# OFFSITE DOSE CALCULATION MANUAL

FOR

CONSUMERS POWER COMPANY

MIDLAND PLANT

JUNE 1983

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## REFERENCES


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## INTRODUCTION

The OFFSITE DOSE CALCULATION MANUAL (ODCM) is a supporting document of the TECHNICAL SPECIFICATIONS (TS). As such the ODCM describes the methodology and parameters to be used in the calculation of offsite doses due to radioactive liquid and gaseous effluents and in the calculation of liquid and gaseous effluent monitoring instrumentation alarm/trip setpoints. The ODCM contains a list and graphical description of the specific sample locations for the Radiological Environmental Monitoring Program. Minimum OPERABLE configurations of the liquid and gaseous radwaste treatment systems are also included.

The ODCM will be maintained at the plant for use as a reference guide and training document of accepted methodologies and calculations. Changes in the calculational methods or parameters will be incorporated into the ODCM in order to assure that the ODCM represents the present methodology in all applicable areas. Computer software to perform the described calculations will be maintained current with this ODCM.

## SECTION 1.0

## LIQUID EFFLUENTS

The Midland Plant is located on the Tittabawassee River which supplies make-up water to the Cooling Pond and receives blowdown from the Cooling Pond.

Radioactive liquid effluents are released via the Cooling Pond Blowdown to the Tittabawassee River.

### 1.1 LIQUID EFFLUENT MONITOR SETPOINTS

The liquid monitor setpoint values determined in the following sections will be regarded as upper bounds for the actual setpoint adjustments. Setpoint adjustments are not required to be performed if the existing monitor setpoint is lower than the calculated value. Setpoints may be established at values lower than the calculated values if desired.

For the Midland Plant, liquid monitor setpoints are calculated for concentrations, in μCi/ml. The actual monitor setpoint, which corresponds to the calculated concentration plus background for the particular monitor, is determined from calibration data or from operational data associated with liquid sample analysis data. (See Section 1.1.4.)

#### 1.1.1 LIQUID RADWASTE AND LAUNDRY EFFLUENT LINE MONITORS

Liquid Radwaste Effluent Line Monitors provide alarm and automatic termination of release functions prior to exceeding the concentration limits specified in 10 CFR 20, Appendix B, Table II, Column 2 at the release point to the unrestricted area. To meet this specification, the alarm/trip setpoints for

liquid effluent monitors and flow measurement devices are set to assure that the following equation is satisfied:

$$\frac{cf}{F + f} < C_{MPC} \qquad (1)$$

where

$C_{MPC}$ = the effluent concentration limit (TS 3.11.1.1) implementing 10 CFR 20 for the site, corresponding to the specific mix of radionuclides in the effluent stream being considered for discharge, in μCi/ml.

c = the setpoint, in μCi/ml, of the radioactivity monitor measuring the concentration of radioactivity in the effluent line prior to dilution and subsequent release; the setpoint, which is inversely proportional to the volumetric flow of the effluent line and proportional to the volumetric flow of the dilution stream plus the effluent stream, represents a value which, if exceeded, would result in concentrations exceeding the limits of 10 CFR 20 in the unrestricted area.

f = the flow setpoint as determined at the radiactivity monitor location, in volume per unit time, but in the same units as F, below.

F = the dilution water flow setpoint as determined prior to the release point, in volume per unit time.

At the Midland Plant, the Liquid Radwaste System Monitor Tanks and the Laundry Drain Tanks discharge via the Cooling Pond Blowdown Line to the Tittabawassee River. The dilution flow (F) may come from Cooling Pond Blowdown or the Cooling Pond Makeup Pumps. The waste process flow (f) and the monitor

setpoint (c) for the particular pathway are determined and set to meet the conditions of Equation (1) for a given effluent concentration, $C_{MPC}$. The method by which this is accomplished is as follows:

Step 1

The radionuclide concentration for a waste tank to be released is obtained from the sum of measured concentrations as determined by the analyses required in TS Table 4.11-1:

$$\sum_i C_i = \sum_g C_g + (C_a + C_s + C_t) \qquad (2)$$

where

$C_g$ = the concentration of each measured gamma emitter observed by gamma-ray spectroscopy of each waste sample.

$C_a$ = the concentration of alpha emitters in liquid waste as measured in the MONTHLY composite sample. (NOTE: Sample is analyzed for gross $\alpha$.)

$C_s$ = the measured concentrations of Sr-89 and Sr-90 in liquid waste as observed in the QUARTERLY composite sample.

$C_t$ = the measured concentration of H-3 in liquid waste as determined from analysis of the MONTHLY composite sample.

The $C_g$ term will be included in the analysis of each batch; terms for alpha, strontiums, and tritium will be included in the evaluation in accordance with TS Table 4.11-1.

Step 2

The measured radionuclide concentrations are used to calculate a Dilution Factor, $F_D$, which is the ratio of total dilution flow rate to tank flow rate required to assure that the limiting concentrations of 10 CFR 20, Appendix B, Table II, Column 2 are met at the point of discharge. The dilution factor is calculated as follows:

$$F_D = \Sigma \ (C_i/MPC_i) \div F_S$$

$$= [\sum_g \ (C_g/MPC_g) + C_a/MPC_a + C_s/MPC_s + C_t/MPC_t] \div F_S \quad (3)$$

where

$C_i$ = measured concentrations of $C_g$, $C_a$, $C_s$, and $C_t$ as defined in Step 1. Terms $C_a$, $C_s$, and $C_t$ will be included in the calculation as appropriate.

$MPC_i$ = $MPC_g$, $MPC_s$, $MPC_a$, and $MPC_t$ are limiting concentrations of the appropriate radionuclide from 10 CFR 20, Appendix B, Table II, Column 2. For dissolved or entrained noble gases, the concentration shall be limited to $2 \times 10^{-4}$ µCi/ml total activity.

$F_S$ = the safety factor; a conservative factor used to compensate for statistical fluctuations and errors of measurements. (For example, $F_S$ = 0.5 corresponds to a 100 percent variation.)

Step 3

For the case $F_D < 1$, the waste tank effluent concentration meets the limits of 10 CFR 20 without dilution and the liquid waste effluent may be released at any desired flow rate. Therefore, the remainder of Step 3 and Step 4 should be omitted and the radioactivity monitor setpoint calculated in accordance with Step 5.

For each liquid release pathway for which $F_D > 1$, a modified dilution factor, $F_{DN}$, must be determined so that available dilution may be apportioned among simultaneous discharge pathways as follows:

$$F_{DN} = F_D \div F_A \quad (4)$$

$F_A$ is an administrative allocation factor which may be assigned any value between 0 and 1 under the condition that:

$$\sum_n (F_A)_n \leq 1 \quad (5)$$

where

n = the number of liquid discharge pathways for which $F_D > 1$ and which are planned for simultaneous release. (For convenience $F_A$ may be assigned the value 1/n, if desired.)

The maximum permissible undiluted waste tank effluent flow rate, $f_p$, is calculated based on a selected fraction of the dilution flow rate, $f_d$, and the modified dilution factor, $F_{DN}$:

$$f_p \leq \frac{f_d + f_p}{F_{DN}} \sim \frac{f_d}{F_{DN}} \text{ for } f_d >> f_p \qquad \text{(see Note 1)} \qquad (6)$$

where

$f_d = F_p$ x expected dilution flow rate (see Note 2).

$F_p$ = a selected percent of actual dilution flow rate.

