LONG ISLAND LIGHTING COMPANY

OFFSITE DOSE CALCULATION MANUAL

REVISION 4 - AUGUST 1984

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PLEASE NOTE

Revision 1 - August 1983 of the LILCO, SNPS-1, Offsite Dose Calculation Manual has been totally revised from the Original - March 1983 Submittal - Therefore, Revision 1 - August 1983 has no change bars.

CHANGE BARS have been used in subsequent revisions to locate a change (additions, deletions, and/or modifications) in engineering, design, methodology, etc.

CHANGE BARS are not used for Errata (i.e., typos, format changes).

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SECTION 1

INTRODUCTION

The purpose of this manual is to show the calculational methodology and parameters used to comply with the Radiological Effluent Technical Specifications (RETS).

Section 2 establishes methods to calculate the Liquid Effluent Monitor set point and the Gaseous Effluent Monitor set points in order to comply with RETS Sections 3.11.1.1 and 3.11.2.1, respectively.

Section 3 establishes dose calculational methods for liquid and gaseous effluents. The liquid effluents dose calculation methods are used to show compliance with RETS Sections 3.11.1.2 and 3.11.1.3. For liquid pathways, the dilution factor of 8.85 used in Section 3.1 is a calculated value based on a submerged, multiport diffuser with a port discharge velocity of 12 fps, a 300 ft radius mixing zone, and 4 recirculation pumps discharging.

The gaseous effluent dose calculation methods are used to show compliance with RETS Sections 3.11.2.1, 3.11.2.2, and 3.11.2.3. The atmospheric dispersion and deposition factors used in calculation methods were calculated based on onsite meteorological data for the 2-year period of October 1, 1973 through September 30, 1975.

Regulatory Guide 1.109, Rev. 1 (October 1977), Methodology and parameters, with the exception of the dilution factor of 8.85, were used in Method 2 (the Backup Method) dose rate and dose conversion factors.

Tables 3.5-10, 3.5-12 and 3.5-13 are incorporated only for future use if there is a change in the land use census which requires considering any combination of cow's milk and meat pathways.

Section 4 identifies the receptor locations which represent critical pathway locations, water dilution, atmospheric dispersion, and deposition factors used in calculation Method 2. Table 4-1 summarizes the above factors for the gaseous effluent pathways.

Section 5 indicates locations at which environmental sampling may be conducted.

Section 6 addresses the Interlaboratory Comparison Program.

SECTION 2

SET POINTS

2.1 LIQUID EFFLUENT MONITOR SET POINTS (Compliance with Section 3.11.1.1 of the Radiological Effluent Technical Specification (RETS))

The radionuclide concentrations released via liquid effluents to unrestricted areas shall be limited to the concentrations specified in 10CFR20, Appendix B, Table II, Column 2 for radionuclides other than dissolved or entrained noble gases. For dissolved or entrained noble gases, the total concentration shall be limited to 2×10^{-4} μCi/ml.

The set points of the effluent monitors are dependent on:

1. Circulating water flow rate, a once-through system (the circulating water system is composed of four pumps and circulates sea water at a rate of 574,000 gpm)

2. Flow rates of effluents from tanks and/or from the RHR heat exchanger service water outlet, and/or yard piping drain sump.

3. Individual concentrations of gamma emitters (other than dissolved or entrained noble gases) and Sr-89, Sr-90, Fe-55, and H-3; and the total concentration of dissolved or entrained noble gases and gross concentration of the alpha emitters in the liquids to be discharged.

4. Maximum allowable concentration of 2×10^{-4} μCi/ml for the total concentration of dissolved or entrained noble gases and maximum permissible concentrations (MPCs) of other gamma emitters, Sr-89, Sr-90, Fe-55, H-3, and alpha emitters in the effluents as specified in 10CFR20, Appendix B, Table II, Column 2 for an unrestricted area.

   NOTE: Precautions should be taken to assure that the circulation system flow rate used in determining the set point remains constant during the period of discharge.

   If the circulating water flow rate during discharge becomes less than the flow rate that was used in calculating the discharge set point, the discharge must be terminated and a new set point calculated.

Service water via the RHR heat exchanger service water outlet will be released continuously to the environment when the RHR heat exchanger is in operation. Reactor building salt water drain tank contents may be released to the environment either as a batch process or continously. The discharge waste sample tanks, recovery sample tanks, and yard piping drain sump contents will always be released to the environment as batch processes.

For batch as well as continuous releases, the sampling and analysis program shall be in accordance with the minimum requirements of RETS Table 4.11.1.1.1-1. Specifically, the analysis program will include the determination of gross alpha concentration of the alpha emitters. In addition, it will include isotopic analysis for determination of individual concentrations of principal gamma emitters, and the specific radionuclides, Sr-89, Sr-90, Fe-55, and H-3. It will also include the determination of total concentration of the dissolved and entrained noble gases (gamma emitters) in the liquids. The concentrations of individual gamma emitters are determined by gamma spectral analysis of 1) the batch sample prior to its release for the batch releases and 2) the weekly composite sample for continuous releases. For gross alpha and the specific radionuclides Sr-89, Sr-90, Fe-55, and H-3, if analysis cannot be performed prior to discharge, then the following concentrations are used in the monitor set point calculations:

Gross alpha and H-3

Gross alpha concentration and H-3 concentrations as determined by analysis of the previous monthly composite sample.

Sr-89, Sr-90, Fe-55

Individual concentrations are determined by analysis of the previous quarterly composite sample for batch releases.

Representative Samples

Representative composite samples utilized in determining the concentrations of H-3, Sr-89, Sr-90, Fe-55, and the gross alpha concentration both for batch and continuous releases,and in determining the concentrations of gamma emitters (excluding dissolved and entrained noble gases) for continuous releases are obtained in accordance with the method stated for obtaining such samples in the RETS Table 4.11.1.1.1-1.

The tank contents are recirculated prior to obtaining samples for analysis. The minimum recirculation time t_r shall be:

$$t_r = \frac{2v}{f_r}$$

where:

v = the volume of liquid in the tank to be sampled

f_r = the recirculation flow rate being used to mix the tank contents.

For the yard drain sump, the above methodology will be used unless it can be determined that there has been no condensate storage tank overflow events since the last batch release. Although designated a batch release, there may be times when non-contaminated yard drain runoff to the sump will occur during the discharge period. This input will not increase the discharge concentration.

The above methodology will ensure that a representative sample will be obtained for batch releases.

Set Point Philosophy

The philosophy of the set points will be based on the sum of the ratios of isotopic concentrations to MPCs being less than 1 for discharges into unrestricted areas. Specifically:

$$\frac{C}{MPC} = \sum_{i=1}^{N} \frac{C_i}{MPC_i}$$

$$= \frac{C_a}{MPC_a} + \frac{C_b}{MPC_b} + \ldots\ldots + \frac{C_n}{MPC_n} + \frac{C_\alpha}{MPC_\alpha} + \frac{C_G}{MPC_G}$$

$$+ \frac{C_s}{MPC_s} + \frac{C_t}{MPC_t} + \frac{C_{Fe}}{MPC_{Fe}} \leq 1 \qquad (2.1\text{-}1)$$

where:

$C_a, C_b, \ldots\ldots C_n$ = Concentration of the individual gamma emitting radionuclides identified (µCi/ml)

C_α = The gross alpha concentration (µCi/ml)

C_G = The total concentration of dissolved or entrained noble gases (µCi/ml)

C_s = The Sr-89 and Sr-90 concentrations (µCi/ml)

C_t = The H-3 concentration (µCi/ml)

C_{Fe} = The Fe-55 concentration (µCi/ml)

MPC_i = MPC_a, MPC_b ....., MPC_n, MPC_α, MPC_G, MPC_s, MPC_t, MPC_{Fe}

= the maximum permissible concentration of the respective radioisotope i (µCi/ml) from 10CFR20, Appendix B, Table II Column 2. For dissolved or entrained noble gases, the maximum allowable concentration (MPC_G) will be 2.00E-04 (µCi/ml). For gross alpha, the MPC assumed will be 3.00E-08 (µCi/ml).

If the C/MPC calculated is greater than 1, then no release is possible. The normalization factor (as defined in Section 2.1.1) must be greater than 1 to permit releases. To permit releases, this factor can be increased to a value greater than 1 by increasing dilution flow F_c (by running more circulating water pumps in the applicable discharge structure), and/or decreasing the effluent flow rates f_D, f_s, f_{HA}, f_{HB}, etc. (defined in Section 2.1.1), and recalculate C/MPC using new C_i in Equation 2.1-1.

2.1.1 Radiation Effluent Monitor (RE-13) High/Trip Alarm Set Point for Discharge Waste Sample Tanks, Recovery Sample Tanks, or Yard Piping Drain Sump

The function of this monitor set point is to ensure that the sum of the ratios of the discharge concentrations to the MPCs of the corresponding radionuclides of the discharges monitored by this monitor and other liquid waste discharges, if any, does not exceed 1. If the monitor count rate is higher than the calculated set point, the radiation monitor will terminate the release.

A sample is taken from any of the following tanks or sump which is to be discharged along with any streams which are in the process of being discharged.

1. Discharge waste tanks
2. Recovery sample tanks
3. Yard piping drain sump
4. Reactor building salt water drain tank
5. Residual heat removal heat exchanger service water

Only one of the first three items above is discharged at any one time, which can be combined with releases from item 4 and/or 5.

Obtain the circulating water flow rate from the control room (see NOTE in Section 2.1).

Define Normalizing factor

$$F = \frac{[f_D + f_{HA} + f_{HB} + f_s + (F_c - f_{HA} - f_{HB})]}{\sum_{i=1}^{N} [\frac{(C_{Di} f_D + C_{HiA} f_{HA} + C_{HiB} f_{HB} + C_{si} f_s)}{MPC_i}]} * 0.8$$

An isotopic analysis of each sample is performed. This analysis includes isotopic analysis for gamma emitters; gross alpha emitters; total dissolved or entrained noble gases; and Sr-89, Sr-90, Fe-55, and H-3. This should be done for all monitors.

Then the set point (NOTE: the background (cpm), if it can be determined, is also added to the set point value. If, however, it cannot be determined, it is considered as zero) for detector RE-13 is calculated as:

$$S_{13} \leq F^* \sum_{i=1}^{N} C_{Di} {}^* E_i \qquad \text{(cpm)}$$

where:

C_{Di} = concentration of radioisotope (i) (μCi/ml) in any of the following tanks or sump that is to be discharged:

1. discharge waste tanks
2. recovery sample tanks
3. yard piping drain sump

f_D = Discharge flow rate (gpm) from any of the following tanks or sump that is to be discharged:

1. discharge waste tanks
2. recovery sample tanks
3. yard piping drain sump.

(Maximum design discharge flow rate = 150 gpm)

C_{Si} = Reactor building salt water drain tank concentration of radioisotope(i) (μCi/ml)

C_{HiA} = RHR heat exchanger service water outlet concentration of radioisotope(i) (μCi/ml) from loop A.

C_{HiB} = RHR heat exchanger service water outlet concentration of radioisotope (i) (μCi/ml) from loop B.

f_S = Reactor building salt water drain tank discharge flow rate (gpm). (Maximum design discharge flow rate = 100 gpm)

f_{HA} = RHR heat exchanger service water outlet discharge flow rate (gpm) from loop A (Maximum design discharge flow rate = 9340 gpm)

f_{HB} = RHR heat exchanger service water outlet discharge flow rate (gpm) from loop B (Maximum design discharge flow rate 9340 gpm)

F_C = Total circulating water flow rate (gpm) (this includes f_{HA} and f_{HB})

E_i = Gamma counting efficiency of RE-13 for radionuclide (i) (cpm/μCi/ml). Figure 2.1-1 shows the energy response. For non-gamma emitters, E_i=0.

0.8 = Safety factor

MPC_i is defined in Section 2.1. The above calculation is made for each batch to be released.

After each batch release, the high alarm set point should be reset as close to the background as practical to prevent spurious alarms and yet assure an alarm should an inadvertent release occur.

2.1.2 Radiation Effluent Monitor (RE-79) High Alarm Set Point for Reactor Building Salt Water Drain Tank

The function of this monitor set point is to ensure that the sum of the ratios of the discharge concentrations to the MPCs of the corresponding radionuclides of the discharges monitored by this monitor and other liquid waste discharges, if any, does not exceed 1.

If the monitor count rate is higher than the calculated set point, the radiation monitor will alarm in the control room.

A sample will be taken from the reactor building salt water drain tank discharge, along with individual samples of any of the following streams which may be in the process of being discharged:

1. Discharge waste sample tanks

2. Recovery sample tanks

3. Yard piping drain sump

4. Residual heat removal heat exchanger service water

In the case of continuous release, samples will be taken as per requirement RETS Table 4.11.1.1.1-1.

Obtain the circulating water flow rate from the control room (see NOTE in Section 2.1).

The set point for continuous or batch release (see NOTE in Section 2.1.1) will be calculated as follows:

$$S_{79} \leq F * [\sum_{i=1}^{N} C_{Si} E_i] \quad \text{(cpm)}$$

where:

E_i = Gamma counting efficiency of RE-79 for radionuclide i (cpm/μCi/ml). Figure 2.1-2 shows the energy response. For non-gamma emitters, E_i = 0

All other parameters are as defined in Section 2.1.1.

When the tank operates in a batch mode, the above calculation is made for each batch to be released.

After each batch release or continuous release period, the high alarm set point should be reset as close to the background as practical to prevent spurious alarms and yet assure an alarm should an inadvertent release occur.

2.1.3 Residual Heat Removal Heat Exchanger Service Water Outlet Monitors (RE-23A, RE-23B) High Alarm Set Points

The function of this monitor set point is to ensure that the sum of the ratios of the discharge concentrations to the MPCs of the corresponding radionuclides of the discharges monitored by this monitor and other liquid waste discharges, if any, does not exceed 1. If the monitor count rate is higher than the calculated set point, the radiation monitor will alarm in the control room.

Monitors RE-23A and RE-23B are independent. Each is dedicated to monitor its respective RHR loop.

A sample will be taken from the RHR heat exchanger service water outlet (A and/or B), along with individual samples of any of the following streams which may be in the process of being discharged:

1. Discharge waste sample tanks
2. Recovery sample tanks
3. Yar' ping drain sump
4. Re. : building salt water drain tank discharge

Obtain the circulating water flow rate from the control room (see NOTE in Section 2.1).

The set points for RE-23A and RE-23B are calculated as follows:

$$S_{23A} \leq F * [\sum_{i=1}^{N} C_{HiA} E_{iA}]$$

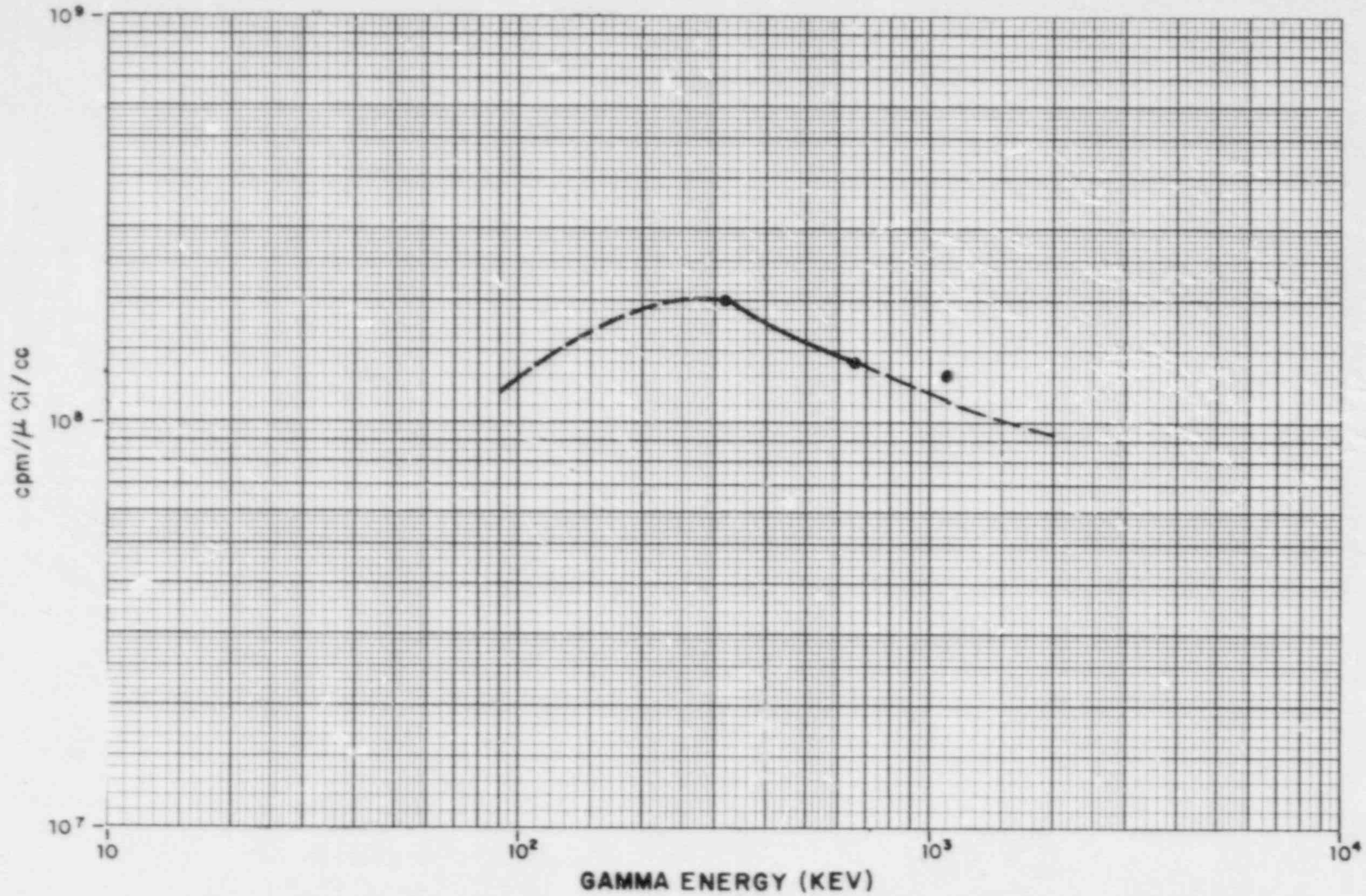
$$S_{23B} \leq F * [\sum_{i=1}^{N} C_{HiB} E_{iB}]$$

where:

E_{iA} = Gamma counting efficiency of RE-23A for radionuclide i (cpm/μCi/ml). Figure 2.1-3 shows the gamma energy response. For non-gamma emitters, $E_{iA} = 0$

E_{iB} = Gamma counting efficiency of RE-23B for radionuclide i (cpm/μCi/ml). Figure 2.1-4 shows the gamma energy response. For non-gamma emitters, $E_{iB} = 0$

All other parameters are as defined in Section 2.1.



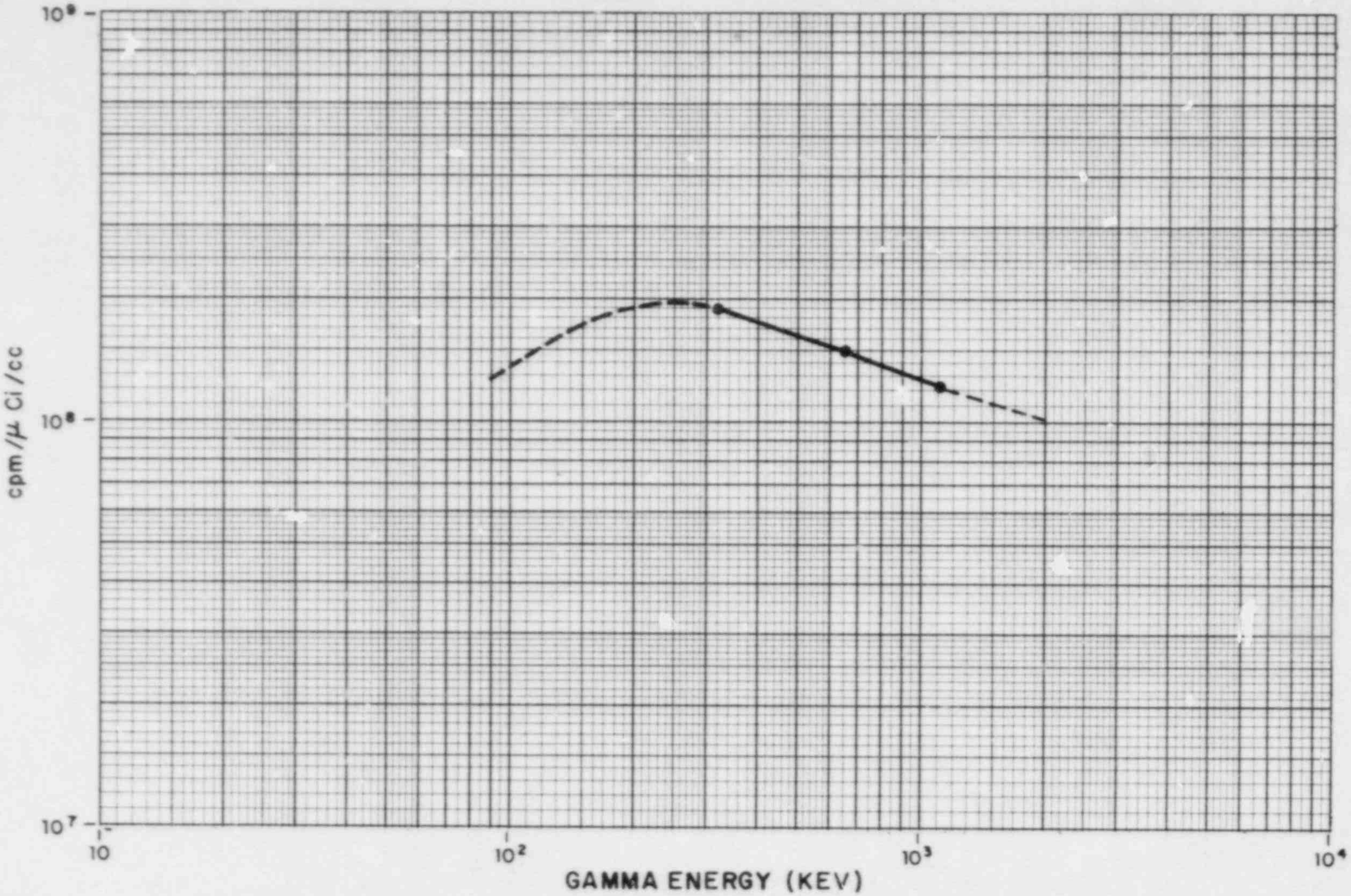
SOURCE:

BATTELLE COLUMBUS INSTITUTE COLUMBUS, OHIO
DATA SHEET: IL-CP-600-D5

(<300 KEV) EXTRAPOLATION FROM GENERAL ATOMIC CO.
GENERIC CALIBRATION CURVE FOR RD-53

(>700 KEV) CALCULATED VALUE

FIGURE 2.1-1
DETECTOR RE—13
EFFICIENCY VS. GAMMA ENERGY
SHOREHAM NUCLEAR POWER STATION-UNIT 1
OFFSITE DOSE CALCULATION MANUAL



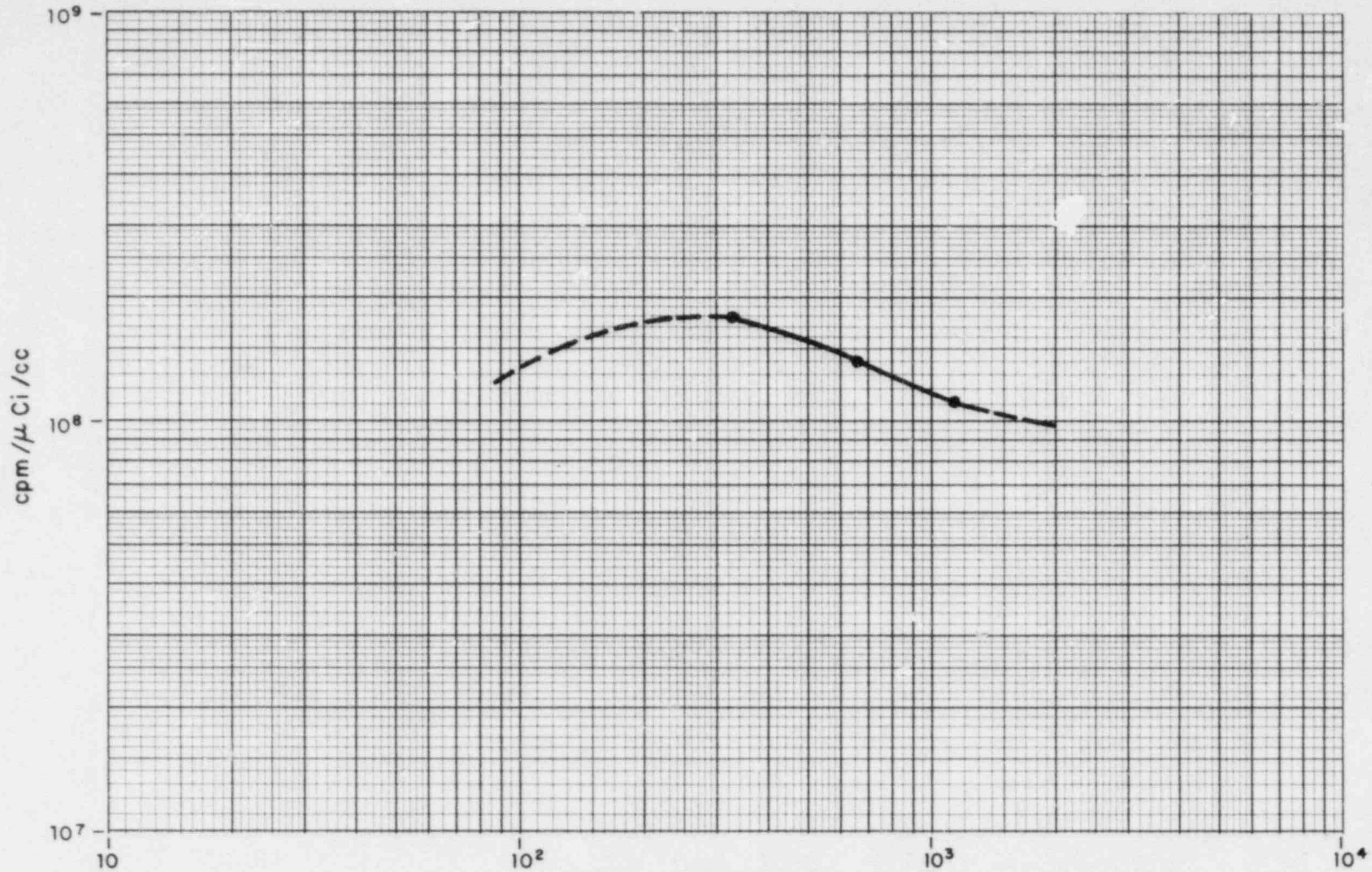
SOURCE:

BATTELLE COLUMBUS INSTITUTE COLUMBUS, OHIO
DATA SHEET: IL-CP-600-D5

(<300 KEV) EXTRAPOLATION FROM GENERAL ATOMIC CO. GENERIC CALIBRATION CURVE FOR RD-53

(>1.15 MEV) CALCULATED VALUE

FIGURE 2.1-2
DETECTOR RE-79
EFFICIENCY VS. GAMMA ENERGY
SHOREHAM NUCLEAR POWER STATION-UNIT 1
OFFSITE DOSE CALCULATION MANUAL



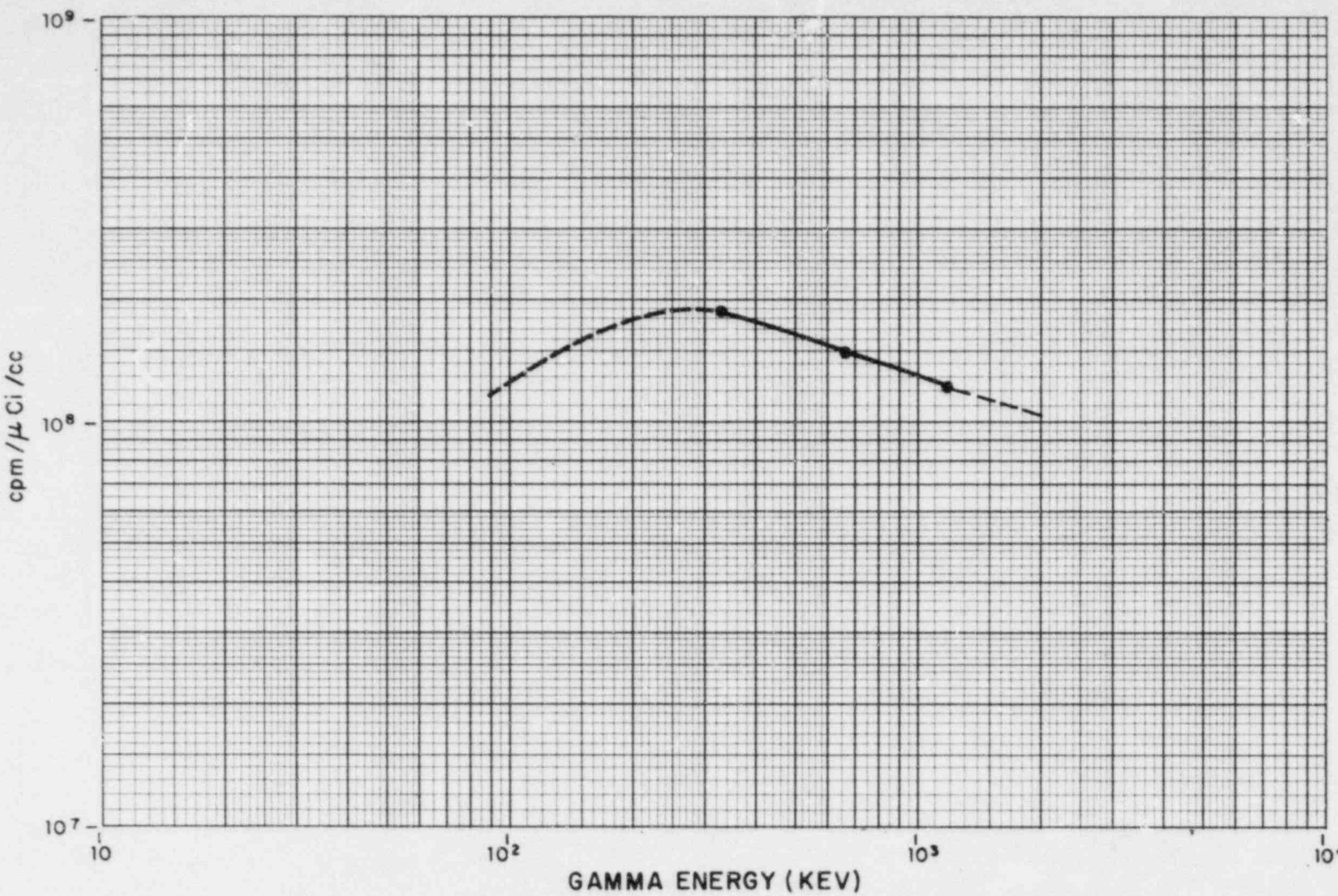
SOURCE:

BATTELLE COLUMBUS INSTITUTE COLUMBUS, OHIO
DATA SHEET: IL-CP-600-D5

(<300 KEV) EXTRAPOLATION FROM GENERAL ATOMIC CO. GENERIC CALIBRATION CURVE FOR RD-53

(>1.15 MEV) CALCULATED VALUE

FIGURE 2.1-3
DETECTOR RE—23A
EFFICIENCY VS. GAMMA ENERGY
SHOREHAM NUCLEAR POWER STATION-UNIT 1
OFFSITE DOSE CALCULATION MANUAL



SOURCE:

BATTELLE COLUMBUS INSTITUTE COLUMBUS, OHIO
DATA SHEET: IL-CP-600-D5

(<300 KEV) EXTRAPOLATION FROM GENERAL ATOMIC CO. GENERIC CALIBRATION CURVE FOR RD-53

(> 1.15 MEV) CALCULATED VALUE

FIGURE 2.1-4

DETECTOR RE—23B

EFFICIENCY VS. GAMMA ENERGY

SHOREHAM NUCLEAR POWER STATION-UNIT 1
OFFSITE DOSE CALCULATION MANUAL

2.2 GASEOUS EFFLUENT MONITOR SET POINTS (Compliance with Section 3.11.2.1 of the RETS)

The high alarm set point for the Station Ventilation Exhaust Monitor (RE-42) is set in accordance with the dose rate limit for noble gases at the site boundary specified in Section 3.11.2.1 of the RETS:

> Less than or equal to 500 mrem/yr to the total body and less than or equal to 3000 mrem/yr to the skin.

The set point for this monitor will be determined based on the lower of the two set points calculated for: 1) the total body dose rate and 2) the skin dose rate, calculated respectively in Sections 2.2.1 and 2.2.2.

The high alarm set points for the Main Condenser Offgas System Effluent Monitors (RE-65A, B) is based on the MPC limit specified in 10CFR20 Appendix B, Table II, Column 1 which is in conformance with the dose rate limits specified above. The high alarm set point for the Main Condenser Air Ejector Monitor (RE-12A, B) in normal operation is based on the RETS limited total noble gas (beta and gamma) release rate at the main condenser air ejector, which is 244,000 μCi/sec at 30 minutes delay. The high alarm set point for the Main Condenser Air Ejector Effluent Monitors in the bypass mode (RE-12A, B in the bypass mode) are based on 25 percent of the limit specified above.

For all the above monitors, the initial set points are based on expected release rates (Ci/year) for radionuclides given in the Safety Evaluation Report (SER) for Shoreham (NUREG-420, April 1981, Table 11-2). An effective initial concentration, C_i(pCi/cc) for each radionuclide, i, is obtained from the release rate, Q_i(Ci/yr) for the radionuclide and the appropriate flow rate V(cc/sec) as follows:

$$C_i(\text{pCi/cc}) = \frac{Q_i(\text{Ci/yr}) * 10^{12} \left(\frac{\text{pCi}}{\text{Ci}}\right)}{3.15 * 10^{7} \left(\frac{\text{sec}}{\text{yr}}\right)} * \frac{1}{V\left(\frac{\text{cc}}{\text{sec}}\right)}$$

When the mechanical vacuum pump is in operation, the release rate Q_{im} (Ci/yr) from mechanical vacuum pump exhaust will be used assuming that the mechanical vacuum pump operates for 100 hours or 3.6×10^5 seconds per year. The effective initial concentration C_i (pCi/cc) for radionuclide, i, when the mechanical vacuum pump is in operation, is calculated as:

$$C_i\ (\text{pCi/cc}) = \frac{Q_{im}\ (\text{Ci/yr}) * 10^{12} \left(\frac{\text{pCi}}{\text{Ci}}\right)}{3.6 * 10^{5} \left(\frac{\text{sec}}{\text{yr}}\right)} * \frac{1}{V\left(\frac{\text{cc}}{\text{sec}}\right)}$$

Once operation has begun, the concentration, C_i, for each radionuclide, will be obtained as the measured value from a grab sample.

The methodology of multipying the observed cpm by the calculated scale factor will be used to obtain the set point in the range where the detector response is linear with changes in nuclide concentration. In the non-linear region, appropriate correction as derived from Figures 2.2-2 or 2.2-4 will be made.

2.2.1 Gaseous Effluent Monitor High Alarm Set Point for Station Ventilation Exhaust Monitor (RE-42)

2.2.1.1 Gaseous Effluent Monitor High Alarm Set Point for Station Ventilation Exhaust Monitor (RE-42) Based on Noble Gases Total Body Dose Rate

1. During operation a gaseous sample from the monitor will be taken and analyzed for isotopic composition and concentration, C_i. Before startup, C_i will be calculated as noted in Section 2.2.

2. At the time of sampling, the net count rate (excluding background), CR (cpm), of the Station Ventilation Exhaust Noble Gas Radiation Monitor will be recorded. Before startup, the estimated CR is calculated as:

$$CR = 10^{-6} * \left(\sum_{i=1}^{N} C_i * E_i \right) \qquad \text{(cpm)}$$

where:

E_i = detector efficiency (cpm/µCi/cc) for RE-42 for radionuclide, i, as provided in Figure 2.2-1. The linearity response for RE-42 is shown in Figure 2.2-2.

3. The noble gas total body dose rate is calculated using the following equation:

$$\sum_i DR_i = \chi/Q * V * \left(\sum_i DFB_i * C_i \right) \qquad \text{(mrem/yr)}$$

where:

DR_i = predicted dose rate based on gas sample for isotope i (mrem/yr),

χ/Q = annual average χ/Q (sec/m^3) at 366 meters NNE due to releases via the station ventilation exhaust point (6.6E-07 sec/m^3),

DFB = total body dose rate conversion factor (mrem/yr/pCi/m^3), from Table 2.2-1,

C_i = sampled isotope release concentration (pCi/cc),

V = station ventilation exhaust rate (cc/sec). (Maximum exhaust rate = 1.73E+08 cc/sec (3.66E+05 cfm).)

