nearest residence with highest depleted X/Q.

3) The goat farm with highest D/Q - 2nd & 3rd quarters only.

4) The cow farm with highest D/Q - 2nd & 3rd quarters only.

The GASPAR program will calculate the whole body and organ doses for each pathway at each location. There is no way to control this with the input, but rather the final results will have to be selectively analyzed. For example, for the nearest residence location, one should only sum the dose due to the plume, ground deposition, inhalation and vegetation pathways and not from the cow's milk, goat's milk, and meat pathways.

NOTE 1: For elevated releases from the Millstone 1 stack, the nearest land boundary and nearest residence may not be the location of highest X/Q's. Therefore the meteorological output table of X/Q's from 0-50 miles must be used and interpolated to determine these locations.

NOTE 2: For CY and M2 which have more than one type of release (batch, continuous, semi-elevated), the locations of highest X/Q's or D/Q's for one type of release may not be the same as the locations for a different type of release.

In that case, the location of highest X/Q or D/Q for one type of release should also be entered for the other releases along with their highest locations, such that the total sum from all releases may determined at each location to determine the location of maximum dose. However, a maximum of 5 locations can be done. Thus, to prevent using the program more than once, some pre-judgement might be necessary.

The format for the Special Location cards is as follows:

Column 2= 1 - Eliminates pages of printout of nuclide breakdown for each pathway and age group.

Columns 3-18 - Location name - Example - Nearest Land.

Columns 19-22 - Compass direction - Example - ENE

Columns 23-29 - Distance in miles - Example - 1.9.

Columns 30-39 - X/Q for that location - right justified - Example 0.273 E-07.

Columns 40-49 - Same as 30-39 except for decayed X/Q.

Columns 50-59 - Same as 30-39 except for depleted X/Q.

Columns 60-69 - Same as 30-39 except for D/Q.

Columns 70, 71, 72, 73, 74, 75 and 76 - 0 in each column - controls printout.

Last special location card is followed by 3 blank cards.

6. Save the old cards for approximately 1 year in case doses must be recalculated.

7. Submit the cards in order to run the program on the IBM-370.

G. ACCEPTANCE CRITERIA

None.

H. CHECKLISTS

None.

I. DEFINITIONS

None.

J. RESPONSIBILITY

Environmental Programs Branch.

APPENDIX F

GASEOUS DOSE CALCULATIONS - AIREM

A. PURPOSE

This procedure is used to implement the EPA computer code AIREM in order to calculate the quarterly maximum individual whole body and skin doses due to elevated releases from the Millstone Unit 1 stack. All other doses due to gaseous radioactive releases are calculated using the NRC computer code GASPAR.

B. REFERENCES

1. AIREM Program Manual - EPA-520/1-74-004 - U.S. EPA - May 1974.
2. U.S. NRC Regulatory Guide 1.109.
3. WASH 1258 - Volume 2 - Pages F-53-55 - Table A-4.

C. PREREQUISITES

1. The plant must supply the total number of curies (gaseous) released for each radionuclide during the quarter.
2. The meteorological program PFEDNJFQ must be run with AIREM=YES for the Millstone 447' elevation in order to generate the necessary meteorological cards.

D. PRECAUTIONS

None.

E. LIMITATIONS AND ACTIONS

None.

F. PROCEDURE

1. Review the plant curie release tables for accuracy and completeness.
2. Obtain the computer deck for the AIREM code.
3. The deck should be in the following order.

```
// 082), 'CRANDALL', MSGLEVEL=1. CLASS=B
// STEP EXEC PGM=PFAIREM
// FT06F001 DD SYSOUT=A
// FT03F001 DD SYSOUT=A, DCB=(LRECL=133,RECFM=US,BLKSIZE=133)
// FT01F001 DD *
```

INPUT CARDS AS GIVEN BELOW

CARDS FROM EGAD-DOSE INTEGRAL RESULTS

```
/*
```

4. The input cards are as follows. Those parameters which may change each quarter are enclosed in blocks.

   a. [CARD 1] - Title Card - Format 5A4, F5.0, 1X, A4, I5, 1X, A4, I5, F10.