<u>NOTE 1</u>: Normally, the calculated maximum permissible flow rate, $f_p$, will be greater than the pump capacity (actual maximum flow) for a particular discharge pathway. However, if $f_p$ is less than pump capacity, steps must be taken to assure that Equation (1) is satisfied prior to making the release. These steps may include decreasing $\sum_i C_i$, increasing $f_d$, reducing $f_p$ for other simultaneous release pathways, or by decreasing the number of simultaneous discharge pathways.

<u>NOTE 2</u>: In the event Cooling Pond Blowdown is being used for dilution and radioactivity in the Cooling Pond exceeds LLD values, the expected dilution flow rate must be multiplied by the term:

$$1 - \sum_i (C_i/MPC_i)_{\text{cooling pond}}$$

This factor is applied to account for reduced dilution capacity due to radioactivity already present in the dilution stream.

Thus, flow rate monitor setpoints are set at or below $f_p$ determined for those discharge pathways for which simultaneous discharges are permissible. For those discharge pathways for which $F_D < 1$, the flow rate setpoint may be assigned any desired value.

Step 4

The dilution flow rate setpoint for minimum dilution flow rate, $S_D$, is established at a selected percent, $F_p$, of the expected dilution flow rate:

$$S_D = f_d \qquad (7)$$

Step 5

The liquid radioactivity monitor setpoint may now be determined based on the values of $\sum_i C_i$, $f_d$, and $f_p$ which were specified to provide compliance with the limits of 10 CFR 20, Appendix B, Table II, Column 2. The monitor response is primarily to gamma radiation; therefore, the actual setpoint is based on $\sum_g C_g$. The monitor setpoint, in μCi/ml, which corresponds to the particular setpoint concentration, c, is determined based on monitor calibration data or on operational data which correlates monitor response to sample analyses associated with actual effluent releases.

The setpoint concentration, c, is determined as follows:

$$c = F_{AA} \sum_g C_g \ \mu Ci/ml \qquad \text{(see Note 3 below)} \qquad (8)$$

where

$F_{AA}$ = adjustment factor which will allow the setpoint to be established in a practical manner for convenience and to prevent spurious alarms.

$$= f_p / f_{(actual)} \qquad \text{(see Note 4 below)} \qquad (9)$$

If $F_{AA} \geq 1$, calculate c and determine the maximum value for the actual monitor setpoint (μCi/ml).

If $F_{AA} < 1$, no release may be made. Re-evaluate the alternatives presented in Steps 3 and 4.

<u>NOTE 3</u>: The calculated setpoint concentration, c, establishes the base value for the monitor setpoint. However, in establishing the actual monitor setpoint for a particular monitor, background radiation levels and monitor response adjustments must be considered. These considerations are discussed in Section 1.1.4.

<u>NOTE 4</u>: If $F_D < 1$, $F_{AA} = 1/F_D$ for the particular pathway based on associated concentrations.

Within the limits of the conditions stated above, the specific monitor setpoints for the Liquid Radwaste Monitor and the Laundry Waste Monitor are determined as follows:

<u>Liquid Radwaste Discharge Line Monitor (ORE-0764)</u>

Perform Step 2, solving Equation (3) for $F_D$ using the appropriate values in the concentration term from the sample analyses for the Liquid Radwaste Monitor Tank batch to be discharged. If $F_D < 1$, then perform Step 5 to determine the radioactivity monitor setpoint.

If $F_D > 1$, then perform Steps 3, 4, and 5 to determine flow monitor setpoints and the radioactivity monitor setpoint.

Laundry Discharge Line Monitor (ORE-0769)

Perform Step 2, solving Equation (3) for $F_D$ using the appropriate values in the concentration term from the sample analyses for the Laundry Drain Tank batch to be discharged. If $F_D < 1$, then perform Step 5 to determine the radioactivity monitor setpoint.

If $F_D > 1$, then perform Steps 3, 4, and 5 to determine flow monitor setpoints and the radioactivity monitor setpoint.

1.1.2 TURBINE BUILDING NEUTRALIZER SUMPS (UNITS 1 AND 2) EFFLUENT LINES

Concentrations of radionuclides in the liquid effluent discharges from the Turbine Building Neutralizer Sumps are expected to be very low. These pathways release to the Cooling Pond Blowdown Line prior to entering the Tittabawassee River. These releases will be regarded as batch releases. In the absence of primary-to-secondary leakage, as determined by TS 4.4.6.3, no effluent sampling is required for this pathway and the monitor setpoint should be established at three (3) times background.

In the event of primary-to-secondary leakage, sampling will be performed in accordance with TS Table 4.11-1, and setpoints will be determined following the same methodology presented in Section 1.1.1 as follows:

Turbine Building Neutralizer Sump Monitors
(Unit 1: 1RE-7007; and Unit 2: 2RE-7007)

For the affected monitor(s), perform Step 2, solving Equation (3) for $F_D$ using the appropriate values in the concentration term from the sample analyses specified in TS Table 4.11-1 for the Turbine Building Neutralizer Sump(s) to

be discharged. If $F_D < 1$, then perform Step 5 to determine the radioactivity monitor setpoint.

If $F_D > 1$, then perform Steps 3, 4, and 5 to determine flow monitor setpoints and the radioactivity monitor setpoint.

1.1.3 OILY WASTE SYSTEM EFFLUENT LINE

Concentrations of radionuclides in the liquid effluent discharge from the Oily Waste System are expected to be very low. This pathway releases to the Cooling Pond Blowdown Line prior to entering the Tittabawassee River. This release will be regarded as a continuous release. In the absence of primary-to-secondary leakage, as determined by TS 4.4.6.3, no effluent sampling is required for this pathway and the monitor setpoint should be established at three (3) times background.

In the event of primary-to-secondary leakage, sampling will be performed in accordance with TS Table 4.11-1, and setpoints will be determined following the same methodology presented in Section 1.1.1 as follows:

Oily Waste System Discharge Monitor (ORE-7054)

Perform Step 2, solving Equation (3) for $F_D$ using the appropriate values in the concentration term from the sample analyses specified in TS Table 4.11-1 for the Oily Waste System. If $F_D < 1$, then perform Step 5 to determine the radioactivity monitor setpoint.

If $F_D > 1$, then perform Steps 3, 4, and 5 to determine flow monitor setpoints and the radioactivity monitor setpoint.

## 1.1.4 CONSIDERATION OF BACKGROUND AND MONITOR RESPONSE ADJUSTMENTS IN ESTABLISHING LIQUID MONITOR SETPOINTS

The calculated setpoint concentration, c, establishes the base value for the monitor setpoint. However, in establishing the actual monitor setpoint for a particular monitor, background radiation levels and monitor response adjustments must be considered.

Contributions to background radiation levels may include ambient background, plant environmental background at monitor locations when plant is in shutdown status, plant environmental background at monitor location when plant is at power, and internal background of monitor due to contamination of sample chamber. Normally, the actual monitor setpoint includes the calculated setpoint value plus background. Background levels must be controlled such that radioactivity levels in the effluent stream being monitored can be accurately assessed at or below the calculated setpoint value.

Monitor response adjustments may be necessary to assure that monitor readout accurately reflects radioactivity levels in the monitored effluent stream. Monitor adjustments (monitor setting) may be based on monitor calibrations, monitor calibration data supplied by the monitor vendor, or by operational data which correlates monitor response to sample analyses associated with actual effluent releases. At the Midland Plant the monitor response adjustment which correlates actual monitor response to monitor response expected, based on associated sample analyses, is referred to as the gain factor.