4. The isotopic release activity concentration is normalized to a total body dose rate of 500 mrem/yr by multiplying by the following normalizing factor:

$$F_B = 500/\sum_i DR_i$$

5. From the above, the set point (see NOTE in Section 2.1.1) based on total body dose rate can be calculated as follows:

$$S^B_{42} \leq 0.8 * F_B * CR \qquad \text{(cpm)}$$

where:

S^B_{42} = high alarm set point that results in a total body dose rate of less than 500 mrem/yr,

F_B = normalization factor (unitless),

CR = station ventilation exhaust noble gas radiation monitor count rate (cpm), and

0.8 = safety factor.

The above procedure and format will be used to calculate the set point for RE-42 when the mechanical vacuum pump is in operation or during containment purge. Under these conditions, the short term atmospheric dispersion factor at 366 meters NNE (3.60E-06 sec/m^3) shall be used instead of the annual average value.

2.2.1.2 <u>Gaseous Effluent Monitor High Alarm Set Point for Station Ventilation Exhaust Monitor (RE-42) Based on Noble Gases Skin Dose Rate</u>

1. During operation a gaseous sample from the monitor will be taken and analyzed for isotopic composition and concentration, C_i. Before startup, C_i will be calculated as noted in Section 2.2.

2. At the time of sampling, the net count rate (excluding background), CR (cpm), of the station ventilation exhaust noble gas radiation monitor will be recorded. Before startup, CR is calculated as noted in Section 2.2.1.

3. The noble gases beta and gamma skin dose rate is calculated using the following equation:

$$\sum_i DR_i = \chi/Q * V * (\sum_i K_{sim} * C_i) \qquad \text{(mrem/yr)}$$

where:

DR_i = predicted dose rate based on gas sample for isotope i (mrem/yr),

χ/Q = annual average χ/Q (sec/m^3) at 366 meters NNE due to releases via the station ventilation exhaust point, (6.6E-07 sec/m^3),

K_{sim} = skin dose rate conversion factor ($mrem/yr/pCi/m^3$), from Table 2.2-1,

C_i = sampled isotope release concentration (pCi/cc),

V = station ventilation exhaust rate (cc/sec). (Maximum exhaust rate = 1.73E+08 cc/sec (3.66E+05 cfm).)

4. The isotopic release activity concentration is normalized to a skin dose rate of 3000 mrem/yr by multiplying by the following normalizing factor:

$$F_S = 3000/\sum_i DR_i$$

5. From the above, the alarm set point (see NOTE in Section 2.1.1), based on skin dose rate, can be calculated as follows:

$$S_{42}^{S} \leq 0.8 * F_S * CR \qquad \text{(cpm)}$$

where:

S_{42}^{S} = high alarm set point that results in a skin dose rate of less than 3000 mrem/yr (cpm),

F_S = normalization factor (unitless),

CR = station ventilation exhaust noble gas radiation monitor count rate (cpm), and

0.8 = safety factor.

The above procedure and format will be used to calculate the set point for RE-42 when the mechanical vacuum pump is in operation or during containment purge. Under these conditions, the short term atmospheric dispersion factor at 366 meters NNE (3.60E-06 sec/m^3) shall be used instead of the annual average value.

2.2.2 Main Condenser Offgas System Effluent Monitors (RE-65A,B) High Alarm Set Point

The Main Condenser Offgas System Effluent Monitor has two chambers (65A, 65B) in series. Each chamber constitutes a separate independent output channel containing a detector composed of 3 GM tubes whose output is summed. The monitor set point will be based on a release rate which results in 0.1 MPC at the site boundary. The set point calculated shall be divided by a factor of 3 to account for the case when only one GM tube per chamber is functional.

1. During operation, a gaseous sample from the monitor will be taken and analyzed for isotopic composition and concentration, C_i. Before startup, C_i will be calculated as noted in Section 2.2.

2. At the time of sampling, the net count rate (excluding background), CR (cpm), of the monitor will be recorded. Before startup, the estimated count rate CR (cpm) due to concentration, C_i, is calculated as:

$$CR = 10^{-6} * \left(\sum_{i=1}^{N} C_i * E_i\right) \qquad \text{(cpm)}$$

where:

E_i = detector efficiency (cpm/µCi/cc) for RE-65A,B for radionuclide, i, as provided in Figure 2.2-3. The generic linearity response for RE-65A,B is shown in Figure 2.2-4

3. The sum of the ratios of the released isotopic concentrations to MPC is normalized to 0.1 at the site boundary by multiplying by the following factor:

$$F = \frac{0.1}{\left(\sum_{i=1}^{N} \frac{C_i}{MPC_i}\right) * V * \chi/Q * 3.0}$$

where:

V = Main condenser offgas system ventilation flow rate (m^3/sec) (Maximum flow rate = 1.18E-02 m^3/sec (25 cfm).)

χ/Q = annual average meteorological dispersion factor at 366 meters NNE (6.6E-07 sec/m^3) due to releases via the station ventilation exhaust point.

3.0 = Safety factor in case of 2 out of 3 GM tube failures.

4. From the above, the high alarm set point for RE-65A,B (see NOTE in Section 2.1.1) is calculated as follows:

$$S_{65} \leq 0.8 * F * CR \qquad \text{(cpm)}$$

2.2.3 Main Condenser Air Ejector Monitors (RE-12A,B) High Alarm Set Point for Non-bypass Mode Operation (normal operation)

The Main Condenser Air Ejector Monitor System has two detectors looking at one chamber. The alarm will be set off by a signal from either detector.

2.2.3.1 Initial Set Point for RE-12A,B Non-bypass Mode Operation

1. Use the t=0 GE noble gas spectrum for off-gas system release rate prior to treatment (GE document 22A2703B Rev. 3, Table V), scale it to the Shoreham RETS (3.11.2.7) limit of 244,000 μCi/sec at 30 minutes decay by multiplying by 2.44. Divide it by the air ejector flow rate (1.05E+06 cc/sec) to obtain the limiting concentrations C_i(μCi/cc) of each radioisotope i.

2. Using the isotopic concentrations, C_i (μCi/cc), defined above and the effective gamma energy per disintegration, $E_{i\ell}$ (MEV/dis) calculate the specific gamma activity, $A_{i\ell}$(MEV/cc-sec), for the i-th isotope in each of the following gamma ray energy bins: 0-0.4, 0.4-0.8, 0.8-1.3, 1.3-1.7, 1.7-2.2, 2.2-2.5, and 2.5-3.5 (MEV). Thus:

$$A_{i\ell} = K * E_{i\ell} * C_i$$

   where $E_{i\ell}$ is the total gamma energy (MEV) emitted per disintegration of the i-th isotope by gamma rays belonging to the ℓ-th energy bin defined above. The factor $K = 3.7 \times 10^4$ (dis/sec/μCi) is introduced for unit conversion.

   The total specific gamma activity, A_ℓ (MEV/cc-sec), for each gamma energy bin, ℓ, is calculated by summing the specific gamma activity, $A_{i\ell}$, for bin ℓ, over all isotopes.

$$A_\ell = \sum_{i=1}^{N} A_{i\ell}$$

3. Using the response curve for RE-12A,B given in Figure 2.2-5, calculate the dose rate. The generic linearity response curve for RE-12A,B is shown in Figure 2.2-6.

$$DR = \sum_{\ell=1}^{7} CF_\ell * A_\ell \qquad \text{(mrem/hr)}$$

   where:

   CF_ℓ is the efficiency $\left(\frac{\text{mrem/hr}}{\text{MEV/cc-sec}}\right)$ at the ℓ-th energy group (MEV)

4. The high alarm set point (see NOTE in Section 2.1.1, but note the background unit is in mrem/hr) for RE-12A,B in the non-bypass mode will be:

$$S_{12} \leq 0.8 * DR \qquad \text{(mrem/hr)}$$

2.2.3.2 Subsequent Adjustments of Set Points for RE-12A,B in Non-bypass Mode Operation

1. During operation, a gaseous sample from the monitor will be taken and analyzed for noble gases isotopic composition and concentration, C_i, (μCi/cc) at t=30 minutes. Before startup, C_i will be calculated as noted in Section 2.2.

2. At the time of sampling, the net dose rate reading (excluding background) of the monitor will be recorded, DR (mrem/hr).

3. The isotopic release activity concentrations, C_i, are summed and multiplied by the air ejector flow rate, V (cc/sec) to obtain the noble gas release rate, μCi/sec.

4. The release rate in step 3 is normalized to the RETS Section 3.11.2.7 release limit of 2.44E+05 μCi/sec at t=30 minutes as follows:

$$F = \frac{2.44E+05}{(\sum_i C_i) * V}$$

5. From above, the high alarm set point (see NOTE in Section 2.1.1, but note the background is in mrem/hr) based on a release rate of 2.44E+05 μCi/sec at t=30 minutes can be calculated as follows:

$$S_{12} \leq 0.8 * F * DR \qquad \text{(mrem/hr)}$$

2.2.4 Main Condenser Air Ejector Monitor (RE-12A,B) High Alarm Set Point for Bypass Mode Operation

2.2.4.1 Initial Set Point for RE-12A,B in Bypass Mode Operation

1. Same as steps 1, 2, and 3 in Section 2.2.3.1

2. The offsite total body dose rate D_T corresponding to the above concentration is calculated as:

$$D_T = 10^{+6} * \chi/Q * V * (\sum_i DFB_i * C_i)$$

and the beta and gamma skin dose rate is calculated as :

$$D_s = 10^{+6} * \chi/Q * V * (\sum_i K_{sim} * C_i)$$

where:

D_T = predicted total body dose rate (mrem/yr)

D_s = predicted beta and gamma skin dose rate (mrem/yr)

χ/Q = annual average atmospheric dispersion factor at 366 meters NNE (6.6E-07 sec/m^3) due to releases via the station ventilation exhaust point

V = Air ejector exhaust flow rate (cc/sec) (Maximum exhaust flow rate is 1.05E+06 cc/sec)

DFB_i = total body dose rate conversion factor $(\frac{mrem/yr}{pCi/m^3})$ from Table 2.2-1

K_{sim} = skin dose rate conversion factor $(\frac{mrem/yr}{pCi/m^3})$ from Table 2.2-1

3. The normalizing factor F is chosen to be the smaller of the two (to comply with 25 percent of the RETS (3.11.2.1) dose rate limit):

$$F_T = \frac{125\ mrem/yr}{D_T}$$

$$F_S = \frac{750\ mrem/yr}{D_S}$$

F = the smaller of F_T or F_S (unitless)

4. The high alarm set point (see NOTE in Section 2.1.1, but note the background is in mrem/hr) RE-12A,B in bypass mode is set at:

$$S_{12} \leq 0.8 * F * DR \qquad \text{(mrem/hr)}$$

2.2.4.2 <u>Subsequent Adjustments of Set Points for RE-12A,B in Bypass Mode Operation</u>

1. A gaseous sample from the monitor will be taken and analyzed for isotopic composition and concentration, C_i (µCi/cc)

2. At the time of sampling, the net dose rate reading, DR (mrem/hr), of the monitor will be recorded.

3. Follow procedures 2, 3, and 4 of Section 2.2.4.1 to get the high alarm set point for RE-12A,B in bypass mode.

TABLE 2.2-1

DOSE FACTORS FOR EXPOSURE TO A SEMI-INFINITE CLOUD OF NOBLE GASES

Radio- nuclide	β-Air[1] (DFb_i)	β-Skin[2] (DFS_i)	γ-Air[1] (DFH_i)	γ-Body[2] (DFB_i)	K_{si}[4] Skin Dose[2]	K_{sim}[5] Skin Dose [2]
Kr-83m	2.88E-04[3]	---	1.93E-05	7.56E-08	1.5E-05	2.1E-05
Kr-85m	1.97E-03	1.46E-03	1.23E-03	1.17E-03	2.4E-03	2.8E-03
Kr-85	1.95E-03	1.34E-03	1.72E-05	1.61E-05	1.4E-03	1.4E-03
Kr-87	1.03E-02	9.73E-03	6.17E-03	5.92E-03	1.5E-02	1.7E-02
Kr-88	2.93E-03	2.37E-03	1.52E-02	1.47E-02	1.4E-02	1.9E-02
Kr-89	1.06E-02	1.01E-02	1.73E-02	1.66E-02	2.4E-02	2.9E-02
Kr-90	7.83E-03	7.29E-03	1.63E-02	1.56E-02	2.0E-02	2.5E-02
Xe-131m	1.11E-03	4.76E-04	1.56E-04	9.15E-05	6.0E-04	6.5E-04
Xe-133m	1.48E-03	9.94E-04	3.27E-04	2.51E-04	1.2E-03	1.4E-03
Xe-133	1.05E-03	3.06E-04	3.53E-04	2.94E-04	5.8E-04	7.0E-04
Xe-135m	7.39E-04	7.11E-04	3.36E-03	3.12E-03	3.3E-03	4.4E-03
Xe-135	2.46E-03	1.86E-03	1.92E-03	1.81E-03	3.4E-03	4.0E-03
Xe-137	1.27E-02	1.22E-02	1.51E-03	1.42E-03	1.3E-02	1.4E-02

TABLE 2.2-1 (CONT'D)

Radio-nuclide	β-Air[(1)] (DFb_i)	β-Skin[(2)] (DFS_i)	γ-Air[(1)] (DFH_i)	γ -Body[(2)] (DFB_i)	K_{si}[(4)] Skin Dose[(2)]	K_{sim}[(5)] Skin Dose [(2)]
Xe-138	4.75E-03	4.13E-03	9.21E-03	8.83E-03	1.1E-02	1.4E-02
Ar-41	3.28E-03	2.69E-03	9.30E-03	8.84E-03	9.9E-03	1.3E-02

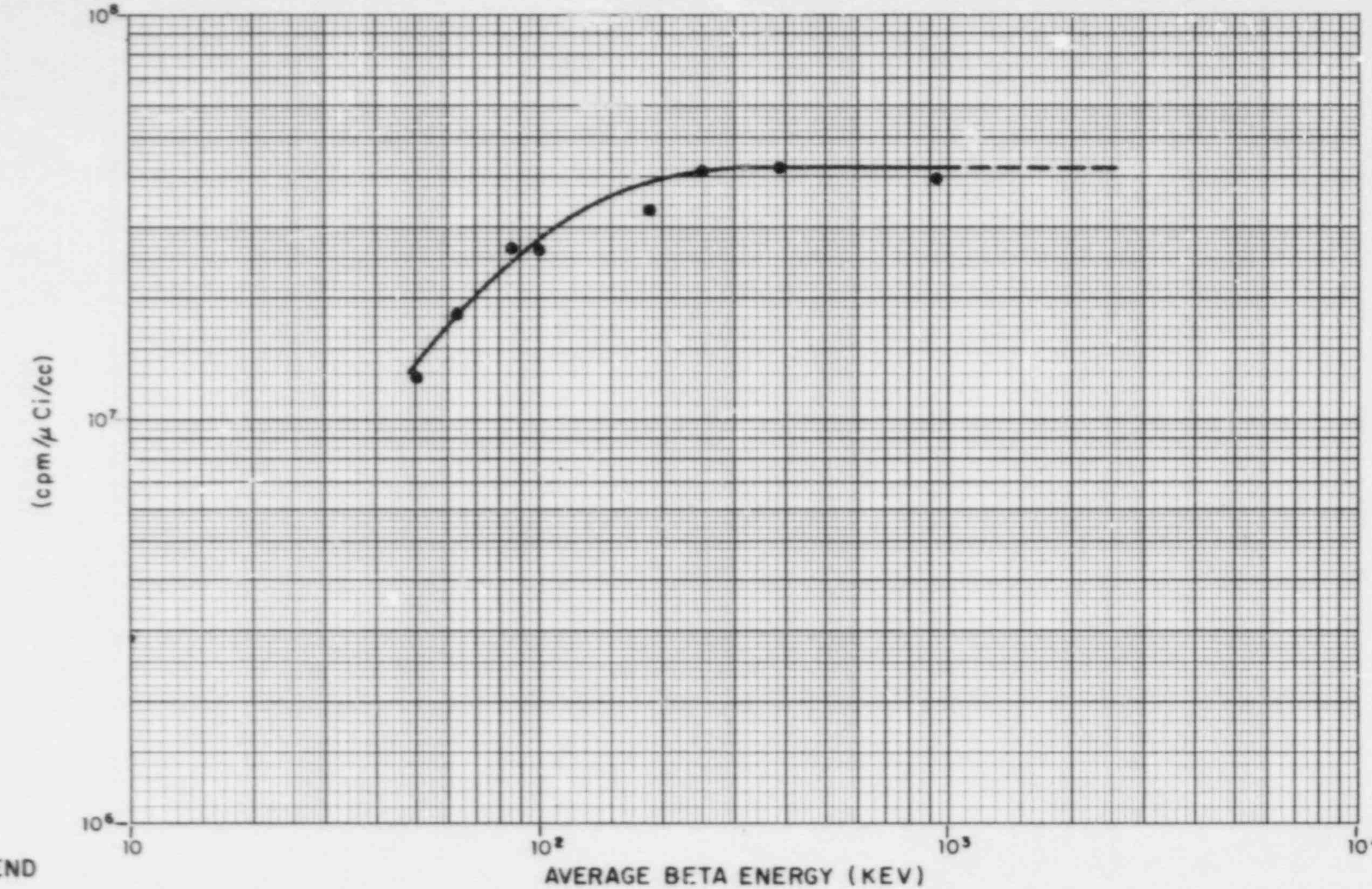
(1) $\frac{mrad\text{-}m^3}{pCi\text{-}yr}$

(2) $\frac{mrem\text{-}m^3}{pCi\text{-}yr}$

(3) $2.88E\text{-}04 = 2.88 * 10^{-4}$

(4) $K_{si} = (0.7 * 1.11 * DFH_i) + DFS_i$

(5) $K_{sim} = (1.11 * DFH_i) + DFS_i$

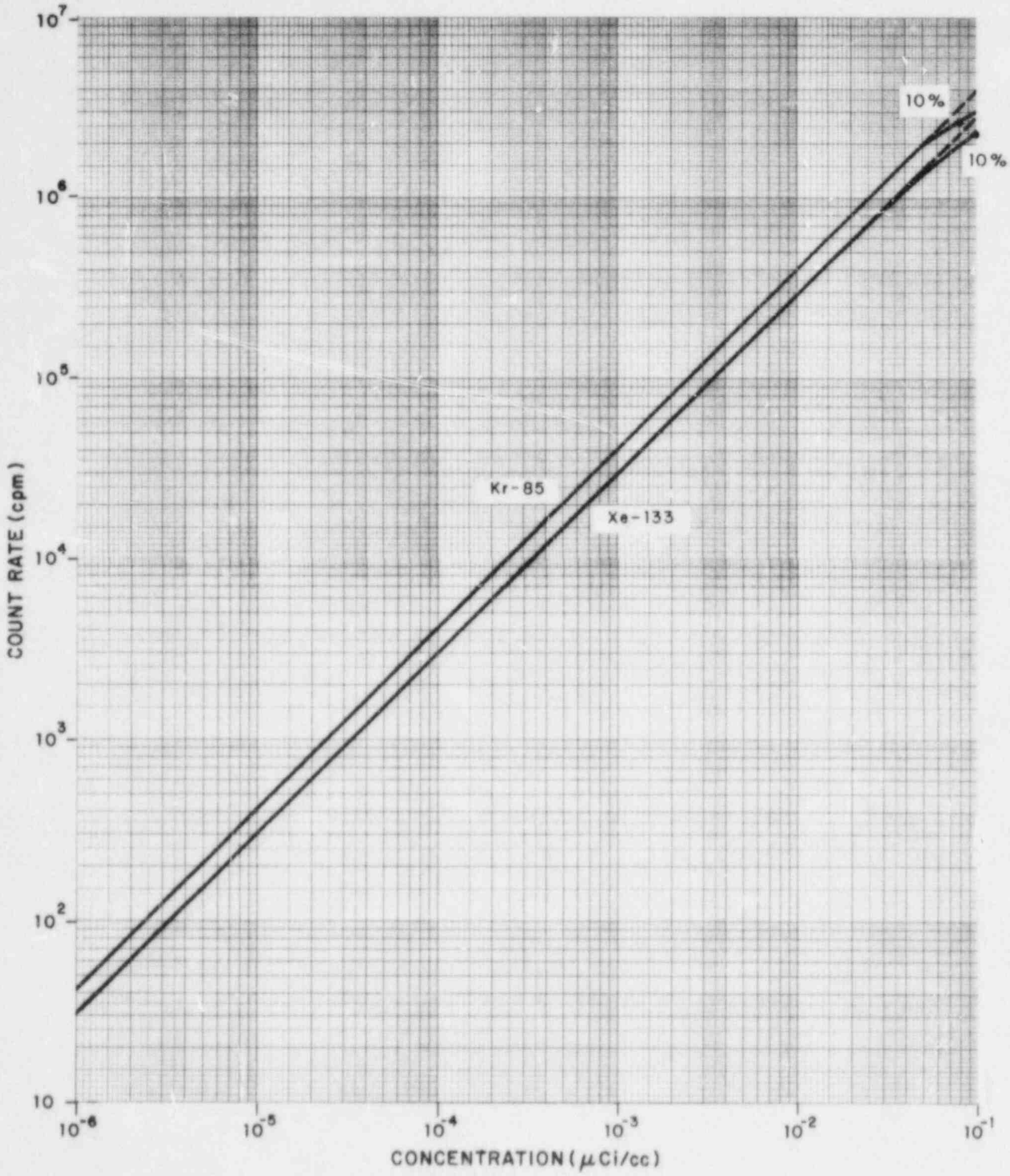


LEGEND

● CALIBRATED DATA

— — — EXTRAPOLATED CURVE BASED ON PREMISE THAT FOR BETA ENERGIES GREATER THAN 1 MEV THE FRACTIONAL LOSS OF BETAS THROUGH SCATTERING OR ABSORPTION IN AIR AND DETECTOR WINDOW IS NEGLIGIBLE.

FIGURE 2.2-1
DETECTOR RE-42
EFFICIENCY VS. AVERAGE BETA ENERGY
SHOREHAM NUCLEAR POWER STATION-UNIT 1
OFFSITE DOSE CALCULATION MANUAL



SOURCE:
LILCO LETTER FILE No. 221.9
LIL-21157

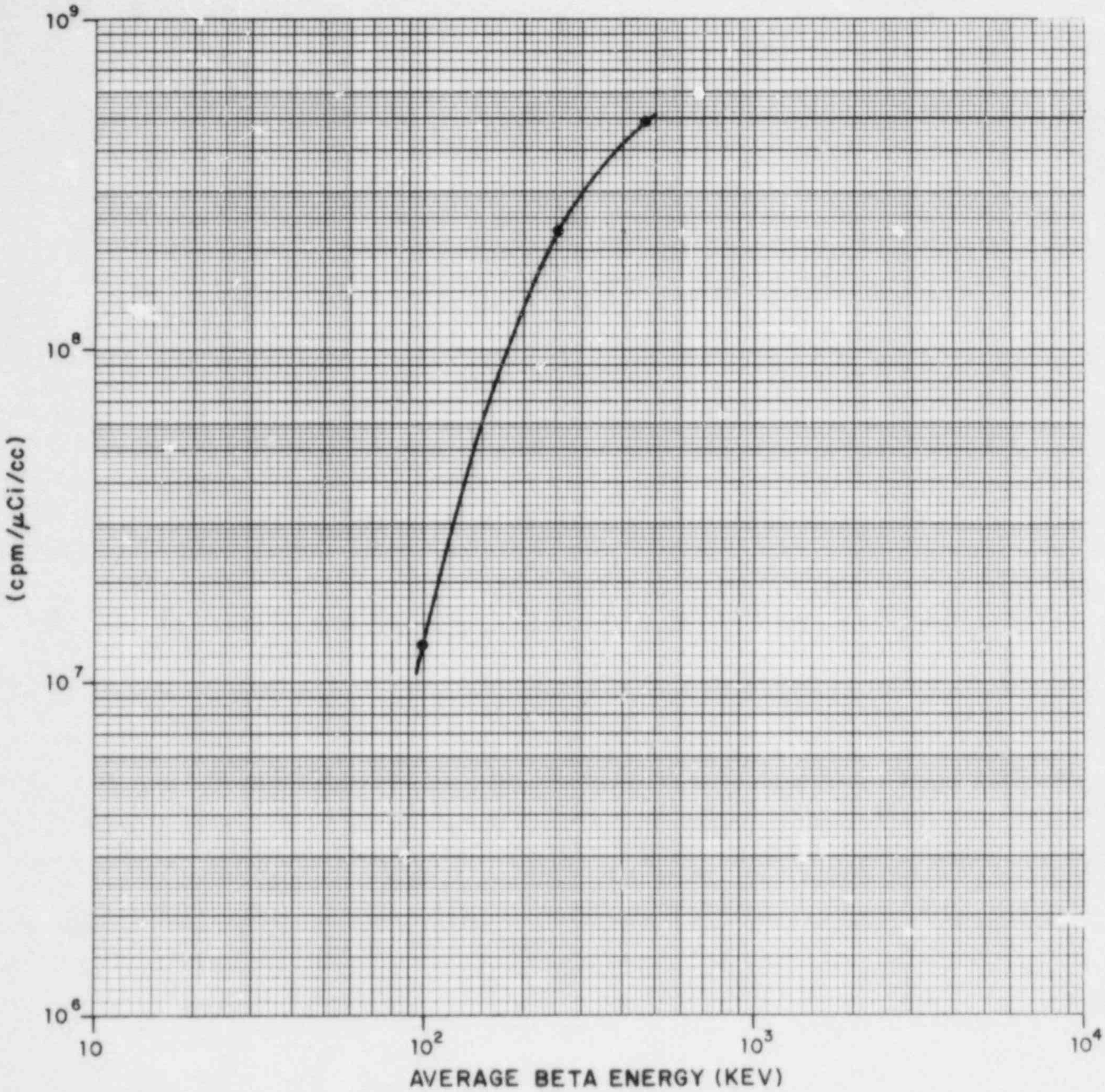
— — — — IDEAL CURVE

——•—— CALIBRATION CURVE (DATA CONSISTENT WITH FIGURE 2.2-1)

FIGURE 2.2-2

LINEARITY RESPONSE CURVE FOR DETECTOR RE-42

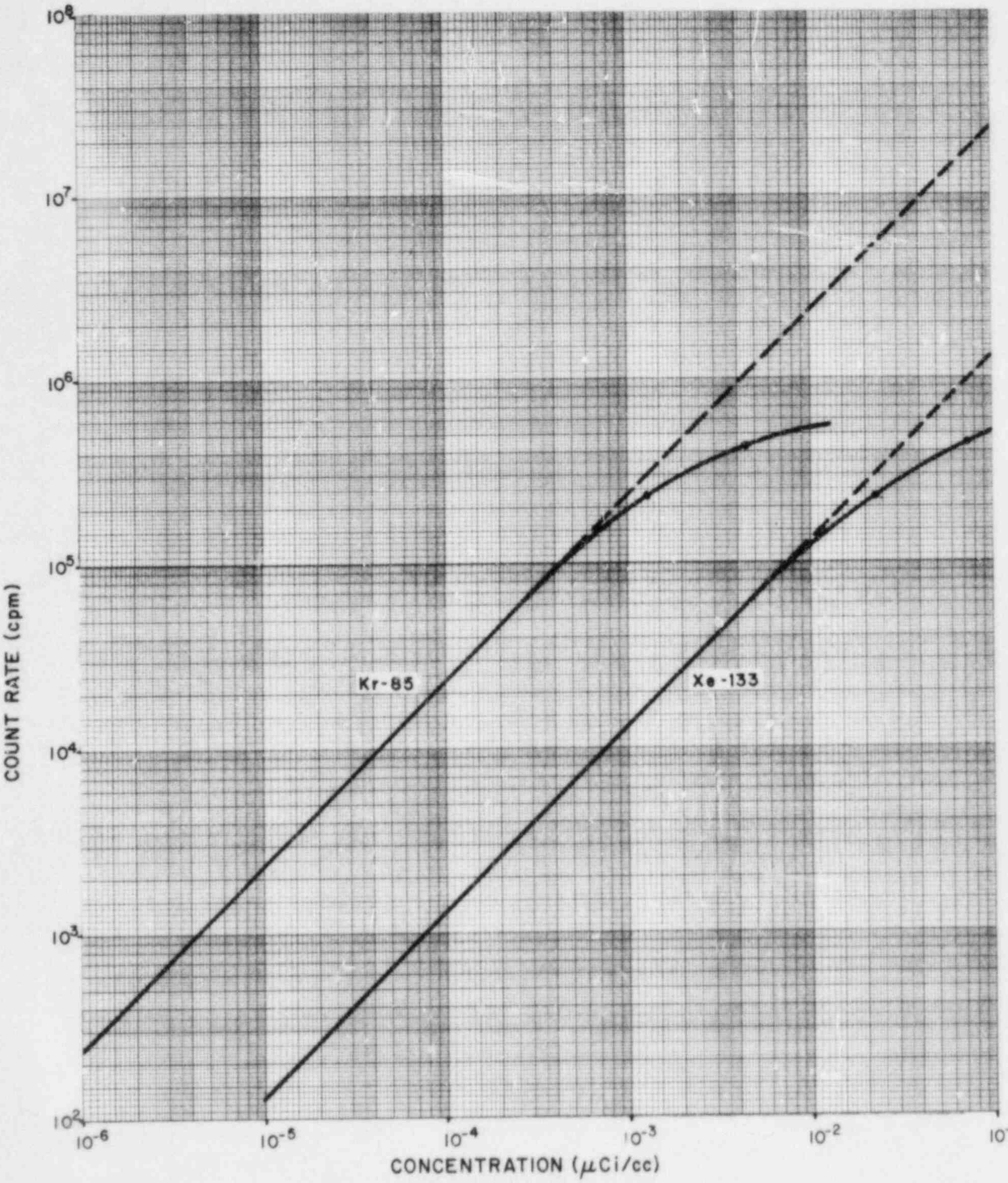
SHOREHAM NUCLEAR POWER STATION-UNIT 1
OFFSITE DOSE CALCULATION MANUAL



SOURCE:
GE MEMO (Pearson) - PROCESS RADIATION SAMPLING SENSITIVITIES. JUNE 26, 1977 (REV. 1)

GENERIC CALIBRATION CURVE

FIGURE 2.2-3
DETECTORS RE-65A, B
GENERIC EFFICIENCY VS. AVERAGE BETA ENERGY
SHOREHAM NUCLEAR POWER STATION-UNIT 1
OFFSITE DOSE CALCULATION MANUAL



SOURCE:
LILCO DOCUMENT No. CS.630.005

IDEAL CURVE

GENERIC CALIBRATION CURVE

FIGURE 2.2-4
GENERIC LINEARITY RESPONSE CURVE FOR DETECTORS RE-65A, B
SHOREHAM NUCLEAR POWER STATION-UNIT 1
OFFSITE DOSE CALCULATION MANUAL

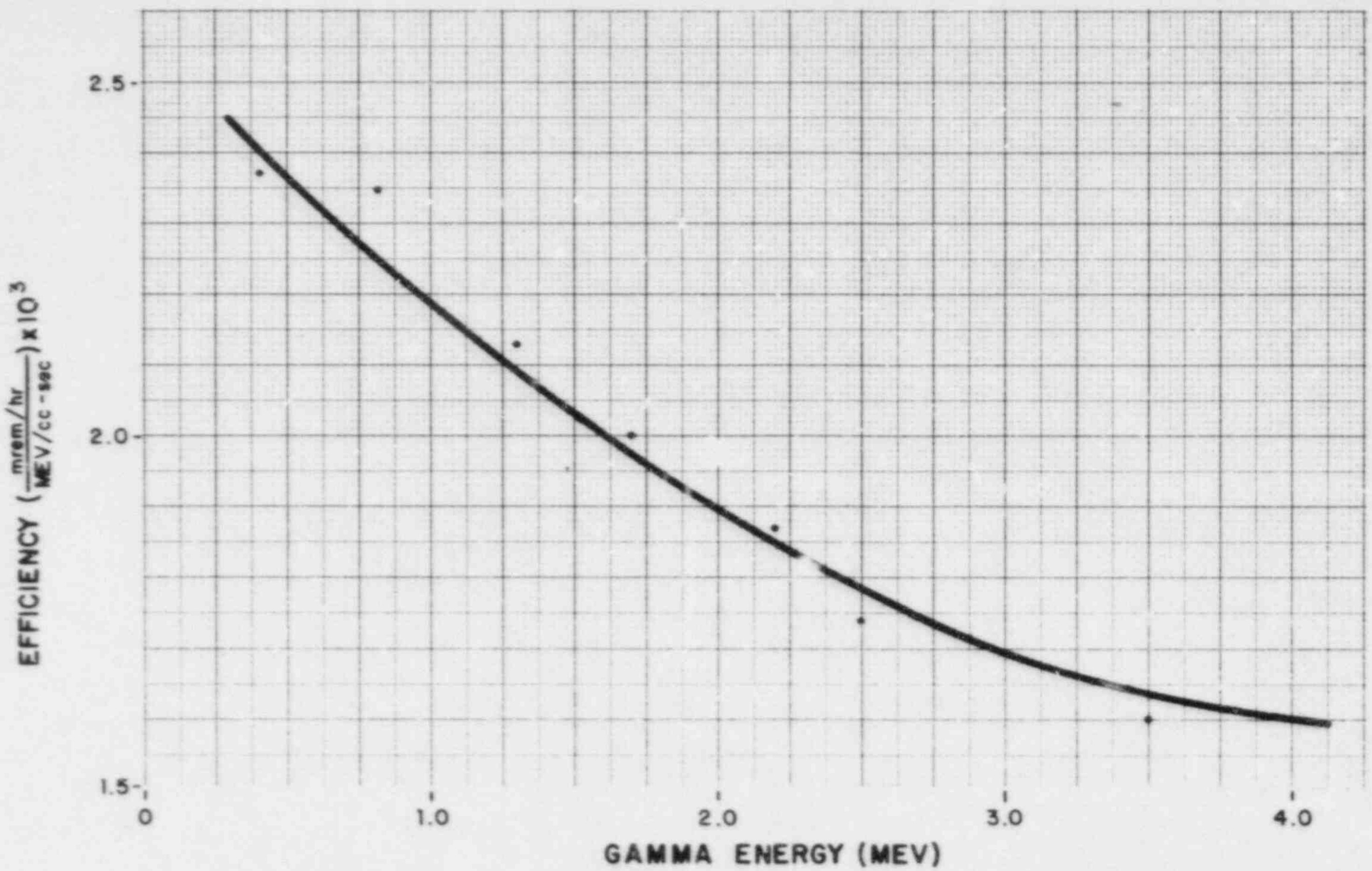
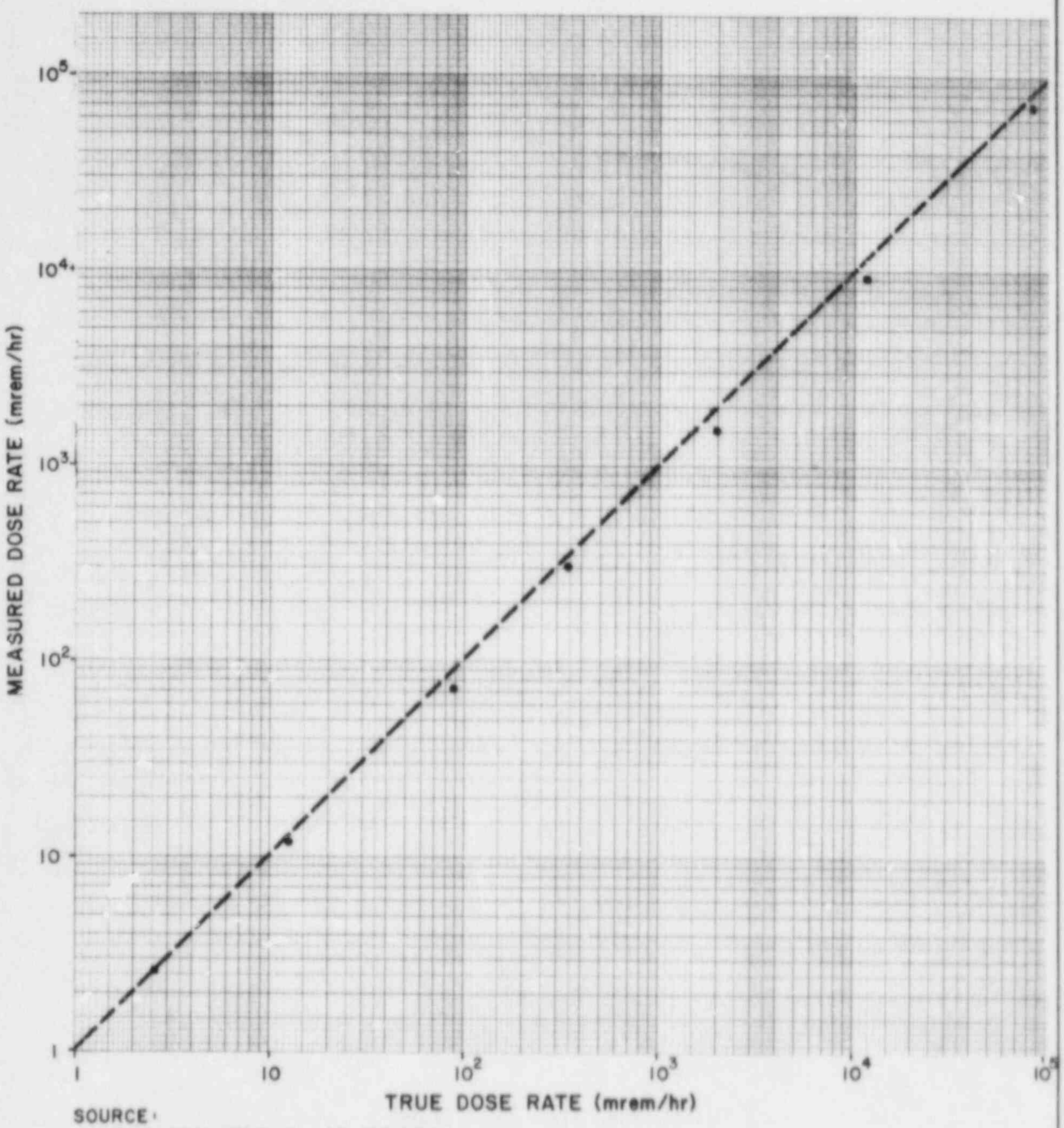


FIGURE 2.2-5
DETECTORS RE-12A,B
EFFICIENCY VS. GAMMA ENERGY
SHOREHAM NUCLEAR POWER STATION-UNIT 1
OFFSITE DOSE CALCULATION MANUAL

SOURCES:
1. LILCO STARTUP PACKAGE No. CS.630.004
2. SWEC CALCULATION 11600.02-SNPS-1-URB-25-P
• GAMMA ENERGY BINS (CF_{ℓ})



SOURCE:
LILCO DOCUMENT No. CS.630.004

--- IDEAL CURVE
• ACTUAL DATA

FIGURE 2.2-6
GENERIC LINEARITY CURVE
FOR DETECTORS RE-12A,B
SHOREHAM NUCLEAR POWER STATION-UNIT 1
OFFSITE DOSE CALCULATION MANUAL

REVISION 1 - AUGUST 1983

SECTION 3

DOSE CALCULATION METHODS

This section presents the calculational specifics required to demonstrate compliance with the following Radiological Effluent Technical Specifications (RETS) sections:

3.11.1.2 - Liquid Effluent Dose Calculation

3.11.1.3 - Operation of Liquid Radwaste Treatment System

3.11.2.1 - Gaseous Effluent Dose Rate

3.11.2.2 - Noble Gas Air Dose

3.11.2.3 - Gaseous Effluent Dose From Radioiodines, Tritium, and Radionuclides In Particulate Form

3.11.2.5 - Operation of Ventilation Exhaust Treatment System

Calculation methods are based on the equation and calculational methods described in Regulatory Guide 1.109 "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10CFR50, Appendix I".