      Columns 2-20 - Facility name = Millstone Unit One
      Columns 21-25 - Number of months of data = 3
      Columns 27-30 - Beginning month [APR]
      Columns 31-35 - Beginning year [1976]
      Columns 37-40 - Ending month [JUNE]
      Columns 41-45 - Ending year [1976]
      Columns 46-55 - Thermal energy generated (MWD) - [100,000]

      This number is not used in the calculation - it is only a reference number. If not readily available - enter 100,000.

   b. [CARD 2] - Parameters - Format = 4I5, 2F10, 3E10. All numbers should be right justified.

      Columns 2-5 - Number of sectors = 16
      Columns 6-10 - Number of classes = 6
      Columns 11-15 - Number of radii = 12
      Columns 16-20 - Number of isotopes = [20]

      The maximum number of isotopes the program will accept is 20.

      If an isotope is used for more than one organ it must be counted each time. Since we are only interested in whole body and skin doses with this program, we can enter 10 isotopes for the whole body and 10 isotopes for the skin.

      The tritium, iodines and particulates need not be entered for they are insignificant compared to the noble gases when performing a finite cloud whole body dose calculation.

      However, Rb-88 and CS-138 (daughter products of Kr-88 and Xe-138) are generally significant and should be entered as 2 of the isotopes. Thus, with present operation without an off gas treatment system the 10 most significant nuclides usually are:

      Kr85m, Kr87, Kr88, Rb88, Xe133, Xe133m, Xe135, Xe135m, Xe138, and CS-138.

      Sometimes the plant will not report the curies for Xe-133m or Xe-135m but they will be included under a column called "other noble gases". Since they are generally a very small contribution to the dose it does not matter if they are omitted, but then the number of isotopes should be changed to 16 or whatever is appropriate.

If it is determined that more than 10 isotopes are significant, then the code must be run twice.

When the off gas treatment system goes into service, the significant nuclides will change.

Columns 21-30 - Stack height in meters = 150. Includes plume rise.
Columns 31-40 - SIGMAX (m) = 760.
Columns 41-50 - Inplant holdup time = blank-activity reported already includes holdup correction.
Columns 51-60 - Rainfall frequency = blank-not using code for iodine deposition.
Columns 61-70 - Washout factor = blank-not using code for iodine deposition.

c. CARDS 3.1-3.16 - Wind frequency cards - Format = 6F10

Wind frequency by stability class (only 6 classes) in %.

One card for each sector.

First card is for the north as the downwind sector and then go clockwise.

Note: These cards are generated by the meteorological program PFEDNJFQ but will be in the wrong order as they will start with south as the downwind sector.

Order of cards shall be rearranged to 9, 10, 11, 12, 13, 14, 15, 16, 1, 2, 3, 4, 5, 6, 7, 8.

d. CARDS 4.1-4.16 - Wind speed cards - Format = 6F10

Same as for wind frequency. Again cards generated by PFEDNJFQ will be in wrong order.

e. CARDS 5.1-5.24 - Population Cards - Format = 8F10

Based on 1980 population estimate in M3 Environmental Report.

f. CARDS 6.1-6.12 - Radii distances - Format 3F10

The distance in meters to the midpoint, lower and upper radii for each of the 12 radial sectors.

g. CARDS 7.1-7.4 - Particulate deposition velocity coefficients - Format = 6E10

Since we are not using the program for deposition, use the default values of all 0.01 values on the first card followed by 3 blank cards.

h. CARDS 8.1-8.4 - Halogen deposition velocity coefficients - Format 6E10. Same as for particulates.

i. CARD 9 - Number of isotopes per organ - Format 4I5.

Normally - 10 10 0 0 - All right justified. A maximum of 4 organs and 20 isotopes are possible. We will normally use 10 for the whole body and 10 for the skin and none for other organs.

j. ISOTOPE CARDS

There will be two to four cards for each isotope. Thus if a maximum of 20 isotopes are used there could be as many as 80 cards.

Finite cloud whole body doses are done only for the first set of isotope cards (in our example the first 10 cards). These isotopes will have 3 or 4 cards per isotope depending on the number of gammas emitted.

The next set of cards (in our example the 10 isotopes for the skin dose calculation) will only have 2 cards per isotope.

FIRST CARD FOR EACH ISOTOPE - Format 1X, A4, 1X, A4, 1X, A4, F10, E10, 3I5

Columns 2-5 - Isotope symbol - Example Xe
Columns 7-10 - Mass number - Example 135m
Columns 11-15 - Critical organ - Example WB
Columns 16-25 - Dose conversion factor - mrem/s per Ci/m^3

From Reg Guide 1.109 Table B-1 for noble gases and WASH 1258 for Cs and Rb with appropriate conversion of units.