## 1.2 DOSE CALCULATION FOR LIQUID EFFLUENTS

The dose contribution to the maximum exposed individual from all radionuclides identified in liquid effluents released to unrestricted areas is calculated using the following expression:

$$D_\tau = \sum_i [A_{i\tau} \sum_{\ell=1}^{m} \Delta t_\ell C_{i\ell} F_\ell] \qquad (10)$$

where

$D_\tau$ = the cumulative dose commitment to the total body or any organ $\tau$ from the liquid effluents for the total time period $\sum_{\ell=1}^{m} \Delta t_\ell$, in mrem (Reference 1).

$\Delta t_\ell$ = the length of the $\ell$th time period over which $C_{i\ell}$ and $F_\ell$ are averaged for all liquid releases, in hours.

$C_{i\ell}$ = the average concentration of radionuclide i in the undiluted liquid effluent during time period $\Delta t_\ell$ from any liquid release, in μCi/ml.

$A_{i\tau}$ = the site related ingestion dose commitment factor to the total body or any organ $\tau$ for each identified principal gamma and beta emitter listed in Table 1.2-3 in mrem-ml per hr-μCi.

$$A_{i\tau} = K_o(U_F BF_i)DF_{i\tau} \qquad (11)$$

$F_{\ell}$ = the near field average dilution factor for $C_{i\ell}$ during any liquid effluent release. Defined as the ratio of the undiluted liquid waste flow during release to the product of the average flow from the discharge structure to unrestricted receiving water times Z.

$$= \frac{\text{(average undiluted liquid waste flow)}}{\text{(average flow from the discharge structure during periods of radioactive materials release)} \times (Z)} \quad (12)$$

where

Z = 3; applicable dilution factor for the receiving water body (Reference 1, Section 4.3; Reference 5, Section 11.2.3).

$K_o$ = units conversion factor, $1.14 \times 10^5$.

$$= 10^6 \text{ pCi/}\mu\text{Ci} \times 10^3 \text{ ml/l} \div 8760 \text{ hr/yr} \quad (13)$$

$U_F$ = adult fish consumption (21 kg/yr; taken from Reference 3, Table E-5).

$BF_i$ = bioaccumulation factor for radionuclide i, in fish, in pCi/kg per pCi/l from Table 1.2-1 (taken from Reference 3, Table A-1).

$DF_{i\tau}$ = dose conversion factor for radionuclide i, for adults in preselected organ $\tau$, in mrem/pCi, from Table 1.2-2 (taken from Reference 3, Table E-11).

TABLE 1.2-1

Bioaccumulation Factors
(pCi/kg per pCi/liter)*

| Element | Freshwater Fish |
|---|---|
| H | 9.0E-01 |
| C | 4.6E+03 |
| Na | 1.0E+02 |
| P | 1.0E+05 |
| Cr | 2.0E+02 |
| Mn | 4.0E+02 |
| Fe | 1.0E+02 |
| Co | 5.0E+01 |
| Ni | 1.0E+02 |
| Cu | 5.0E+01 |
| Zn | 2.0E+03 |
| Br | 4.2E+02 |
| Rb | 2.0E+03 |
| Sr | 3.0E+01 |
| Y | 2.5E+01 |
| Zr | 3.3E+00 |
| Nb | 3.0E+04 |
| Mo | 1.0E+01 |
| Tc | 1.5E+01 |
| Ru | 1.0E+01 |
| Rh | 1.0E+01 |
| Te | 4.0E+02 |
| I | 1.5E+01 |
| Cs | 2.0E+03 |
| Ba | 4.0E+00 |
| La | 2.5E+01 |
| Ce | 1.0E+00 |
| Pr | 2.5E+01 |
| Nd | 2.5E+01 |
| W | 1.2E+03 |
| Np | 1.0E+01 |

*Values in Table 1.2-1 are taken from Reference 3, Table A-1.

TABLE 1.2-2

Adult Ingestion Dose Factors*
(mrem/pCi Ingested)
Page 1 of 3

| Nuclide | Bone | Liver | T Body | Thyroid | Kidney | Lung | GI-LLI |
|---|---|---|---|---|---|---|---|
| H-3 | No Data | 1.05E-07 | 1.05E-07 | 1.05E-07 | 1.05E-07 | 1.05E-07 | 1.05E-07 |
| C-14 | 2.84E-06 | 5.68E-07 | 5.68E-07 | 5.68E-07 | 5.68E-07 | 5.68E-07 | 5.68E-07 |
| Na-24 | 1.70E-06 | 1.70E-06 | 1.70E-06 | 1.70E-06 | 1.70E-06 | 1.70E-06 | 1.70E-06 |
| P-32 | 1.93E-04 | 1.20E-05 | 7.46E-06 | No Data | No Data | No Data | 2.17E-05 |
| Cr-51 | No Data | No Data | 2.66E-09 | 1.59E-09 | 5.86E-10 | 3.53E-09 | 6.69E-07 |
| Mn-54 | No Data | 4.57E-06 | 8.72E-07 | No Data | 1.36E-06 | No Data | 1.40E-05 |
| Mn-56 | No Data | 1.15E-07 | 2.04E-08 | No Data | 1.46E-07 | No Data | 3.67E-06 |
| Fe-55 | 2.75E-06 | 1.90E-06 | 4.43E-07 | No Data | No Data | 1.06E-06 | 1.09E-06 |
| Fe-59 | 4.34E-06 | 1.02E-05 | 3.91E-06 | No Data | No Data | 2.85E-06 | 3.40E-05 |
| Co-58 | No Data | 7.45E-07 | 1.67E-06 | No Data | No Data | No Data | 1.51E-05 |
| Co-60 | No Data | 2.14E-06 | 4.72E-06 | No Data | No Data | No Data | 4.02E-05 |
| Ni-63 | 1.30E-04 | 9.01E-06 | 4.36E-06 | No Data | No Data | No Data | 1.88E-06 |
| Ni-65 | 5.28E-07 | 6.86E-08 | 3.13E-08 | No Data | No Data | No Data | 1.74E-06 |
| Cu-64 | No Data | 8.33E-08 | 3.91E-08 | No Data | 2.10E-07 | No Data | 7.10E-06 |
| Zn-65 | 4.84E-06 | 1.54E-05 | 6.96E-06 | No Data | 1.03E-05 | No Data | 9.70E-06 |
| Zn-69 | 1.03E-08 | 1.97E-08 | 1.37E-09 | No Data | 1.28E-08 | No Data | 2.96E-09 |
| Br-83 | No Data | No Data | 4.02E-08 | No Data | No Data | No Data | 5.79E-08 |
| Br-84 | No Data | No Data | 5.21E-08 | No Data | No Data | No Data | 4.09E-13 |
| Br-85 | No Data | No Data | 2.14E-09 | No Data | No Data | No Data | LT E-24 |
| Rb-86 | No Data | 2.11E-05 | 9.83E-06 | No Data | No Data | No Data | 4.16E-06 |
| Rb-88 | No Data | 6.05E-08 | 3.21E-08 | No Data | No Data | No Data | 8.36E-19 |
| Rb-89 | No Data | 4.01E-08 | 2.82E-08 | No Data | No Data | No Data | 2.33E-21 |
| Sr-89 | 3.08E-04 | No Data | 8.84E-06 | No Data | No Data | No Data | 4.94E-05 |
| Sr-90 | 7.58E-03 | No Data | 1.86E-03 | No Data | No Data | No Data | 2.19E-04 |
| Sr-91 | 5.67E-06 | No Data | 2.29E-07 | No Data | No Data | No Data | 2.70E-05 |
| Sr-92 | 2.15E-06 | No Data | 9.30E-08 | No Data | No Data | No Data | 4.26E-05 |
| Y-90 | 9.62E-09 | No Data | 2.58E-10 | No Data | No Data | No Data | 1.02E-04 |
| Y-91m | 9.09E-11 | No Data | 3.52E-12 | No Data | No Data | No Data | 2.67E-10 |
| Y-91 | 1.41E-07 | No Data | 3.77E-09 | No Data | No Data | No Data | 7.76E-05 |
| Y-92 | 8.45E-10 | No Data | 2.47E-11 | No Data | No Data | No Data | 1.48E-05 |

*Values in Table 1.2-2 are taken from Reference 3, Table E-11.