Two methods are provided for each analysis. The first method is the method used by the computerized radiation monitoring system. Method 2 is a backup hand calculational method to be used only if the computer is not functional.

3.1 LIQUID EFFLUENT, DOSE CALCULATION

To comply with Section 3.11.1.2 of the RETS, the liquid effluents released to unrestricted areas shall be limited:

1. During any calendar quarter to less than or equal to 1.5 mrem to the total body and to less than or equal to 5 mrem to any organ.

2. During any calendar year to less than or equal to 3 mrem to the total body and to less than or equal to 10 mrem to any organ.

The site boundary for liquid effluents is shown in Figure 3.1-1. The liquid radwaste system model is shown in Figure 3.1-2.

3.1.1 Method 1: (Computerized Method)

The equations which follow are used by the computer software to calculate the offsite doses due to release of liquid radwaste. For this dose calculation the actual concentration to be discharged by isotope, the total volume of liquid to be discharged, and the number of circulating water pumps running, supplied by the operator, shall be used.

The software computes the isotopic releases by multiplying the lab measurements by the volume of the liquid to be released:

$$Q_i = 3.785 \times 10^{-3} V q_i$$

where:

Q_i = total inventory of isotope i in the liquid to be released (Ci)

q_i = concentration of isotope i in the liquid to be discharged (as measured in laboratory) (μCi/cc)

V = volume of liquid to be discharged (gallons)

3.785×10^{-3} = [(Ci/μCi) (cc/gal)]

The dose equations which follow are from Regulatory Guide 1.109, with minor modifications. They are employed for the computation of dose from any single batch discharge. Weekly and quarterly cumulative doses are also calculated and stored in data files for reporting.

(a) Organ Dose due to Ingestion of Saltwater Fish

$$R_{ja}^{ing\ fish} = 0.389\ U_{ap}^{fis} (1/K) \sum_{part+I} Q_i\ B_{ip}^{fis}\ DFI_{ija} e^{-24\lambda_i}$$

where:

$R_{ja}^{ing\ fish}$ = dose to organ j of individual in age group a due to ingestion of fish contaminated with particulates and radioiodines (mrem) (Ref. Reg. Guide 1.109, with the following special values:

- F (flow rate of liquid effluent) is represented by product $K * F_{pump}$ [ft^3/sec], where K is the number of pumps operating and F_{pump} is the flow rate per unit pump
- $F_{pump} = 1.435 \times 10^5$ [gpm] = 319.7 [ft^3/sec]
- M_p (mixing ratio (reciprocal of dilution factor 8.85) at the point of exposure) = 0.113
- D_{aipj} (dose factor) = DFI_{ija} (see below)
- t_p (transit time required for nuclides to reach the point of exposure) = 24 [hr] (see pg 1.109-12 of the Regulatory Guide)

U_{ap}^{fis} = fish consumption rate by individual in age group a [kg/yr] (from Table E-5 of the Guide, for maximum individual)

K = number of pumps operating (circulating water system)

Q_i = total activity of isotope i released [Ci], from above

B_{ip}^{fis} = Bioaccumulation factor for saltwater fish [(pCi/kg)/(pCi/liter)] (from Table A-1 of the Guide)

DFI_{ija} = dose conversion factor for nuclide i to organ j of individual in age group a due to ingestion [mrem/pCi ingested] (from Tables E-11 through E-14 of the Guide)

λ_i = radionuclide decay constant [hr^{-1}] (from Table 3.1-1)

0.389 = 1100 M_p/F_{pump} = 1100 x 0.113 / 319.7 [(pCi/ℓ)/(Ci/yr)]

part+I = 68 particulates and 5 iodines in the summation sign

(b) <u>Organ dose due to ingestion of saltwater invertebrate</u>

$$R_{ja}^{ing\ inv} = 0.389\ U_{ap}^{inv}(1/K) \sum_{part+I} Q_i\ B_{ip}^{inv}\ DFI_{ija} e^{-24\lambda_i}$$

where:

$R_{ja}^{ing\ inv}$ = dose to organ j of individual in age group a due to the ingestion of saltwater invertebrate contaminated with radioactive particulates and iodines [mrem] (Ref.: Reg. Guide 1.109 Eq. A-3 with the special values identified in the fish-ingestion equation above)

B_{ip}^{inv} = Bioaccumulation factor for saltwater invertebrate [(pCi/kg)/(pCi/liter)] (from Table A-1 of the Guide)

U_{ap}^{inv} = invertebrate consumption rate by individual in age group a [kg/yr] (from Table E-5 of the Guide, for maximum individual)

(c) Total body dose from shoreline deposits

$$R_{wb,a}^{shore} = 0.561\ U_{ap}^{shore}\ (1/K) \sum_{part+I} Q_i\ DFG_{i1} \left(\frac{1-e^{-t_b \lambda_i}}{\lambda_i}\right)$$

where:

$R_{wb,a}^{shore}$ = total body dose to individual in age group a from shoreline deposits [mrem] (Ref.: Reg. Guide 1.109 Eq. A-7 with the following special values:

- F(flow rate of liquid effluent) is represented by the product $K*F_{pump}$ [ft^3/sec], where K is the number of operating pumps and F_{pump} is the flow rate per unit pump
- $F_{pump} = 1.435 \times 10^5$ [gpm] = 319.7 [ft^3/sec]
- M_p (mixing ratio) = 0.113
- W (shore-width factor that describes the geometry of the exposure) = 0.5 for ocean site (from Table A-2 of the guide)
- t_p (transit time from source to shoreline) = 0 (see Reg. Guide pg 1.109-69, for Eq. A-7)
- T_i (radionuclide half life, days) = $0.693/(24\lambda_i)$ where $0.693 = \log_e 2$ and λ_i is the decay constant in [hr^{-1}]
- $D_{aipj} = DFG_{i1}$ (see below)

U_{ap}^{shore} = shoreline exposure time for individual in age group a [hr/yr] (from Table E-5 of the Guide, for maximum individual)

K = number of pumps operating (circulating water system)

Q_i = total activity of isotope i released [Ci], from above

DFG_{i1} = total body conversion factor for standing on contaminated ground (shore) [(mrem/hr)/(pCi/m^2)] (from Table E-6 of the guide)

t_b = time period over which accumulation is evaluated (15 years, or 1.314×10^5 hours)

$0.561 = 110{,}000\ M_p\ W\ (T_i \lambda_i)/\ F_{pump}\ [(pCi/\ell)/(Ci/yr)]$

$= 110{,}000 \times 0.113 \times 0.5 \times (0.693/24)/\ 319.7$

part+I = 68 particulates and 5 iodines in the summation sign

(d) Skin dose from shoreline deposits

$$R^{shore}_{skin,\ a} = 0.561\ U^{shore}_{ap}\ (1/k) \sum_{part+I} Q_i\ DFG_{i2} \left(\frac{1-e^{-t_b \lambda_i}}{\lambda_i}\right)$$

where:

$R^{shore}_{skin,\ a}$ = skin dose to individual in age group a from shoreline deposits [mrem]; (Ref.: Reg. Guide 1.109 Eq. A-7 with the special values listed for the total body dose)

DFG_{i2} = skin dose conversion factor for standing on contaminated ground (shore) [(mrem/hr)/(pCi/m^2)] (from Table E-6 of the Guide)

Other parameters are as defined earlier for the total body dose from shoreline deposits.

(e) Total doses

The individual dose components described in items (a), (b), (c), and (d) above are summed in the following way for the computation of total doses:

$$R_{ja} = R^{ing\ fish}_{ja} + R^{ing\ inv}_{ja}$$

$$R_{wb,a} = R^{ing\ fish}_{wb,a} + R^{ing,\ inv}_{wb,a} + R^{shore}_{wb,a}$$

$$R_{skin,a} = R^{shore}_{skin,a}$$

where:

R_{ja} = total dose to organ j (exclusive of the total body) of individual in age group a due to the ingestion of fish and invertebrate (mrem)

$R_{wb,a}$ = total dose to the total body of individual in age group a due to the ingestion of fish and invertebrates, and direct radiation from shoreline deposits

and

$R_{skin,a}$ = total dose to the skin of an individual in age group a from shoreline deposits (mrem).

3.1.2 Method 2: (Backup Method)

The dose contributions for the total release period shall be calculated for all radionuclides identified in liquid effluents released to unrestricted areas using the following expression:

$$D_\tau = \sum_{i=1}^{N} \left[A_{i\tau} \sum_{\ell=1}^{M} \Delta t_\ell \; C_{i\ell} F_\ell \right] \qquad (3.1\text{-}1)$$

where:

D_τ = the cumulative dose or dose commitment to the total body or an organ from the liquid effluents for the total release period $\sum_{\ell=1}^{M} \Delta t_\ell$ (mrem),

Δt_ℓ = the length of the ℓth release period over which $C_{i\ell}$ and F_ℓ are averaged for all liquid released (minutes),

$C_{i\ell}$ = the average concentration of radionuclide C_i in undiluted liquid effluent during release period Δt_ℓ from any liquid release (μCi/cc),

$A_{i\tau}$ = the site-related ingestion dose or dose commitment factor to the total body or any organ for each identified principal gamma and beta emitter listed in Table 3.1-2 (mrem/min per μCi/cc), see Appendix A for derivation

F_ℓ = the near field average dilution factor for $C_{i\ell}$, during any liquied effluent release, defined as the undiluted liquid waste flow rate during release divided by the product of the circulating water flow rate times 8.85 *(N/4). (8.85 is the near field mixing factor for the mixing of the diffuser discharge into Long Island Sound based on 4 operating recirculating pumps. N is the number of recirculating pumps operating during discharge.)

The total dose from liquid effluents from all discharges, D_{Total}, is:

$$D_{Total} = D_{\tau D} + D_{\tau R} + D_{\tau H} + D_{\tau S} + D_{\tau p}$$

where:

$D_{\tau D}$ = Dose contribution from discharge waste sample tanks as calculated in Equation 3.1-1

$D_{\tau R}$ = Dose contribution from recovery sample tanks as calculated in Equation 3.1-1

$D_{\tau H}$ = Dose contribution from RHR heat exchanger, service water as calculated in Equation 3.1-1

$D_{\tau S}$ = Dose contribution from reactor building salt water drain tank as calculated in Equation 3.1-1

$D_{\tau p}$ = Dose contribution from yard piping drain sump as calculated in Equation 3.1-1.

If the calculated total dose exceeds the limit specified in Section 3.1, consult RETS Section 3.11.1.2.

TABLE 3.1-1

DECAY CONSTANTS (1/hr)

Radio- nuclide	Constant	Radio- nuclide	Constant
H-3	6.408E-06	Ru-103	7.300E-04
C-14	1.379E-08	Ru-105	1.600E-01
Na-24	4.600E-02	Ru-106	7.800E-05
P-32	2.000E-03	Ag-110m	1.100E-04
Cr-51	1.044E-03	Te-125m	5.000E-04
Mn-54	9.252E-05	Te-127m	2.600E-04
Mn-56	2.700E-01	Te-127	7.400E-02
Fe-55	2.930E-05	Te-129m	8.600E-04
Fe-59	6.480E-04	Te-129	5.900E-01
Co-58	4.068E-04	Te-131m	2.300E-02
Co-60	1.501E-05	Te-131	1.700E+00
Ni-63	8.600E-07	Te-132	8.900E-03
Ni-65	2.700E-01	I-130	5.600E-02
Cu-64	5.400E-02	I-131	3.593E-03
Zn-65	1.184E-04	I-132	3.000E-01
Zn-69	7.296E-01	I-133	3.334E-02
Br-83	2.900E-01	I-134	7.900E-01
Br-84	1.300E+00	I-135	1.100E-01
Br-85	1.449E+01	Cs-134	3.852E-05
Rb-86	1.500E-03	Cs-136	2.203E-03
Rb-88	2.400E+00	Cs-137	2.635E-06
Rb-89	2.700E+00	Cs-138	1.300E+00
Sr-89	5.724E-04	Ba-139	5.000E-01
Sr-90	2.776E-06	Ba-140	2.257E-03
Sr-91	7.300E-02	Ba-141	2.300E+00
Sr-92	2.600E-01	Ba-142	3.900E+00
Y-90	1.100E-02	La-140	1.700E-02
Y-91m	8.300E-01	La-142	4.500E-01
Y-91	4.900E-04	Ce-141	8.392E-04
Y-92	2.00E-01	Ce-143	2.100E-02
Y-93	6.800E-02	Ce-144	1.019E-04
Zr-95	4.392E-04	Pr-143	2.100E-03
Zr-97	4.100E-02	Pr-144	2.400E+00
Nb-95	8.200E-04	Nd-147	2.600E-03
Mo-99	1.000E-02	W-187	2.900E-02
Tc-99m	1.200E-01	Np-239	1.200E-02
Tc-101	2.900E+00		

TABLE 3.1-2

ADULT DOSE RATE CONVERSION FACTORS[1], $A_{i\tau}$

FOR (FISH AND INVERTEBRATE) INGESTION PATHWAY
(mrem/min per μCi/cc)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	-[1]	4.6E-03	4.6E-03	4.6E-03	4.6E-03	4.6E-03	4.6E-03
C-14	2.4E+02	4.7E+01	4.7E+01	4.7E+01	4.7E+01	4.7E+01	4.7E+01
F-18	1.2E-05	-	1.4E-06	-	-	-	3.7E-07
NA-24	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03
P-32	2.6E+05	1.6E+04	1.0E+04	-	-	-	3.0E+04
CR-51	-	-	9.0E-02	5.3E-02	2.0E-02	1.2E-01	2.2E+01
MN-54	-	1.2E+02	2.2E+01	-	3.4E+01	-	3.5E+02
MN-56	-	4.6E-03	8.1E-04	-	5.9E-03	-	1.4E-01
FE-55	8.3E+02	5.8E+02	1.4E+02	-	-	3.2E+02	3.3E+02
FE-59	1.3E+03	3.1E+03	1.2E+03	-	-	8.6E+02	1.0E+04
CO-58	-	9.8E+00	2.2E+01	-	-	-	2.0E+02
CO-60	-	2.8E+01	6.3E+01	-	-	-	5.4E+02
NI-63	8.1E+02	5.6E+01	2.7E+01	-	-	-	1.2E+01
NI-65	4.8E-03	6.2E-04	2.9E-04	-	-	-	1.6E-02
CU-64	-	9.6E-01	4.5E-01	-	2.4E+00	-	8.2E+01
ZN-65	2.7E+03	8.4E+03	3.8E+03	-	5.6E+03	-	5.3E+03
ZN-69M	1.7E+00	3.3E+00	2.2E-01	-	2.1E+00	-	4.9E-01
BR-83	-	-	1.1E-06	-	-	-	1.6E-06
BR-84	-	-	2.7E-17	-	-	-	
RB-86	-	9.8E+00	4.6E+00	-	-	-	1.9E+00
SR-89	8.1E+01	-	2.3E+00	-	-	-	1.3E+01
SR-90	2.0E+03	-	5.0E+02	-	-	-	5.8E+01
SR-91	2.6E-01	-	1.0E-02	-	-	-	1.2E+00
SR-92	1.2E-03	-	5.3E-05	-	-	-	2.4E-02
Y-90	7.6E-02	-	2.1E-03	-	-	-	8.2E+02
Y-91M	1.9E-12	-	7.2E-14	-	-	-	5.4E-12
Y-91	1.4E+00	-	3.9E-02	-	-	-	8.0E+02
Y-92	7.9E-05	-	2.3E-06	-	-	-	1.4E+00
Y-93	5.4E-03	-	1.5E-04	-	-	-	1.8E+02
ZR-95	2.6E-01	8.3E-02	5.6E-02	-	1.3E-01	-	2.6E+02

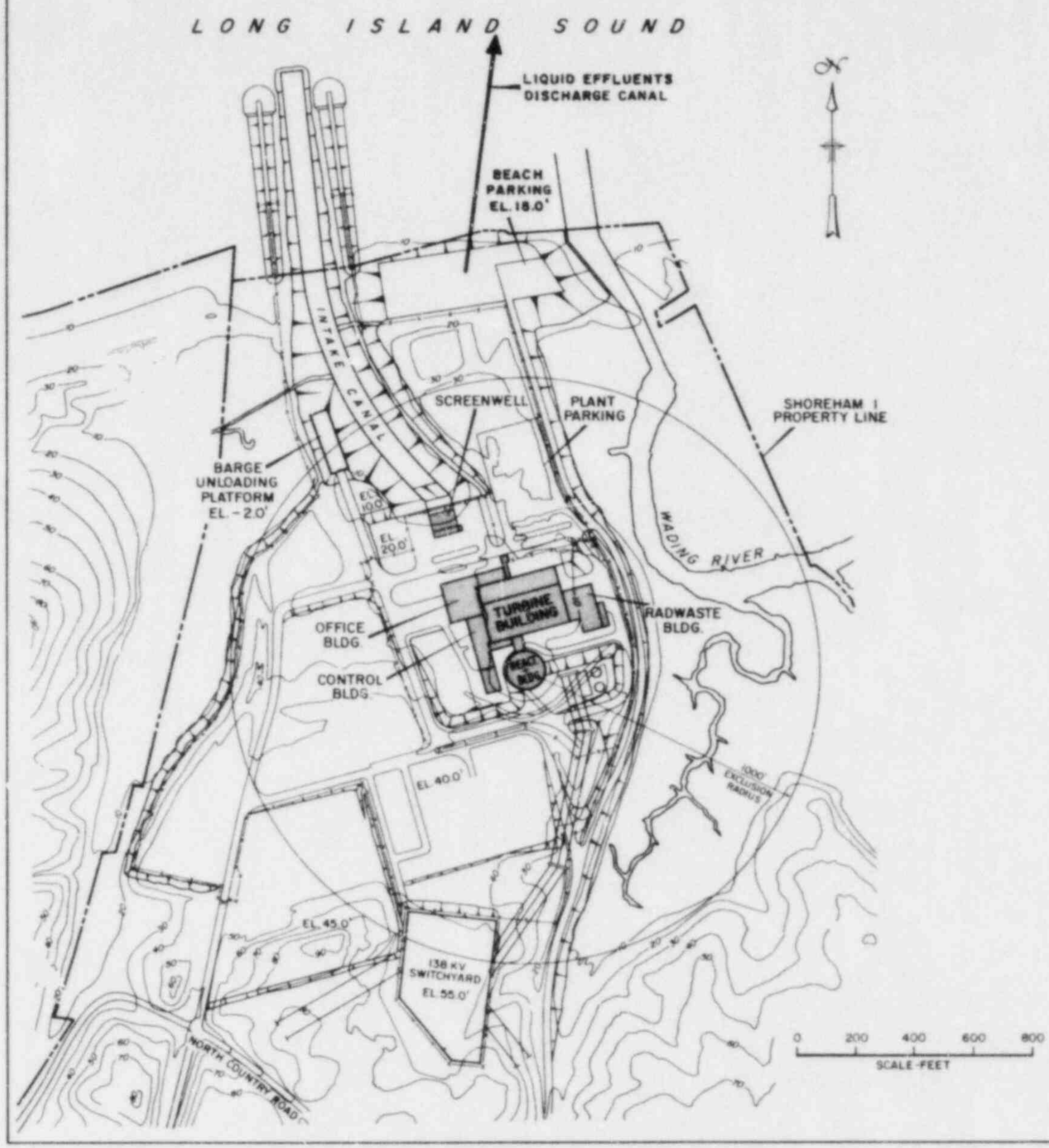
TABLE 3.1-2 (CONT'D)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
ZR-97	5.4E-03	1.1E-03	4.9E-04	-	1.6E-03	-	3.4E+02
NB-95	7.2E+00	4.0E+00	2.1E+00	-	4.0E+00	-	2.4E+04
MO-99	-	1.6E+00	3.1E-01	-	3.7E+00	-	3.8E+00
TC-99M	1.3E-05	3.8E-05	4.8E-04	-	5.7E-04	1.8E-05	2.2E-02
RU-103	1.7E+00	-	7.4E-01	-	6.6E+00	-	2.0E+02
RU-105	3.4E-03	-	1.3E-03	-	4.5E-02	-	2.1E+00
RU-106	2.6E+01	-	3.2E+00	-	5.1E+01	-	1.7E+03
AG-110M	2.6E+01	2.4E+01	1.4E+01	-	4.7E+01	-	9.7E+03
SB-124	4.5E+00	8.5E-02	1.8E+00	1.1E-02	-	3.5E+00	1.2E+02
TE-125M	3.5E+00	1.3E+00	4.7E-01	1.0E+00	1.4E+01	-	1.4E+01
TE-127M	8.9E+00	3.1E+00	1.1E+00	2.3E+00	3.7E+01	-	3.0E+01
TE-127	2.5E-02	8.9E-03	5.4E-03	1.8E-02	1.0E-01	-	2.0E+00
TE-129M	1.5E+01	5.6E+00	2.4E+00	5.1E+00	6.2E+01	-	7.5E+01
TE-129	2.7E-08	1.0E-08	6.5E-09	2.1E-08	1.1E-07	-	2.0E-08
TE-131M	1.3E+00	6.4E-01	5.4E-01	1.0E+00	6.5E+00	-	6.4E+01
TE-131	1.3E-19	5.4E-20	4.1E-20	1.1E-19	5.7E-19	-	1.9E-20
TE-132	2.7E+00	1.7E+00	1.7E+00	2.0E+00	1.7E+01	-	8.2E+01
I-130	1.7E-01	5.0E-01	2.0E-01	4.2E+01	7.9E-01	-	4.4E-01
I-131	3.3E+00	4.7E+00	2.7E+00	1.5E+03	8.1E+00	-	1.2E+00
I-132	1.2E-04	3.3E-04	1.1E-04	1.1E-02	5.2E-04	-	6.1E-05
I-133	5.5E-01	9.6E-01	2.9E-01	1.4E+02	1.7E+00	-	8.6E-01
I-134	5.1E-10	1.4E-09	4.9E-10	2.4E-08	2.2E-09	-	1.2E-12
I-135	3.1E-02	8.1E-02	3.0E-02	5.3E+00	1.3E-01	-	9.0E-02
CS-134	1.1E+02	2.7E+02	2.2E+02	-	8.6E+01	2.9E+01	4.7E+00
CS-136	1.1E+01	4.4E+01	3.2E+01	-	2.4E+01	3.3E+00	5.0E+00
CS-137	1.5E+02	2.0E+02	1.3E+02	-	6.7E+01	2.2E+01	3.8E+00
CS-138	3.6E-15	7.0E-15	3.4E-15	-	5.2E-15	5.2E-16	3.0E-20
BA-139	8.1E-07	5.8E-10	2.4E-08	-	5.4E-10	3.3E-10	1.4E-06
BA-140	2.6E+01	3.2E-02	1.7E+00	-	1.1E-02	1.8E-02	5.3E+01
LA-140	1.7E-02	8.6E-03	2.3E-03	-	-	-	6.3E+02
LA-142	2.7E-08	1.2E-08	3.1E-09	-	-	-	8.9E-05
CE-141	5.5E-02	3.7E-02	4.2E-03	-	1.7E-02	-	1.4E+02
CE-143	6.0E-03	4.4E+00	4.9E-04	-	1.9E-03	-	1.6E+02
CE-144	2.9E+00	1.2E+00	1.6E-01	-	7.3E-01	-	9.9E+02
PR-143	9.1E-02	3.6E-02	4.5E-03	-	2.1E-02	-	4.0E+02

TABLE 3.1-2 (CONT'D)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
ND-147	6.1E-02	7.1E-02	4.2E-03	-	4.1E-02	-	3.4E+02
W-187	7.5E-02	6.3E-02	2.2E-02	-	-	-	2.1E+01
NP-239	4.3E-04	4.2E-05	2.3E-05	-	1.3E-04	-	8.7E+00

(1) The dash (-) indicates insufficient data or that the dose factor is < 1.0E-20.



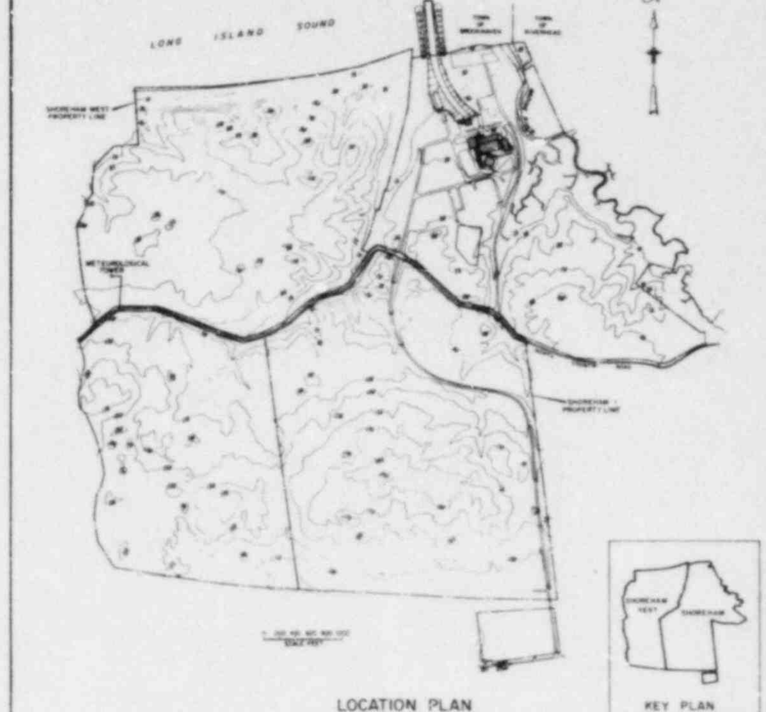


FIGURE 3.1-1
SITE BOUNDARY FOR LIQUID EFFLUENTS
SHOREHAM NUCLEAR POWER STATION-UNIT 1
OFFSITE DOSE CALCULATION MANUAL

REVISION 1-AUGUST 1983

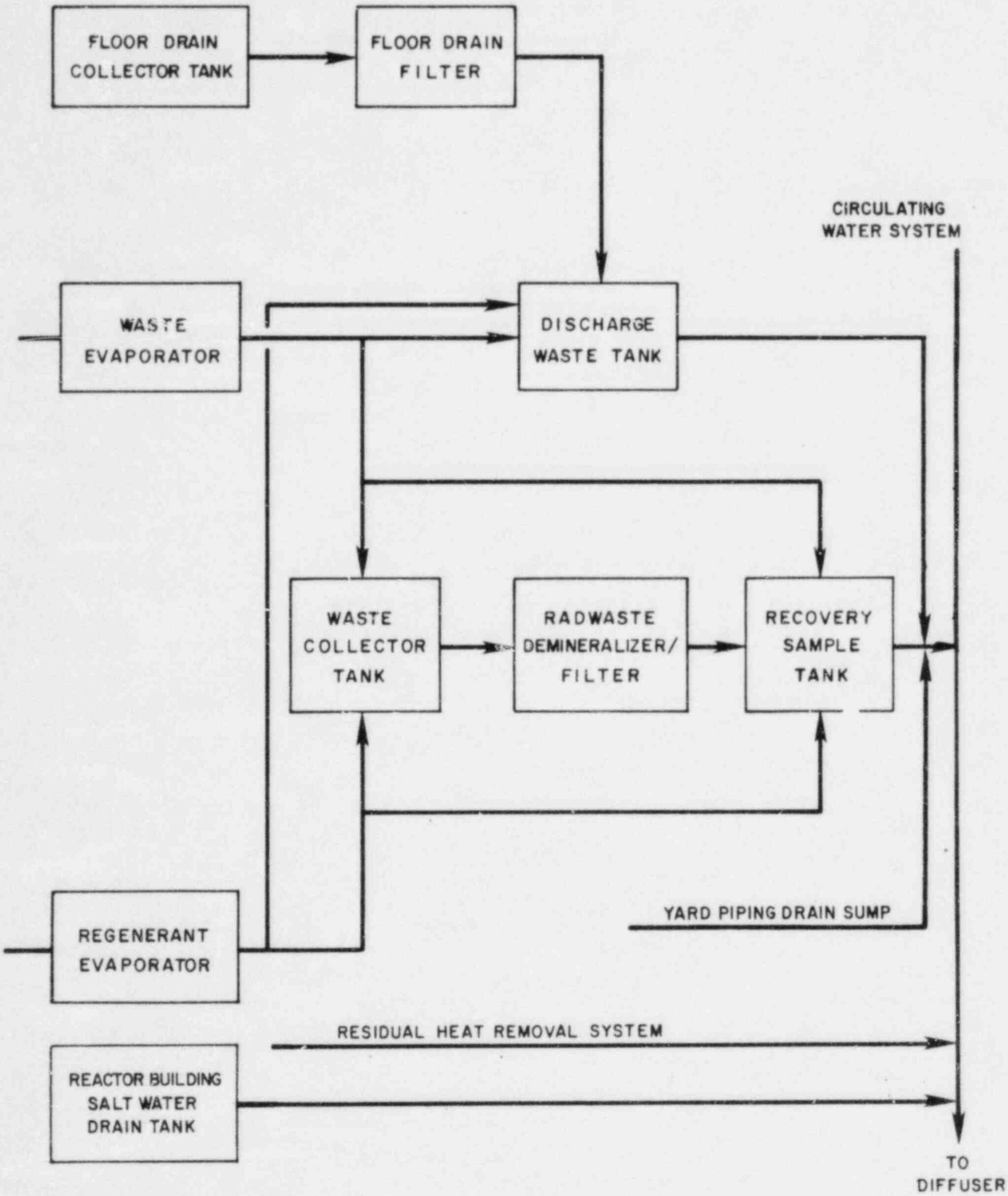


FIGURE 3.1-2

LIQUID RADWASTE SYSTEM MODEL

SHOREHAM NUCLEAR POWER STATION - UNIT 1
OFFSITE DOSE CALCULATION MANUAL

3.2 OPERATION OF LIQUID WASTE TREATMENT SUBSYSTEMS

The dose projection analysis will be performed using the methodology described in Section 3.1 with the exception that the calculated doses will be compared with the limits specified in RETS Section 3.11.1.3.

The liquid radwaste treatment system shall be OPERABLE and appropriate portions of the system shall be used to reduce releases of radioactivity when the projected doses due to the liquid effluent to UNRESTRICTED AREAS would exceed 0.06 mrem to the total body or 0.2 mrem to any organs in a 31-day period.

Liquid radwaste treatment subsystems are shown on Figure 3.2-1.

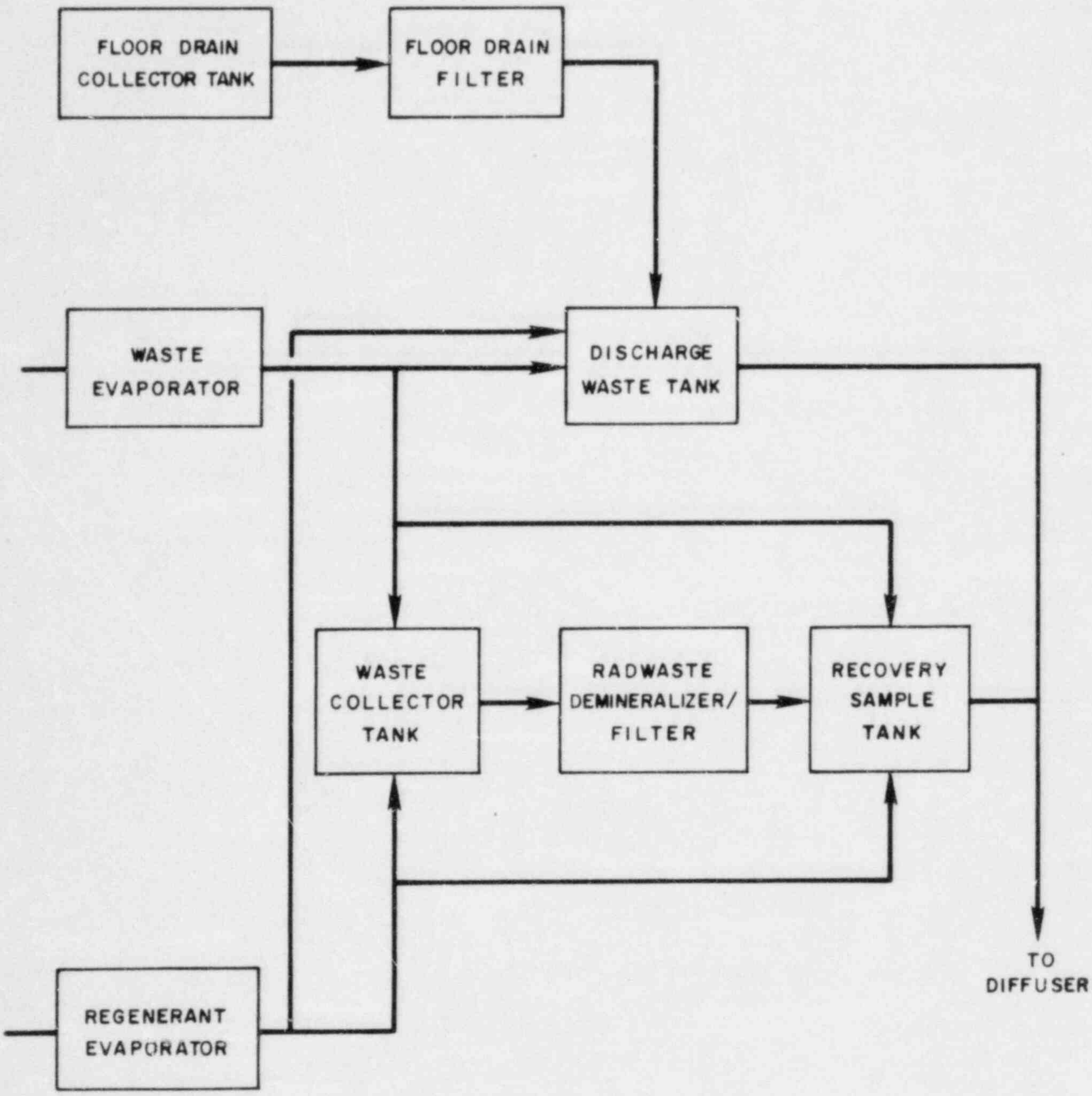


FIGURE 3.2-1
LIQUID RADWASTE TREATMENT SYSTEM
SHOREHAM NUCLEAR POWER STATION-UNIT 1
OFFSITE DOSE CALCULATION MANUAL

3.3 DOSE RATE DUE TO GASEOUS EFFLUENTS

To comply with Section 3.11.2.1 of RETS, the dose rate at any time in the unrestricted area for noble gas dose and for organ dose due to radioactive materials in gaseous effluents released via the station ventilation exhaust duct shall be limited to the following values:

1. For noble gases: Less than or equal to 500 mrem/yr to the total body and less than or equal to 3000 mrem/yr to the skin, and

2. For I-131, I-133, tritium, and for all radionuclides in particulate form with half lives greater than 8 days: Less than or equal to 1500 mrem/yr to any organ.