This is the dose conversion factor for the particular organ as specified in columns 11-15.

Columns 26-35 - Decay constant in (sec^{-1}) Example 0.15E-05 should be right justified.
Columns 36-40 - Deposition call code - Leave blank if not using deposition Set = 1 for particualtes - Rb88 and Cs138 - Right justified.
Columns 41-45 - Finite cloud call code.

For whole body dose calculation ent... the number of gammas to be considered on cards 2 or 2 and 3 for that isotope. The maximum number of gammas possible is 10. For skin dose the semi-infinite cloud model and hence the dose conversion factor will be used. Therefore enter 0. All numbers are right justified.

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Columns 46-50 - Daughter call code.

Enter 0 for noble gases - enter 1 for Rb 88 and Cs 138. The isotope cards for Rb88 and Cs 138 must immediately follow the isotope cards for Kr88 and Xe138 respectively.

2nd CARD OR 2nd & 3rd CARDS FOR WHOLE BODY ISOTOPES

Format = 12F6

The energy and abundance for each gamma. If 3 gammas are specified in columns 41-45 of first card, then there must be 3 pairs of numbers, $E\gamma_1$, $\%\gamma_1$, $E\gamma_2$, $\%\gamma_2$, $E\gamma_3$, $\%\gamma_3$.
Example for Xe-135: .250 .97 .360 .0009 .604 .03

LAST CARD FOR EACH ISOTOPE - Format = F10, E10

Enter in columns 1-10 the curies of the isotope released Example 8400. - Right justified.

Columns 11-20 - In plant decontamination factor - leave blank.

For Cs-138 and Rb88, the curies released will be zero. A blank card will work okay.

b. EGAD CARDS

These cards are the results of the dose integral program EGAD for finite cloud calculations for an elevated release of 150 meters.

5. Save the old cards for approximately 1 year in case the doses must be recalculated.

6. Submit the cards in order to run the program on the IBM370.

G. ACCEPTANCE CRITERIA

None.

H. CHECKLISTS

None.

I. DEFINITIONS

None.

J. RESPONSIBILITY

Environmental Programs Branch.

APPENDIX G

METEOROLOGICAL CALCULATIONS

Values of X/Q and D/Q are calculated using an in-house computer code (PFAADRG), developed in accordance with the requirements of Regulatory Guide 1.111. The program uses quarter-hourly meteorological data determined during the actual periods of release.

The following lists the methodology, assumptions and input parameters used in this code:

1. Basic formula for elevated release:

$$X/Q = (RECIRC)(RDECAY)(DRYDEP)(WETDEP)\ \frac{2.032}{\sigma_z \bar{u} x} \left\{ \exp\left[-1/2\ \frac{(he)^2}{(\sigma_z)^2}\right] \right\} \quad (1)$$

Where

RECIRC = An input matrix of correction factors for recirculation of plume, given in attached Table G.1.

RDECAY = A radioactive decay factor computed from travel time from source to receptor (SEC) derived from $X/\bar{u}$ and an input half-life (HLIFE) (SEC) via the expression:

$$RDECAY = EXP \left\{ -0.693\ \frac{x}{\bar{u}} \Big/ (HLIFE) \right\}$$

Half life is set at 2.26 days to calculate X/Q decayed.
Half life is set at 8 days to calculate X/Q depleted and D/Q.

DRYDEP = A dry deposition factor to account for depletion of a portion of plume due to contact with surface; factor is a function of stability class (based on delta-T), distance X(M) to receptor, and physical stack height h_s (M). The functions are given in Figures 3-6 of Regulatory Guide 1.111. Curvefit functions are calculated using the DEPLET subroutine taken from the NRC XOQDOQ code, revised November 8, 1976.

WETDEP = A wet deposition factor to account for depletion of a portion of plume due to washout of nuclides by rain. This has not been developed at this time, so WETDEP is set to 1.0.