## TABLE 1.2-2 (Continued)

Adult Ingestion Dose Factors
(mrem/pCi ingested)
Page 2 of 3

| Nuclide | Bone | Liver | T Body | Thyroid | Kidney | Lung | GI-LLI |
|---|---|---|---|---|---|---|---|
| Y-93 | 2.68E-09 | No Data | 7.40E-11 | No Data | No Data | No Data | 8.50E-05 |
| Zr-95 | 3.04E-08 | 9.75E-09 | 6.60E-09 | No Data | 1.53E-08 | No Data | 3.09E-05 |
| Zr-97 | 1.68E-09 | 3.39E-10 | 1.55E-10 | No Data | 5.12E-10 | No Data | 1.05E-04 |
| Nb-95 | 6.22E-09 | 3.46E-09 | 1.86E-09 | No Data | 3.42E-09 | No Data | 2.10E-05 |
| Mo-99 | No Data | 4.31E-06 | 8.20E-07 | No Data | 9.76E-06 | No Data | 9.99E-06 |
| Tc-99m | 2.47E-10 | 6.98E-10 | 8.89E-09 | No Data | 1.06E-08 | 3.42E-10 | 4.13E-07 |
| Tc-101 | 2.54E-10 | 3.66E-10 | 3.59E-09 | No Data | 6.59E-09 | 1.87E-10 | 1.10E-21 |
| Ru-103 | 1.85E-07 | No Data | 7.97E-08 | No Data | 7.06E-07 | No Data | 2.16E-05 |
| Ru-105 | 1.54E-08 | No Data | 6.08E-09 | No Data | 1.99E-07 | No Data | 9.42E-06 |
| Ru-106 | 2.75E-06 | No Data | 3.48E-07 | No Data | 5.31E-06 | No Data | 1.78E-04 |
| Ag-110m | 1.60E-07 | 1.48E-07 | 8.79E-08 | No Data | 2.91E-07 | No Data | 6.04E-05 |
| Te-125m | 2.68E-06 | 9.71E-07 | 3.59E-07 | 8.06E-07 | 1.09E-05 | No Data | 1.07E-05 |
| Te-127m | 6.77E-06 | 2.42E-06 | 8.25E-07 | 1.73E-06 | 2.75E-05 | No Data | 2.27E-05 |
| Te-127 | 1.10E-07 | 3.95E-08 | 2.38E-08 | 8.15E-08 | 4.48E-07 | No Data | 8.68E-06 |
| Te-129m | 1.15E-05 | 4.29E-06 | 1.82E-06 | 3.95E-06 | 4.80E-05 | No Data | 5.79E-05 |
| Te-129 | 3.14E-08 | 1.18E-08 | 7.65E-09 | 2.41E-08 | 1.32E-07 | No Data | 2.37E-08 |
| Te-131m | 1.73E-06 | 8.46E-07 | 7.05E-07 | 1.34E-06 | 8.57E-06 | No Data | 8.40E-05 |
| Te-131 | 1.97E-08 | 8.23E-09 | 6.22E-09 | 1.62E-08 | 8.63E-08 | No Data | 2.79E-09 |
| Te-132 | 2.52E-06 | 1.63E-06 | 1.53E-06 | 1.80E-06 | 1.57E-05 | No Data | 7.71E-05 |
| I-130 | 7.56E-07 | 2.23E-06 | 8.80E-07 | 1.89E-04 | 3.48E-06 | No Data | 1.92E-06 |
| I-131 | 4.16E-06 | 5.95E-06 | 3.41E-06 | 1.95E-03 | 1.02E-05 | No Data | 1.57E-06 |
| I-132 | 2.03E-07 | 5.43E-07 | 1.90E-07 | 1.90E-05 | 8.65E-07 | No Data | 1.02E-07 |
| I-133 | 1.42E-06 | 2.47E-06 | 7.53E-07 | 3.63E-04 | 4.31E-06 | No Data | 2.22E-06 |
| I-134 | 1.06E-07 | 2.88E-07 | 1.03E-07 | 4.99E-06 | 4.58E-07 | No Data | 2.51E-10 |
| I-135 | 4.43E-07 | 1.16E-06 | 4.28E-07 | 7.65E-05 | 1.86E-06 | No Data | 1.31E-06 |
| Cs-134 | 6.22E-05 | 1.48E-04 | 1.21E-04 | No Data | 4.79E-05 | 1.59E-05 | 2.59E-06 |
| Cs-136 | 6.51E-06 | 2.57E-05 | 1.85E-05 | No Data | 1.43E-05 | 1.96E-06 | 2.92E-06 |
| Cs-137 | 7.97E-05 | 1.09E-04 | 7.14E-05 | No Data | 3.70E-05 | 1.23E-05 | 2.11E-06 |
| Cs-138 | 5.52E-08 | 1.09E-07 | 5.40E-08 | No Data | 8.01E-08 | 7.91E-09 | 4.65E-13 |
| Ba-139 | 9.70E-08 | 6.91E-11 | 2.84E-09 | No Data | 6.46E-11 | 3.92E-11 | 1.72E-07 |
| Ba-140 | 2.03E-05 | 2.55E-08 | 1.33E-06 | No Data | 8.67E-09 | 1.46E-08 | 4.18E-05 |
| Ba-141 | 4.71E-08 | 3.56E-11 | 1.59E-09 | No Data | 3.31E-11 | 2.02E-11 | 2.22E-17 |
| Ba-142 | 2.13E-08 | 2.19E-11 | 1.34E-09 | No Data | 1.85E-11 | 1.24E-11 | 3.00E-26 |

## TABLE 1.2-2 (Continued)

Adult Ingestion Dose Factors
(mrem/pCi ingested)
Page 3 of 3

| Nuclide | Bone | Liver | T Body | Thyroid | Kidney | Lung | GI-LLI |
|---|---|---|---|---|---|---|---|
| La-140 | 2.50E-09 | 1.26E-09 | 3.33E-10 | No Data | No Data | No Data | 9.25E-05 |
| La-142 | 1.28E-10 | 5.82E-11 | 1.45E-11 | No Data | No Data | No Data | 4.25E-07 |
| Ce-141 | 9.36E-09 | 6.33E-09 | 7.18E-10 | No Data | 2.94E-09 | No Data | 2.42E-05 |
| Ce-143 | 1.65E-09 | 1.22E-06 | 1.35E-10 | No Data | 5.37E-10 | No Data | 4.56E-05 |
| Ce-144 | 4.88E-07 | 2.04E-07 | 2.62E-08 | No Data | 1.21E-07 | No Data | 1.65E-04 |
| Pr-143 | 9.20E-09 | 3.69E-09 | 4.56E-10 | No Data | 2.13E-09 | No Data | 4.03E-05 |
| Pr-144 | 3.01E-11 | 1.25E-11 | 1.53E-12 | No Data | 7.05E-12 | No Data | 4.33E-18 |
| Nd-147 | 6.29E-09 | 7.27E-09 | 4.35E-10 | No Data | 4.25E-09 | No Data | 3.49E-05 |
| W-187 | 1.03E-07 | 8.61E-08 | 3.01E-08 | No Data | No Data | No Data | 2.82E-05 |
| Np-239 | 1.19E-09 | 1.17E-10 | 6.45E-11 | No Data | 3.65E-10 | No Data | 2.40E-05 |