The gaseous effluent model is shown in Figure 3.3-1.

3.3.1 Method 1: (Computerized Method)

3.3.1.1 Release Rate Estimation

Dose rate estimation is performed every 15 minutes by making use of the atmospheric dispersion calculation made every hour from meteorological data taken every minute (see Section 4), and of the following equation for the release rate (Ci/hr):

$$Q_i = F' f_i$$

where:

$$F' = 4 k \sum_{j=1}^{15} F_s(j) \dot{C}_{ng}(j) \Delta t$$

f_i $= 10^{-6} q_i (\tau) / \dot{C}_{ng}(\tau)$

k $= 2.832 \times 10^4$ (cc/ft^3)

$F_s(j)$ = vent flow during time interval j (cfm)

$\dot{C}_{ng}(j)$ = noble gas effluent monitor count rate during time interval j (cpm)

Δt = time interval (=1 minute)

q_i = concentration of isotope i in the effluent as measured in the lab at time τ (μCi/cc)

F' = 15-minute average of the flow and countrate product (for dose rate estimation every 15 minutes) assumed to apply for a 60-minute interval [(cc/hr) (cpm)]

4×15 = number of Δt intervals per hour (1/hr)

3.3.1.2 Total Body Dose Rate

$$D_{wb} = D_{wb}^{cloud} + D_{wb}^{inh} + D_{wb}^{ground}$$

where:

$$D_{wb}^{cloud} = (\chi/Q)_{\gamma}^{sa}\ F'\ 2.22 \times 10^{4} \sum_{nobles} f_i DFB_i$$

$$D_{wb}^{inh} = (\chi/Q)^{sa}\ F'\ 3.17 \times 10^{4}\ R_{ad} \sum_{part+I} f_i\ DFA_{ij,ad}$$

$$D_{wb}^{ground} = (D/Q)\ F'\ 7 \times 10^{11} \sum_{part+I} f_i\ DFG_{il}[1-e^{-t_b\lambda_i}]/\lambda_i$$

D_{wb}^{cloud} = total body dose due to direct radiation from the radioactive cloud [mrem/hr] (Ref.: Reg. Guide 1.109 Eq. B-8; also similar to Eq. B-6 if one makes use of the gamma (χ/Q) and the DFB_i instead of DF_i^{γ} dose conversion factor)

D_{wb}^{inh} = total body dose (j = total body) due to inhalation [mrem/hr] (Ref.: Reg. Guide 1.109, Eqs. C-3 and C-4, for an adult)

D_{wb}^{ground} = total body dose due to particulate and iodine radioactivity depositing on the ground [mrem/hr] (Ref.: Reg. Guide 1.109, Eqs. C-1 and C-2 with the product 8760 [hr/yr] $(1/\lambda_i)$ [yr] replaced by $(1/\lambda_i)$ [hr] and parameter $\delta_i(r,\theta)$ represented by the (D/Q)).

DFB_i = gamma dose to body conversion factor [(mrem/yr)/(pCi/m^3)] (from Table B-1 of the guide)

$DFA_{ij,ad}$ = dose conversion factor for nuclide i to organ j of an adult individual [mrem/pCi inhaled] (from Tables E-7 through E-10 of Reg. Guide 1.109)

DFG_{il} = total body conversion factor for standing on contaminated ground [(mrem/hr)/(pCi/m^2)] (from Table E-6 of Reg. Guide 1.109)

$(\chi/Q)^{sa}$ = concentration dispersion factor (sector-average model) for the period of release (site boundary only) (sec/m^3)

$(\chi/Q)_{\gamma}^{sa}$ = gamma (χ/Q) (finite cloud sector-average model) for the period of release (site boundary only) (sec/m^3)

(D/Q) = particulate deposition rate (site boundary only) (1/m^2)

$F'\ f_i$ = Q_i (Ci/hr) (as defined in Section 3.3.1.1)

R_{ad} = adult breathing rate (m^3/yr) (from Table E-5 of the Guide)

λ_i = radionuclide decay constant (hr^{-1})

t_b = time period over which the accumulation is evaluated, which is 15 years (1.314×10^5 hours) (Reg. Guide pg 1.109-24)

$3.17\text{x}10^4$ = $10^{12}/(8760 \times 3600)$ [(pCi/Ci) (yr/sec)]

$2.2\text{x}10^4$ = $3.17 \times 10^4 \times 0.7$, where 0.7 is the shielding factor which accounts for the dose reduction due to the shielding effects of residential structures during occupancy (Ref.: Reg. Guide 1.109 Table E-15)

$7\text{x}10^{11}$ = $10^{12} \times 0.7$, where 0.7 is the shielding factor and 10^{12} is the number of pCi per Ci (see Eqs. C-1 and C-2 of the guide)

part+I = 68 particulates and 5 iodines in the summation sign

3.3.1.3 Skin Dose Rate

$$D_{skin} = D_{skin}^{cloud} + D_{skin}^{ground}$$

where:

$$D_{skin}^{cloud} = 1.11 \times 0.7\ (\chi/Q)_\gamma^{sa}\ F'\ 3.17 \times 10^4 \sum_{nobles} f_i\ DF_i^\gamma + (\chi/Q)^{sa}\ F'\ 3.17 \times 10^4 \sum_{nobles} f_i\ DFS_i$$

$$D_{skin}^{ground} = (D/Q)\ F'\ 7 \times 10^{11} \sum_{part+I} f_i\ DFG_{i2}\ [1 - e^{-t_b \lambda_i}]/\lambda_i$$

D_{skin}^{cloud} = skin dose due to direct gamma radiation from the radioactive cloud (first component of the equation with finite cloud modeling) and beta radiation (second component, semi-infinite cloud immersion) [mrem/hr] (Ref.: Reg. Guide 1.109 Eq. B-9; also similar to Eq. B-7 if one makes use of the gamma (χ/Q))

D_{skin}^{ground} = skin dose due to particulate and iodine radioactivity depositing on the ground [mrem/hr] (Ref.: Reg. Guide 1.109, Eqs. C-1 and C-2 with the product 8760 [hr/yr] ($1/\lambda_i$) [yr] replaced by ($1/\lambda_i$) [hr] and parameter δ_i (r,Θ) represented by the (D/Q))

DF_i^γ = gamma dose to air conversion factor [(mrad/yr)/(pCi/m^3)] (from Table B-1 of the Guide)

DFS_i = beta dose to skin conversion factor [(mrem/yr)/(pCi/m^3)] (from Table B-1 of the Guide)

DFG_{i2} = skin dose conversion factor for standing on contaminated ground $[(mrem/hr)/(pCi/m^2)]$ (from Table E-6 of Reg. Guide 1.109)

1.11 = average ratio of tissue to air energy absorption coefficient (from Reg. Guide 1.109, pg 1.109-6)

0.7 = shielding dose-reduction factor (see pg 1.109-68 of the Guide)

λ_i = radionuclide decay constant $[hr^{-1}]$

3.3.1.4 <u>Organ Dose Rate (I-131, I-133, Tritium and Particulate Release)</u>

$$D_{ja}^{inh} = \left(\chi/Q^{sa}\ F'\ 3.17 \times 10^4\ R_a\right) \sum_{part+I} f_i DFA_{ija}$$

where:

D_{ja}^{inh} = dose to organ j of individual in age group a due to inhalation of airborne radioactivity [mrem/hr] (Ref.: Reg. Guide 1.109, Eqs. C-3 and C-4.)

DFA_{ija} = dose conversion factor for nuclide i to organ j of individual in age group a [mrem/pCi inhaled] (from Tables E-7 through E-10 of the Guide)

R_a = breathing rate of individual in age group a $[m^3/yr]$ (from Table E-5 of Reg. Guide 1.109, for the maximum individuals)

The analysis is limited to the computation of the thyroid dose to a child at the site boundary in the downwind sector for the period of the release (i.e., j = thyroid, a = child).

3.3.2 Method 2: (Backup Method)

3.3.2.1 Noble Gas Total Body Dose Rate

$$DT_s = 0.7 * \chi/Q_1 * \sum_i [DFB_i *(C_{i1}* V_1 - C_{i2}* V_2 - C_{i3}* V_3)]$$
$$+ 0.7 * V_2 * \chi/Q_2 * \sum_i [DFB_i * C_{i2}]$$
$$+ 0.7 * V_3* \chi/Q_3 * \sum_i [DFB_i * C_{i3}] \quad \text{(mrem/yr)}$$

During periods of no intermittent releases such as no main condenser air removal pump operation and no containment drywell purge the above formula reduces to the following:

$$DT_s = 0.7 * V_1 * \chi/Q_1 * \sum_i [DFB_i * C_{i1}] \quad \text{(mrem/yr)}$$

where:

DT_s = total body dose rate from all radionuclides releases (mrem/yr),

DFB_i = the total body dose rate factor due to gamma emissions for each identified noble gas radionuclide (mrem/yr per pCi/m^3) (Table 2.2-1),

C_{i1} = the station ventilation exhaust duct release concentration of radionuclide, i, (pCi/cc) (from the isotopic analyses performed on the gaseous sample taken from the station ventilation exhaust monitor),

C_{i2} = the air removal pump ventilation exhaust duct release concentration of radionuclide, i, (pCi/cc) (from the isotopic analyses performed on the gaseous sample taken from the air removal pump discharge monitor),

C_{i3} = the containment drywell purge ventilation exhaust concentration of radionuclide, i, (pCi/cc) (from the isotopic analyses performed on the gaseous sample taken from the containment drywell filter train exhaust monitor),

V_1 = 1.73E+08 cc/sec (3.66E+05 cfm), station ventilation exhaust duct ventilation exhaust flow rate,

V_2 = 5.70E+05 cc/sec (1200 cfm), air removal pump exhaust duct ventilation exhaust flow rate,

V_3 = 5.70E+05 cc/sec (1200 cfm), containment drywell purge ventilation exhaust flow rate,

χ/Q_1 = annual average χ/Q at 366 meters NNE due to release via the station ventilation exhaust point (6.6E-07 sec/m^3),

χ/Q_2 = short term χ/Q at 366 meters NNE due to air removal pump release via the station ventilation exhaust point (3.6E-06 sec/m^3),

χ/Q_3 = short term χ/Q at 366 meters NNE due to containment drywell purge via the station ventilation exhaust point (3.6E-06 sec/m^3).

0.70 = shielding factor that accounts for dose reduction due to shielding from residential structures.

3.3.2.2 Noble Gas Skin Dose Rate

$$DS_s = \chi/Q_1 * \sum_i [K_{si} *(C_{i1} * V_1 - C_{i2} * V_2 - C_{i3} * V_3)]$$

$$+ V_2 * \chi/Q_2 * \sum_i [K_{si} * C_{i2}] + V_3 * \chi/Q_3 * \sum_i [K_{si} * C_{i3}] \quad \text{(mrem/yr)}$$

During periods of no intermittent releases such as no main condenser air removal pump operation and no containment drywell purge the above formula reduces to the following:

$$DS_s = V_1 * \chi/Q_1 * \sum_i [K_{si} * C_{i1}] \quad \text{(mrem/yr)}$$

where:

DS_s = skin dose rate from all radionuclides released (mrem/yr),

K_{si} = the skin dose factor due to beta and gamma emissions for each identified noble gas radionuclide (mrem/yr per pCi/m^3) from Table 2.2-1,

C_{i1} = the station ventilation exhaust duct release concentration of radionuclide, i, (pCi/cc) (from isotopic analyses performed on the gaseous sample taken from the station ventilation exhaust monitor),

C_{i2} = the air removal pump ventilation exhaust duct release concentration of radionuclide, i, (pCi/cc) (from the isotopic analyses performed on the gaseous sample taken from the air removal pump discharge monitor),

C_{i3} = the containment drywell purge ventilation exhaust concentration of radionuclide, i, (pCi/cc) (from the isotopic analyses performed on the gaseous sample taken from the containment drywell filter train exhaust monitor),

V_1 = 1.73E+08 cc/sec (3.66E+05 cfm), station ventilation exhaust duct ventilation exhaust flow rate,

V_2 = 5.70E+05 cc/sec (1200 cfm), air removal pump exhaust duct ventilation exhaust flow rate,

V_3 = 5.70E+05 cc/sec (1200 cfm), containment drywell purge ventilation exhaust flow rate,

χ/Q_1 = annual average χ/Q at 366 meters NNE due to release via the station ventilation exhaust point (6.6E-07 sec/m^3),

χ/Q_2 = short term χ/Q at 366 meters NNE due to air removal pump release via the station ventilation exhaust point (3.6E-06 sec/m^3),

χ/Q_3 = short term χ/Q at 366 meters NNE due to containment drywell purge via the station ventilation exhaust point (3.6E-06 sec/m^3).

3.3.2.3 <u>Organ Dose Rate (Particulate Releases)</u>

$$D_{sj} = \sum_i \left[10^6 * R_a * P_{ij} * \chi/Q_1 * (C_{i1} V_1 - C_{i2} V_2 - C_{i3} V_3)\right]$$
$$+ V_2 * \sum_i \left[10^6 * R_a * P_{ij} * \chi/Q_2 * C_{i2}\right]$$
$$+ V_3 * \sum_i \left[10^6 * R_a * P_{ij} * \chi/Q_3 * C_{i3}\right] \quad \text{(mrem/yr)}$$

During periods of no intermittent releases, such as no main condenser air removal pump operation and no containment drywell purge, the above formula reduces to the following:

$$D_{sj} = V_1 * \sum_i 10^6 * R_a * P_{ij} * \chi/Q_1 * C_{i1} \quad \text{(mrem/yr)}$$

where:

D_{sj} = total dose rate to organ, j, mrem/yr.

P_{ij} = the inhalation dose conversion factor, for radionuclides other than noble gases, i, and organ, j, in mrem per pCi from Table 3.5-3.

The dose factor P_{ij} is based on the critical individual organ for the Child group, which is most restictive. Inhalation dose factors for other age groups are given in Tables 3.5-1, 3.5-2, and 3.5-4.

R_a = inhalation rate (m^3/yr), from Table 3.5-5.

C_{i1} = the station ventilation exhaust duct release concentration of radionuclide, i, (µCi/cc) (from the isotopic analyses performed on the filter paper and charcoal cartridge taken from the station ventilation exhaust monitor),

C_{i2} = the air removal pump ventilation exhaust duct release concentration of radionuclide, i, (μCi/cc) (from the isotopic analyses performed on the iodine and filter cartridge taken from the air removal pump discharge monitor),

C_{i3} = the containment drywell purge ventilation exhaust concentration of radionuclide, i, (μCi/cc) (from the isotopic analyses performed on the gaseous sample taken from the containment drywell filter train exhaust monitor),

V_1 = 1.70E+08 cc/sec (3.60E+05 cfm), station ventilation exhaust duct ventilation exhaust flow rate,

V_2 = 5.70E+05 cc/sec (1200 cfm), air removal pump exhaust duct ventilation exhaust flow rate,

V_3 = 5.70E+05 cc/sec (1200 cfm), containment drywell purge ventilation exhaust flow rate,

χ/Q_1 = annual average χ/Q at 2478 meters ESE due to releases via the station ventilation exhaust point (1.54E-07 sec/m^3),

χ/Q_2 = short term χ/Q at 2478 meters ESE due to condenser air removal pump release via the station ventilation exhaust point (4.22E-07 sec/m^3),

χ/Q_3 = short term χ/Q at 2478 meters ESE due to containment drywell purge via the station ventilation exhaust point (4.22E-07 sec/m^3).

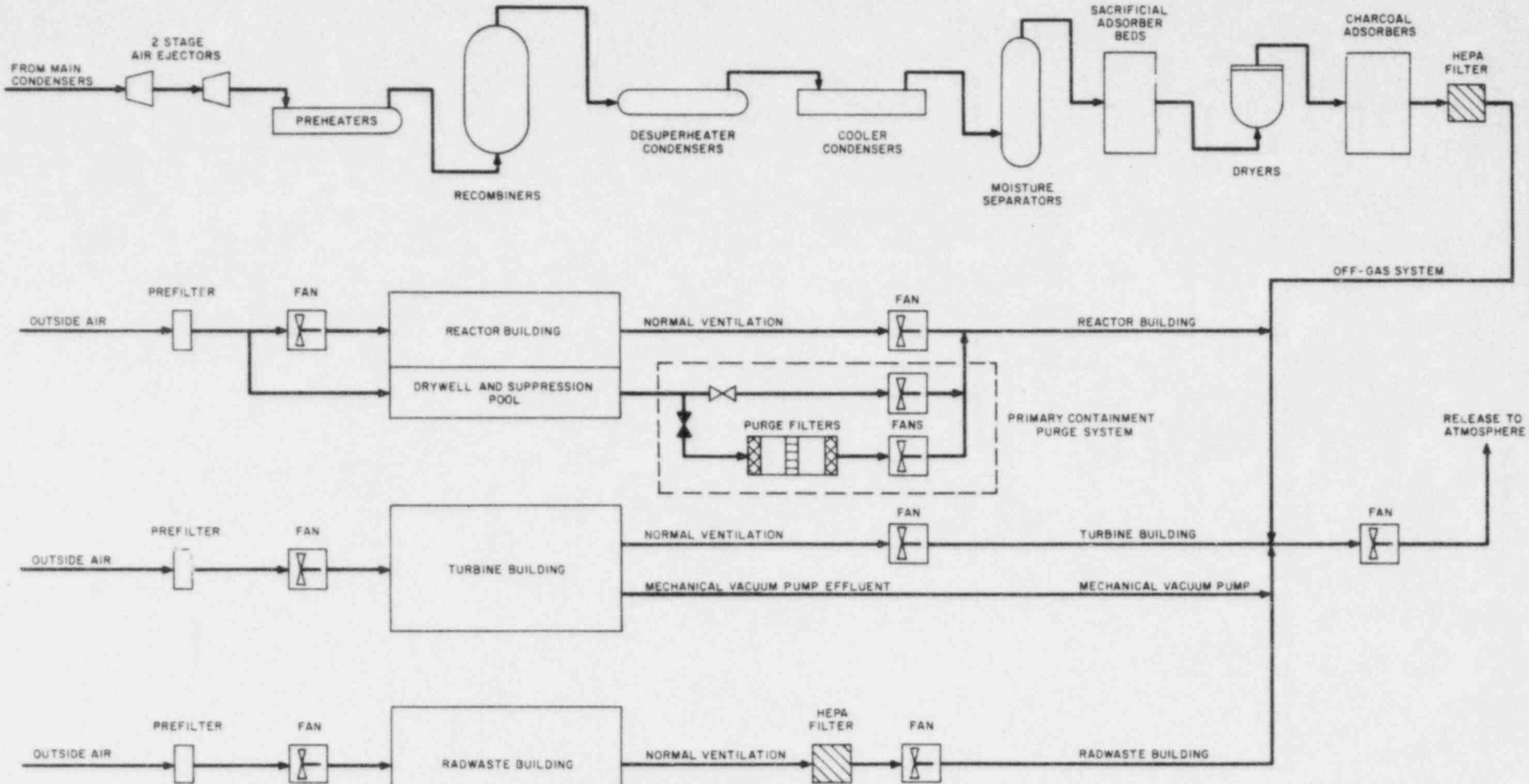


FIGURE 3.3-1
GASEOUS EFFLUENT MODEL
SHOREHAM NUCLEAR POWER STATION-UNIT 1
OFFSITE DOSE CALCULATION MANUAL

REVISION 1 - AUGUST 1983

3.4 GASEOUS EFFLUENTS NOBLE GAS AIR DOSE

To comply with Section 3.11.2.2 of the RETS, the air dose in unrestricted area location due to releases via the station ventilation exhaust point shall be limited to the following:

1. During any calendar quarter: Less than or equal to 5 mrads for gamma radiation and less than or equal to 10 mrads for beta radiation.

2. During any calendar year: Less than or equal to 10 mrads for gamma radiation and less than or equal to 20 mrads for beta radiation.

3.4.1 Method 1: (Computerized Method)

Cumulative doses are calculated by making use of hourly dose rate equations presented in the following subsections.

3.4.1.1 Release Estimation

Dose estimation is performed every hour by making use of the atmospheric dispersion calculation made every hour from meteorological data taken every minute (see Section 4), and of the following equation for the release rate (Ci/hr):

$$Q_i = F' f_i$$

where:

$$F' = k \sum_{j=1}^{60} F_s(j)\, \dot{C}_{ng}(j)\, \Delta t$$

$$f_i = 10^{-6}\, q_i(\tau) \,/\, \dot{C}_{ng}(\tau)$$

k = 2.832×10^4 (cc/ft^3)

$F_s(j)$ = vent flow rate during interval j (cfm)

$\dot{C}_{ng}(j)$ = noble gas effluent monitor count rate during interval j (cpm)

Δt = time interval (= 1 minute)

q_i = concentration of isotope i in the effluent as measured in the lab at time τ (μCi/cc)

F' = 60-minute average of the flow and count-rate product [(cc/hr) (cpm)]

60 = number of Δt intervals per hour (1/hr)

3.4.1.2 Noble Gas Gamma Air Dose

$$D_{\gamma,air} = (\chi/Q)_{\gamma}^{sa}\ F'\ 3.17 \times 10^{4} \sum_{nobles} f_i\ DF_i^{\gamma}$$

where

$D_{\gamma,air}$ = gamma dose to air at the site boundary in the downwind sector during the period of release (mrad/hr) (Ref.: Reg. Guide 1.109, Eqs. B-4 and B-5, and also Eq. B-1 with the substitution of $(\chi/Q)_{\gamma}$

$(\chi/Q)_{\gamma}^{sa}$ = finite-cloud sector-average 'gamma' dilution factor at the downwind site-boundary [sec/m^3]

DF_i^{γ} = gamma dose to air conversion factor (from Table B-1 of Reg. Guide 1.109) [(mrad/yr)/(pCi/m^3)]

$F'f_i$ = Q_i (Ci/hr) (see Section 3.4.1.1)

3.4.1.3 Noble Gas Beta Air Dose

$$D_{\beta,air} = (\chi/Q)^{sa}\ F'\ 3.17 \times 10^{4} \sum_{nobles} f_i\ DF_i^{\beta}$$

where

$D_{\beta,air}$ = beta dose to air at the site boundary in the downwind sector during the period of release [mrad/hr] (Ref.: Reg. Guide 1.109, Eqs. B-4 and B-5)

DF_i^{β} = beta dose to air conversion factor (from Table B-1 of Reg. Guide 1.109) [(mrad/yr)/(pCi/m^3)]

$F'f_i$ = Q_i (Ci/hr) (see Section 3.4.1.1)

$(\chi/Q)^{sa}$ = sector-average concentration dilution factor at the site boundary during the period of release [sec/m^3]

3.4.2 Method 2: (Backup Method)

3.4.2.1 Noble Gas Gamma Air Dose

The general equation is:

$$D_{G_s} = 3.17E\text{-}08 * \chi/Q_1 * \sum_i \left[M_i * (C_{i1}\, V_1\, t_1 - C_{i2}\, V_2\, t_2 - C_{i3}\, V_3 t\,)\right]$$
$$+\ 3.17E\text{-}08 * V_2 * t_2 * \chi/Q_2 * \sum_i \left[M_i * C_{i2}\right]$$
$$+\ 3.17E\text{-}08 * V_3 * t_3 * \chi/Q_3 * \sum_i \left[M_i * C_{i3}\right] \qquad \text{(mrad)}$$

During periods of no intermittent releases, such as no main condenser air removal pump operation and no containment drywell purge, the above formula reduces to the following:

$$D_{G_s} = 3.17E\text{-}08 * V_1 * t_1 * \chi/Q_1 * \Sigma_i \left[M_i * C_{i1}\right] \qquad \text{(mrad)}$$

where:

D_{G_s} = the total gamma air dose from the releases (mrad),

3.17E-08 = the inverse of number of seconds in a year,

M_i = the air dose factor due to gamma emissions for each identified noble gas radionuclide (mrad/yr per $\mu Ci/m^3$) from Table 3.4-1,

t_1 = 7.88E+06 sec for quarterly dose calculation,
= 3.15E+07 sec for yearly dose calculation

t_2 = release period (sec) for condenser air removal pump

t_3 = release period (sec) for containment drywell purge exhaust

C_{i1} = the station ventilation exhaust duct release concentration of radionuclide, i, (μCi/cc) (from the isotopic analyses performed on the gaseous sample taken from the station ventilation exhaust monitor),

C_{i2} = the air removal pump ventilation exhaust duct release concentration of radionuclide, i, (μCi/cc) (from the isotopic analyses performed on the gaseous sample taken from the air removal pump discharge monitor),

C_{i3} = the containment drywell purge ventilation exhaust concentration of radionuclide, i, (μCi/cc) (from the isotopic analyses performed on the gaseous sample taken from the containment drywell filter train exhaust monitor),

V_1 = 1.73E+08 cc/sec (3.66E+05 cfm), station ventilation exhaust duct ventilation exhaust flow rate,

V_2 = 5.70E+05 cc/sec (1200 cfm), air removal pump exhaust duct ventilation exhaust flow rate,

V_3 = 5.70E+05 cc/sec (1200 cfm), containment drywell purge ventilation exhaust flow rate,

χ/Q_1 = annual average χ/Q at 457 meters ESE due to release via the station ventilation exhaust point (8.44E-07 sec/m^3),

χ/Q_2 = short term χ/Q at 457 meters ESE due to condenser air removal pump release via the station ventilation exhaust point (1.83E-06 sec/m^3),

χ/Q_3 = short term χ/Q at 457 meters ESE due to containment drywell purge release via the station ventilation exhaust release point (1.83E-06 sec/m^3).

3.4.2.2 Noble Gas Beta Air Dose

The general equation is:

$$D_{B_s} = 3.17E\text{-}08 * \chi/Q_1 * \sum_i \left[N_i *(C_{i1} V_1 t_1 - C_{i2} V_2 t_2 - C_{i3} V_3 t_3)\right]$$

$$+ 3.17E\text{-}08 * \chi/Q_2 * V_2 * t_2 * \sum_i \left[N_i * C_{i2}\right]$$

$$+ 3.17E\text{-}08 * \chi/Q_3 * V_3 * t_3 * \sum_i \left[N_i * C_{i3}\right] \qquad \text{(mrad)}$$

During periods of no intermittent releases, such as no main condenser air removal pump operation and no containment drywell purge, the above formula reduces to the following:

$$D_{B_s} = 3.17E\text{-}08 * \chi/Q_1 * V_1 * t_1 \sum_i \left[N_i * C_{i1}\right] \qquad \text{(mrad)}$$

where:

D_{B_s} = beta air dose from all radionuclides released (mrad),

N_i = the air dose factor due to beta emissions for each identified noble gas radionuclide (mrad/yr per $\mu Ci/m^3$) from Table 3.4-1,

3.17E-08 = the inverse of number of seconds in a year,

t_1 = 7.88E+06 sec for quarterly dose calculation,
= 3.15E+07 sec for yearly dose calculation,

t_2 = release period (sec) for condenser air removal pump,

t_3 = release period (sec) for containment drywell purge exhuast,

C_{i1} = the station ventilation exhaust duct release concentration of radionuclide, i, (μCi/cc) (from the isotopic analyses performed on the gaseous sample taken from the station ventilation exhaust monitor),

C_{i2} = the air removal pump ventilation exhaust duct release concentration of radionuclide, i, (μCi/cc) (from the isotopic analyses performed on the gaseous sample taken from the air removal pump discharge monitor),

C_{i3} = the containment drywell purge ventilation exhaust concentration of radionuclide, i, (μCi/cc) (from the isotopic analysis performed on the gaseous sample taken from the containment drywell filter train exhaust monitor),

V_1 = 1.73E+08 cc/sec (3.66E+05 cfm), station ventilation exhaust duct ventilation exhaust flow rate,

V_2 = 5.70E+05 cc/sec (1200 cfm), air removal pump exhaust duct ventilation exhaust flow rate,

V_3 = 5.70E+05 cc/sec (1200 cfm), containment drywell purge ventilation exhaust flow rate,

χ/Q_1 = annual average χ/Q at 457 meters ESE due to release via the station ventilation exhaust point (8.44E-07 sec/m^3),

χ/Q_2 = short term χ/Q at 457 meters ESE due to condenser air removal pump release via the station ventilation exhaust point (1.83E-06 sec/m^3), and

χ/Q_3 = short term χ/Q at 457 meters ESE due to containment drywell purge release via the station ventilation exhaust point (1.83E-06 sec/m^3).

TABLE 3.4-1

NOBLE GAS DOSE FACTORS

Isotope	Gamma Air Dose Factor M_i (mrad/yr per $\mu Ci/m^3$)	Beta Air Dose Factor N_i (mrad/yr per $\mu Ci/m^3$)
Kr - 83m	1.9E+01	2.9E+02
Kr - 85m	1.2E+03	2.0E+03
Kr - 85	1.7E+01	2.0E+03
Kr - 87	6.2E+03	1.0E+04
Kr - 88	1.5E+04	2.9E+03
Kr - 89	1.7E+04	1.1E+04
Kr - 90	1.6E+04	7.8E+03
Xe - 131m	1.6E+02	1.1E+03
Xe - 133m	3.3E+02	1.5E+03
Xe - 133	3.5E+02	1.1E+03
Xe - 135m	3.4E+03	7.4E+02
Xe - 135	1.9E+03	2.5E+03
Xe - 137	1.5E+03	1.3E+02
Xe - 138	9.2E+03	4.8E+03
Ar - 41	9.3E+03	3.3E+03

3.5 GASEOUS EFFLUENTS, DOSE DUE TO RADIOIODINES AND RADIOACTIVE MATERIALS IN PARTICULATE FORM AND RADIONUCLIDES (other than Noble Gases) WITH HALF-LIVES GREATER THAN 8 DAYS

To comply with Section 3.11.2.3 of the Radiological Effluent Technical Specifications, the organ dose to maximum individual in unrestricted area due to radioiodines and particulates releases via the station ventilation exhaust point shall be limited to the following:

1. During any calendar quarter: Less than or equal to 7.5 mrem to any organ, and

2. During any calendar year: Less than or equal to 15 mrem to any organ.

3.5.1 Method 1: (Computerized Method)

Cumulative doses are calculated by making use of hourly dose rate equations presented in the following subsections.

3.5.1.1 Release Estimation

Dose estimation is peformed every hour by making use of the atmospheric dispersion calculation made every hour from meteorological data taken every minute (see Section 4), and of the following equation for the release rate (Ci/hr):

$$Q_i = F' f_i$$

where:

$$F' = k \sum_{j=1}^{60} F_s(j)\, \dot{C}_{ng}(j)\, \Delta t$$

$$f_i = 10^{-6}\, q_i(\tau) \,/\, \dot{C}_{ng}(\tau)$$

k = 2.832×10^4 (cc/ft^3)

$F_s(j)$ = vent flow rate during interval j (cfm)

$\dot{C}_{ng}(j)$ = noble gas effluent monitor count rate during interval j (cpm)

Δt = time interval (= 1 minute)

q_i = concentration of isotope i in the effluent as measured in the lab at time τ (µCi/cc)

F' = 60-minute average of the flow and count-rate product [(cc/hr) (cpm)]

60 = number of Δt intervals per hour (1/hr)

3.5.1.2 Total Body Dose

$$D_{wb} = D_{wb}^{cloud} + D_{wb}^{inh} + D_{wb}^{ground}$$

where:

$$D_{wb}^{cloud} = (\chi/Q)_{\gamma}^{sa} \; F' \; 2.22 \times 10^{4} \sum_{nobles} f_i \; DFB_i$$

$$D_{wb}^{inh} = (\chi/Q)^{sa} \; F' \; 3.17 \times 10^{4} \; R_{ad} \sum_{part+I} f_i DFA_{ij,ad}$$

$$D_{wb}^{ground} = (D/Q) \; F' \; 7 \times 10^{11} \sum_{part+I} f_i \; DFG_{i1} \; [1 - e^{-t_b \lambda_i}]/\lambda_i$$

D_{wb}^{cloud} = total body dose due to direct radiation from the radioactive cloud [mrem/hr] (Ref.: Reg. Guide 1.109 Eq. B-8; also similar to Eq. B-6 if one makes use of the gamma (χ/Q) and the DFB_i instead of DF_i^{γ} dose conversion factor)

D_{wb}^{inh} = total body dose (j = total body) due to inhalation [mrem/hr] (Ref.: Reg. Guide 1.109, Eqs. C-3 and C-4, for an adult)

D_{wb}^{ground} = total body dose due to particulate and iodine radioactivity depositing on the ground [mrem/hr] (Ref.: Reg. Guide 1.109, Eqs. C-1 and C-2 with the product 8760 [hr/yr] $(1/\lambda_i)$ [yr] replaced by $[1/\lambda_i)$ [hr] and parameter $\delta_i(r,\theta)$ represented by the $(D/Q))$

DFB_i = gamma dose to body conversion factor $[(mrem/yr)/(pCi/m^3)]$ (from Table B-1 of the Reg. Guide)

$DFA_{ij,ad}$ = dose conversion factor for nuclide i to organ j of an adult individual [mrem/pCi inhaled] (from Tables E-7 through E-10 of Reg. Guide 1.109)

DFG_{i1} = total body conversion factor for standing on contaminated ground $[(mrem/hr)/(pCi/m^2)]$ (from Table E-6 of Reg. Guide 1.109)

$(\chi/Q)^{sa}$ = concentration dispersion factor (sector-average model) for the period of release (site boundary only) (sec/m^3)

$(\chi/Q)_{\gamma}^{sa}$ = gamma (χ/Q) (finite cloud sector-average model) for the period of release (site boundary only) (sec/m^3)

(D/Q) = particulate deposition rate (site boundary only) (1/m^2)

$F' f_i$ = Q_i (Ci/hr) (as defined in Section 3.5.1.1)

R_{ad} = adult breathing rate (m^3/yr) (from Table E-5)

λ_i = radionuclide decay constant (1/hr)

t_b = time period over which the accumulation is evaluated, which is 15 years (1.314×10^5 hours) (Reg. Guide pg 1.109-24)

3.17×10^4 = $10^{12}/(8760 \times 3600)$ [(pCi/Ci) (yr/sec)]

2.22×10^4 = $3.17 \times 10^4 \times 0.7$, where 0.7 is the shielding factor which accounts for the dose reduction due to the shielding effects of residential structures during occupancy (Ref.: Reg. Guide 1.109 Table E-15)

7×10^{11} = $10^{12} \times 0.7$, where 0.7 is the shielding factor and 10^{12} is the number of pCi per Ci (see Eqs. C-1 and C-2 of the guide)

part+I = 68 particulates and 5 iodines in the summation sign

Note that the total "total body" dose as computed above is used only for hourly assessment of plant operation within the specification limits. The reports prepared by the dose software include the total body dose due to inhalation as a separate parameter. Also note that the equation conservatively includes the dose due to the airborne noble gases, even though this section addresses only the iodines and particulates.