$h_e = h_s + h_{pr} - h_t - c$ (if $h_e < 0$, SET = 0.0)

h_s = stack height = 114.3 meters for the MP1 stack and 44.8 meters for the MP2 roof vent

$$h_{pr} = 3\ \frac{Vs}{\bar{u}}\ d$$

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V_s = Stack exit velocity = 24.1 m/sec for the MP1 stack and 8.6 m/sec for the MP2 roof vent

d = Stack diameter = 2.13 m for the MP1 stack and 1.06 m for the MP2 roof vent

$\bar{u}$ = Avg. wind speed = m/sec

h_t = Terrain height (m) from terrn input matrix, given in Table G-2. If any H_t in terrn input is < 0, it is set equal to 0. The maximum height between the source and receptor is used.

c = Downwash correction factor = $3 \left(1.5 - \frac{V_s}{\bar{u}}\right) d$

Applied only when $V_s < 1.5\ \bar{u}$, otherwise set equal to 0.

2. Basic formula for a ground release:

$$X/Q = (RECIRC)(RDECAY)(DRYDEP)(WETDEP) \frac{2.032}{\Sigma_z \bar{u} x} \qquad (2)$$

Where

Σ_z = A vertical dispersion coefficient corrected for building wake:

= $\left(\sigma_z^2 + 0.5 \frac{D^2}{\pi}\right)^{1/2}$

σ_z is calculated at distance x, D is height of building = 44.7 m for MP2

Σ_z = Limited to $\leq 1.73\ \sigma_z$

3. Mixed Releases

Releases from the MP2 roof vent may occur in the elevated, ground level or mixed mode. In the mixed mode a weighted combination of the elevated and ground release formulas must be used. This weighting depends on the ratio of the stack exit velocity (V_s) to the wind speed ($\bar{u}$) and is determined as follows:

For $V_s/\bar{u} \geq 5.0$ - use elevated formula (1).

For $V_s/\bar{u} < 1.0$ - use ground formula (2).

For $1.0 \leq V_s/\bar{u} < 5.0$ use a weighted combination as follows:

$$X/Q = [(1-E_t) \times (1)] + [E_t \times (2)] \qquad (3)$$

Where,

E_t = Weighted coefficient derived from

$E_t = 2.58 - 1.58\ (V_s/\bar{u})$ for $1.0 \leq V_s/\bar{u} \leq 1.5$

$E_x = 0.3 - 0.06\ (V_s/\bar{u})$ for $1.5 < V_s/\bar{u} < 5$

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4. Relative Deposition (D/Q)

In order to determine the relative deposition (D/Q in M^{-2}) at each receptor point, the following methodology is used:

a. 3 matrices of downwind sector versus stability class are determined. One matrix is for elevated releases (i.e., where equation (1) was used), one for ground releases (i.e., where equation (2) was used), and one for mixed releases (i.e., where equation (3) was used). The matrix elements are the number of hours associated with a particular combination of downwind sector, stability class, and release mode.

b. RDRATE = relative deposition rate is determined at each receptor point. This factor is a function of release mode, stability, stack height and downwind distance. The functions are given in Figures 7-10 of Regulatory Guide 1.111. The program calculates this function using the DEPOST subroutine taken from the NRC XOQDOQ code, revised November 8, 1976. For mixed mode releases the ground level curve is used.

c. D/Q = relative deposition is determined as follows:

$$D/Q = \sum_i \frac{\text{RDRATE x matrix element i}}{\text{0.3927 D x total hours}}$$

Where D = downwind distance in meters

Total hours = Total number of hours in all matrices
= number of valid data in sample

5. Other Notes

a. For case where wind speed = calm, the wind speed is set at the threshold value = 0.5 m/sec.

b. Releases from the MP1 stack are considered to be elevated at all times. The 447' meteorological data is used for MP1 stack releases.

c. Releases from the MP2 roof vent are considered mixed releases. Wind speed from the 142' level is used to determine if the releases are elevated, ground, or mixed. For the elevated portion, the 142' meteorological data is used. For the ground portion, the 33' wind data is used.