TABLE 1.2-3

Site Related Ingestion Dose Commitment Factor, $A_{i\tau}$
(mrem/hr per μCi/ml)
Page 1 of 3

| Nuclide | Bone | Liver | T Body | Thyroid | Kidney | Lung | GI-LLI |
|---|---|---|---|---|---|---|---|
| H-3 | 0.00E+00 | 2.26E-01 | 2.26E-01 | 2.26E-01 | 2.26E-01 | 2.26E-01 | 2.26E-01 |
| C-14 | 3.13E+04 | 6.26E+03 | 6.26E+03 | 6.26E+03 | 6.26E+03 | 6.26E+03 | 6.26E+03 |
| Na-24 | 4.07E+02 | 4.07E+02 | 4.07E+02 | 4.07E+02 | 4.07E+02 | 4.07E+02 | 4.07E+02 |
| P-32 | 4.62E+07 | 2.87E+06 | 1.79E+06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.19E+06 |
| Cr-51 | 0.00E+00 | 0.00E+00 | 1.27E+00 | 7.61E-01 | 2.81E-01 | 1.69E+00 | 3.20E+02 |
| Mn-54 | 0.00E+00 | 4.38E+03 | 8.35E+02 | 0.00E+00 | 1.30E+03 | 0.00E+00 | 1.34E+04 |
| Mn-56 | 0.00E+00 | 1.10E+02 | 1.95E+01 | 0.00E+00 | 1.40E+02 | 0.00E+00 | 3.51E+03 |
| Fe-55 | 6.58E+02 | 4.55E+02 | 1.06E+02 | 0.00E+00 | 0.00E+00 | 2.54E+02 | 2.61E+02 |
| Fe-59 | 1.04E+03 | 2.44E+03 | 9.36E+02 | 0.00E+00 | 0.00E+00 | 6.82E+02 | 8.14E+03 |
| Co-58 | 0.00E+00 | 8.92E+01 | 2.00E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.81E+03 |
| Co-60 | 0.00E+00 | 2.56E+02 | 5.65E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.81E+03 |
| Ni-63 | 3.11E+04 | 2.16E+03 | 1.04E+03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.50E+02 |
| Ni-65 | 1.26E+02 | 1.64E+01 | 7.49E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.17E+02 |
| Cu-64 | 0.00E+00 | 9.97E+00 | 4.68E+00 | 0.00E+00 | 2.51E+01 | 0.00E+00 | 8.50E+02 |
| Zn-65 | 2.32E+04 | 7.37E+04 | 3.33E+04 | 0.00E+00 | 4.93E+04 | 0.00E+00 | 4.64E+04 |
| Zn-69 | 4.93E+01 | 9.43E+01 | 6.56E+00 | 0.00E+00 | 6.13E+01 | 0.00E+00 | 1.42E+01 |
| Br-83 | 0.00E+00 | 0.00E+00 | 4.04E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.82E+01 |
| Br-84 | 0.00E+00 | 0.00E+00 | 5.24E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.11E-04 |
| Br-85 | 0.00E+00 | 0.00E+00 | 2.15E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.01E-15 |
| Rb-86 | 0.00E+00 | 1.01E+05 | 4.71E+04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.99E+04 |
| Rb-88 | 0.00E+00 | 2.90E+02 | 1.54E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.00E-09 |
| Rb-89 | 0.00E+00 | 1.92E+02 | 1.35E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.12E-11 |
| Sr-89 | 2.21E+04 | 0.00E+00 | 6.35E+02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.55E+03 |
| Sr-90 | 5.44E+05 | 0.00E+00 | 1.34E+05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.57E+04 |
| Sr-91 | 4.07E+02 | 0.00E+00 | 1.64E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.94E+03 |
| Sr-92 | 1.54E+02 | 0.00E+00 | 6.68E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.06E+03 |
| Y-90 | 5.76E-01 | 0.00E+00 | 1.54E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.10E+03 |
| Y-91m | 5.44E-03 | 0.00E+00 | 2.11E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.60E-02 |
| Y-91 | 8.44E+00 | 0.00E+00 | 2.26E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.64E+03 |
| Y-92 | 5.06E-02 | 0.00E+00 | 1.48E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.86E+02 |

*Calculated using Equation (11).

TABLE 1.2-3 (Continued)

Site Related Ingestion Dose Commitment Factor, $A_{i\tau}$
(mrem/hr per μCi/ml)
Page 2 of 3

| Nuclide | Bone | Liver | T Body | Thyroid | Kidney | Lung | GI-LLI |
|---|---|---|---|---|---|---|---|
| Y-93 | 1.60E-01 | 0.00E+00 | 4.43E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.09E+03 |
| Zr-95 | 2.40E-01 | 7.70E-02 | 5.21E-02 | 0.00E+00 | 1.21E-01 | 0.00E+00 | 2.44E+02 |
| Zr-97 | 1.33E-02 | 2.68E-03 | 1.22E-03 | 0.00E+00 | 4.04E-03 | 0.00E+00 | 8.30E+02 |
| Nb-95 | 4.47E+02 | 2.48E+02 | 1.34E+02 | 0.00E+00 | 2.46E+02 | 0.00E+00 | 1.51E+06 |
| Mo-99 | 0.00E+00 | 1.03E+02 | 1.96E+01 | 0.00E+00 | 2.34E+02 | 0.00E+00 | 2.39E+02 |
| Tc-99m | 8.87E-03 | 2.51E-02 | 3.19E-01 | 0.00E+00 | 3.81E-01 | 1.23E-02 | 1.48E+01 |
| Tc-101 | 9.12E-03 | 1.31E-02 | 1.29E-01 | 0.00E+00 | 2.37E-01 | 6.72E-03 | 3.95E-14 |
| Ru-103 | 4.43E+00 | 0.00E+00 | 1.91E+00 | 0.00E+00 | 1.69E+01 | 0.00E+00 | 5.17E+02 |
| Ru-105 | 3.69E-01 | 0.00E+00 | 1.46E-01 | 0.00E+00 | 4.76E+00 | 0.00E+00 | 2.26E+02 |
| Ru-106 | 6.58E+01 | 0.00E+00 | 8.33E+00 | 0.00E+00 | 1.27E+02 | 0.00E+00 | 4.26E+03 |
| Ag-110m | 8.81E-01 | 8.15E-01 | 4.84E-01 | 0.00E+00 | 1.60E+00 | 0.00E+00 | 3.33E+02 |
| Te-125m | 2.57E+03 | 9.30E+02 | 3.44E+02 | 7.72E+02 | 1.04E+04 | 0.00E+00 | 1.02E+04 |
| Te-127m | 6.48E+03 | 2.32E+03 | 7.90E+02 | 1.66E+03 | 2.63E+04 | 0.00E+00 | 2.17E+04 |
| Te-127 | 1.05E+02 | 3.78E+01 | 2.28E+01 | 7.80E+01 | 4.29E+02 | 0.00E+00 | 8.31E+03 |
| Te-129m | 1.10E+04 | 4.11E+03 | 1.74E+03 | 3.78E+03 | 4.60E+04 | 0.00E+00 | 5.54E+04 |
| Te-129 | 3.01E+01 | 1.13E+01 | 7.33E+00 | 2.31E+01 | 1.26E+02 | 0.00E+00 | 2.27E+01 |
| Te-131m | 1.66E+03 | 8.10E+02 | 6.75E+02 | 1.28E+03 | 8.21E+03 | 0.00E+00 | 8.04E+04 |
| Te-131 | 1.89E+01 | 7.88E+00 | 5.96E+00 | 1.55E+01 | 8.26E+01 | 0.00E+00 | 2.67E+00 |
| Te-132 | 2.41E+03 | 1.56E+03 | 1.47E+03 | 1.72E+03 | 1.50E+04 | 0.00E+00 | 7.38E+04 |
| I-130 | 2.71E+01 | 8.01E+01 | 3.16E+01 | 6.79E+03 | 1.25E+02 | 0.00E+00 | 6.89E+01 |
| I-131 | 1.49E+02 | 2.14E+02 | 1.22E+02 | 7.00E+04 | 3.66E+02 | 0.00E+00 | 5.64E+01 |
| I-132 | 7.29E+00 | 1.95E+01 | 6.82E+00 | 6.82E+02 | 3.11E+01 | 0.00E+00 | 3.66E+00 |
| I-133 | 5.10E+01 | 8.87E+01 | 2.70E+01 | 1.30E+04 | 1.55E+02 | 0.00E+00 | 7.97E+01 |
| I-134 | 3.81E+00 | 1.03E+01 | 3.70E+00 | 1.79E+02 | 1.64E+01 | 0.00E+00 | 9.01E-03 |
| I-135 | 1.59E+01 | 4.17E+01 | 1.54E+01 | 2.75E+03 | 6.68E+01 | 0.00E+00 | 4.70E+01 |
| Cs-134 | 2.98E+05 | 7.09E+05 | 5.79E+05 | 0.00E+00 | 2.29E+05 | 7.61E+04 | 1.24E+04 |
| Cs-136 | 3.12E+04 | 1.23E+05 | 8.86E+04 | 0.00E+00 | 6.85E+04 | 9.38E+03 | 1.40E+04 |
| Cs-137 | 3.82E+05 | 5.22E+05 | 3.42E+05 | 0.00E+00 | 1.77E+05 | 5.89E+04 | 1.01E+04 |
| Cs-138 | 2.64E+02 | 5.22E+02 | 2.59E+02 | 0.00E+00 | 3.84E+02 | 3.79E+01 | 2.23E-03 |
| Ba-139 | 9.29E-01 | 6.62E-04 | 2.72E-02 | 0.00E+00 | 6.19E-04 | 3.75E-04 | 1.65E+00 |
| Ba-140 | 1.94E+02 | 2.44E-01 | 1.27E+01 | 0.00E+00 | 8.30E-02 | 1.40E-01 | 4.00E+02 |
| Ba-141 | 4.51E-01 | 3.41E-04 | 1.52E-02 | 0.00E+00 | 3.17E-04 | 1.93E-04 | 2.13E-10 |
| Ba-142 | 2.04E-01 | 2.10E-04 | 1.28E-02 | 0.00E+00 | 1.77E-04 | 1.19E-04 | 2.87E-19 |