3.5.1.3 Skin Dose

$$D_{skin} = D_{skin}^{cloud} + D_{skin}^{ground}$$

where:

$$D_{skin}^{cloud} = 1.11 \times 0.7\,(\chi/Q)_{\gamma}^{sa}\,F'\,3.17 \times 10^4 \sum_{nobles} f_i\,DF_i^{\gamma}$$

$$+ (\chi/Q)^{sa}\,F'\,3.17 \times 10^4 \sum_{nobles} f_i\,DFS_i$$

$D_{skin}^{ground} = (D/Q)\ F'\ 7 \times 10^{11} \sum_{part+I} f_i\ DFG_{i2}[1 - e^{-t_b \lambda_i}]/\lambda_i$

D_{skin}^{cloud} = skin dose due to direct gamma radiation from the radioactive cloud (first component of the equation with finite cloud modeling) and beta radiation (second component, semi-infinite cloud immersion) [mrem/hr] (Ref.: Reg. Guide 1.109 Eq. B-9; also similar to Eq. B-7 if one makes use of the gamma (χ/Q))

D_{skin}^{ground} = skin dose due to particulate and iodine radioactivity depositing on the ground [mrem/hr] (Ref.: Reg. Guide 1.109, Eqs. C-1 and C-2 with the product 8760[hr/yr] ($1/\lambda_i$)[yr] replaced by ($1/\lambda_i$)[hr] and parameter δ_i (r,θ) represented by the (D/Q))

DF_i^{γ} = gamma dose to air conversion factor [(mrad/yr)/(pCi/m^3)] (from Table B-1 of the Guide)

DFS_i = beta dose to skin conversion factor [(mrem/yr)/(pCi/m^3)] (from Table B-1 of the Guide)

DFG_{i2} = skin dose conversion factor for standing on contaminated ground [(mrem/hr)/(pCi/m^2)] (from Table E-6 of Reg. Guide 1.109)

1.11 = average ratio of tissue to air energy absorption coefficient (from Reg. Guide 1.109, pg 1.109-6)

0.7 = shielding dose-reduction factor (from Reg. Guide 1.109, pg 1.109-68)

and the remaining parameters are as defined above in Section 3.5.1.2.

Note that the total skin dose as described here includes the contribution of airborne noble gases, even though this section addresses only the iodines and particulates.

3.5.1.4 Organ Doses Due to Inhalation

$$D_{ja}^{inh} = (\chi/Q)^{sa} F' \, 3.17 \times 10^{4} R_a \sum_{part+I} f_i \, DFA_{ija}$$

where:

D_{ja}^{inh} = dose to organ j of individual in age group a due to inhalation of airborne radioactivity [mrem/hr] (Ref.: Reg. Guide 1.109 Eqs. C-3 and C-4)

DFA_{ija} = dose conversion factor for nuclide i to organ j of individual in age group a [mrem/pCi inhaled] (from Tables E-7 through E-10 of the Guide)

R_a = breathing rate of individual in age group a [m^3/yr] (from Table E-5 of Reg. Guide 1.109, for the maximum individuals)

$(\chi/Q)^{sa}$ = concentration dispersion factor (Sector-Average model) for the period of release (nearest garden and nearest residence) [sec/m^3]

3.5.1.5 Organ Doses Due to Ingestion of Leafy Vegetables

$$D_{ja}^{ing} = \left(D_{ja}^{ing}\right)_{part} + \left(D_{ja}^{ing}\right)_{iodines} + \left(D_{ja}^{ing}\right)_{C14} + \left(D_{ja}^{ing}\right)_{H3}$$

where:

$$\left(D_{ja}^{ing}\right)_{part} = (D/Q) \, F' \, 1.1 \times 10^{8} \sum_{part} U_a^L \, f_i \, DFI_{ija} \times \left\{\frac{0.2}{2(\lambda_i + 0.0021)} + \frac{B_{iv}}{240 \, \lambda_i}\right\} e^{-24\lambda_i}$$

$$\left(D_{ja}^{ing}\right)_{iodines} = (D/Q) \, F' \, 5.5 \times 10^{7} \sum_{iodines} U_a^L \, f_i \, DFI_{ija} \times \left\{\frac{1.0}{2(\lambda_i + 0.0021)} + \frac{B_{iv}}{240 \, \lambda_i}\right\} e^{-24\lambda_i}$$

$$\left(D_{ja}^{ing}\right)_{C14} = (\chi/Q)^{sa} F' \, 2.2 \times 10^{7} \, U_a^L \, f_{C14} \, DFI_{C14,ja}$$

$$\left(D_{ja}^{ing}\right)_{H3} = (\chi/Q)^{sa} F' \left(\frac{1.2 \times 10^{7}}{H}\right) U_a^L \, f_{H3} \, DFI_{H3,ja}$$

$(D_{ja}^{ing})_{part}$ = dose to organ j of individual in age group a due to ingestion of leafy vegetables contaminated with particulate radioactivity [mrem/hr] (Ref.: Reg. Guide 1.109, Eqs. C-5, C-6 and C-13 for leafy vegetables only, with the following:

- r(fraction of deposited activity retained on crops) = 0.2 (see pg 1.109-68 of the Guide)
- t_e (time period that crops are exposed to contamination during growing season) = ∞ [hrs]
- t_b (time period over which the accumulation is evaluated) = ∞ [hrs]
- t_h (time delay between harvest of vegetation or crops and ingestion) = 24 [hrs]
- Y_v (agricultural productivity) = 2 [kg/m^2]
- P (soil effective surface density) = 240 [kg/m^2]
- $\lambda_{Ei} = \lambda_i + 0.0021$ [hr^{-1}] (Ref.: Reg. Guide 1.109, pgs 1.109-4 and 1.109-69)
- δ_i (r,θ) = (D/Q) [m^{-2}]
- f_ℓ (fraction of leafy vegetables growing in garden of interest) = 1.0

$(D_{ja}^{ing})_{iodines}$ = dose to organ j of individual in age group a due to ingestion of leafy vegetables contaminated with radioiodines [mrem/hr] (Ref.: Reg. Guide 1.109 Eqs. C-5, C-7 and C-13 for leafy vegetables only; similar to the organ dose due to particulate radioactivity given above but with r = 1.0 and different multiplying constant)

$(D_{ja}^{ing})_{C14}$ = dose to organ j of individual in age group a due to ingestion of leafy vegetables exposed to airborne Carbon-14 [mrem/hr] (Ref.: Reg. Guide 1.109, Eqs. C-8 and C-13 for leafy vegetables only, with p (the ratio of the total annual release time to the total annual time during which photosynthesis occurs) = 1)

$(D_{ja}^{ing})_{H3}$ = dose to organ j of individual in age group a due to ingestion of leafy vegetables exposed to airborne tritium [mrem/hr] (Ref.: Reg. Guide 1.109, Eqs. C-9 and C-13 for leafy vegetables only)

U_a^L = ingestion rate of leafy vegetables by individual in age group a (from Table E-5 of the Guide, maximum individual) [kg/yr]

B_{iv} = concentration factor for uptake of radionuclide i from soil by edible parts of crops [(pCi/kg)(wet weight)/ (pCi/kg) (dry soil)] (Ref.: Reg. Guide 1.109, Table E-1 and included on Table 3.5-6)

DFI_{kja} = dose conversion factor for nuclide i to organ j of individual in age group a due to ingestion of contaminated food [mrem/pCi ingested] (from Tables E-11 through E-14 of the Guide)

$DFI_{C14,ja}$ = DFI_{ija} for Carbon-14

$DFI_{H3,ja}$ = DFI_{ija} for tritium

F_{C14} = f_i for Carbon-14 (see Section 3.5.1.1 above)

f_{H3} = f_i for tritium

H = absolute humidity of the atmosphere at the location of interest [g/m^3] (See Table 3.5-7)

$(\chi/Q)^{sa}$ = concentration dispersion factor (Sector - Average model) for the period of release (nearest garden and nearest residence) [sec/m^3]

(D/Q) = particulate deposition rate (nearest garden and nearest residence) [$1/m^2$]

3.5.1.6 Infant Thyroid Dose Due to Inhalation and Ingestion of Goat Milk

Infant is used here as a default age group but in locations where there is no infant, such as 681 (see Table 5-5), child parameters will be substituted as appropriate.

$$D_{thy,inf} = D_{thy,inf}^{inh} + D_{thy,inf}^{milk}$$

where:

$$D_{thy,inf}^{milk} = \left(D_{thy,inf}^{milk}\right)_{part} + \left(D_{thy,inf}^{milk}\right)_{iodines} + \left(D_{thy,inf}^{milk}\right)_{C14} + \left(D_{thy,inf}^{milk}\right)_{H3}$$

$$D_{thy,inf}^{inh} = (\chi/Q)^{sa}\ F'\ 3.17 \times 10^4\ R_{inf} \sum_{part+I} f_i\ DFA_{i,thy,inf}$$

$$\left(D^{milk}_{thy,inf}\right)_{part} = (D/Q)\ F'\ 1.1 \times 10^{8} \sum_{part} U^{m}_{inf}\ f_i\ DFI_{i,thy,inf}$$

$$\times\ 6\ F_{mi}\ \left\{\frac{0.2}{0.7(\lambda_i + 0.0021)} + \frac{B_{iv}}{240\ \lambda_i}\right\} e^{-48\lambda_i}$$

$$\left(D^{milk}_{thy,inf}\right)_{iodines} = (D/Q)\ F'\ 5.5 \times 10^{7} \sum_{iodines} U^{m}_{inf}\ f_i\ DFI_{i,thy,inf}$$

$$\times\ 6\ F_{mi}\ \left\{\frac{1.0}{0.7\ (\lambda_i + 0.0021)} + \frac{B_{iv}}{240\ \lambda_i}\right\} e^{-48\lambda_i}$$

$$\left(D^{milk}_{thy,inf}\right)_{C14} = (\chi/Q)^{sa}\ F'\ 2.2 \times 10^{7}\ U^{m}_{inf}\ f_{C14}\ DFI_{C14,thy,inf}$$

$$\times\ 6\ F_{m,C14} \exp(-48\ \lambda_{C14})$$

$$\left(D^{milk}_{thy,inf}\right)_{H3} = (\chi/Q)^{sa}\ F'\ \left(\frac{1.2 \times 10^{7}}{H}\right) U^{m}_{inf}\ f_{H3}\ DFI_{H3,thy,inf}$$

$$\times\ 6\ F_{m,H3}\ \exp(-48\lambda_{H3})$$

$D^{inh}_{thy,inf}$ = infant thyroid dose due to inhalation of airborne radioactivity [mrem/hr] (Ref.: Reg. Guide 1.109, Eqs. C-3 and C-4)

$\left(D^{milk}_{thy,inf}\right)_{part}$ = infant thryoid dose due to ingestion of milk contaminated with radioactive particulates [mrem/hr] (Reg. Guide Eqs. C-5, C-6, C-10, C-11 and C-13) for milk, with the following:

- r (fraction of deposited activity retained on crops) = 0.2 (see pg 1.109-68 of the Guide)
- t_e (time period that crops are exposed to contamination during growing season) = ∞ [hrs]
- t_b (time period over which accumulation is evaluated) = ∞ [hrs]
- t_h (time delay for ingestion of forage by animals) = 0 [hrs] (see pg 1.109-69 of Reg. Guide)
- Y_v (agricultural productivity, grass-animal- milk-man pathway) = 0.7 [kg/m^2] (Reg Guide 1.109, Rev. 0)
- P (soil effective surface density) = 240 [kg/m^2]

- $\lambda_{Ei} = \lambda_i + 0.0021$ [hr^{-1}] (see pgs 1.109-4 and 1.109-69)
- $\delta_i (r,\theta) = (D/Q)$ [m^{-2}]
- t_f (average transport time of activity from the feed into the milk and to the receptor) = 48 [hrs]
- f_p (fraction of the year that animals graze on pasture) = 1 (conservative assumption)
- f_s (fraction of daily feed that is pasture grass when the animal grazes on pasture) = 1 (conservative assumption)

$\left(D^{milk}_{thy,inf}\right)_{iodines}$ = infant thyroid dose due to ingestion of milk contaminated with radio-iodines [mrem/hr] (Ref.: Reg. Guide Eqs. C-5, C-7, C-10, C-11, and C-13 for milk; similar to the infant thyroid dose due to the ingestion of particulates given above, with the exception of a different multiplying factor and r = 1.0)

$\left(D^{milk}_{thy,inf}\right)_{C14}$ = infant thyroid dose due to ingestion of milk contaminated with C14 [mrem/hr] (Ref.: Reg. Guide 1.109, Eqs. C-8, C-10, C-11 and C-13 for milk, with p (the ratio of the total annual release time to the total annual time during which photosynthesis occurs) = 1, and t_f, f_p, and f_s as given above for the particulates)

$\left(D^{milk}_{thy,inf}\right)_{H3}$ = infant thyroid dose due to ingestion of milk contaminated with tritium [mrem/hr] (Ref.: Reg. Guide 1.109, Eqs. C-9, C-10, C-11, and C-13 for milk, with t_f, f_p, and f_s as given above for the particulates)

R_{inf} = infant breathing rate [m^3/yr] (from Table E-5 of the Guide, for maximum individual)

$DFA_{i,thy,inf}$ = dose conversion factor for nuclide i to the infant thyroid due to inhalation [mrem/pCi inhaled] (from Table E-[illegible] of the Guide)

$DFI_{i,thy,inf}$ = dose conversion factor for nuclide i to the infant thyroid due to ingestion [mrem/pCi ingested] (from Table E-14 of the Guide)

$DFI_{C14,thy,inf}$ = $DFI_{i,thy,inf}$ for Carbon-14

$DFI_{H3,thy,inf}$ = $DFI_{i,thy,inf}$ for tritium

F_{C14}	= f_i for Carbon-14 (see Section 3.5.1.1 above)
F_{H3}	= f_i for tritium
U^m_{inf}	= milk ingestion rate by infant [liters/yr] (Ref.: Reg. Guide 1.109, Table E-5, max ind.)
F_{mi}	= average fraction of the animal's daily intake of radionuclide i which appears in each liter of milk [days/liter] from Table E-2 of the Guide, with F_m = F_{mi}, for goat)
B_{iv}	= concentration factor for uptake of radionuclide i from soil by edible parts of crops [(pCi/kg) (wet weight) / (pCi/kg) (dry soil)] (from Table E-1 of the Guide and included on Table 3.5-6)
H	= absolute humidity of the atmosphere at the location of interest [g/m^3] (See Table 3.5-7)
6	= amount of feed consumed by a goat per day [kg/day] (from Table E-3 of the Guide, Q_F factor)
48	= average transport time of activity from the feed into the milk and the receptor [hrs] (see page 1.109-27 of the Guide)
$(\chi/Q)^{sa}$	= concentration dispersion factor (Sector - Average model) for the period of release (nearest goat location) [sec/m^3]
(D/Q)	= particulate deposition rate (nearest goat location) [1/m^2]

3.5.2 Method 2: (Backup Method)

3.5.2.1 Organ Doses:

$$D_j = 3.17E\text{-}08* \sum_i \left[(10^6*R_a*P_{ij}*\chi/Q_1 + P_{oij}*D/Q_1)*\right.$$

$$\left.(C_{i1}*V_1*t_1 - C_{i2}*V_2*t_2 - C_{i3}*V_3*t_3)\right]$$

$$+ 3.17E\text{-}08*V_2*t_2*\sum_i \left[(10^6*R_a*P_{ij}*\chi/Q_2 + P_{oij}*D/Q_2)*C_{i2}\right]$$

$$+ 3.17E\text{-}08*V_3*t_3*\sum_i \left[(10^6*R_a*P_{ij}*\chi/Q_3 + P_{oij}*D/Q_3)*C_{i3}\right] \quad \text{(mrem)}$$

(3.5.2-1)

During periods of no intermittent releases, such as no main condenser air removal pump operation and no containment drywell purge, the above formula reduces to the following:

$$D_j = 3.17E\text{-}08*V_1*t_1 \sum_i \left[(10^6*R_a*P_{ij}*\chi/Q_1 + P_{oij}*D/Q_1)*C_{i1}\right] \quad \text{(mrem)}$$

(3.5.2-2)

where:

D_j = total dose to organ j (mrem),

P_{ij} = the inhalation dose conversion factor for radionuclides, i, (other than noble gases, tritium, carbon-14), and organ j, (mrem per pCi inhaled) from Table 3.5-3. For tritium and carbon-14, P_{ij} includes the contribution from ingestion of leafy and stored vegetables and from inhalation pathways and is listed in Table 3.5-15.

P_{ij} values listed in Tables 3.5-16 and 3.5-17 are the dose rate conversion factors for tritium and carbon-14 from ingestion of goat's milk.

Note: For short term releases such as from condenser air removal pump or containment drywell purge P_{ij} for C-14 must be adjusted (see note in Tables 3.5-15, 3.5-16 and 3.5-17).

R_a = inhalation rate (m^3/yr) from Table 3.5-5,

P_{oij} = the dose conversion factor for radionuclides, other than noble gases, i, and organ j, for the leafy vegetables, stored vegetables, and contaminated ground pathways in m^2 (mrem/yr per μCi/sec) respectively, from Table 3.5-9.

The dose factors P_{ij}, P_{oij} are based on the critical individual organ for the child group, since this group is most restrictive.

t_1 = 7.88E+06 sec for quarterly dose calculation
= 3.15E+07 sec for yearly dose calculation,

t_2 = release period (sec) for condenser air removal pump,

t_3 = release period (sec) for containment drywell purge exhaust,

C_{i1} = the station ventilation exhaust duct release concentration of radionuclide, i, (μCi/cc) (from the isotopic analyses performed on the iodine and filter cartridge taken from the station ventilation exhaust monitor),

C_{i2} = the air removal pump ventilation exhaust duct release concentration of radionuclide, i, (μCi/cc) (from the isotopic analyses performed on the iodine and filter cartridge taken from the air removal pump discharge monitor),

C_{i3} = the containment drywell purge ventilation exhaust concentration of radionuclide, i, (μCi/cc) (from the isotopic analyses performed on the gaseous sample taken from the containment drywell filter train exhaust monitor),

V_1 = 1.73E+08 cc/sec (3.66E+05 cfm), station ventilation exhaust duct ventilation exhaust flow rate,

V_2 = 5.70E+05 cc/sec (1200 cfm), air removal pump exhaust duct ventilation exhaust flow rate,

V_3 = 5.70E+05 cc/sec (1200 cfm), containment drywell purge ventilation exhaust flow rate,

χ/Q_1 = annual average χ/Q at 2478 meters ESE due to releases via the station ventilation exhaust point (1.54E-07 sec/m^3),

χ/Q_2 = short term χ/Q at 2478 meters ESE due to condenser air removal pump release via the station ventilation exhaust point (4.22E-07 sec/m^3),

χ/Q_3 = short term χ/Q at 2478 meters ESE due to containment drywell purge via the station ventilation exhaust point (4.22E-07 sec/m^3),

D/Q_1 = annual average D/Q deposition factor at 2478 meters ESE due to releases via the station ventilation exhaust point (3.08E-09 m^{-2}),

D/Q_2 = short term D/Q deposition factor at 2478 meters ESE due to condenser air removal pump releases via the station ventilation exhaust point (8.47E-09 m^{-2}),

D/Q_3 = short term D/Q deposition factor at 2478 meters ESE due to containment drywell purge exhaust via the station ventilation exhaust point ($8.47E-09\ m^{-2}$),

3.17E-08 = inverse of 3.15E+07 sec/yr, and

NOTE:

If the land use census (see Table 3.5-8) changes, the critical location, i.e., the location where an individual would be exposed to the highest dose, must be reevaluated using Equation 3.5.2-1 for each of the following locations:

1. nearest residence,
2. nearest vegetable garden, and
3. nearest milk cow or goat.

P_{oij} used in Equation 3.5.2-1 will include the values in Tables 3.5-10 through 3.5-14, if those pathways exist.

At each location, the following pathways must be considered and dose (dose rates) reevaluated if any actual pathway exists:

1. inhalation,
2. leafy vegetables (fresh),
3. stored vegetables,
4. goat's or cow's milk (if both exist choose the one resulting in a higher dose), and
5. deposition on ground.

Since a person will always be present, pathways 1 and 5 must always be evaluated.

Once the location of the critical individual is determined and found to be other than the one at 2478 meters ESE, the values of χ/Q and D/Q at the updated critical location must be used.

TABLE 3.5-1

INHALATION DOSE FACTORS FOR ADULTS
(mrem per pCi inhaled)

Radio-nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	1.58E-07	1.58E-07	1.58E-07	1.58E-07	1.58E-07	1.58E-07
C-14	2.27E-06	4.26E-07	4.26E-07	4.26E-07	4.26E-07	4.26E-07	4.26E-07
Na-24	1.28E-06	1.28E-06	1.28E-06	1.28E-06	1.28E-06	1.28E-06	1.28E-06
P-32	1.65E-04	9.64E-06	6.26E-06	No Data	No Data	No Data	1.08E-05
Cr-51	No Data	No Data	1.25E-08	7.44E-09	2.85E-09	1.80E-06	4.15E-07
Mn-54	No Data	4.95E-06	7.87E-07	No Data	1.23E-06	1.75E-04	9.67E-06
Mn-56	No Data	1.55E-10	2.29E-11	No Data	1.63E-10	1.18E-06	2.53E-06
Fe-55	3.07E-06	2.12E-06	4.98E-07	No Data	No Data	9.01E-06	7.54E-07
Fe-59	1.47E-06	3.47E-06	1.32E-06	No Data	No Data	1.27E-04	2.35E-05
Co-58	No Data	1.98E-07	2.59E-07	No Data	No Data	1.16E-04	1.33E-05
Co-60	No Data	1.44E-06	1.85E-06	No Data	No Data	7.46E-04	3.56E-05
Ni-63	5.40E-05	3.03E-06	1.81E-06	No Data	No Data	2.23E-05	1.67E-06
Ni-65	1.92E-10	2.62E-11	1.14E-11	No Data	No Data	7.00E-07	1.54E-06
Cu-64	No Data	1.83E-10	7.69E-11	No Data	5.78E-10	8.48E-07	6.12E-06
Zn-65	4.05E-06	1.29E-05	5.82E-06	No Data	8.62E-06	1.08E-04	6.68E-06
Zn-69	4.23E-12	8.14E-12	5.65E-13	No Data	5.27E-12	1.15E-07	2.04E-09
Br-83	No Data	No Data	3.01E-08	No Data	No Data	No Data	2.90E-08
Br-84	No Data	No Data	3.91E-08	No Data	No Data	No Data	2.05E-13
Br-85	No Data	No Data	1.60E-09	No Data	No Data	No Data	<1.00E-24
Rb-86	No Data	1.69E-05	7.37E-06	No Data	No Data	No Data	2.08E-06
Rb-88	No Data	4.84E-08	2.41E-08	No Data	No Data	No Data	4.18E-19
Rb-89	No Data	3.20E-08	2.12E-08	No Data	No Data	No Data	1.16E-21
Sr-89	3.80E-05	No Data	1.09E-06	No Data	No Data	1.75E-04	4.37E-05
Sr-90	1.24E-02	No Data	7.62E-04	No Data	No Data	1.20E-03	9.02E-05
Sr-91	7.74E-09	No Data	3.13E-10	No Data	No Data	4.56E-06	2.39E-05
Sr-92	8.43E-10	No Data	3.64E-11	No Data	No Data	2.06E-06	5.38E-06
Y-90	2.61E-07	No Data	7.01E-09	No Data	No Data	2.12E-05	6.32E-05
Y-91m	3.26E-11	No Data	1.27E-12	No Data	No Data	2.40E-07	1.66E-10
Y-91	5.78E-05	No Data	1.55E-06	No Data	No Data	2.13E-04	4.81E-05
Y-92	1.29E-09	No Data	3.77E-11	No Data	No Data	1.96E-06	9.19E-06
Y-93	1.18E-05	No Data	3.26E-10	No Data	No Data	6.06E-06	5.27E-05

TABLE 3.5-1 (CONT'D)

Radio-nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Zr-95	1.34E-05	4.30E-06	2.91E-06	No Data	6.77E-06	2.21E-04	1.88E-05
Zr-97	1.21E-08	2.45E-09	1.13E-09	No Data	3.71E-09	9.84E-06	6.54E-05
Nb-95	1.76E-06	9.77E-07	5.26E-07	No Data	9.67E-07	6.31E-05	1.30E-05
Mo-99	No Data	1.51E-08	2.87E-09	No Data	3.64E-08	1.14E-05	3.10E-05
Tc-99m	1.29E-13	3.64E-13	4.63E-12	No Data	5.52E-12	9.55E-08	5.20E-07
Tc-101	5.22E-15	7.52E-15	7.38E-14	No Data	1.35E-13	4.99E-08	1.36E-21
Ru-103	1.91E-07	No Data	8.23E-08	No Data	7.29E-07	6.31E-05	1.38E-05
Ru-105	9.88E-11	No Data	3.89E-11	No Data	1.27E-10	1.37E-06	6.02E-06
Ru-106	8.64E-06	No Data	1.09E-06	No Data	1.67E-05	1.17E-03	1.14E-04
Ag-110m	1.35E-06	1.25E-06	7.43E-07	No Data	2.46E-06	5.79E-04	3.78E-05
Te-125m	4.27E-07	1.98E-07	5.84E-08	1.31E-07	1.55E-06	3.92E-05	8.83E-06
Te-127m	1.58E-06	7.21E-07	1.96E-07	4.11E-07	5.72E-06	1.20E-04	1.87E-05
Te-127	1.75E-10	8.03E-11	3.87E-11	1.32E-10	6.37E-10	8.14E-07	7.17E-06
Te-129m	1.22E-06	5.84E-07	1.98E-07	4.30E-07	4.57E-06	1.45E-04	4.79E-05
Te-129	6.22E-12	2.99E-12	1.55E-12	4.87E-12	2.34E-11	2.42E-07	1.96E-08
Te-131m	8.74E-09	5.45E-09	3.63E-09	6.88E-09	3.86E-08	1.82E-05	6.95E-05
Te-131	1.39E-12	7.44E-13	4.49E-13	1.17E-12	5.46E-12	1.74E-07	2.30E-09
Te-132	3.25E-08	2.69E-08	2.02E-08	2.37E-08	1.82E-07	3.60E-05	6.37E-05
I-130	5.72E-07	1.68E-06	6.60E-07	1.42E-04	2.61E-06	No Data	9.61E-07
I-131	3.15E-06	4.47E-06	2.56E-06	1.49E-03	7.66E-06	No Data	7.85E-07
I-132	1.45E-07	4.07E-07	1.45E-07	1.43E-05	6.48E-07	No Data	5.08E-08
I-133	1.08E-06	1.85E-06	5.65E-07	2.69E-04	3.23E-06	No Data	1.11E-06
I-134	8.05E-08	2.16E-07	7.69E-08	3.73E-06	3.44E-07	No Data	1.26E-10
I-135	3.35E-07	8.73E-07	3.21E-07	5.60E-05	1.39E-06	No Data	6.56E-07
Cs-134	4.66E-05	1.06E-04	9.10E-05	No Data	3.59E-05	1.22E-05	1.30E-06
Cs-136	4.88E-06	1.83E-05	1.38E-05	No Data	1.07E-05	1.50E-06	1.46E-06
Cs-137	5.98E-05	7.76E-05	5.35E-05	No Data	2.78E-05	9.40E-06	1.05E-06
Cs-138	4.14E-05	7.76E-08	4.05E-08	No Data	6.00E-08	6.07E-09	2.33E-13
Ba-139	1.17E-10	8.32E-14	3.42E-12	No Data	7.78E-14	4.70E-07	1.12E-07
Ba-140	4.88E-06	6.13E-09	3.21E-07	No Data	2.09E-09	1.59E-04	2.73E-05
Ba-141	1.25E-11	9.41E-15	4.20E-13	No Data	8.75E-15	2.42E-07	1.45E-17
Ba-142	3.29E-12	3.38E-15	2.07E-13	No Data	2.86E-15	1.49E-07	1.96E-26
La-140	4.30E-08	2.17E-08	5.73E-09	No Data	No Data	1.70E-05	5.73E-05
La-142	8.54E-11	3.88E-11	9.65E-12	No Data	No Data	7.91E-07	2.64E-07

TABLE 3.5-1 (CONT'D)

Radio-nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ce-141	2.49E-06	1.69E-06	1.91E-07	No Data	7.83E-07	4.52E-05	1.50E-05
Ce-143	2.33E-08	1.72E-08	1.91E-09	No Data	7.60E-09	9.97E-06	2.83E-05
Ce-144	4.29E-04	1.79E-04	2.30E-05	No Data	1.06E-04	9.72E-04	1.02E-04
Pr-143	1.17E-06	4.69E-07	5.80E-08	No Data	2.70E-07	3.51E-05	2.50E-05
Pr-144	3.76E-12	1.56E-12	1.91E-13	No Data	8.81E-13	1.27E-07	2.69E-18
Nd-147	6.59E-07	7.62E-07	4.56E-08	No Data	4.45E-07	2.76E-05	2.16E-05
W-187	1.06E-09	8.85E-10	3.10E-10	No Data	No Data	3.63E-06	1.94E-05
Np-239	2.87E-08	2.82E-09	1.55E-09	No Data	8.75E-09	4.70E-06	1.49E-05

TABLE 3.5-2

INHALATION DOSE FACTORS FOR TEENAGER
(mrem per pCi inhaled)

Radio-nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	1.59E-07	1.59E-07	1.59E-07	1.59E-07	1.59E-07	1.59E-07
C-14	3.25E-06	6.09E-07	6.09E-07	6.09E-07	6.09E-07	6.09E-07	6.09E-07
Na-24	1.72E-06	1.72E-06	1.72E-06	1.72E-06	1.72E-06	1.72E-06	1.72E-06
P-32	2.36E-04	1.37E-05	8.95E-06	No Data	No Data	No Data	1.16E-05
Cr-51	No Data	No Data	1.69E-08	9.37E-09	3.84E-09	2.62E-06	3.75E-07
Mn-54	No Data	6.39E-06	1.05E-06	No Data	1.59E-06	2.48E-04	8.35E-06
Mn-56	No Data	2.12E-10	3.15E-11	No Data	2.24E-10	1.90E-06	7.18E-06
Fe-55	4.18E-06	2.98E-06	6.93E-07	No Data	No Data	1.55E-05	7.99E-07
Fe-59	1.99E-06	4.62E-06	1.79E-06	No Data	No Data	1.91E-04	2.23E-05
Co-58	No Data	2.59E-07	3.47E-07	No Data	No Data	1.66E-04	1.19E-05
Co-60	No Data	1.89E-06	2.48E-06	No Data	No Data	1.09E-03	3.24E-05
Ni-63	7.25E-05	5.43E-06	2.47E-06	No Data	No Data	3.84E-05	1.77E-06
Ni-65	2.73E-10	3.66E-11	1.59E-11	No Data	No Data	1.17E-06	4.59E-06
Cu-64	No Data	2.54E-10	1.06E-10	No Data	8.01E-10	1.39E-06	7.68E-06
Zn-65	4.82E-06	1.67E-05	7.80E-06	No Data	1.08E-05	1.55E-04	5.83E-06
Zn-69	6.04E-12	1.15E-11	8.07E-13	No Data	7.53E-12	1.98E-07	3.56E-08
Br-83	No Data	No Data	4.30E-08	No Data	No Data	No Data	<1.00E-24
Br-84	No Data	No Data	5.41E-08	No Data	No Data	No Data	<1.00E-24
Br-85	No Data	No Data	2.29E-09	No Data	No Data	No Data	<1.00E-24
Rb-86	No Data	2.38E-05	1.05E-05	No Data	No Data	No Data	2.21E-06
Rb-88	No Data	6.82E-08	3.40E-08	No Data	No Data	No Data	3.65E-15
Rb-89	No Data	4.40E-08	2.91E-08	No Data	No Data	No Data	4.22E-17
Sr-89	5.43E-05	No Data	1.56E-06	No Data	No Data	3.02E-04	4.64E-05
Sr-90	1.35E-02	No Data	8.35E-04	No Data	No Data	2.06E-03	9.56E-05
Sr-91	1.10E-08	No Data	4.39E-10	No Data	No Data	7.59E-06	3.24E-05
Sr-92	1.19E-09	No Data	5.08E-11	No Data	No Data	3.43E-06	1.49E-05
Y-90	3.73E-07	No Data	1.00E-08	No Data	No Data	3.66E-05	6.99E-05
Y-91m	4.63E-11	No Data	1.77E-12	No Data	No Data	4.00E-07	3.77E-09
Y-91	8.26E-05	No Data	2.21E-06	No Data	No Data	3.67E-04	5.11E-05
Y-92	1.84E-09	No Data	5.36E-11	No Data	No Data	3.35E-06	2.06E-05
Y-93	1.69E-08	No Data	4.65E-10	No Data	No Data	1.04E-05	7.24E-05

TABLE 3.5-2 (CONT'D)

Radio-nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Zr-95	1.82E-05	5.73E-06	3.94E-06	No Data	8.42E-06	3.36E-04	1.86E-05
Zr-97	1.72E-08	3.40E-09	1.57E-09	No Data	5.15E-09	1.62E-05	7.88E-05
Nb-95	2.32E-06	1.29E-06	7.08E-07	No Data	1.25E-06	9.39E-05	1.21E-05
Mo-99	No Data	2.11E-08	4.08E-09	No Data	5.14E-08	1.92E-05	3.36E-05
Tc-99m	1.73E-13	4.83E-13	6.24E-12	No Data	7.20E-12	1.44E-07	7.66E-07
Tc-101	7.40E-15	1.05E-14	1.03E-13	No Data	1.90E-13	8.34E-08	1.09E-16
Ru-103	2.63E-07	No Data	1.12E-07	No Data	9.29E-07	9.79E-05	1.36E-05
Ru-105	1.40E-10	No Data	5.42E-11	No Data	1.76E-10	2.27E-06	1.13E-05
Ru-106	1.23E-05	No Data	1.55E-06	No Data	2.38E-05	2.01E-03	1.20E-04
Ag-110m	1.73E-06	1.64E-06	9.99E-07	No Data	3.13E-06	8.44E-04	3.41E-05
Te-125m	6.10E-07	2.80E-07	8.34E-08	1.75E-07	No Data	6.70E-05	9.38E-06
Te-127m	2.25E-06	1.02E-06	2.73E-07	5.48E-07	8.17E-06	2.07E-04	1.99E-05
Te-127	2.51E-10	1.14E-10	5.52E-11	1.77E-10	9.10E-10	1.40E-06	1.01E-05
Te-129m	1.74E-06	8.23E-07	2.81E-07	5.72E-07	6.49E-06	2.47E-04	5.06E-05
Te-129	8.87E-12	4.22E-12	2.20E-12	6.48E-12	3.32E-11	4.12E-07	2.02E-07
Te-131m	1.23E-08	7.51E-09	5.03E-09	9.06E-09	5.49E-08	2.97E-05	7.76E-05
Te-131	1.97E-12	1.04E-12	6.30E-13	1.55E-12	7.72E-12	2.92E-07	1.89E-09
Te-132	4.50E-08	3.63E-08	2.74E-08	3.07E-08	2.44E-07	5.61E-05	5.79E-05
I-130	7.80E-07	2.24E-06	8.96E-07	1.86E-04	3.44E-06	No Data	1.14E-06
I-131	4.43E-06	6.14E-06	3.30E-06	1.83E-03	1.05E-05	No Data	8.11E-07
I-132	1.99E-07	5.47E-07	1.97E-07	1.89E-05	8.65E-07	No Data	1.59E-07
I-133	1.52E-06	2.56E-06	7.78E-07	3.65E-04	4.49E-06	No Data	1.29E-06
I-134	1.11E-07	2.90E-07	1.05E-07	4.94E-06	4.58E-07	No Data	2.55E-09
I-135	4.62E-07	1.18E-06	4.36E-07	7.76E-05	1.86E-06	No Data	8.69E-07
Cs-134	6.28E-05	1.41E-04	6.86E-05	No Data	4.69E-05	1.83E-05	1.22E-06
Cs-136	6.44E-06	2.42E-05	1.71E-05	No Data	1.38E-05	2.22E-06	1.36E-06
Cs-137	8.38E-05	1.06E-04	3.89E-05	No Data	3.80E-05	1.51E-05	1.06E-06
Cs-138	5.82E-08	1.07E-07	5.58E-08	No Data	8.28E-08	9.84E-09	3.38E-11
Ba-139	1.67E-10	1.18E-13	4.87E-12	No Data	1.11E-13	8.08E-07	8.06E-07
Ba-140	6.84E-06	8.38E-09	4.40E-07	No Data	2.85E-09	2.54E-04	2.86E-05
Ba-141	1.78E-11	1.32E-14	5.93E-13	No Data	1.23E-14	4.11E-07	9.33E-14
Ba-142	4.62E-12	4.63E-15	2.84E-13	No Data	3.92E-15	2.39E-07	5.99E-20
La-140	5.99E-08	2.95E-08	7.82E-09	No Data	No Data	2.68E-05	6.09E-05
La-142	1.20E-10	5.31E-11	1.32E-11	No Data	No Data	1.27E-06	1.50E-06