Table G-1

MILLSTONE NUCLEAR POWER STATION / UNIT 1

RECIRCULATION RATE

	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	20000	30000	40000	50000	60000	70000	80000
NNE	4.0000	3.2000	2.1000	1.6000	1.4000	1.3000	1.2500	1.1800	1.1500	1.1200	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
NE	4.0000	3.2000	2.1000	1.6000	1.4000	1.3000	1.2500	1.1800	1.1500	1.1200	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
ENE	4.0000	3.2000	2.1000	1.6000	1.4000	1.3000	1.2500	1.1800	1.1500	1.1200	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
E	4.0000	3.2000	2.1000	1.6000	1.4000	1.3000	1.2500	1.1800	1.1500	1.1200	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
ESE	4.0000	3.2000	2.1000	1.6000	1.4000	1.3000	1.2500	1.1800	1.1500	1.1200	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SE	4.0000	3.2000	2.1000	1.6000	1.4000	1.3000	1.2500	1.1800	1.1500	1.1200	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SSE	4.0000	3.2000	2.1000	1.6000	1.4000	1.3000	1.2500	1.1800	1.1500	1.1200	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
S	4.0000	3.2000	2.1000	1.6000	1.4000	1.3000	1.2500	1.1800	1.1500	1.1200	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SSW	4.0000	3.2000	2.1000	1.6000	1.4000	1.3000	1.2500	1.1800	1.1500	1.1200	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
SW	4.0000	3.2000	2.1000	1.6000	1.4000	1.3000	1.2500	1.1800	1.1500	1.1200	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
WSW	4.0000	3.2000	2.1000	1.6000	1.4000	1.3000	1.2500	1.1800	1.1500	1.1200	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
W	4.0000	3.2000	2.1000	1.6000	1.4000	1.3000	1.2500	1.1800	1.1500	1.1200	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
WNW	4.0000	3.2000	2.1000	1.6000	1.4000	1.3000	1.2500	1.1800	1.1500	1.1200	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
NW	4.0000	3.2000	2.1000	1.6000	1.4000	1.3000	1.2500	1.1800	1.1500	1.1200	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
NNW	4.0000	3.2000	2.1000	1.6000	1.4000	1.3000	1.2500	1.1800	1.1500	1.1200	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
N	4.0000	3.2000	2.1000	1.6000	1.4000	1.3000	1.2500	1.1800	1.1500	1.1200	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Table G-2

MILLSTONE NUCLEAR POWER STATION / UNIT 1

TERRAIN HEIGHT (FT)

	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	20000	30000	40000	50000	60000	70000	80000
NNE	36.	46.	106.	176.	166.	229.	176.	196.	236.	296.	386.	329.	286.	646.	751.	798.	717.
NE	16.	26.	96.	96.	76.	116.	126.	146.	186.	136.	286.	486.	547.	586.	615.	598.	686.
ENE	-4.	21.	96.	98.	101.	86.	66.	56.	126.	136.	186.	286.	286.	386.	486.	386.	186.
E	-4.	21.	76.	66.	66.	56.	1.	1.	16.	26.	86.	86.	172.	86.	86.	-14.	-14.
ESE	6.	-4.	36.	6.	6.	-14.	-14.	-14.	-14.	-14.	-14.	-14.	-14.	86.	157.	-14.	-14.
SE	-9.	-9.	-14.	-14.	-14.	-14.	-14.	-14.	-14.	-14.	-14.	-14.	86.	-14.	-14.	-14.	-14.
SSE	-5.	-14.	-14.	-14.	-14.	-14.	-14.	-14.	-14.	-14.	-14.	86.	86.	-14.	-14.	-14.	-14.
S	-9.	-14.	-14.	-14.	-14.	-14.	-14.	-14.	-14.	-14.	87.	86.	41.	36.	-14.	-14.	-14.
SSW	-9.	36.	36.	36.	36.	36.	36.	36.	36.	36.	42.	236.	253.	86.	-14.	-14.	0.
SW	-14.	-14.	16.	16.	-14.	-14.	-14.	-14.	-14.	-14.	36.	36.	36.	215.	281.	256.	0.
WSW	-14.	-14.	46.	26.	6.	-14.	56.	46.	36.	11.	-14.	-14.	-14.	-14.	86.	86.	0.
W	-14.	-14.	36.	96.	98.	126.	126.	146.	206.	201.	217.	186.	486.	486.	645.	586.	0.
WNW	-14.	36.	36.	106.	196.	136.	186.	216.	256.	386.	386.	506.	686.	586.	986.	1026.	0.
NW	-4.	16.	156.	206.	206.	206.	271.	326.	339.	438.	552.	562.	634.	86.	386.	786.	0.
NNW	46.	6.	6.	209.	246.	190.	206.	246.	266.	486.	615.	496.	694.	786.	986.	1061.	0.
N	106.	116.	136.	146.	216.	176.	236.	294.	326.	598.	529.	486.	586.	751.	960.	906.	0.