TABLE 1.2-3 (Continued)

Site Related Ingestion Dose Commitment Factor, $A_{i\tau}$
(mrem/hr per μCi/ml)
Page 3 of 3

| Nuclide | Bone | Liver | T Body | Thyroid | Kidney | Lung | GI-LLI |
|---|---|---|---|---|---|---|---|
| La-140 | 1.50E-01 | 7.54E-02 | 1.99E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.54E+03 |
| La-142 | 7.66E-03 | 3.48E-03 | 8.68E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.54E+01 |
| Ce-141 | 2.24E-02 | 1.52E-02 | 1.72E-03 | 0.00E+00 | 7.04E-03 | 0.00E+00 | 5.79E+01 |
| Ce-143 | 3.95E-03 | 2.92E+00 | 3.23E-04 | 0.00E+00 | 1.29E-03 | 0.00E+00 | 1.09E+02 |
| Ce-144 | 1.17E+00 | 4.88E-01 | 6.27E-02 | 0.00E+00 | 2.90E-01 | 0.00E+00 | 3.95E+02 |
| Pr-143 | 5.51E-01 | 2.21E-01 | 2.73E-02 | 0.00E+00 | 1.27E-01 | 0.00E+00 | 2.41E+03 |
| Pr-144 | 1.80E-03 | 7.48E-04 | 9.16E-05 | 0.00E+00 | 4.22E-04 | 0.00E+00 | 2.59E-10 |
| Nd-147 | 3.76E-01 | 4.35E-01 | 2.60E-02 | 0.00E+00 | 2.54E-01 | 0.00E+00 | 2.09E+03 |
| W-187 | 2.96E+02 | 2.47E+02 | 8.65E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.10E+04 |
| Np-239 | 2.85E-02 | 2.80E-03 | 1.54E-03 | 0.00E+00 | 8.74E-03 | 0.00E+00 | 5.75E+02 |

## 1.3 DEFINITIONS OF LIQUID EFFLUENT PARAMETERS

| Term | Definition | Section of Initial Use |
|---|---|---|
| $A_{i\tau}$ | = the site related ingestion dose commitment factor to the the total body or any organ τ for each identified principal gamma and beta emitter listed in Table 1.2-3 in mrem-ml per hr-μCi. | 1.2 |
| $BF_i$ | = bioaccumulation factor for radionuclide i, in fish, in pCi/kg per pCi/liter, from Table 1.2-1. | 1.2 |
| $C_{MPC}$ | = the effluent concentration limit (TS 3.11.1.1) implementing 10 CFR 20 for the site, in μCi/ml. | 1.1.1 |
| $C_a$ | = the effluent concentration of alpha-emitting nuclides observed by gross alpha analysis of the MONTHLY composite sample. | 1.1.1 |
| $C_g$ | = the effluent concentration of a gamma-emitting nuclide g observed by gamma ray spectroscopy of the waste sample. | 1.1.1 |
| $C_i$ | = the concentration of nuclide i as determined by the analysis of the waste sample. | 1.1.1 |
| $C_s$ | = the concentration of Sr-89 or Sr-90 in liquid wastes as determined by analysis of the QUARTERLY composite sample. | 1.1.1 |
| $C_t$ | = the measured concentration of H-3 in liquid waste as determined by analysis of the MONTHLY composite. | 1.1.1 |

1.3 DEFINITIONS OF LIQUID EFFLUENT PARAMETERS (Continued)

| Term | Definition | Section of Initial Use |
|---|---|---|
| $C_{i\ell}$ | = the concentration of radionuclide i in the undiluted liquid effluent averaged over the duration of the release, $\Delta t_{\ell}$, in µCi/ml. | 1.2 |
| c | = the setpoint, in µCi/ml, of the radioactivity monitor measuring the concentration of radioactivity in the effluent line prior to dilution and subsequent release. | 1.1.1 |
| $D_{\tau}$ | = the cumulative dose commitment to the total body or any organ τ from the liquid effluents for the total time period. | 1.2 |
| $DF_{i\tau}$ | = a dose conversion factor for radionuclide i for adults in preselected organ τ, in mrem/pCi found in Table 1.2-2. | 1.2 |
| F | = the dilution water flow setpoint as determined prior to the release point, in volume per unit time. | 1.1.1 |
| $F_A$ | = administrative allocation factor applied to apportion liquid releases. | 1.1.1 |
| $F_D$ | = the dilution factor, which is the ratio of the total dilution flow rate to the effluent stream flow rate(s), required to assure that the limiting concentrations of 10 CFR, Part 20, Appendix B, Table II, Column 2 are met at the point of discharge. | 1.1.1 |
| $F_P$ | = a selected percentage of dilution flow. | 1.1.1 |