TABLE 3.5-2 (CONT'D)

Radio-nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ce-141	3.55E-06	2.37E-06	2.71E-07	No Data	1.11E-06	7.67E-05	1.58E-05
Ce-143	3.32E-08	2.42E-08	2.70E-09	No Data	1.08E-08	1.63E-05	3.19E-05
Ce-144	6.11E-04	2.53E-04	3.28E-05	No Data	1.51E-04	1.67E-03	1.08E-04
Pr-143	1.67E-06	6.64E-07	8.28E-08	No Data	3.86E-07	6.04E-05	2.67E-05
Pr-144	5.37E-12	2.20E-12	2.72E-13	No Data	1.26E-12	2.19E-07	2.94E-14
Nd-147	9.83E-07	1.07E-06	6.41E-08	No Data	6.28E-07	4.65E-05	2.28E-05
W-187	1.50E-09	1.22E-09	4.29E-10	No Data	No Data	5.92E-06	2.21E-05
Np-239	4.23E-08	3.99E-09	2.21E-09	No Data	1.25E-08	8.11E-06	1.65E-05

TABLE 3.5-3

INHALATION DOSE FACTORS FOR CHILD
(mrem per pCi inhaled)

Radio-nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	3.04E-07	3.04E-07	3.04E-07	3.04E-07	3.04E-07	3.04E-07
C-14	9.70E-06	1.82E-06	1.82E-06	1.82E-06	1.82E-06	1.82E-06	1.82E-06
Na-24	4.35E-06	4.35E-06	4.35E-06	4.35E-06	4.35E-06	4.35E-06	4.35E-06
P-32	7.04E-04	3.09E-05	2.67E-05	No Data	No Data	No Data	1.14E-05
Cr-51	No Data	No Data	4.17E-08	2.31E-08	6.57E-09	4.59E-06	2.93E-07
Mn-54	No Data	1.16E-05	2.57E-06	No Data	2.71E-06	4.26E-04	6.19E-06
Mn-56	No Data	4.48E-10	8.43E-11	No Data	4.52E-10	3.55E-06	3.33E-05
Fe-55	1.28E-05	6.80E-06	2.10E-06	No Data	No Data	3.00E-05	7.75E-07
Fe-59	5.59E-06	9.04E-06	4.51E-06	No Data	No Data	3.43E-04	1.91E-05
Co-58	No Data	4.79E-07	8.55E-07	No Data	No Data	2.99E-04	9.29E-06
Co-60	No Data	3.55E-06	6.12E-06	No Data	No Data	1.91E-03	2.60E-05
Ni-63	2.22E-04	1.25E-05	7.56E-06	No Data	No Data	7.43E-05	1.71E-06
Ni-65	8.08E-10	7.99E-11	4.44E-11	No Data	No Data	2.21E-06	2.27E-05
Cu-64	No Data	5.39E-10	2.90E-10	No Data	1.63E-09	2.59E-06	9.92E-06
Zn-65	1.15E-05	3.06E-05	1.90E-05	No Data	1.93E-05	2.69E-04	4.41E-06
Zn-67	1.81E-11	2.61E-11	2.41E-12	No Data	1.58E-11	3.84E-07	2.75E-06
Br-83	No Data	No Data	1.28E-07	No Data	No Data	No Data	<1.00E-24
Br-84	No Data	No Data	1.48E-07	No Data	No Data	No Data	<1.00E-24
Br-85	No Data	No Data	6.84E-09	No Data	No Data	No Data	<1.00E-24
Rb-86	No Data	5.36E-05	3.09E-05	No Data	No Data	No Data	2.16E-06
Rb-88	No Data	1.52E-07	9.90E-08	No Data	No Data	No Data	4.66E-09
Rb-89	No Data	9.33E-08	7.83E-08	No Data	No Data	No Data	5.11E-10
Sr-89	1.62E-04	No Data	4.66E-06	No Data	No Data	5.83E-04	4.52E-05
Sr-90	2.73E-02	No Data	1.74E-03	No Data	No Data	3.99E-03	9.28E-05
Sr-91	3.28E-08	No Data	1.24E-09	No Data	No Data	1.44E-05	4.70E-05
Sr-92	3.54E-09	No Data	1.42E-10	No Data	No Data	6.49E-06	6.55E-05
Y-90	1.11E-06	No Data	2.99E-08	No Data	No Data	7.07E-05	7.24E-05
Y-91m	1.37E-10	No Data	4.98E-12	No Data	No Data	7.60E-07	4.64E-07
Y-91	2.47E-04	No Data	6.59E-06	No Data	No Data	7.10E-04	4.97E-05
Y-92	5.50E-09	No Data	1.57E-10	No Data	No Data	6.46E-06	6.46E-05
Y-93	5.04E-08	No Data	1.38E-09	No Data	No Data	2.01E-05	1.05E-04

TABLE 3.5-3 (CONT'D)

Radio-nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Zr-95	5.13E-05	1.13E-05	1.00E-05	No Data	1.61E-05	6.03E-04	1.65E-05
Zr-97	5.07E-08	7.34E-09	4.32E-09	No Data	1.05E-08	3.06E-05	9.49E-05
Nb-95	6.35E-06	2.48E-06	1.77E-06	No Data	2.33E-06	1.66E-04	1.00E-05
Mo-99	No Data	4.66E-08	1.15E-08	No Data	1.06E-07	3.66E-05	3.42E-05
Tc-99m	4.81E-13	9.41E-13	1.56E-11	No Data	1.37E-11	2.57E-07	1.30E-06
Tc-101	2.19E-14	2.30E-14	2.91E-13	No Data	3.92E-13	1.58E-07	4.41E-09
Ru-103	7.55E-07	No Data	2.90E-07	No Data	1.90E-06	1.79E-04	1.21E-05
Ru-105	4.13E-10	No Data	1.50E-10	No Data	3.63E-10	4.30E-06	2.69E-05
Ru-106	3.68E-05	No Data	4.57E-06	No Data	4.97E-05	3.87E-03	1.16E-04
Ag-110m	4.56E-06	3.08E-06	2.47E-06	No Data	5.74E-06	1.48E-03	2.71E-05
Te-125m	1.82E-06	6.29E-07	2.47E-07	5.20E-07	No Data	1.29E-04	9.13E-06
Te-127m	6.72E-06	2.31E-06	8.16E-07	1.64E-06	1.72E-05	4.00E-04	1.93E-05
Te-127	7.49E-10	2.57E-10	1.65E-10	5.30E-10	1.91E-09	2.71E-06	1.52E-05
Te-129m	5.19E-06	1.85E-06	8.22E-07	1.71E-06	1.36E-05	4.76E-04	4.91E-05
Te-129	2.64E-11	9.45E-12	6.44E-12	1.93E-11	6.94E-11	7.93E-07	6.89E-06
Te-131m	3.63E-08	1.60E-08	1.37E-08	2.64E-08	1.08E-0[illegible]	5.56E-05	8.32E-05
Te-131	5.87E-12	2.28E-12	1.78E-12	4.[illegible]9E-12	1.59E-11	5.55E-07	3.60E-07
Te-132	1.30E-07	7.36E-08	7.12E-08	8.58E-08	4.79E-07	1.02E-04	3.72E-05
I-130	2.21E-06	4.43E-06	2.28E-06	4.99E-04	6.61E-06	No Data	1.38E-06
I-131	1.30E-05	1.30E-05	7.37E-06	4.39E-03	2.13E-05	No Data	7.68E-07
I-132	5.72E-07	1.10E-06	5.07E-07	5.23E-05	1.69E-06	No Data	8.65E-07
I-133	4.48E-06	5.49E-06	2.08E-06	1.04E-03	9.13E-06	No Data	1.48E-06
I-134	3.17E-07	5.84E-07	2.69E-07	1.37E-05	8.92E-07	No Data	2.58E-07
I-135	1.33E-06	2.36E-06	1.12E-06	2.14E-04	3.62E-06	No Data	1.20E-06
Cs-134	1.76E-04	2.74E-04	6.07E-05	No Data	8.93E-05	3.27E-05	1.04E-06
Cs-136	1.76E-05	4.62E-05	3.14E-05	No Data	2.58E-05	3.93E-06	1.13E-06
Cs-137	2.45E-04	2.23E-04	3.47E-05	No Data	7.63E-05	2.81E-05	9.78E-07
Cs-138	1.71E-07	2.27E-07	1.50E-07	No Data	1.68E-07	1.84E-08	7.29E-08
Ba-139	4.98E-10	2.66E-13	1.45E-11	No Data	2.33E-13	1.56E-06	1.56E-05
Ba-140	2.00E-05	1.75E-08	1.17E-06	No Data	5.71E-09	4.71E-04	2.75E-05
Ba-141	5.29E-11	2.95E-14	1.72E-12	No Data	2.56E-14	7.89E-07	7.44E-08
Ba-142	1.35E-11	9.73E-15	7.54E-13	No Data	7.87E-15	4.44E-07	7.41E-10
La-140	1.74E-07	6.08E-08	2.04E-08	No Data	No Data	4.94E-05	6.10E-05
La-142	3.50E-10	1.11E-10	3.49E-11	No Data	No Data	2.35E-06	2.05E-05

TABLE 3.5-3 (CONT'D)

Radio-nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ce-141	1.06E-05	5.28E-06	7.83E-07	No Data	2.31E-06	1.47E-04	1.53E-05
Ce-143	9.89E-08	5.37E-08	7.77E-09	No Data	2.26E-08	3.12E-05	3.44E-05
Ce-144	1.83E-03	5.72E-04	9.77E-05	No Data	3.17E-04	3.23E-03	1.05E-04
Pr-143	4.99E-06	1.50E-06	2.47E-07	No Data	8.11E-07	1.17E-04	2.63E-05
Pr-144	1.61E-11	4.99E-12	8.10E-13	No Data	2.64E-12	4.23E-07	5.32E-08
Nd-147	2.92E-06	2.36E-06	1.84E-07	No Data	1.30E-06	8.87E-05	2.22F-05
W-187	4.41E-09	2.61E-09	1.17E-09	No Data	No Data	1.11E-05	2.46E-05
Np-239	1.26E-07	9.04E-09	6.35E-09	No Data	2.63E-08	1.57E-05	1.73E-05

TABLE 3.5-4

INHALATION DOSE FACTORS FOR INFANT
(mrem per pCi inhaled)

Radio-nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	4.62E-07	4.62E-07	4.62E-07	4.62E-07	4.62E-07	4.62E-07
C-14	1.89E-05	3.79E-06	3.79E-06	3.79E-06	3.79E-06	3.79E-06	3.79E-06
Na-24	7.54E-06	7.54E-06	7.54E-06	7.54E-06	7.54E-06	7.54E-06	7.54E-06
P-32	1.45E-03	8.03E-05	5.53E-05	No Data	No Data	No Data	1.15E-05
Cr-51	No Data	No Data	6.39E-08	4.11E-08	9.45E-09	9.17E-06	2.55E-07
Mn-54	No Data	1.81E-05	3.56E-06	No Data	3.56E-06	7.14E-04	5.04E-06
Mn-56	No Data	1.10E-09	1.58E-10	No Data	7.86E-10	8.95E-06	5.12E-05
Fe-55	1.41E-05	8.39E-06	2.38E-06	No Data	No Data	6.21E-05	7.82E-07
Fe-59	9.69E-06	1.68E-05	6.77E-06	No Data	No Data	7.25E-04	1.77E-05
Co-58	No Data	8.71E-07	1.30E-06	No Data	No Data	5.55E-04	7.95E-06
Co-60	No Data	5.73E-06	8.41E-06	No Data	No Data	3.22E-03	2.28E-05
Ni-63	2.42E-04	1.46E-05	8.29E-06	No Data	No Data	1.49E-04	1.73E-06
Ni-65	1.71E-09	2.03E-10	8.79E-11	No Data	No Data	5.80E-06	3.58E-05
Cu-64	No Data	1.34E-09	5.53E-10	No Data	2.84E-09	6.64E-06	1.07E-05
Zn-65	1.38E-05	4.47E-05	2.22E-05	No Data	2.32E-05	4.62E-04	3.67E-05
Zn-69	3.85E-11	6.91E-11	5.13E-12	No Data	2.87E-11	1.05E-06	9.44E-06
Br-83	No Data	No Data	2.72E-07	No Data	No Data	No Data	<1.00E-24
Br-84	No Data	No Data	2.86E-07	No Data	No Data	No Data	<1.00E-24
Br-85	No Data	No Data	1.46E-08	No Data	No Data	No Data	<1.00E-24
Rb-86	No Data	1.36E-04	6.30E-05	No Data	No Data	No Data	2.17E-06
Rb-88	No Data	3.98E-07	2.05E-07	No Data	No Data	No Data	2.42E-07
Rb-89	No Data	2.29E-07	1.47E-07	No Data	No Data	No Data	4.87E-08
Sr-89	2.84E-04	No Data	8.15E-06	No Data	No Data	1.45E-03	4.57E-05
Sr-90	2.92E-02	No Data	1.85E-03	No Data	No Data	8.03E-03	9.36E-05
Sr-91	6.83E-08	No Data	2.47E-09	No Data	No Data	3.76E-05	5.24E-05
Sr-92	7.50E-09	No Data	2.79E-10	No Data	No Data	1.70E-05	1.00E-04
Y-90	2.35E-06	No Data	6.30E-08	No Data	No Data	1.92E-04	7.43E-05
Y-91m	2.91E-10	No Data	9.90E-12	No Data	No Data	1.99E-06	1.68E-06
Y-91	4.20E-04	No Data	1.12E-05	No Data	No Data	1.75E-03	5.02E-05
Y-92	1.17E-08	No Data	3.29E-10	No Data	No Data	1.75E-05	9.04E-05
Y-93	1.07E-07	No Data	2.91E-09	No Data	No Data	5.46E-05	1.19E-04

TABLE 3.5-4 (CONT'D)

Radio-nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Zr-95	8.24E-05	1.99E-05	1.45E-05	No Data	2.22E-05	1.25E-03	1.55E-05
Zr-97	1.07E-07	1.83E-08	8.36E-09	No Data	1.85E-08	7.88E-05	1.00E-04
Nb-95	1.12E-05	4.59E-06	2.70E-06	No Data	3.37E-06	3.42E-04	9.05E-06
Mo-99	No Data	1.18E-07	2.31E-08	No Data	1.89E-07	9.63E-05	3.48E-05
Tc-99m	9.98E-13	2.06E-12	2.66E-11	No Data	2.22E-11	5.79E-07	1.45E-06
Tc-101	4.65E-14	5.88E-14	5.80E-13	No Data	6.99E-13	4.17E-07	6.03E-07
Ru-103	1.44E-06	No Data	4.85E-07	No Data	3.03E-06	3.94E-04	1.15E-05
Ru-105	8.74E-10	No Data	2.93E-10	No Data	6.42E-10	1.12E-05	3.46E-05
Ru-106	6.20E-05	No Data	7.77E-06	No Data	7.61E-05	8.26E-03	1.17E-04
Ag-110m	7.13E-06	5.16E-06	3.57E-06	No Data	7.80E-06	2.62E-03	2.36E-05
Te-125m	3.40E-06	1.42E-06	4.70E-07	1.16E-06	No Data	3.19E-04	9.22E-06
Te-127m	1.19E-05	4.93E-06	1.48E-06	3.48E-06	2.68E-05	9.37E-04	1.95E-05
Te-127	1.59E-09	6.81E-10	3.49E-10	1.32E-09	3.47E-09	7.39E-06	1.74E-05
Te-129m	1.01E-05	4.35E-06	1.59E-06	3.91E-06	2.27E-05	1.20E-03	4.93E-05
Te-129	5.63E-11	2.48E-11	1.34E-11	4.82E-11	1.25E-10	2.14E-06	1.88E-05
Te-131m	7.62E-08	3.93E-08	2.59E-08	6.38E-08	1.89E-07	1.42E-04	8.51E-05
Te-131	1.24E-11	5.87E-12	3.57E-12	1.13E-11	2.85E-11	1.47E-06	5.87E-06
Te-132	2.66E-07	1.69E-07	1.26E-07	1.99E-07	7.39E-07	2.43E-04	3.15E-05
I-130	4.54E-06	9.91E-06	3.98E-06	1.14E-03	1.09E-05	No Data	1.42E-06
I-131	2.71E-05	3.17E-05	1.40E-05	1.06E-02	3.70E-05	No Data	7.56E-07
I-132	1.21E-06	2.53E-06	8.99E-07	1.21E-04	2.82E-06	No Data	1.36E-06
I-133	9.46E-06	1.37E-05	4.00E-06	2.54E-03	1.60E-05	No Data	1.54E-06
I-134	6.58E-07	1.34E-06	4.75E-07	3.18E-05	1.49E-06	No Data	9.21E-07
I-135	2.76E-06	5.43E-06	1.98E-06	4.97E-04	6.05E-06	No Data	1.31E-06
Cs-134	2.83E-04	5.02E-04	5.32E-05	No Data	1.36E-04	5.69E-05	9.53E-07
Cs-136	3.45E-05	9.61E-05	3.78E-05	No Data	4.03E-05	8.40E-06	1.02E-06
Cs-137	3.92E-04	4.37E-04	3.25E-05	No Data	1.23E-04	5.09E-05	9.53E-07
Cs-138	3.61E-07	5.58E-07	2.84E-07	No Data	2.93E-07	4.67E-08	6.26E-07
Ba-139	1.06E-09	7.03E-13	3.07E-11	No Data	4.23E-13	4.25E-06	3.64E-05
Ba-140	4.00E-05	4.00E-08	2.07E-06	No Data	9.59E-09	1.14E-03	2.74E-05
Ba-141	1.12E-10	7.70E-14	3.55E-12	No Data	4.64E-14	2.12E-06	3.39E-06
Ba-142	2.84E-11	2.36E-14	1.40E-12	No Data	1.36E-14	1.11E-06	4.95E-07
La-140	3.61E-07	1.43E-07	3.68E-08	No Data	No Data	1.20E-04	6.06E-05
La-142	7.36E-10	2.69E-10	6.46E-11	No Data	No Data	5.87E-06	4.25E-05

TABLE 3.5-4 (CONT'D)

Radio-nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
Ce-141	1.98E-05	1.19E-05	1.42E-06	No Data	3.75E-06	3.69E-04	1.54E-05
Ce-143	2.09E-07	1.38E-07	1.58E-08	No Data	4.03E-08	8.30E-05	3.55E-05
Ce-144	2.28E-03	8.65E-04	1.26E-04	No Data	3.84E-04	7.03E-03	1.06E-04
Pr-143	1.00E-05	3.74E-06	4.99E-07	No Data	1.41E-06	3.09E-04	2.66E-05
Pr-144	3.42E-11	1.32E-11	1.72E-12	No Data	4.80E-12	1.15E-06	3.06E-06
Nd-147	5.67E-06	5.81E-06	3.57E-07	No Data	2.25E-06	2.30E-04	2.23E-05
W-187	9.26E-09	6.44E-09	2.23E-09	No Data	No Data	2.83E-05	2.54E-05
Np-239	2.65E-07	2.37E-08	1.34E-08	No Data	4.73E-08	4.25E-05	1.78E-05

TABLE 3.5-5

RECOMMENDED VALUES FOR U_{ap} TO BE USED FOR THE MAXIMUM EXPOSED INDIVIDUAL IN LIEU OF SITE-SPECIFIC DATA

Pathway	Infant	Child	Teen	Adult
Fruits, vegetables & grain (kg/yr)[1],[2]	N/A[7]	520	630	520
Leafy vegetables (kg/yr)[1]	N/A	26	42	64
Milk (ℓ/yr)[1]	330	330	400	310
Meat & poultry (kg/yr)[1]	N/A	41	65	110
Fish (fresh or salt) (kg/yr)[3]	N/A	6.9	16	21
Other seafood (kg/yr)[1]	N/A	1.7	3.8	5
Drinking water (ℓ/yr)[4]	330	510	510	730
Shoreline recreation (hr/yr)[4]	N/A	14	67	12
Inhalation (m^3/yr)	1400[5]	3700[6]	8000[6]	8000[5]

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(1) Consumption rate obtained from Reference 19 for average individual and age-prorated and maximized using techniques contained in Reference 10 of Regulatory Guide 1.109, Rev 1, Oct. 1977.

(2) Consists of the following (on a mass basis): 22% fruit, 54% vegetables (including leafy vegetables), and 24% grain.

TABLE 3.5-5 (CONT'D)

(3) Consumption rate for adult obtained by averaging data from References 10 and 21-24 of Regulatory Guide 1.109, Rev. 1, Oct. 1977 and age-prorated using techniques contained in Reference 10.

(4) Data obtained directly from Reference 10 of Regulatory Guide 1.109, Rev. 1, Oct 1977.

(5) Data obtained directly from Reference 20 of Regulatory Guide 1.109, Rev. 1, Oct. 1977.

(6) Inhalation rate derived from data provided in Reference 20 of Regulatory Guide 1.109, Rev. 1, Oct. 1977.

(7) N/A indicates not applicable.

TABLE 3.5-6

STABLE ELEMENT TRANSFER DATA[1]

Element	B Veg/Soil	F (Cow) Milk (d/l)	F Meat (d/kg)
H[2]	4.8E+00	1.0E-02	1.2E-02
C[2]	5.5E+00	1.2E-02	3.1E-02
Na	5.2E-02	4.0E-02[3]	3.0E-02
P	1.1E+00	2.5E-02	4.6E-02
Cr	2.5E-04	2.2E-03	2.4E-03
Mn	2.9E-02	2.5E-04	8.0E-04
Fe	6.6E-04	1.2E-03	4.0E-02
Co	9.4E-03	1.0E-03	1.3E-02
Ni	1.9E-02	6.7E-03	5.3E-02
Cu	1.2E-01	1.4E-02	8.0E-03
Zn	4.0E-01	3.9E-02	3.0E-02
Rb	1.3E-01	3.0E-02	3.1E-02
Sr	1.7E-02	8.0E-04[3]	6.0E-04
Y	2.6E-03	1.0E-05	4.6E-03
Zr	1.7E-04	5.0E-06	3.4E-02
Nb	9.4E-03	2.5E-03	2.8E-01
Mo	1.2E-01	7.5E-03	8.0E-03
Tc	2.5E-01	2.5E-02	4.0E-01
Ru	5.0E-02	1.0E-06	4.0E-01
Rh	1.3E-01	1.0E-02	1.5E-03
Ag	1.5E-01	5.0E-02	1.7E-02
Te	1.3E-00	1.0E-03	7.7E-02
I	2.0E-02	6.0E-03[4]	2.9E-03
Cs	1.0E-02	1.2E-02[3]	4.0E-03
Ba	5.0E-03	4.0E-04[3]	3.2E-03
La	2.5E-03	5.0E-06	2.0E-04
Ce	2.5E-03	1.0E-04[3]	1.2E-03
Pr	2.5E-03	5.0E-06	4.7E-03
Nd	2.4E-03	5.0E-06	3.3E-03
W	1.8E-02	5.0E-04	1.3E-03
Np	2.5E-03	5.0E-06	2.0E-04[5]

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[1] Data presented in this table is from Reference 1 of Regulatory Guide 1.109, Rev. 1, Oct. 1977.
[2] Meat and milk coefficients are based on specific activity considerations.
[3] From Reference 15 of Regulatory Guide 1.109, Rev. 1, Oct. 1977.
[4] See text (Regulatory Guide 1.109, Rev. 1, Oct. 1977).
[5] From Reference 13 of Regulatory Guide 1.109, Rev. 1, Oct. 1977.

TABLE 3.5-7

HUMIDITY PARAMETERS AT RECEPTORS

Monthly Average Absolute Humidity (gm/m^3)	
January	3.06
February	3.09
March	3.83
April	5.71
May	8.19
June	12.62
July	15.53
August	14.62
September	11.68
October	8.11
November	5.37
December	3.73

TABLE 3.5-8

LOCATION OF NEAREST RESIDENCE, VEGETABLE GARDEN, AND SITE BOUNDARY BY SECTOR*

Sector	Nearest Residence Distance* (M)	Nearest Residence Elevation** (M)	Nearest Vegetable Garden Distance* (M)	Nearest Vegetable Garden Elevation** (M)	Nearest Site Boundary Distance* (M)	Nearest Site Boundary Elevation** (M)
N	-	-	-	-	436	6.1
NNE	381	6.1	-	-	365	6.1
NE	518	6.1	-	-	32	6.1
ENE	884	6.1	1,932	30	311	6.1
E	1,128	6.1	3,867	67	346	6.1
ESE	914	6.1	1,932	25	457	6.1
SE	1,097	26	2,091	50	1,105	26
SSE	914	30	1,771	40	876	30
S	610	25	1,771	37	610	25
SSW	518	28	7,080	58	457	22
SW	549	17	4,073	46	533	17
WSW	1,585	33	2,252	42	457	15
W	1,570	31	2,252	35	360	6.1
WNW	610	6.1	-	-	354	6.1
NW	-	-	-	-	419	6.1
NNW	-	-	-	-	436	6.1

NOTES:

* Distances are given from the reactor center lines out to 8,046 meters.

There are no milk cows or meat animals within the 8,046 m radius of the site. The nearest milk cow is located 8,690 m east of the site. The nearest milk goats are located 2,478 m east-southeast, 3,846 m southwest and 7,725 m south-southwest of the site. Corresponding elevations above mean sea level are 49 m, 46 m, and 58 m respectively.

** Elevations (meters) given are above mean sea level.

TABLE 3.5-9

P_{oij}

CONTAMINATED GROUND, INGESTION OF LEAFY AND STORED VEGETABLES DOSE RATE CONVERSION FACTORS FOR CHILD
m^2 (mrem/yr/μ Ci/sec)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
N-13	4.0E+04	4.0E+04	4.0E+04	4.0E+04	4.0E+04	4.0E+04	4.0E+04
F-18	4.0E+05	4.0E+05	4.0E+05	4.0E+05	4.0E+05	4.0E+05	4.0E+05
NA-24	1.2E+07	1.2E+07	1.2E+07	1.2E+07	1.2E+07	1.2E+07	1.2E+07
P-32	3.6E+09	1.7E+08	1.4E+08	-(1)	-	-	9.9E+07
CR-51	4.9E+06	4.9E+06	5.0E+06	5.0E+06	4.9E+06	5.0E+06	1.1E+07
MN-54	1.3E+09	1.9E+09	1.5E+09	1.3E+09	1.5E+09	1.3E+09	1.8E+09
MN-56	9.0E+05	9.0E+05	9.0E+05	9.0E+05	9.0E+05	9.0E+05	9.0E+05
FE-55	7.3E+08	3.8E+08	1.2E+08	-	-	2.1E+08	7.1E+07
FE-59	6.5E+08	8.8E+08	5.8E+08	2.8E+08	2.8E+08	4.5E+08	9.1E+08
CO-58	3.8E+08	4.4E+08	5.6E+08	3.8E+08	3.8E+08	3.8E+08	7.3E+08
CO-60	2.3E+10	2.3E+10	2.4E+10	2.3E+10	2.3E+10	2.3E+10	2.5E+10
NI-63	4.6E+10	2.4E+09	1.6E+09	-	-	-	1.6E+08
NI-65	3.0E+05	3.0E+05	3.0E+05	3.0E+05	3.0E+05	3.0E+05	3.0E+05
CU-64	6.1E+05	6.2E+05	6.2E+05	6.1E+05	6.4E+05	6.1E+05	1.1E+06
ZN-65	1.8E+09	3.4E+09	2.5E+09	8.6E+08	2.5E+09	8.6E+08	1.3E+09
ZN-69M	1.3E+06	1.3E+06	1.3E+06	1.3E+06	1.3E+06	1.3E+06	1.5E+06
BR-83	4.9E+03	4.9E+03	4.9E+03	4.9E+03	4.9E+03	4.9E+03	4.9E+03
BR-84	2.0E+05	2.0E+05	2.0E+05	2.0E+05	2.0E+05	2.0E+05	2.0E+05
RB-86	9.0E+06	4.5E+08	2.8E+08	9.0E+06	9.0E+06	9.0E+06	3.7E+07
RB-88	3.3E+04	3.3E+04	3.3E+04	3.3E+04	3.3E+04	3.3E+04	3.3E+04
RB-89	1.2E+05	1.2E+05	1.2E+05	1.2E+05	1.2E+05	1.2E+05	1.2E+05
SR-89	3.3E+10	2.2E+04	9.5E+08	2.2E+04	2.2E+04	2.2E+04	1.3E+09
SR-90	1.4E+12	6.7E+06	3.4E+11	6.7E+06	6.7E+06	6.7E+06	1.8E+10
SR-91	3.8E+06	3.3E+06	3.3E+06	3.3E+06	3.3E+06	3.3E+06	4.4E+06
SR-92	9.5E+05	9.5E+05	9.5E+05	9.5E+05	9.5E+05	9.5E+05	9.6E+05
Y-90	2.7E+04	4.5E+03	5.1E+03	4.5E+03	4.5E+03	4.5E+03	6.3E+07
Y-91M	1.0E+05	1.0E+05	1.0E+05	1.0E+05	1.0E+05	1.0E+05	1.0E+05
Y-91	1.8E+07	1.1E+06	1.6E+06	1.1E+06	1.1E+06	1.1E+06	2.3E+09
Y-92	1.8E+05	1.8E+05	1.8E+05	1.8E+05	1.8E+05	1.8E+05	1.9E+06
Y-93	1.8E+05	1.8E+05	1.8E+05	1.8E+05	1.8E+05	1.8E+05	4.5E+06
ZR-95	5.0E+08	5.0E+08	5.0E+08	5.0E+08	5.0E+08	5.0E+08	1.3E+09
ZR-97	5.3E+06	5.3E+06	5.3E+06	5.3E+06	5.3E+06	5.3E+06	1.7E+07

TABLE 3.5-9 (CONT'D)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
NB-95	1.4E+08	1.4E+08	1.4E+08	1.4E+08	1.4E+08	1.4E+08	4.2E+08
MO-99	6.1E+06	1.4E+07	7.9E+06	6.1E+06	2.2E+07	6.1E+06	1.2E+07
TC-99M	1.8E+05	1.8E+05	1.8E+05	1.8E+05	1.8E+05	1.8E+05	1.9E+05
TC-101	2.0E+04	2.0E+04	2.0E+04	2.0E+04	2.0E+04	2.0E+04	2.0E+04
RU-103	1.2E+08	1.1E+08	1.2E+08	1.1E+08	1.5E+08	1.1E+08	4.9E+08
RU-105	7.3E+05	7.3E+05	7.3E+05	7.3E+05	7.3E+05	7.3E+05	7.9E+05
RU-106	1.1E+09	4.2E+08	5.1E+08	4.2E+08	1.4E+09	4.2E+08	1.1E+10
AG-110M	3.5E+09	3.5E+09	3.5E+09	3.5E+09	3.5E+09	3.5E+09	6.2E+09
SB-124	6.8E+08	6.0E+08	6.3E+08	6.0E+08	6.0E+08	6.6E+08	3.08+09
TE-125M	4.2E+08	1.1E+08	5.7E+07	1.2E+08	1.6E+06	1.6E+06	4.1E+08
TE-127M	1.9E+09	4.9E+08	2.2E+08	4.4E+08	5.2E+09	9.2E+05	1.4E+09
TE-127	1.3E+04	5.7E+03	5.2E+03	9.9E+03	3.2E+04	3.0E+03	3.9E+05
TE-129M	9.7E08	2.9E+08	1.8E+08	3.3E+08	2.7E+09	3.8E+07	1.2E+09
TE-129	2.6E+04	2.6E+04	2.6E+04	2.6E+04	2.6E+04	2.6E+04	2.6E+04
TE-131M	1.4E+07	1.3E+07	1.3E+07	1.3E+07	1.7E+07	1.2E+07	3.4E+07
TE-131	6.6E+04	6.6E+04	6.6E+04	6.6E+04	6.6E+04	6.6E+04	6.6E+04
TE-132	5.4E+07	5.0E+07	5.1E+07	5.2E+07	7.6E+07	4.7E+07	7.9E+07
I-130	3.1E+06	3.4E+06	3.1E+06	6.9E+07	3.7E+06	2.8E+06	3.1E+06
I-131	7.7E+07	7.8E+07	4.8E+07	2.3E+10	1.2E+08	8.6E+06	1.5E+07
I-132	6.2E+05	6.2E+05	6.2E+05	6.2E+05	6.2E+05	6.2E+05	6.2E+05
I-133	2.9E+06	3.3E+06	2.0E+06	3.9E+08	4.7E+06	1.2E+06	2.0E+06
I-134	2.2E+05	2.2E+05	2.2E+05	2.2E+05	2.2E+05	2.2E+05	2.2E+05
I-135	1.3E+06	1.4E+06	1.3E+06	6.0E+06	1.4E+06	1.3E+06	1.3E+06
CS-134	2.2E+10	3.1E+10	1.2E+10	6.9E+09	1.4E+10	9.6E+09	7.0E+09
CS-136	2.3E+08	3.6E+08	2.9E+08	1.5E+08	2.6E+08	1.7E+08	1.6E+08
CS-137	3.7E+10	3.6E+10	1.6E+10	1.3E+10	2.1E+10	1.6E+10	1.3E+10
CS-138	3.6E+05	3.6E+05	3.6E+05	3.6E+05	3.6E+05	3.6E+05	3.6E+05
BA-139	1.1E+05	1.1E+05	1.1E+05	1.1E+05	1.1E+05	1.1E+05	1.1E+05
BA-140	4.3E+08	1.7E+08	1.9E+08	1.7E+08	1.7E+08	1.7E+08	3.0E+08
BA-141	5.0E+04	5.0E+04	5.0E+04	5.0E+04	5.0E+04	5.0E+04	5.0E+04
BA-142	1.3E+05	1.3E+05	1.3E+05	1.3E+05	1.3E+05	1.3E+05	1.3E+05
LA-140	1.9E+07	1.9E+07	1.9E+07	1.9E+07	1.9E+07	1.9E+07	4.9E+07
LA-142	7.3E+05	7.3E+05	7.3E+05	7.3E+05	7.3E+05	7.3E+05	7.3E+05
CE-141	1.5E+07	1.4E+07	1.4E+07	1.4E+07	1.4E+07	1.4E+07	4.0E+08
CE-143	2.3E+06	3.2E+06	2.3E+06	2.3E+06	2.3E+06	2.3E+06	1.5E+07
CE-144	2.3E+08	1.5E+08	1.2E+08	1.1E+08	1.3E+08	1.1E+08	9.6E+09

TABLE 3.5-9 (CONT'D)

Nuclide	Bone	Liver	T. Body	Thydoid	Kidney	Lung	GI-LLI
PR-143	1.4E+05	4.2E+04	6.8E+03	-	2.3E+04	-	1.5E+08
PR-144	1.8E+03	1.8E+03	1.8E+03	1.8E+03	1.8E+03	1.8E+03	1.8E+03
ND-147	8.5E+06	8.5E+06	8.4E+06	8.4E+06	8.4E+06	8.4E+06	9.5E+07
W-187	2.5E+06	2.4E+06	2.4E+06	2.4E+06	2.4E+06	2.4E+06	7.6E+06
NP-239	1.7E+06	1.7E+06	1.7E+06	1.7E+06	1.7E+06	1.7E+06	1.5E+07

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(1) The dash (-) indicates insufficient data or that the dose factor is < 1.0E-20.