## 1.3 DEFINITIONS OF LIQUID EFFLUENT PARAMETERS (Continued)

| Term | Definition | Section of Initial Use |
|---|---|---|
| $F_S$ | = the safety factor, a conservative factor used to compensate for statistical fluctuations and errors of measurements. | 1.1.1 |
| $F_\ell$ | = the near field average dilution factor for $C_{i\ell}$ during any liquid effluent release. | 1.2 |
| $F_{AA}$ | = adjustment factor applied to facilitate setting actual monitor setpoints. | 1.1.1 |
| $F_{DN}$ | = modified dilution factor for simultaneous release pathways. | 1.1.1 |
| f | = the flow rate setpoint as determined for the radioactivity monitor location (general expression for Equation (1)). | 1.1.1 |
| $f_d$ | = the flow rate of the dilution stream (cooling pond blow-down or makeup pump discharge) during the time of release. = $F_p$ x expected dilution flow. | 1.1.1 |
| $f_p$ | = maximum permissible undiluted waste tank effluent flow rate. | 1.1.1 |
| $K_o$ | = $1.14 \times 10^5$, units conversion factor. | 1.2 |
| $MPC_i$ | = $MPC_g$, $MPC_a$, $MPC_s$, and $MPC_t$ = the limiting concentrations of the appropriate gamma-emitting radionuclides, alpha-emitting radionuclides, Sr-89 and Sr-90, and tritium, respectively, from 10 CFR, Part 20, Appendix B, Table II, Column 2. | 1.1.1 |

1.3 DEFINITIONS OF LIQUID EFFLUENT PARAMETERS (Continued)

| Term | Definition | Section of Initial Use |
|---|---|---|
| n | = the number of liquid discharge pathways for which $F_D$ and which are planned for simulantaneous release. | 1.1.1 |
| $S_D$ | = the dilution water flow monitor setpoint as determined prior to the release point, in volume per unit time. | 1.1.1 |
| $U_F$ | = 21 kg/yr, fish consumption (adult). | 1.2 |
| Z | = applicable factor when additional receiving water body dilution is to be considered; Z = 3. | 1.2 |
| $\Delta t_\ell$ | = duration of the $\ell$th release under consideration. | 1.2 |

## 1.4 LIQUID RADWASTE TREATMENT SYSTEM

Minimum OPERABLE Liquid Radwaste Treatment System is presented in Figures 1.4-1 and 1.4-2. Figure 1.4-1 depicts the Liquid Radwaste Treatment System and the Laundry Waste Treatment System flow diagram. The Treatment Systems Discharge Pathways are presented in Figure 1.4-2.

FIGURE 1.4-1

MINIMUM OPERABLE LIQUID RADWASTE TREATMENT SYSTEM

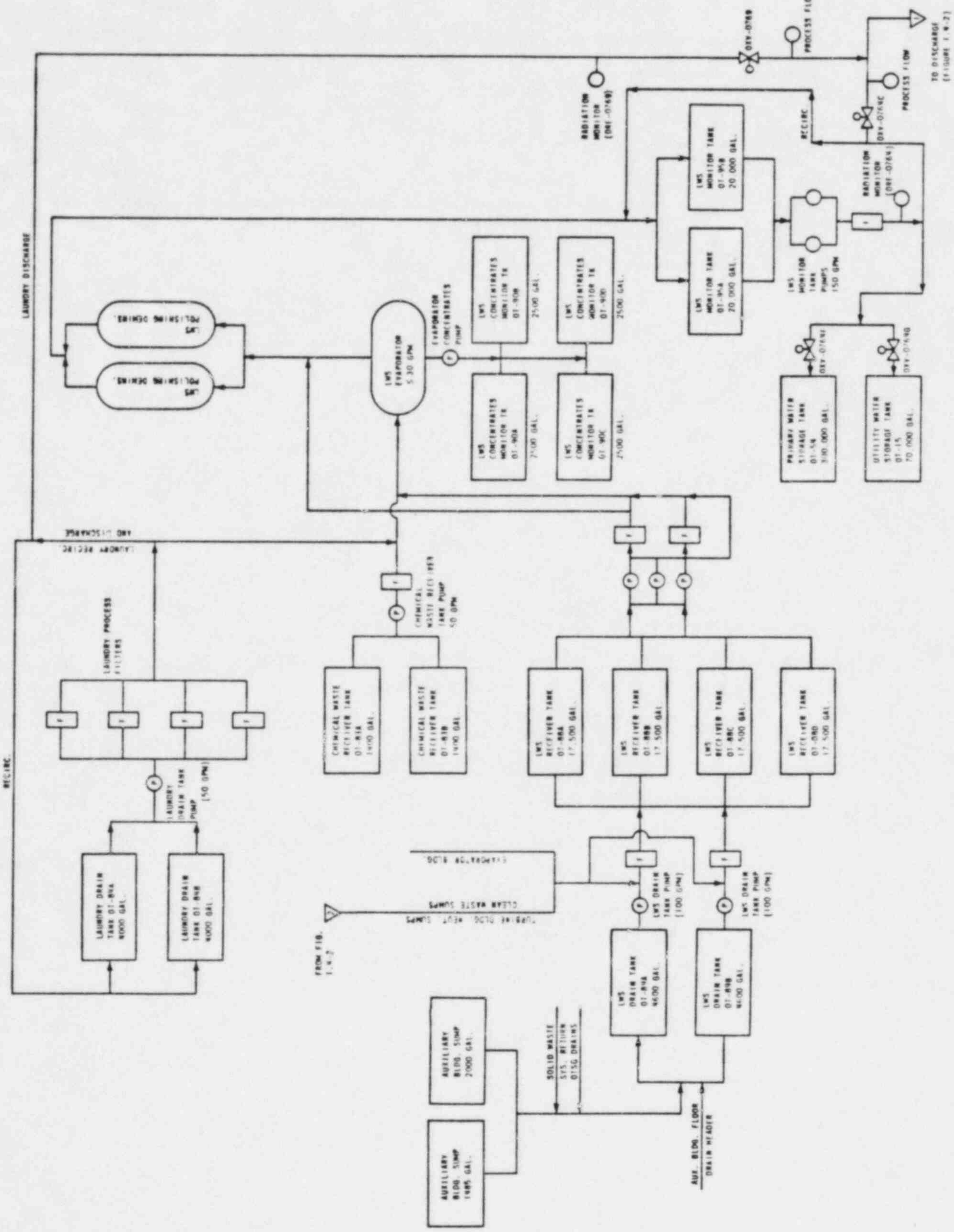
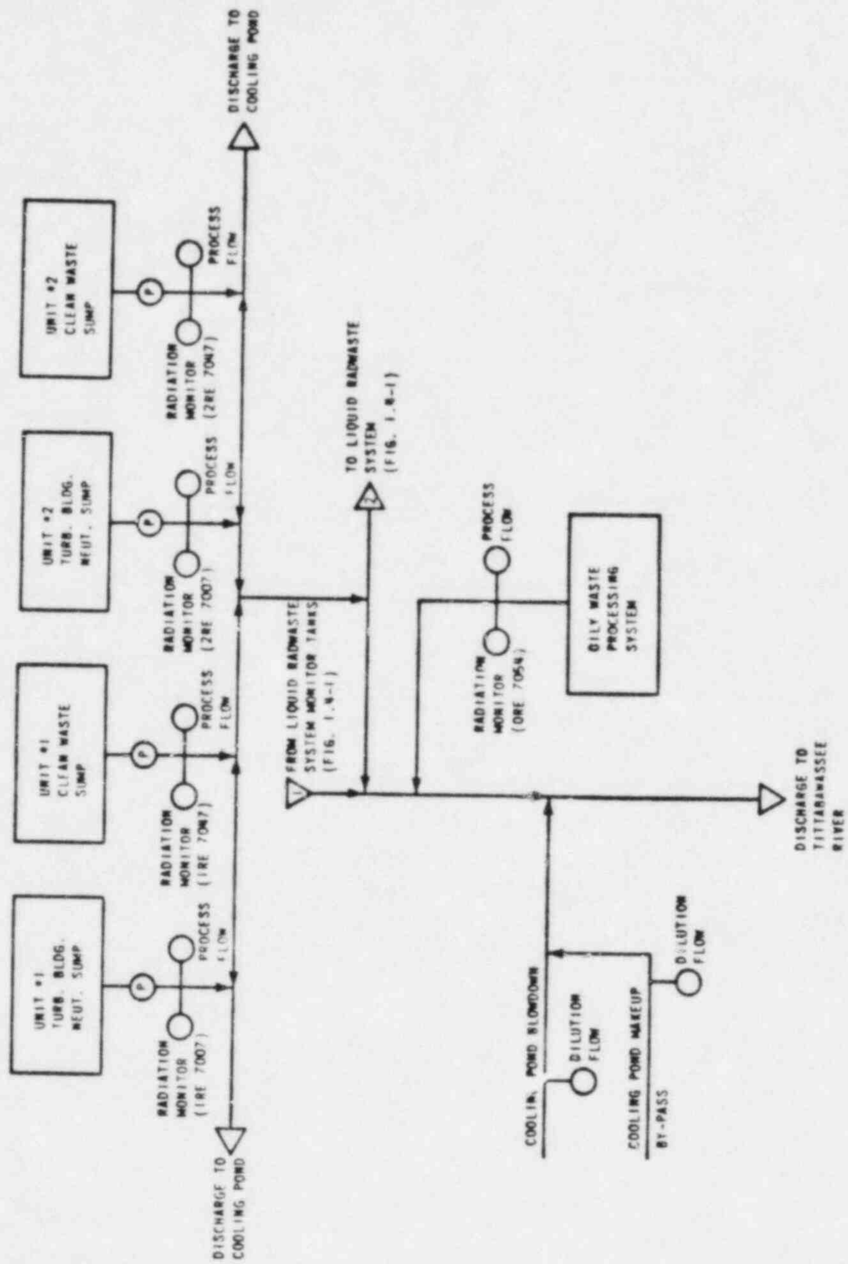