TABLE 3.5-10

P_{oij}

CHILD INGESTION OF COW'S MILK DOSE RATE CONVERSION FACTORS
m^2(mrem/yr/μ Ci/sec)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
F-18	3.5E-03	-	3.9E-04	-	-	-	1.0E-04
NA-24	4.3E+06	4.3E+06	4.3E+06	4.3E+06	4.3E+06	4.3E+06	4.3E+06
P-32	3.7E+10	1.7E+09	1.4E+09	-	-	-	1.0E+09
CR-51	-(1)	-	4.6E+04	2.5E+04	7.0E+03	4.6E+04	2.4E+06
MN-54	-	1.1E+07	2.9E+06	-	3.0E+06	-	9.0E+06
MN-56	-	6.2E-03	1.4E-03	-	7.5E-03	-	9.0E-01
FE-55	5.8E+07	3.1E+07	9.5E+06	-	-	1.7E+07	5.7E+06
FE-59	5.4E+07	8.8E+07	4.4E+07	-	-	2.5E+07	9.1E+07
CO-58	-	5.6E+06	1.7E+07	-	-	-	3.3E+07
CO-60	-	2.3E+07	6.9E+07	-	-	-	1.3E+08
NI-63	1.8E+10	9.8E+08	6.2E+08	-	-	-	6.6E+07
NI-65	9.5E-01	8.9E-02	5.2E-02	-	-	-	1.1E+01
CU-64	-	3.7E+04	2.3E+04	-	9.1E+04	-	1.8E+06
ZN-65	2.4E+09	6.5E+09	4.1E+09	-	4.1E+09	-	1.1E+09
ZN-69M	2.5E+04	3.6E+04	3.3E+03	-	2.2E+04	-	2.2E+06
BR-83	-	-	2.3E-01	-	-	-	-
RB-86	-	4.0E+09	2.4E+09	-	-	-	2.5E+08
SR-89	3.0E+09	-	8.6E+07	-	-	-	1.2E+08
SR-90	6.6E+10	-	1.7E+10	-	-	-	8.9E+08
SR-91	6.2E+04	-	2.4E+03	-	-	-	1.4E+05
SR-92	1.1E+00	-	4.2E-02	-	-	-	2.0E+01
Y-90	1.5E+02	-	4.1E+00	-	-	-	4.4E+05
Y-91M	1.5E-19	-		-	-	-	2.9E-16
Y-91	1.8E+04	-	4.8E+02	-	-	-	2.4E+06
Y-92	1.2E-04	-	3.5E-06	-	-	-	1.4E+02
Y-93	5.1E-01	-	1.4E-02	-	-	-	7.6E+03
ZR-95	1.8E+03	3.9E+02	3.5E+02	-	5.6E+02	-	4.1E+05
ZR-97	9.0E-01	1.5E-01	7.7E-02	-	1.9E-01	-	2.0E+04

TABLE 3.5-10 (CONT'D)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
NB-95	1.4E+05	5.5E+04	3.9E+04	-	5.2E+04	-	1.0E+08
MO-99	-	3.9E+07	9.7E+06	-	8.4E+07	-	3.2E+07
TC-99M	6.5E+00	1.3E+01	2.1E+02	-	1.8E+02	6.4E+00	7.2E+03
RU-103	1.9E+03	-	7.4E+02	-	4.8E+03	-	5.0E+04
RU-105	1.9E-03	-	6.8E-04	-	1.6E-02	-	1.2E+00
RU-106	4.9E+04	-	6.1E+03	-	6.6E+04	-	7.6E+05
AG-110M	1.1E+08	7.6E+07	6.1E+07	-	1.4E+08	-	9.0E+09
SB-124	1.3E+07	2.4E+05	5.0E+06	3.0E+04	-	9.8E+06	3.6E+08
TE-125M	3.8E+07	1.0E+07	5.1E+06	1.1E+07	-	-	3.7E+07
TE-127M	1.3E+08	3.4E+07	1.5E+07	3.0E+07	3.6E+08	-	1.0E+08
TE-127	1.5E+03	4.0E+02	3.2E+02	1.0E+03	4.3E+03	-	5.8E+04
TE-129M	1.3E+08	3.6E+07	2.0E+07	4.2E+07	3.8E+08	-	1.6E+08
TE-129	7.8E-10	2.2E-10	1.8E-10	5.5E-10	2.3E-09	-	4.8E-08
TE-131M	7.9E+05	2.7E+05	2.9E+05	5.6E+05	2.6E+06	-	1.1E+07
TE-132	5.0E+06	2.2E+06	2.7E+06	3.2E+06	2.1E+07	-	2.2E+07
I-130	4.2E+05	8.6E+05	4.4E+05	9.4E+07	1.3E+06	-	4.0E+05
I-131	3.1E+08	3.1E+08	1.8E+08	1.0E+11	5.1E+08	-	2.7E+07
I-132	1.6E-01	2.8E-01	1.3E-01	1.3E+01	4.4E-01	-	3.4E-01
I-133	4.1E+06	5.1E+06	1.9E+06	9.5E+08	8.5E+06	-	2.1E+06
I-134	2.0E-12	3.7E-12	1.7E-12	8.5E-11	5.7E-12	-	2.5E-12
I-135	1.3E+04	2.3E+04	1.1E+04	2.1E+06	3.6E+04	-	1.8E+04
CS-134	1.2E+10	1.9E+10	4.1E+09	-	6.0E+09	2.2E+09	1.0E+08
CS-136	4.6E+08	1.3E+09	8.2E+08	-	6.7E+08	1.0E+08	4.4E+07
CS-137	1.8E+10	1.7E+10	2.6E+09	-	5.7E+09	2.0E+09	1.1E+08
BA-139	1.1E-07	5.7E-11	3.1E-09	-	5.0E-11	3.4E-11	6.2E-06
BA-140	5.4E+07	4.7E+04	3.1E+06	-	1.5E+04	2.8E+04	2.7E+07
LA-140	9.4E+00	3.3E+00	1.0E+00	-	-	-	9.1E+04
LA-142	2.0E-11	6.3E-12	2.0E-12	-	-	-	1.2E-06
CE-141	9.7E+03	4.8E+03	7.2E+02	-	2.1E+03	-	6.0E+06
CE-143	9.0E+01	4.9E+04	7.1E+00	-	2.1E+01	-	7.2E+05
CE-144	8.2E+05	2.6E+05	4.4E+04	-	1.4E+05	-	6.7E+07
PR-143	3.3+02	9.8E+01	1.6E+01	-	5.3E+01	-	3.5E+05

TABLE 3.5-10 (CONT'D)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
ND-147	2.1E+02	1.7E+02	1.3E+01	-	9.1E+01	-	2.6E+05
W-187	1.4E+04	8.3E+03	3.7E+03	-	-	-	1.2E+06
NP-239	8.3E+00	6.0E-01	4.2E-01	-	1.7E+00	-	4.4E+04

(1) The dash (-) indicates insufficient data or that the dose factor is < 1.0E-20.

TABLE 3.5-11

P_{oij}

CHILD INGESTION OF GOAT'S MILK DOSE RATE CONVERSION FACTORS
m^2 (mrem/yr/µ Ci/sec)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
F-18	3.0E-04	-	3.3E-05	-	-	-	8.8E-06
NA-24	5.2E+05	5.2E+05	5.2E+05	5.2E+05	5.2E+05	5.2E+05	5.2E+05
P-32	4.4E+10	2.1E+09	1.7E+09	-	-	-	1.2E+09
CR-51	-[1]	-	5.5E+03	3.1E+03	8.3E+02	5.6E+03	2.9E+05
MN-54	-	[illegible].3E+06	3.4E+05	-	3.6E+05	-	1.1E+06
MN-56	-	7.5E-04	1.7E-04	-	9.0E-04	-	1.1E-01
FE-55	7.5E+05	4.0E+05	1.2E+05	-	-	2.3E+05	7.4E+04
FE-59	7.0E+05	1.1E+06	5.7E+05	-	-	3.3E+05	1.2E+06
CO-58	-	6.8E+05	2.1E+06	-	-	-	3.9E+06
CO-60	-	2.8E+06	8.2E+06	-	-	-	1.5E+07
NI-63	2.2E+09	1.2E+08	7.4E+07	-	-	-	7.9E+06
NI-65	1.1E-01	1.1E-02	6.2E-03	-	-	-	1.3E+00
CU-64	-	4.2E+03	2.5E+03	-	1.0E+04	-	2.0E+05
ZN-65	2.9E+08	7.8E+08	4.9E+08	-	4.9E+08	-	1.4E+08
ZN-69M	3.0E+03	4.3E+03	3.9E+02	-	2.6E+03	-	2.7E+05
BR-83	-	-	2.8E-02	-	-	-	-
RB-86	-	4.7E+08	2.9E+08	-	-	-	3.1E+07
SR-89	6.3E+09	-	1.8E+08	-	-	-	2.4E+08
SR-90	1.4E+11	-	3.5E+10	-	-	-	1.9E+09
SR-91	1.3E+05	-	4.9E+03	-	-	-	2.9E+05
SR-92	2.2E+00	-	8.9E-02	-	-	-	4.2E+01
Y-90	1.9E+01	-	5.0E-01	-	-	-	5.3E+04
Y-91M	1.8E-20	-		-	-	-	3.4E-17
Y-91	2.1E+03	-	5.7E+01	-	-	-	2.9E+05
Y-92	1.5E-05	-	4.2E-07	-	-	-	1.7E+01
Y-93	6.1E-02	-	1.7E-03	-	-	-	9.1E+02
ZR-95	2.1E+02	4.7E+01	4.2E+01	-	6.7E+01	-	4.9E+04
ZR-97	1.1E-01	1.6E-02	9.2E-03	-	2.2E-02	-	2.4E+03

TABLE 3.5-11 (CONT'D)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
NB-95	1.7E+04	6.6E+03	4.7E+03	-	6.2E+03	-	1.2E+07
MO-99	-	4.7E+06	1.2E+06	-	1.0E+07	-	3.9E+06
TC-99M	8.1E-01	1.6E+00	2.6E+01	-	2.3E+01	8.0E-01	9.0E+02
RU-103	2.3E+02	-	8.9E+01	-	5.8E+02	-	6.0E+03
RU-105	2.2E-04	-	8.1E-05	-	2.0E-03	-	1.5E-01
RU-106	5.8E+03	-	7.3E+02	-	7.9E+03	-	9.1E+04
AG-110M	1.3E+07	9.1E+06	7.3E+06	-	1.7E+07	-	1.1E+09
SB-124	1.5E+06	2.9E+04	6.0E+05	3.7E+03	-	1.2E+06	4.3E+07
TE-125M	4.6E+06	1.2E+06	6.1E+05	1.3E+06	-	-	4.4E+06
TE-127M	1.5E+07	4.1E+06	1.8E+06	3.6E+06	4.3E+07	-	1.2E+07
TE-127	1.8E+02	4.8E+01	3.8E+01	1.2E+02	5.1E+02	-	7.0E+03
TE-129M	1.6E+07	4.4E+06	2.4E+06	5.0E+06	4.6E+07	-	1.9E+07
TE-129	9.3E-11	2.6E-11	2.2E-11	6.6E-11	2.7E-10	-	5.8E-09
TE-131M	9.4E+04	3.3E+04	3.5E+04	6.7E+04	3.2E+05	-	1.3E+06
TE-132	6.0E+05	2.7E+05	3.2E+05	3.9E+05	2.5E+06	-	2.7E+06
I-130	5.1E+05	1.0E+06	5.3E+05	1.1E+08	1.5E+06	-	4.8E+05
I-131	3.7E+08	3.7E+08	2.1E+08	1.2E+11	6.1E+08	-	3.3E+07
I-132	1.9E-01	3.4E-01	1.6E-01	1.6E+01	5.2E-01	-	4.0E-01
I-133	5.0E+06	6.1E+06	2.3E+06	1.1E+09	1.0E+07	-	2.5E+06
I-134	2.4E-12	4.4E-12	2.0E-12	1.0E-10	6.8E-12	-	3.0E-12
I-135	1.6E+04	2.8E+04	1.3E+04	2.5E+06	4.3E+04	-	2.1E+04
CS-134	3.6E+10	5.8E+10	1.2E+10	-	1.8E+10	6.5E+09	3.1E+08
CS-136	1.4E+09	3.8E+09	2.5E+09	-	2.0E+09	3.0E+08	1.3E+08
CS-137	5.5E+10	5.2E+10	7.7E+09	-	1.7E+10	6.1E+09	3.3E+08
BA-139	1.3E-08	6.8E-12	3.7E-10	-	6.0E-12	4.0E-12	7.4E-07
BA-140	6.4E+06	5.6E+03	3.8E+05	-	1.8E+03	3.4E+03	3.3E+06
LA-140	1.1E+00	3.9E-01	1.2E-01	-	-	-	1.1E+04
LA-142	2.4E-12	7.5E-13	2.4E-13	-	-	-	1.5E-07
CE-141	7.0E+03	3.5E+03	5.2E+02	-	1.5E+03	-	4.4E+06
CE-143	6.5E+01	3.5E+04	5.1E+00	-	1.5E+01	-	5.2E+05
CE-144	5.9E+05	1.8E+05	3.1E+04	-	1.0E+05	-	4.8E+07
PR-143	3.9E+01	1.2E+01	1.9E+00	-	6.4E+00	-	4.2E+04

TABLE 3.5-11 (CONT'D)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
ND-147	2.5E+01	2.0E+01	1.5E+00	-	1.1E+01	-	3.2E+04
W-187	1.7E+03	1.0E+03	4.5E+02	-	-	-	1.4E+05
NP-239	1.0E+00	7.2E-02	5.1E-02	-	2.1E-01	-	5.3E+03

(1) The dash (-) indicates insufficient data or that the dose factor is < 1.0E-20.

TABLE 3.5-12

P_{oij}

CHILD INGESTION OF MEAT DOSE RATE CONVERSION FACTORS
m^2 (mrem/yr/μ Ci/sec)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
NA-24	9.5E-04	9.5E-04	9.5E-04	9.5E-04	9.5E-04	9.5E-04	9.5E-04
P-32	3.5E+09	1.7E+08	1.4E+08	-	-	-	9.8E+07
CR-51	-(1)	-	4.0E+03	2.2E+03	6.1E+02	4.1E+03	2.1E+05
MN-54	-	4.1E+06	1.1E+06	-	1.1E+06	-	3.4E+06
FE-55	2.4E+08	1.3E+08	3.9E+07	-	-	7.1E+07	2.3E+07
FE-59	1.7E+08	2.8E+08	1.4E+08	-	-	8.0E+07	2.9E+08
CO-58	-	7.6E+06	2.3E+07	-	-	-	4.5E+07
CO-60	-	3.7E+07	1.1E+08	-	-	-	2.1E+08
NI-63	1.8E+09	9.6E+07	6.1E+07	-	-	-	6.5E+06
CU-64	-	2.0E-07	1.2E-07	-	4.7E-07	-	9.2E-06
ZN-65	2.2E+08	5.9E+08	3.7E+08	-	3.7E+08	-	1.0E+08
ZN-69M	1.0E-06	1.5E-06	1.4E-07	-	9.0E-07	-	9.[illegible]-05
RB-86	-	2.6E+08	1.6E+08	-	-	-	1.7E+07
SR-89	2.2E+08	-	6.2E+06	-	-	-	8.5E+06
SR-90	6.2E+09	-	1.6E+09	-	-	-	8.3E+07
SR-91	1.1E-10	-	4.2E-12	-	-	-	2.5E-10
Y-90	8.3E+01	-	2.2E+00	-	-	-	2.4E+05
Y-91	8.2E+05	-	2.2E+04	-	-	-	1.1E+08
Y-93	5.1E-12	-	1.4E-13	-	-	-	7.6E-08
ZR-95	1.2E+06	2.7E+05	2.4E+05	-	3.9E+05	-	2.8E+08
ZR-97	1.3E-05	1.9E-06	1.1E-06	-	2.7E-06	-	2.8E-01

TABLE 3.5-12 (CONT'D)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
NB-95	1.4E+06	5.4E+05	3.8E+05	-	5.0E+05	-	9.9E+08
MO-99	-	5.6E+04	1.4E+04	-	1.2E+05	-	4.6E+04
TC-99M	-	-	1.1E-19	-	-	-	3.8E-18
RU-103	7.0E+07	-	2.7E+07	-	1.8E+08	-	1.8E+09
RU-106	2.3E+09	-	2.9E+08	-	3.2E+09	-	3.6E+10
AG-110M	4.5E+06	3.0E+06	2.4E+06	-	5.7E+06	-	3.6E+08
SB-124	3.4E+06	6.4E+04	1.3E+06	8.2E+03	-	2.6E+06	9.6E+07
TE-125M	3.0E+08	8.0E+07	3.9E+07	8.3E+07	-	-	2.9E+08
TE-127M	1.1E+09	2.9E+08	1.3E+08	2.6E+08	3.1E+09	-	8.7E+08
TE-127	2.0E-10	5.5E-11	4.4E-11	1.4E-10	5.8E-10	-	8.0E-09
TE-129M	8.6E+08	2.4E+08	1.3E+08	2.8E+08	2.5E+09	-	1.0E+09
TE-131M	3.5E+02	1.2E+02	1.3E+02	2.5E+02	.12E+03	-	4.9E+03
TE-132	1.0E+06	4.6E+05	5.5E+05	6.6E+05	4.2E+06	-	4.6E+06
I-130	8.7E-07	1.7E-06	9.0E-07	1.9E-04	2.6E-06	-	8.2E-07
I-131	3.9E+06	3.9E+06	2.2E+06	1.3E+09	6.4E+06	-	3.5E+05
I-133	1.4E-01	1.7E-01	6.6E-02	3.2E+01	2.9E-01	-	7.0E-02
I-135	1.6E-17	2.8E-17	1.3E-17	2.5E-15	4.3E-17	-	2.1E-17
CS-134	4.8E+08	7.9E+08	1.7E+08	-	2.5E+08	8.8E+07	4.3E+06
CS-136	7.3E+06	2.0E+07	1.3E+07	-	1.1E+07	1.6E+06	7.0E+05
CS-137	7.5E+08	7.2E+08	1.1E+08	-	2.4E+08	8.5E+07	4.5E+06
BA-139	-	-	-	-	-	-	-
BA-140	2.0E+07	1.8E+04	1.2E+06	-	5.7E+03	1.0E+04	1.0E+07
LA-140	2.8E-02	9.6E-03	3.0E-03	-	-	-	2.7E+02
CE-141	9.9E+03	4.9E+03	7.3E+02	-	2.2E+03	-	6.1E+06
CE-143	1.5E-02	8.4E+00	1.2E-03	-	3.5E-03	-	1.2E+02
CE-144	1.2E+06	3.7E+05	6.2E+04	-	2.0E+05	-	9.5E+07
PR-143	1.5E+04	4.6E+03	7.6E+02	-	2.5E+03	-	1.6E+07

TABLE 3.5-12 (CONT'D)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
ND-147	5.4E+03	4.4E+03	3.4E+02	-	2.4E+03	-	6.9E+06
W-187	1.6E-02	9.7E-03	4.4E-03	-	-	-	1.4E+00
NP-239	2.1E-01	1.5E-02	1.1E-02	-	4.4E-02	-	1.1E+03

(1) The dash (-) indicates insufficient data or that the dose factor is < 1.0E-20.

TABLE 3.5-13

P_{oij}

INFANT INGESTION OF COW'S MILK DOSE RATE CONVERSION FACTORS
m^2 (mrem/yr/μ Ci/sec)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
F-18	3.5E-03	-	3.9E-04	-	-	-	1.0E-04
NA-24	7.5E+06	7.5E+06	7.5E+06	7.5E+06	7.5E+06	7.5E+06	7.5E+06
P-32	7.6E+10	4.5E+09	2.9E+09	-	-	-	1.0E+09
CR-51	-(1)	-	7.3E+04	4.7E+04	1.0E+04	9.2E+04	2.1E+06
MN-54	-	2.0E+07	4.5E+06	-	4.4E+06	-	7.3E+06
MN-56	-	1.5E-02	2.6E-03	-	1.3E-02	-	1.4E+00
FE-55	7.0E+07	4.5E+07	1.2E+07	-	-	2.2E+07	5.8E+06
FE-59	1.0E+08	1.8E+08	7.0E+07	-	-	5.2E+07	8.4E+07
CO-58	-	1.1E+07	2.8E+07	-	-	-	2.8E+07
CO-60	-	4.8E+07	1.1E+08	-	-	-	1.1E+08
NI-63	2.1E+10	1.3E+09	7.5E+08	-	-	-	6.6E+07
NI-65	2.0E+00	2.3E-01	1.0E-01	-	-	-	1.7E+01
CU-64	-	9.3E+04	4.3E+04	-	1.6E+05	-	1.9E+06
ZN-65	3.3E+09	1.1E+10	5.2E+09	-	5.5E+09	-	9.5E+09
ZN-69M	5.2E+04	9.4E+04	7.0E+03	-	3.9E+04	-	7.7E+06
BR-83	-	-	4.9E-01	-	-	-	-
RB-86	-	1.0E+10	5.0E+09	-	-	-	2.6E+08
SR-89	5.7E+09	-	1.6E+08	-	-	-	1.2E+08
SR-90	7.2E+10	-	1.8E+10	-	-	-	9.0E+08
SR-91	1.3E+05	-	4.7E+03	-	-	-	1.5E+05
SR-92	2.2E+00	-	8.3E-02	-	-	-	2.4E+01
Y-90	3.3E+02	-	8.8E+00	-	-	-	4.5E+05
Y-91M	3.1E-19	-	1.1E-20	-	-	-	1.0E-15
Y-91	3.3E+04	-	8.9E+02	-	-	-	2.4E+06
Y-92	2.6E-04	-	7.3E-06	-	-	-	4.9E+00
Y-93	1.1E+00	-	2.9E-02	-	-	-	8.6E+03
ZR-95	3.1E+03	7.7E+02	5.4E+02	-	8.3E+02	-	3.8E+05

TABLE 3.5-13 (CONT'D)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
ZR-97	1.9E+00	3.3E-01	1.5E-01	-	3.3E-01	-	2.1E+04
NB-95	2.6E+05	1.1E+05	6.3E+04	-	7.8E+04	-	9.2E+07
MO-99	-	1.0E+08	2.0E+07	-	1.5E+08	-	3.3E+07
TC-99M	1.3E+01	2.8E+01	3.6E+02	-	3.0E+02	1.5E+01	8.1E+03
RU-103	3.9E+03	-	1.3E+03	-	8.1E+03	-	4.7E+04
RU-105	3.9E-03	-	1.3E-03	-	2.9E-02	-	1.6E+00
RU-106	1.0E+05	-	1.3E+04	-	1.2E+05	-	7.6E+05
AG-110M	2.1E+08	1.5E+08	1.0E+08	-	2.2E+08	-	7.8E+09
SB-124	1.3E+07	2.4E+05	5.0E+06	3.0E+04	-	9.8E+06	3.6E+08
TE-125M	7.8E+07	2.6E+07	1.1E+07	2.6E+07	-	-	3.7E+07
TE-127M	2.5E+08	8.4E+07	3.1E+07	7.3E+07	6.3E+08	-	1.0E+08
TE-127	3.2E+03	1.1E+03	6.8E+02	2.6E+03	7.7E+03	-	6.7E+04
TE-129M	2.7E+08	9.2E+07	4.1E+07	1.0E+08	6.7E+08	-	1.6E+08
TE-129	1.6E-09	5.7E-10	3.8E-10	1.4E-09	4.1E-09	-	1.3E-07
TE-131M	1.7E+06	6.7E+05	5.5E+05	1.4E+06	4.6E+06	-	1.1E+07
TE-132	1.0E+07	5.1E+06	4.8E+06	7.5E+06	3.2E+07	-	1.9E+07
I-130	8.7E+05	1.9E+06	7.7E+05	2.2E+08	2.1E+06	-	4.1E+05
I-131	6.4E+08	7.5E+08	3.3E+08	2.5E+11	8.8E+08	-	2.7E+07
I-132	3.2E-01	6.5E-01	2.3E-01	3.1E+01	7.3E-01	-	5.3E-01
I-133	8.7E+06	1.3E+07	3.7E+06	2.3E+09	1.5E+07	-	2.2E+06
I-134	4.1E-12	8.5E-12	3.0E-12	2.0E-10	9.5E-12	-	8.8E-12
I-135	2.7E+04	5.4E+04	2.0E+04	4.8E+06	6.0E+04	-	1.9E+04
CS-134	1.9E+10	3.6E+10	3.6E+09	-	9.2E+09	3.8E+09	9.7E+07
CS-136	9.0E+08	2.6E+09	9.9E+08	-	1.1E+09	2.2E+08	4.0E+07
CS-137	2.9E+10	3.4E+10	2.4E+09	-	9.1E+09	3.7E+09	1.1E+08
BA-139	2.3E-07	1.5E-10	6.6E-09	-	9.1E-11	9.1E-11	1.4E-05
BA-140	1.1E+08	1.1E+05	5.7E+06	-	2.6E+04	6.8E+04	2.7E+07
LA-140	2.0E+01	7.7E+00	2.0E+00	-	-	-	9.1E+04
LA-142	4.1E-11	1.5E-11	3.6E-12	-	-	-	2.6E-06
CE-141	1.9E+04	1.2E+04	1.4E+03	-	3.6E+03	-	6.1E+06
CE-143	1.9E+02	1.3E+05	1.4E+01	-	3.7E+01	-	7.4E+05
CE-144	1.2E+06	4.8E+05	6.6E+04	-	1.9E+05	-	6.7E+07
PR-143	6.8E+02	2.5E+02	3.4E+01	-	9.4E+01	-	3.6E+05

TABLE 3.5-13 (CONT'D)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
ND-147	4.1E+02	4.2E+02	2.6E+01	-	1.6E+02	-	2.6E+05
W-187	2.9E+04	2.1E+04	7.1E+03	-	-	-	1.2E+06
NP-239	1.8E+01	1.6E+00	8.9E-01	-	3.1E+00	-	4.6E+04

(1) The dash (-) indicates insufficient data or that the dose factor is < 1.0E-20.

TABLE 3.5-14

P_{oij}

INFANT INGESTION OF GOAT'S MILK DOSE RATE CONVERSION FACTORS
m^2 (mrem/yr/μ Ci/sec)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
F-18	3.0E-04	-	3.3E-05	-	-	-	8.8E-06
NA-24	9.1E+05	9.1E+05	9.1E+05	9.1E+05	9.1E+05	9.1E+05	9.1E+05
P-32	9.1E+10	5.4E+09	3.5E+09	-	-	-	1.2E+09
CR-51	-[1]	-	8.7E+03	5.7E+03	1.2E+03	1.1E+04	2.5E+05
MN-54	-	2.4E+06	5.4E+05	-	5.3E+05	-	8.8E+05
MN-56	-	1.8E-03	3.1E-04	-	1.6E-03	-	1.7E-01
FE-55	9.1E+05	5.9E+05	1.6E+05	-	-	2.9E+05	7.5E+04
FE-59	1.3E+06	2.3E+06	9.1E+05	-	-	6.8E+05	1.1E+06
CO-58	-	1.4E+06	3.4E+06	-	-	-	3.4E+06
CO-60	-	5.7E+06	1.3E+07	-	-	-	1.4E+07
NI-63	2.6E+09	1.6E+08	8.9E+07	-	-	-	7.9E+06
NI-65	2.4E-01	2.7E-02	1.2E-02	-	-	-	2.1E+00
CU-64	-	1.0E+04	4.8E+03	-	1.8E+04	-	2.1E+05
ZN-65	3.9E+08	1.4E+09	6.2E+08	-	6.6E+08	-	1.1E+09
ZN-69M	6.3E+03	1.1E+04	8.4E+02	-	4.7E+03	-	9.2E+05
BR-83	-	-	5.8E-02	-	-	-	-
RB-86	-	1.2E+09	6.0E+08	-	-	-	3.1E+07
SR-89	1.2E+10	-	3.4E+08	-	-	-	2.5E+08
SR-90	1.5E+11	-	3.9E+10	-	-	-	1.9E+09
SR-91	2.7E+05	-	9.9E+03	-	-	-	3.2E+05
SR-92	4.7E+00	-	1.7E-01	-	-	-	5.1E+01
Y-90	3.9E+01	-	1.1E+00	-	-	-	5.4E+04
Y-91M	3.7E-20	-	-	-	-	-	1.2E-16
Y-91	4.0E+03	-	1.1E+02	-	-	-	2.9E+05
Y-92	3.1E-05	-	8.7E-07	-	-	-	5.9E-01
Y-93	1.3E-01	-	3.5E-03	-	-	-	1.0E+03
ZR-95	3.8E+02	9.2E+01	6.5E+01	-	9.9E+01	-	4.6E+04
ZR-97	2.3E-01	3.9E-02	1.8E-02	-	4.0E-02	-	2.5E+03

TABLE 3.5-14 (CONT'D)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
NB-95	3.2E+04	1.3E+04	7.5E+03	-	9.4E+03	-	1.1E+07
MO-99	-	1.2E+07	2.3E+06	-	1.8E+07	-	4.0E+06
TC-99M	1.7E+00	3.5E+00	4.5E+01	-	3.7E+01	1.8E+00	1.0E+03
RU-103	4.7E+02	-	1.6E+02	-	9.7E+02	-	5.7E+03
RU-105	4.7E-04	-	1.6E-04	-	3.5E-03	-	1.9E-01
RU-106	1.2E+04	-	1.5E+03	-	1.4E+04	-	9.1E+04
AG-110M	2.5E+07	1.8E+07	1.2E+07	-	2.6E+07	-	9.4E+08
SB-124	1.5E+06	2.9E+04	6.0E+05	3.7E+03	-	1.2E+06	4.3E+07
TE-125M	9.4E+06	3.1E+06	1.3E+06	3.2E+06	-	-	4.5E+06
TE-127M	3.0E+07	1.0E+07	3.7E+06	8.8E+06	7.5E+07	-	1.2E+07
TE-127	3.8E+02	1.3E+02	8.2E+01	3.1E+02	9.3E+02	-	8.0E+03
TE-129M	3.2E+07	1.1E+07	4.9E+06	1.2E+07	8.0E+07	-	1.9E+07
TE-129	2.0E-10	6.8E-11	4.6E-11	1.7E-10	4.9E-10	-	1.6E-08
TE-131M	2.0E+05	8.0E+04	6.6E+04	1.6E+05	5.5E+05	-	1.3E+06
TE-132	1.2E+06	6.1E+05	5.7E+05	9.1E+05	3.8E+06	-	2.3E+06
I-130	1.0E+06	2.3E+06	9.2E+05	2.6E+08	2.5E+06	-	4.9E+05
I-131	7.7E+08	9.0E+08	4.0E+08	3.0E+11	1.1E+09	-	3.2E+07
I-132	3.9E-01	7.8E-01	2.8E-01	3.7E+01	8.7E-01	-	6.3E-01
I-133	1.0E+07	1.5E+07	4.5E+06	2.8E+09	1.8E+07	-	2.6E+05
I-134	5.0E-12	1.0E-11	3.6E-12	2.4E-10	1.1E-11	-	1.1E-11
I-135	3.2E+04	6.4E+04	2.3E+04	5.8E+06	7.2E+04	-	2.3E+04
CS-134	5.7E+10	1.1E+11	1.1E+10	-	2.8E+10	1.1E+10	2.9E+08
CS-136	2.7E+09	7.9E+09	3.0E+09	-	3.2E+09	6.5E+08	1.2E+08
CS-137	8.7E+10	1.0E+11	7.2E+09	-	2.7E+10	1.1E+10	3.2E+08
BA-139	2.7E-08	1.8E-11	7.9E-10	-	1.1E-11	1.1E-11	1.7E-06
BA-140	1.3E+07	1.3E+04	6.8E+05	-	3.1E+03	8.1E+03	3.3E+06
LA-140	2.3E+00	9.3E-01	2.4E-01	-	-	-	1.1E+04
LA-142	5.0E-12	1.8E-12	4.4E-13	-	-	-	3.1E-07
CE-141	1.4E+04	8.5E+03	1.0E+03	-	2.6E+03	-	4.4E+06
CE-143	1.4E+02	9.1E+04	1.0E+01	-	2.7E+01	-	5.3E+05
CE-144	8.4E+05	3.5E+05	4.7E+04	-	1.4E+05	-	4.8E+07

TABLE 3.5-14 (CONT'D)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
PR-143	8.1E+01	3.0E+01	4.0E+00	-	1.1E+01	-	4.3E+04
ND-147	4.9E+01	5.0E+01	3.1E+00	-	1.9E+01	-	3.2E+04
W-187	3.5E+03	2.5E+03	8.5E+02	-	-	-	1.4E+05
NP-239	2.1E+00	1.9E-01	1.1E-01	-	3.8E-01	-	5.5E+03

(1) The dash (-) indicates insufficient data or that the dose factor is < 1.0E-20.

TABLE 3.5-15

P_{ij}

CHILD INHALATION AND INGESTION OF LEAFY AND STORED VEGETABLES DOSE RATE CONVERSION FACTORS
(mrem per pCi)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	-	1.4E-6	1.4E-6	1.4E-6	1.4E-6	1.4E-6	1.4E-6
C-14*	9.6E-4	1.9E-4	1.9E-4	1.9E-4	1.9E-4	1.9E4	1.9E-4

Note:

* For short term releases such as from air removal pump or from containment drywell purge vent C-14 values should be multiplied by 2.

TABLE 3.5-16

P_{ij}

CHILD INGESTION OF GOAT'S MILK DOSE RATE CONVERSION FACTORS
(mrem per pCi)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	-	8.6E-7	8.6E-7	8.6E-7	8.6E-7	8.6E-7	8.6E-7
C-14*	4.7E-4	8.9E-5	8.9E-5	8.9E-5	8.9E-5	8.9E-5	8.9E-5

*See Note in Table 3.5-15

TABLE 3.5-17

P_{ij}

INFANT INGESTION OF GOAT'S MILK DOSE RATE CONVERSION FACTORS
(mrem per pCi)

Nuclide	Bone	Liver	T. Body	Thyroid	Kidney	Lung	GI-LLI
H-3	-	3.5E-12	3.5E-12	3.5E-12	3.5E-12	3.5E-12	3.5E-12
C-14*	2.4E-9	4.9E-10	4.9E-10	4.9E-10	4.9E-10	4.9E-10	4.9E-10

*See Note in Table 3.5-15

3.6 OPERATION OF VENTILATION EXHAUST TREATMENT SYSTEM

The Ventilation Exhaust Treatment System (see Figure 3.6-1) shall be used to reduce radioactive materials in gaseous waste prior to their discharge as specified in RETS Section 3.11.2.5. The dose analysis will be performed as described in Sections 3.5.1 or 3.5.2. If the calculated doses exceed the limits specified above consult RETS Section 3.11.2.5.

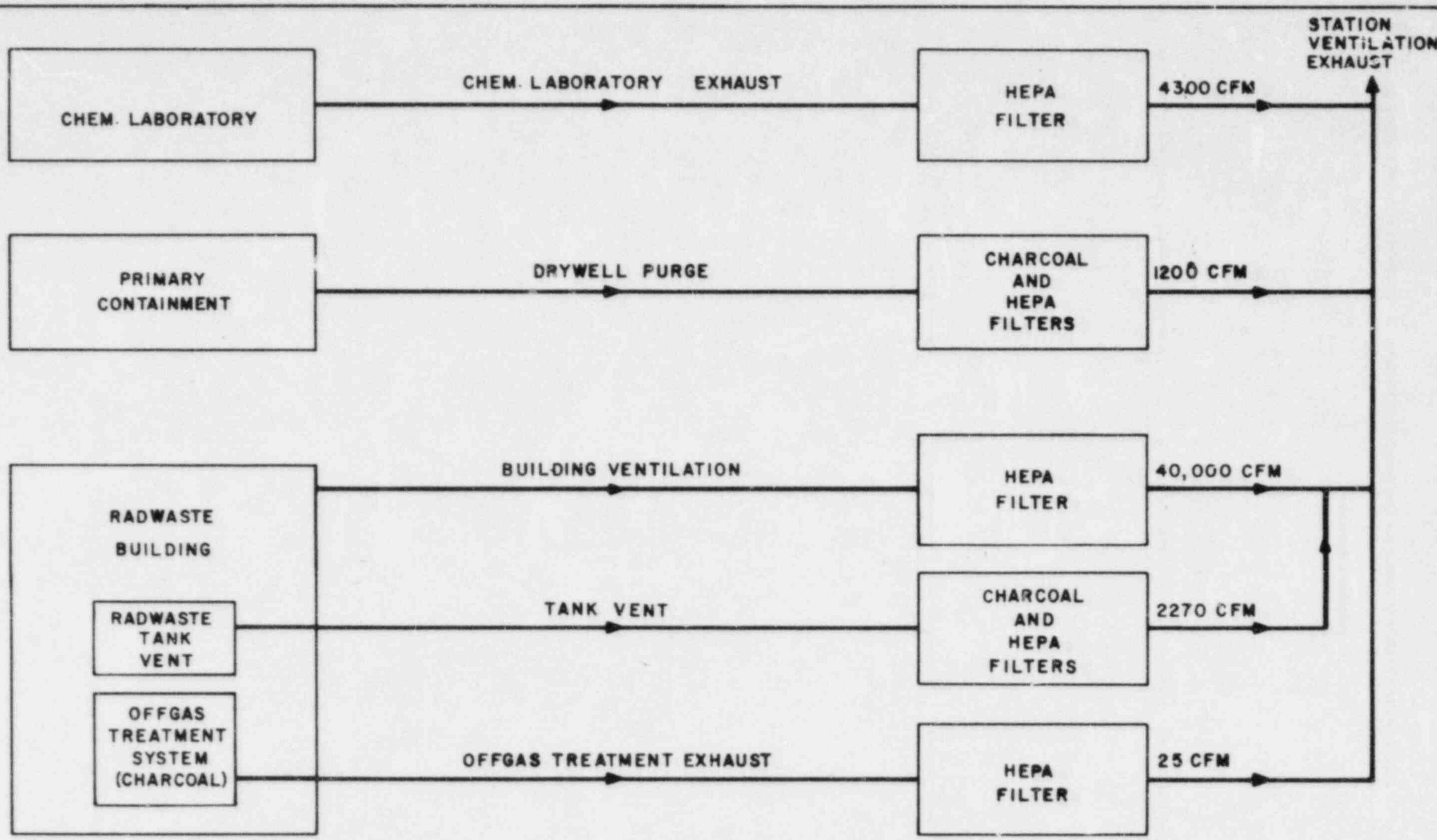

FIGURE 3.6-1
VENTILATION EXHAUST
TREATMENT SYSTEM
SHOREHAM NUCLEAR POWER STATION - UNIT-1
OFFSITE DOSE CALCULATION MANUAL

REVISION 1 - AUGUST 1983

3.7 TOTAL DOSE FOR THE URANIUM FUEL CYCLE

To comply with Section 3.11.4 of the RETS which implements 40CFR190, radiation doses shall be limited as follows:

> The dose or dose commitment to a member of the public, due to releases of radioactivity and radiation, from uranium fuel cycle sources shall be limited to 25 mrem, or less, to the total body and/or any organ (except the thyroid, which shall be limited to 75 mrem, or less), over any 12 consecutive months.

3.7.1 Sources of Radiation and Radioactivity

The uranium fuel cycle is defined in 40CFR190 to include:

a. operations of milling of uranium ore,

b. chemical conversion of uranium,

c. isotopic enrichment of uranium,

d. fabrication of uranium fuel,

e. generation of electricity by a nuclear power plant using uranium fuel, and

f. reprocessing of spent uranium fuel.

The maximum individual doses due to each of the processing facilities for items a, b, c, d, and f above are required to be less than 10CFR20 limits. Therefore, the dose contribution to any person living in the Shoreham service area due to the above facilities, which are all more than 125 kilometers distance away, is expected to be negligible compared to 40CFR190 limits.

The only radiological source of concern will be due to item e above. The nearest nuclear power plant using uranium fuel is more than 75 kilometers away.

3.7.2 Radiological Impact of Generation of Electricity

The generation of electricity using a nuclear power plant results in radioactivity released in gaseous and liquid effluents. The dose rate assessment of these is done in Section 3.3. The radiological impact of direct radiation (including skyshine) from the plant can be determined by measurement. The direct radiation measuring devices (TLD systems) are provided by the Radiological Environmental Monitoring Program (REMP) and are listed in Tables 5-1 and 5-4.

Dose registered by the TLDs will be added to the doses calculated in Sections 3.1.1 (Dose From Liquid Effluent) and 3.5.1 (dose to maximum individual due to inhalation and ingestion from gaseous effluents) to determine the total body dose due to all sources of radiation in the uranium fuel cycle.

SECTION 4

METEOROLOGICAL AND HYDROLOGICAL PARAMETERS UTILIZED IN THE CALCULATION OF DOSES

4.1 INTRODUCTION

This section specifies the liquid pathway dilution factor and the dispersion and deposition factors utilized for atmospheric releases. A description is given of the meteorological methodology and parameters utilized in the computerized method for atmospheric releasese. Critical locations for receptors and their respective dispersion and deposition factors are provided for the backup method for atmospheric releases.

For liquid effluent pathways a calculated dilution factor of 8.85 is used.

4.2 PARAMETERS AND METHODOLOGY USED IN THE COMPUTERIZED METHOD

4.2.1 Meteorological Data

Hourly average values (based upon 60 one-minute values) of temperature, wind speed, wind direction and temperature difference from the 33- and 150-ft levels of the Shoreham meteorological towers are used in the computerized method, to determine χ/Q and D/Q values at the locations given in Table 3.5.-8.

4.2.2 Long-Term χ/Q and D/Q Values

Sector-average atmospheric concentration dispersion factors $(\chi/Q)^{SA}$, gamma dispersion factors $(\chi/Q)^{SA}$ and relative deposition factors (D/Q) are calculated every hour using 60 one-minute meteorological data values obtained from the meteorological towers. The methodology utilized is described in the report "Shoreham Nuclear Power Station EMSP Software (Rev. B.1)" (Entech Engineering Inc., P104-R3, Section 2.0, July 1983, by J. N. Hamawi). General site specific data values that may be required for the calculation of dispersion parameters are given in Table 4-2.

The basic methodology used to obtain the $(\chi/Q)^{SA}$ and D/Q values is the straight-line trajectory model with Gaussian dispersion described in Regulatory Guide 1.111, Rev. 1. The list of selected options and variations from the Regulatory Guide is as follows:

(a) Plume depletion due to dry and wet depositions, as well as to en-route radioactive decay is conservatively ignored.

(b) Plume recirculation is accounted for by making use of the conservative open-terrain recirculation correction factors in Revision 0 of Reg. Guide 1.111, which are also used in the χOQDOQ computer code (NUREG/CR-2919, August 1982).

(c) The atmospheric dispersion equations employed include terms to account for the plume eddy reflections between the ground and an inversion layer aloft. The reflection, model was based on Turner's 'Workbook of Atmospheric Dispersion Estimates', (USEPA, Publication AP-26, 1970) and has the additional capability of predicting the entire range of effects from no reflection to the attainment of uniform vertical concentration resulting from multiple reflections.

(d) According to Regulatory Guide 1.111, Rev. 1, effluents can be considered to be ground-level releases, elevated releases, or mixed-mode releases depending on (a) the elevation of the release point above grade relative to the height of adjacent buildings, and (b) the effluent exit velocity relative to the speed of the prevailing wind during the period of interest./ At the Shoreham station, vent releases are assumed to be either at ground level or totally elevated. Conditions leading to a mixed mode release under Regulatory Guide 1.111, Rev. 1 criteria are conservatively assumed to result in a ground level release in the computerized method.

(e) The wind speed at the release height is computed by subjecting the wind speed measured at the upper instrument level of the meteorological tower to the height-dependent wind speed relatiionship in the XOQDOQ computer code (NUREG/CR-2919, August 1982); the same relationship is used to replace missing wind speed data at either the lower or upper instrument levels of the meteorological towers

(f) Sector- average $(\chi/Q)^{SA}$ values are not permitted to exceed the plume centerline values corresponding to the same atmospheric conditions, plume centerline values are computed using the equations in Regulatory Guide 1.145 Rev. 1 for non-meandering plumes, and the recirculation factor described in item (b) above.

(g) Vertical plume standard deviations for Pasquill stability $G(\sigma_z(G))$ are computed using the relationship between the stability classes F and G given in Reg. Guide 1.145. All σ_z values are limited to a maximum value of 1000 m.

(h) Site specific, sector-and distance-dependent terain heights are employed in connection with elevated releases. These terrain heights (as given in Table 3.5-8) represent the maximum heights between the release point and the locations where the concentrations are being calculated, in accordance with Regulatory Guide 1.111 Rev. 1.

(i) Relative deposition factors (D/Q) are calculated using the relative deposition rates given in Regulatory Guide 1.111 Rev. 1 in graphical form; the height-dependent curves in the guide are used as follows:

Calculated Effective Height Range (m)	Applicability Regulatory Guide 1.111 Rev. 1 Curve
0 - 15	Ground-level releases
15 - 45	30-m releases
45 - 80	60-m releases
>80	100-m releases

In addition to the atmospheric dispersion factors, the computerized method also computes certain "effective gamma dispersion factors" $(\chi/Q)^{SA}$ which permit evaluation of external air and whole body doses from finite clouds of multi-energetic gamma sources. The basic definition of the χ/Q^{SA} was derived by expressing the finite-cloud dose rate equations in Regulatory Guide 1.109 in a form identical to the standard dose rate equation for semi-infinite clouds. It includes the I function of Appendix F of Regulatory Guide 1.109, and for large plume standard deviations its numerical value reduces to that of the standard χ/Q. The gamma spectrum is representative of the actual nuclide mix in the effluent. The finite cloud model is employed for both ground-level and elevated releases. Recirculation correction and inversion layer reflection are accounted for, and sector-average finite cloud values are not allowed to exceed corresponding plume center-line values computed in accordance whti the three-dimensional Gaussian puff model described by Slade ('Metorology and Atomic Energy 1968', USAEC TID-24190, 1968, Sec. 7-5.2.2).

4.3 PARAMETERS AND METHODOLOGY USED IN THE BACKUP METHOD

For gaseous effluent pathways, Table 4-1 lists the critical locations for receptors and their respective dispersion and deposition factors. The atomospheric dispersion and deposition factors were calculated utilizing Shoreham onsite meteorological data for the 2-year period of October 1, 1973 through September 30, 1975, Regulatory Guide 1.111 Rev. 0, March 1976, and Rev. 1, July 1977. Several χ/Q values were obtained from the Final Environmental Statement, NUREG-0285, dated October 1977, docket No. 50-322 (See Table 4-1).

TABLE 4-1

CRITICAL RECEPTOR LOCATIONS FOR GASEOUS EFFLUENT CALCULATIONS

Technical Specification Section	3.11.2.1	3.11.2.2	3.11.2.3	3.11.2.5
Sections in this Manual Limiting Criteria	3.3 Instantaneous Dose Rate to Whole Body and Skin due to Noble Gas and Dose to any organ due to radionuclides other than Noble Gas	3.4 Quarterly and Annual Air Doses due to Gamma and Beta radiation	3.5 Quarterly and Annual Dose due to radionuclides other than Noble Gas	3.6 Dose to any organ due to radionuclides other than Noble Gas for 31 day period
Distance and Direction of Receptor from the Plant	1) Noble Gas: 366 meters, NNE 2) Organ: 2478 meters, ESE	457 meters, ESE	2478 meters, ESE	2478 meters, ESE
Description of Location	Location of highest Dose Rate	Location of highest Dose	Location of highest Dose	Location of highest Dose
Long Term Atmospheric Dispersion Factor for Station Ventilation Exhaust χ/Q_1	1) 6.6E-07 $sec/m^{3(1)}$ 2) 1.54E-07 $sec/m^{3(3)}$	8.44E-07 $sec/m^{3(2)}$	1.54E-07 $sec/m^{3(3)}$	1.54E-07 $sec/m^{3(3)}$
Short Term Atmospheric Dispersion Factor for Air Removal Pump χ/Q_2	1) 3.6E-06 $sec/m^{3(1)}$ 2) 4.22E-07 $sec/m^{3(3)}$	1.83E-06 $sec/m^{3(2)}$	4.22E-07 $sec/m^{3(3)}$	4.22E-07 $sec/m^{3(3)}$
Short Term Atmospheric Dispersion Factor for Containment Drywell Purge χ/Q_3	1) 3.6E-06 $sec/m^{3(1)}$ 2) 4.22E-07 $sec/m^{3(3)}$	1.83E-06 $sec/m^{3(2)}$	4.22E-07 $sec/m^{3(3)}$	4.22E-07 $sec/m^{3(3)}$

TABLE 4-1 (CONT'D)

Long Term Relative Deposition Factor for Station Ventilation Exhaust D/Q_1	1) NA 2) 3.08E-09 m^{-2}(3)	NA	3.08E-09 m^{-2}(3)	3.08E-09m^{-2}(3)
Short Term Relative Deposition Factor for Air Removal Pump D/Q_2	1) NA 2) 8.47E-09 m^{-2}(3)	NA	8.47E-09 m^{-2}(3)	8.47E-09 m^{-2}(3)
Short Term Relative Deposition Factor for Containment Drywell Purge D/Q_3	1) NA 2) 8.47E-09 m^{-2}(3)	NA	8.47E-09 m^{-2}(3)	8.47E-09 m^{-2}(3)

(1) Long Island Lighting Company, Shoreham Nuclear Station - Unit One, FINAL ENVIRONMENTAL STATEMENT, NUREG 0285, October 1977, Docket 50-322.

(2) "Compliance with 10CFR50 Appendix I", Shoreham Nuclear Power Station - Unit One, Long Island Lighting Company, Docket 50-322, SNAC-119, July 30, 1976.

(3) Internal Calculation using methodology outlined in NRC Regulatory Guide 1.111, Revision 1, July 1977.

TABLE 4-2

GENERAL SITE SPECIFIC DATA

PARAMETER	VALUE
Elevation of low-level met. instruments (1)	33 ft above ground level
Elevation of upper-level met. instruments (2)	150 ft above ground level
Temperature sensor separation	117 feet
Release height for station vent	249 ft above MSL
Station grade elevation	20 ft above MSL
Reactor building height	65 m
Reactor building cross-sectional area	2600 m^2
Station vent equivalent diameter	2.664 m
Maximum effective plume height allowed	400 m
Height of inversion layer aloft	600 m
Maximum plume vertical standard deviation	σ_z = 1000 m

(1) Onsite 10 m meteorological tower
(2) Offsite 400 ft meteorological tower

SECTION 5

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM SAMPLING LOCATIONS

The purpose of this section is to identify those sampling locations from which the radiological environmental monitoring samples shall be collected pursuant to Technical Specification 3/4.12.

Sampling locations for onsite and offsite locations are shown on Figures 5-1 and 5-2, respectively. The number and frequency for sampling at these locations is given in Table 5-1 which is taken from Technical Specification Table 3.12.1-1.

Radiological Environmental Monitoring Program monitoring stations are given in Tables 5-2, 5-3, 5-4, and 5-5.

TABLE 5-1

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM*
(TYPICAL SAMPLING AND COLLECTION FREQUENCY)
REFER TO TECHNICAL SPECIFICATIONS FOR CURRENT PROGRAM

EXPOSURE PATHWAY AND/OR SAMPLE	NUMBER OF REPRESENTATIVE SAMPLES AND SAMPLE LOCATION[a]	SAMPLING AND COLLECTION FREQUENCY	TYPE AND FREQUENCY OF ANALYSIS
1. DIRECT RADIATION[b]	36 routine monitoring stations, DR1-DR36, either with two or more dosimeters or with one instrument for measuring and recording dose rate continuously, placed as follows: a. An inner ring of stations, one in each meteorological sector in the general area of the SITE BOUNDARY, DR1-DR16; b. An outer ring of stations, one in each meteorological sector in the 6- to 8-km range from the site, DR17-DR25; c. The balance of the stations, DR26-DR36, to be placed in special interest areas such as population centers, nearby residences, schools, and in 1 or 2 areas to serve as control stations.	Quarterly.	Gamma dose quarterly.

*The number, media, frequency, and location of samples may vary from site to site. This table presents an acceptable minimum program for a site at which each entry is applicable. Local site characteristics must be examined to determine if pathways not covered by this table may significantly contribute to an individual's dose and should be included in the sampling program. The code letters in parentheses, e.g., DR1, A1, provide one way of defining generic sample locations in this specification that can be used to identify the specific locations in the map(s) and tables in the ODCM.

TABLE 5-1 (CONT'D)

EXPOSURE PATHWAY AND/OR SAMPLE	NUMBER OF REPRESENTATIVE SAMPLES AND SAMPLE LOCATION[a]	SAMPLING AND COLLECTION FREQUENCY	TYPE AND FREQUENCY OF ANALYSIS
2. AIRBORNE			
Radioiodine and Particulates	Samples from 5 locations, A1-A5: 3 samples, A1-A3* from close to the 3 SITE BOUNDARY locations, in different sectors, of the highest calculated annual average groundlevel D/Q. 1 sample, A4, from the vicinity of a community having the highest calculated annual average groundlevel D/Q. 1 sample, A5, from a control location, as for example 15-30 km distant and in the least prevalent wind direction. [c]	Continuous sampler operation with sample collection weekly, or more frequently if required by dust loading.	Radioiodine Cannister: I-131 analysis weekly. Particulate Sampler: Gross beta radioactivity analysis following filter change; [d] Gamma isotopic analysis[e] of composite (by location) quarterly.
3. WATERBORNE			
a. Surface [h] (Long Island Sound)	1 sample control, WA1 1 sample discharge, WA2 or WA3	Grab sample semi-annually.	Gamma isotopic analysis[e] and tritium analysis semiannually.
b. Ground	Samples from 1 or 2 sources, Wb1, Wb2, only if likely to be affected. [f]	Quarterly.	Gamma isotopic[e] and tritium analysis quarterly.
c. Sediment form shoreline	1 sample from downstream area with existing or potential recreational value, Wd1.	Semiannually.	Gamma isotopic analysis[e] semiannually.

*The first and second highest D/Q sectors have radioiodine and particulate samples. The third highest D/Q sector at the SITE BOUNDARY is approximately 150 ft from the first highest sector.

TABLE 5-1 (CONT'D)

EXPOSURE PATHWAY AND/OR SAMPLE	NUMBER OF REPRESENTATIVE SAMPLES AND SAMPLE LOCATION[a]	SAMPLING AND COLLECTION FREQUENCY	TYPE AND FREQUENCY OF ANALYSIS
4. INGESTION			
a. Milk	Samples from milking animals in location, Ia1, within 5 km distance having the highest dose potential. If there are none, then, 1 sample from milking animals in each of 3 areas, Ia1, between 5 to 8 km distant where doses are calculated to be greater than 1 mrem per yr, or if there are none available within 8 km, then a location 8 to 17 km distant will be used.[g]	Semimonthly when animals are on pasture, monthly at other times.	Gamma isotopic[e] and I-131 analysis semimonthly when animals are on pasture; monthly at other times.
	1 sample from milking animals at a control location, Ia2, 15-30 km distant, and not in the least prevalent wind directions.		
b. Fish and Invertebrates	1 sample of each commercially and recreationally important species in vicinity of plant discharge area, Ib1 - Ib2.	Sample in season or semiannually if they are not seasonal.	Gamma isotopic analysis[e] on edible portions.
	1 sample of same species in areas not influenced by plant discharge, Ib3.		
c. Food Products	Samples of 3 different kinds of broad leaf vegetation grown nearest each of two different offsite locations of highest predicted annual average ground-level D/Q, if milk sampling is not performed, Ic1 - Ic3.	At time of harvest.[i]	Gamma Isotopic[e] and I-131 analysis.
	1 sample of each of the similar broad leaf vegetation grown 15-30 km distant in the least prevalent wind direction if milk sampling is not performed. Ic3.	At time of harvest. i	Gamma Isotopic[e] and I-131 analysis.

TABLE 5-1 (CONT'D)

TABLE NOTATION

[a] Specific parameters of distance and direction sector from the centerline of one reactor, and additional description where pertinent, are provided for each and every sample location in Table 3.12.1-1 in a table and figure in the ODCM. Refer to NUREG-0133, "Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants," October 1978, and to Radiological Assessment Branch Technical Position, Revision 1, November 1979. Deviations are permitted from the required sampling schedule if specimens are unobtainable due to hazardous conditions, seasonal unavailability, malfunction of automatic sampling equipment, and other legitimate reasons. If specimens are unobtainable due to sampling equipment malfunction, every effort shall be made to complete corrective action prior to the end of the next sampling period. All deviations from the sampling schedule shall be documented in the Annual Radiological Environmental Operating Report pursuant to Specification 6.9.1.7. It is recognized that, at times, it may not be possible or practicable to continue to obtain samples of the media of choice at the most desired location or time. In these instances suitable alternative media and locations may be chosen for the particular pathway in question and appropriate substitutions made within 30 days in the radiological environmental monitoring program. In lieu of a Licensee Event Report and pursuant to Specification 6.9.1.9, identify the cause of the unavailability of samples for that pathway and identify the new location(s) for obtaining replacement samples in the next Semi-annual Radioactive Effluent Release Report and also include in the report a revised figure(s) and table for the ODCM reflecting the new location(s).

[b] One or more instruments, such as a pressurized ion chamber, for measuring and recording dose rate continuously may be used in place of, or in addition to, integrating dosimeters. For the purposes of this table, a thermoluminescent dosimeter (TLD) is considered to be one phosphor; two or more phosphors in packet are considered as two or more dosimeters. Film badges shall not be used as dosimeters for measuring direct radiation. The frequency of analysis or readout for TLD systems will depend upon the characteristics of the specific system used and should be selected to obtain optimum dose information with minimal fading.

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

TABLE 5-1 (CONT'D)

TABLE NOTATION

[d] Airborne particulate sample filters shall be analyzed for gross beta radioactivity 24 hours or more after sampling to allow for radon and thoron daughter decay. If gross beta activity in air particulate samples is greater than 10 times the yearly mean of control samples, gamma isotopic analysis shall be performed on individual samples.

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

[f] Groundwater samples shall be taken when this source is tapped for drinking or irrigation purposes in areas where the hydraulic gradient or recharge properties are suitable for contamination.

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

[h] The "control" sample shall be taken at a distance beyond significant influence of the discharge. The "discharge" sample shall be taken in an area beyond but near the mixing zone.

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

TABLE 5-2

RADIOLOGICAL ENVIRONMENTAL
MONITORING PROGRAM (REMP)
WATERBORNE MONITORING STATIONS

Location NUREG-0473	Codes Shoreham REMP	Location Description
WA1	13G2	Surface, background area, 13.3 mi. W
WA2	14C1	Surface, outfall area, 2.1 mi. WNW
WA3	3C1	Surface, outfall area, 2.9 mi. NE
Wb1	2S1	Potable Water, well on site, 0.1 mi. NNE
Wb2	13S2	Potable Water, well on site, 0.2 mi. W
Wd1	2A4	Sediment, beach, 0.4 mi NNE

TABLE 5-3

RADIOLOGICAL ENVIRONMENTAL
MONITORING PROGRAM (REMP)
(PARTICULATES AND RADIOIODINE)

Location Codes NUREG-0473	Shoreham REMP	Location Description
A1	6S2	Site Boundary, 0.1 mi. ESE
A2	2A2	West end of Creek Road, 0.2 mi. NNE
A3	3S1	Site Boundary, 0.1 mi, NE
A4	7B1	Overhill Road, 1.5 mi. SE
A5	11G1	MacArthur Substation, 16.6 mi. SW

TABLE 5-4

RADIOLOGICAL ENVIRONMENTAL
MONITORING PROGRAM (REMP)
DIRECT RADIATION MONITORING STATIONS

Location NUREG-0473	Codes Shoreham REMP	Location Description
DR1	1S1	Beach east of intake, 0.3 mi. N
DR2	2A2	West end of Creek Road, 0.2 mi. NNE
DR3	3S1	Site Boundary, 0.1 mi. NE
DR4	4S1	Site Boundary, 0.1 mi. ENE
DR5	5S2	Site Boundary, 0.1 mi. E
DR6	6S2	Site Boundary, 0.1 mi. ESE
DR7	7A2	North Country Road, 0.7 mi. SE
DR8	8A3	North Country Road, 0.6 mi. SSE
DR9	9S1	Service Road SNPS, 0.3 mi. S
DR10	10A1	North Country Road, 0.3 mi. SSW
DR11	11A1	Site Boundary, 0.2 mi. SW
DR12	12A1	Meteorological Tower, 0.9 mi, WSW
DR13	13S3	Site Boundary, 0.3 mi. W
DR14	14S2	St. Joseph's Villa, 0.4 mi. WNW
DR15	15S1	Beach west of intake, 0.3 mi. NW
DR16	16S2	Site Boundary 0.2 mi. NNW
DR17	5D3	Wildwood State Park, 3.1 mi. E
DR18	6E1	LILCO ROW, 4.8 mi. ESE
DR19	7E1	Calverton, 4.9 mi. SE
DR20	8E1	Calverton, 4.4 mi. SSE
DR21	9E1	Brookhaven National Laboratory, 5.0 mi. S
DR22	10E1	Ridge Substation, 4.0 mi. SSW
DR23	11E1	LILCO ROW. 4.7 mi. SW
DR24	12D1	North Shore Beach Substation, 3.7 mi. WSW
DR25	13E1	Sound Way Drive, 4.5 mi. W
DR26	5D1	Wildwood State Park, 3.4 mi. E
DR27	5F3	Dairy Farm, 7.8 mi. E
DR28	7B1	Overhill Road, 1.4 mi. SE
DR29	12G2	Flowerfield Substation, 15.4 mi. WSW
DR30	12G1	Central Islip Substation, 19.9 mi. WSW
DR31	11G1	MacArthur Substation, 16.6 mi. SW
DR32	8G1	Wading River Road, 10.1 mi. SSE
DR33	6G1	Hampton Bays Substation, 19.0 mi. ESE
DR34	6A1	Sound Road, 0.7 mi. ESE
DR35	2A3	Nearest Residence, 0.3 mi. NNE
DR36	9S2	East Gate SNPS, 0.3 mi. S

TABLE 5-5

RADIOLOGICAL ENVIRONMENTAL
MONITORING PROGRAM (REMP)
INGESTION MONITORING STATIONS

Location Codes NUREG-0473	Shoreham REMP	Location Description
Ia1	6B1	Goat Farm, 1.54 mi. ESE
Ia2	10F1	Goat Farm, 9.2 mi. SSW
Ib1	3C1	Fish and Invertebrates, outfall area, 2.9 mi. NE
Ib2	14C1	Fish and Invertebrates, outfall area, 2.1 mi. WNW
Ib3	13G2	Fish and Invertebrates, background, 13.3 mi. W
Ic1	8B1	Local Farm, 1.2 mi. SSE
Ic2	5C2	Local Farm, 2.8 mi. E
Ic3	12H1	Background Farm, 26 mi. WSW

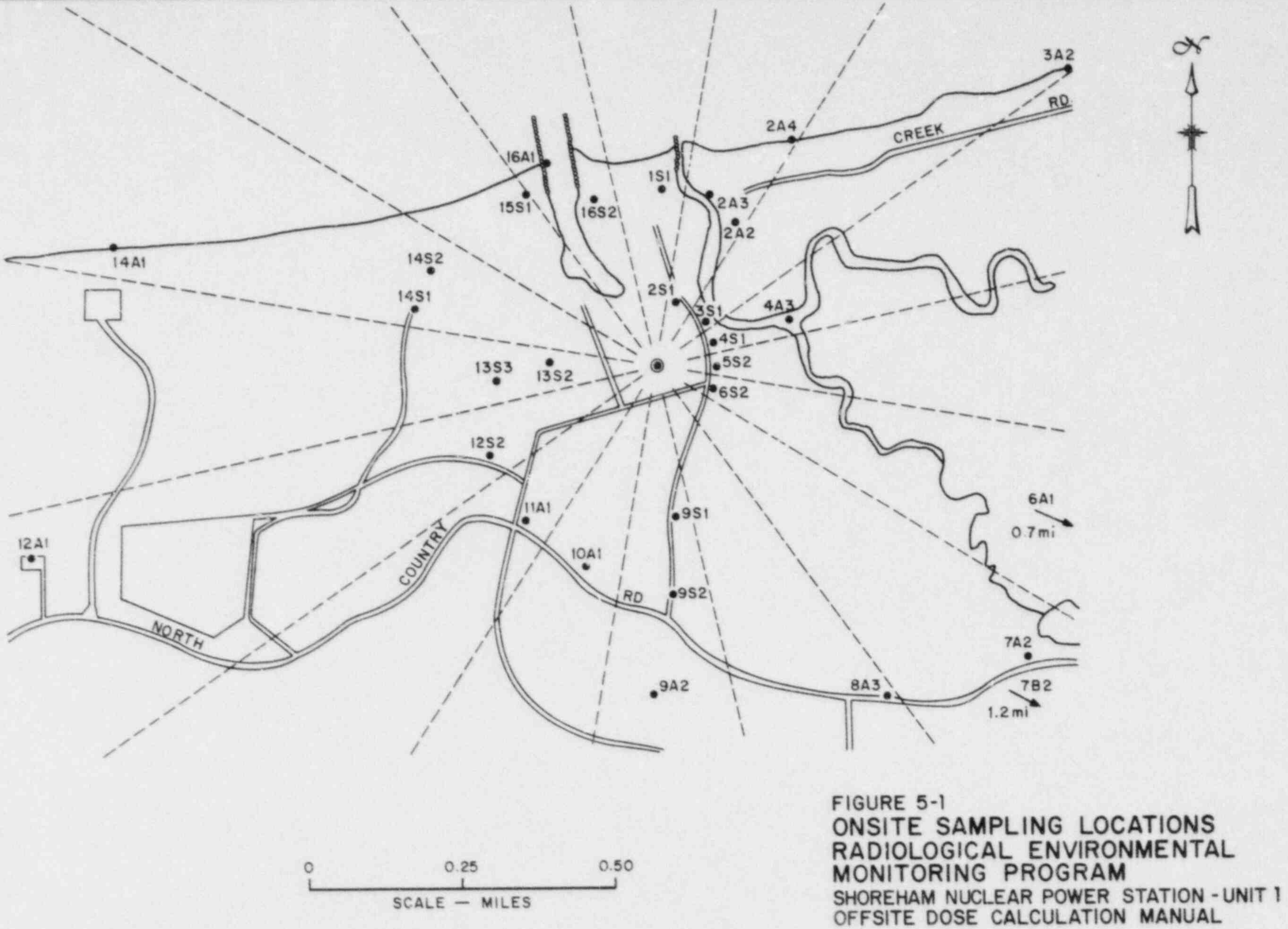

FIGURE 5-1
ONSITE SAMPLING LOCATIONS
RADIOLOGICAL ENVIRONMENTAL
MONITORING PROGRAM
SHOREHAM NUCLEAR POWER STATION - UNIT 1
OFFSITE DOSE CALCULATION MANUAL

REVISION 3 - DECEMBER 1983

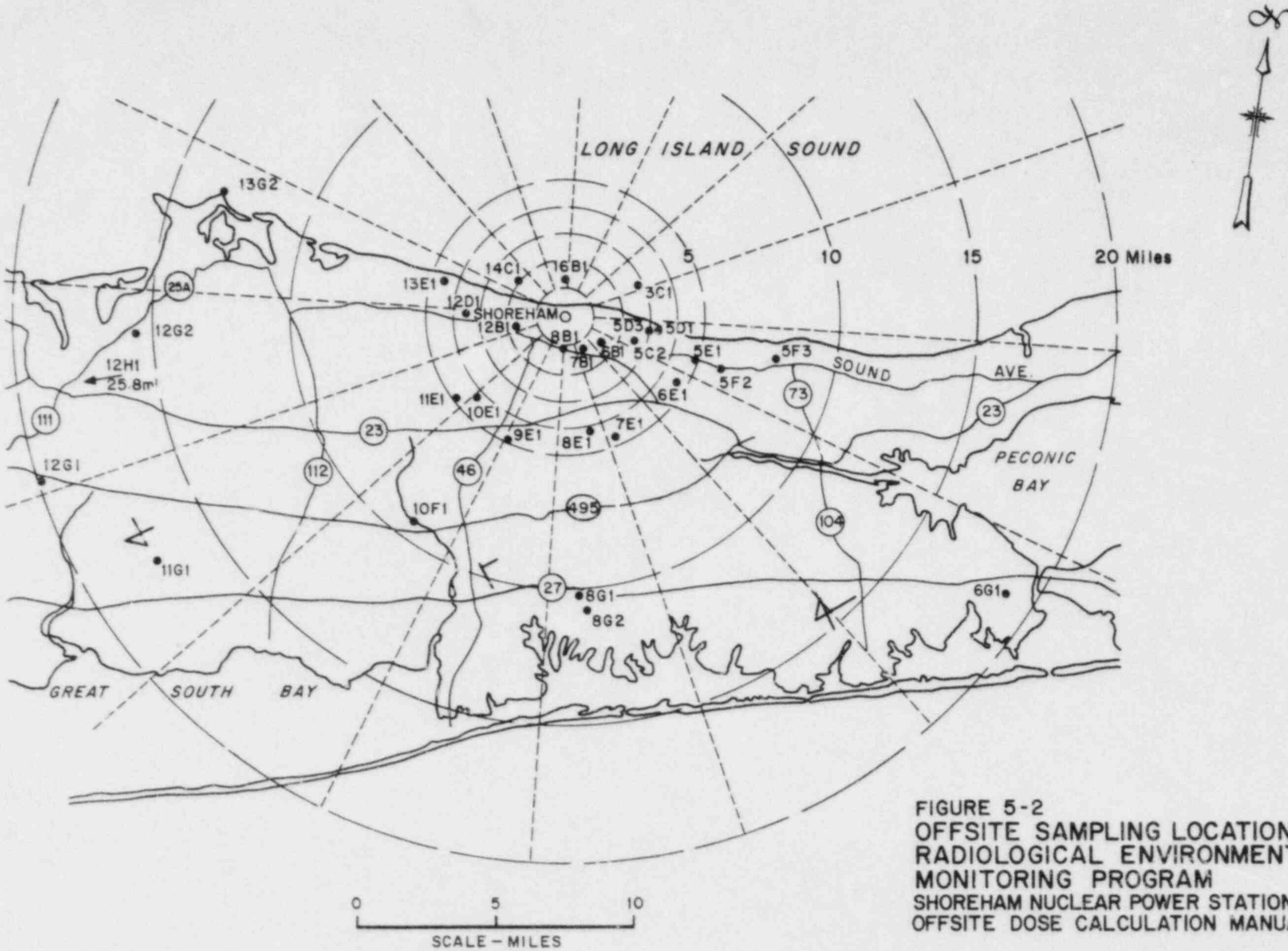

FIGURE 5-2
OFFSITE SAMPLING LOCATIONS
RADIOLOGICAL ENVIRONMENTAL
MONITORING PROGRAM
SHOREHAM NUCLEAR POWER STATION-UNIT 1
OFFSITE DOSE CALCULATION MANUAL

REVISION 4 - AUGUST 1984

SECTION 6

INTERLABORATORY COMPARISON PROGRAM

The laboratory performing the radiological environmental analyses shall participate in an interlaboratory comparison program which has been approved by the NRC. Currently this program is the Environmental Protection Agency (EPA) environmental radioactivity laboratory intercomparison studies (cross-check) program. Our participation code is "CJ".

APPENDIX A

DERIVATION OF $A_{i\tau}$

$A_{i\tau}$ (mrem/min per μCi/cc) is the dose conversion factor for the combined fish plus seafood pathways due to a liquid radwaste system discharge.

The doses to organ, j, due to ingestion of fish and seafood (contribution from shoreline deposit is considered insignificant) containing isotope, i, were calculated by a computer code based on Regulatory Guide 1.109, Rev. 1 methodology and default parameters.

The computer isotopic dose rates output were normalized to unit intake concentration with the following equation:

$$A_{\tau ij} = \frac{D_{Fij} + D_{sij}}{C_i/F}$$

where:

D_{Fij} = Calculated fish ingestion dose rate (mrem/min) to organ, j, from isotope, i, (Ref. Reg. Guide 1.109, Eq. (A-3))

D_{sij} = Calculated seafood ingestion dose rate (mrem/min) to organ, j, from isotope, i, (Ref. Reg. Guide 1.109, Eq. (A-3))

C_i = Discharge concentration of isotope, i, (μCi/cc)

F = Near field dilution factor, 8.85 (unitless)

APPENDIX B

DERIVATION OF P_{oij}

P_{oij} $\left(\frac{m^2 \cdot mrem/yr}{\mu Ci/sec}\right)$ is the dose conversion factor due to combined effect of ingestion of leafy vegetables, ingestion of stored vegetables, (fruits, vegetables, and grains), and contaminated ground pathways.

The dose delivered to organ, j, due to the combined effect of the 3 pathways were calculated for each radioisotope, i, using a computer code based on Regulatory Guide 1.109, Rev. 1 methodology and default parameters.

The computer isotopic dose rates output were normalized to unit isotopic release rate and deposition factor with the equation:

$$P_{oij} = \frac{D_{cij} + D_{Lij} + D_{sij}}{3.17*10^{-2} * C_i * D/Q}$$

where:

D_{cij} = Calculated contaminated ground dose to organ, j, from isotope, i,

D_{Lij} = Calculated leafy vegetable ingestion dose to organ, j, from isotope, i,

D_{sij} = Calculated stored vegetables dose to organ, j, from isotope, i,

C_i = Gaseous effluent release rate of isotope, i, (Ci/yr)

D/Q = Deposition factor (m^{-2}) as used in calculation of D_{cij}, D_{Lij}, D_{sij}.

$3.17*10^{-2}$ = The number of years per second (3.17×10^{-8}) times the number of µCi per Ci (10^6).

LILCO LONG ISLAND LIGHTING

LONG ISLAND LIGHTING COMPANY

SHOREHAM NUCLEAR POWER STATION

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JOHN D. LEONARD, JR.
VICE PRESIDENT - NUCLEAR OPERATIONS

September 12, 1984 SNRC-1076

Mr. Harold R. Denton, Director
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Offsite Dose Calculation Manual
Shoreham Nuclear Power Station - Unit 1
Docket No. 50-322

Dear Mr. Denton:

Enclosed please find forty (40) copies of Revision 4 of Shoreham's Offsite Dose Calculation Manual (ODCM), dated August 1984.

Revisions are indicated by change bars in the margins.

If you require additional information, do not hesitate to contact this office.

Very truly yours,

John D. Leonard, Jr.

John D. Leonard, Jr.
Vice President - Nuclear Operations

NRL:ck

Enclosure

cc: P. Eselgroth
C. Petrone

A009
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