FIGURE 1.4-2

MINIMUM OPERABLE LIQUID RADWASTE TREATMENT SYSTEM
(TREATMENT SYSTEMS DISCHARGE PATHWAYS)



## SECTION 2.0

## GASEOUS EFFLUENTS

Gaseous effluent monitor setpoints are required only for noble gas monitors; methodology for calculating noble gas monitor setpoints is covered in Section 2.1. Although setpoint calculations are not required for radioiodine and particulate monitors, the methodology for assuring the potential organ dose rates due to radioiodines, tritium, and particulates in gaseous releases from the site do not exceed the limits of TS 3.11.2.1(b) is presented in the note following 2.2.1.b.

### 2.1 GASEOUS EFFLUENT MONITOR SETPOINTS

The gaseous monitor setpoint values determined in the following sections will be regarded as upper bounds for the actual setpoint adjustments. Setpoint adjustments are not required to be performed if the existing monitor setpoint is lower than the calculated value. Setpoints may be established at values lower than the calculated values if desired.

If a calculated setpoint is less than the monitor reading associated with the particular release pathway, no release may be made under current conditions. Under such circumstances, the number of simultaneous release pathways may be reduced or contributing source terms may be reduced and the setpoint recalculated.

For the Midland Plant, gaseous monitor setpoints are calculated for concentrations, in μCi/cc. The actual monitor setpoint, which corresponds to the calculated concentration plus background for the particular monitor, is

determined from calibration data or from operational data associated with sample analysis data (see Section 2.1.4).

2.1.1 REACTOR CONTAINMENT BUILDING VENT STACK (UNIT 1 AND UNIT 2), AUXILIARY BUILDING VENT STACK NO. 1, AND CONDENSER AIR EJECTOR (UNIT 1 AND UNIT 2)

Monitors: 1RE-5377, 2RE-6277, 0RE-5470, 1RE-3347, 2RE-3447

For the purpose of implementation of TS 3.3.3.10, the alarm setpoint level for these noble gas monitors will be calculated as follows:

$C_S$ = monitor reading of the noble gas monitor at the alarm setpoint concentration, in μCi/cc.

$$= \text{the lesser of} \begin{cases} (F_B \times F_S) \times R_t \times D_{TB} & (1) \\ \text{or} & \\ (F_B \times F_S) \times R_s \times D_{ss} & (2) \end{cases}$$

where

$F_S$ = safety factor; a conservative factor applied to each noble gas monitor to compensate for statistical fluctuations and errors of measurement. (For example, $F_S$ = 0.5 corresponds to a 100 percent variation; value must be between 0 and 1.)

$F_B$ = an administrative allocation factor applied to apportion the release setpoints among all gaseous release discharge pathways to assure that release limits will not be exceeded by simultaneous releases. The allocation factor for a particular pathway may be assigned any desired value between 0 and 1 under the condition that:

$$\sum_{n} (F_B)_n \leq 1 \qquad (3)$$

In the equation above, n is the number of simultaneous final gaseous release points. Turbine Building release points (condenser air ejectors) are included only if primary-to-secondary leakage exists as determined in accordance with TS 4.4.6.3. Final gaseous release points would normally include Unit 1 Reactor Containment Building Ventilation Exhaust, Unit 2 Reactor Containment Building Ventilation Exhaust, and Auxiliary Building Vent Stack No. 1.

$D_{TB}$ = dose rate limit to the total body of an individual in an unrestricted area.

= 500 mrem/year

$R_t$ = monitor reading per mrem/year to the total body.

$$= C \div (\overline{X/Q}) \sum_{i} K_i Q_i \qquad (4)$$

C = monitor reading of a noble gas monitor corresponding to grab sample radionuclide concentrations. For batch releases the sample is taken prior to the release. For continuous releases, the sample is taken concurrently with the release. For continuous releases, the monitor setpoint is calculated based on the most recent sample information for the particular pathway in accordance with TS Table 4.11-2.

$\overline{X/Q}$ = the highest annual average relative concentration at or beyond the site boundary.

= $(\overline{X/Q})_M$ = mixed-mode; applies to Reactor Containment Building Ventilation and Auxiliary Building Ventilation. Containment Building Ventilation includes Containment Purges and Air Room Purges. Auxiliary Building Ventilation includes Gaseous Radwaste System.

= $2.74 \times 10^{-6}$ sec/m$^3$ in the NNE sector.

= $(\overline{X/Q})_G$ = ground-level; applies to Condenser Air Ejectors.

= $2.55 \times 10^{-5}$ sec/m$^3$ in the NNE sector.

$K_i$ = total body dose factor due to gamma emissions from radionuclide i (mrem/year per μCi/m$^3$) from Table 2.1-1.

$Q_i$ = rate of release of noble gas radionuclide i (μCi/sec) from the release pathway under consideration, determined by multiplying the release flow rate for the pathway by the concentration of radionuclide i.

= $(Q_i)_M$ = mixed-mode release; Reactor Containment Building Ventilation (including Containment and Air Room Purges) and Auxiliary Building Ventilation (including Gaseous Radwaste System).

= $(Q_i)_G$ = ground-level release; Condenser Air Ejectors.

$D_{ss}$ = dose rate limit to the skin of an individual in an unrestricted area.

= 3000 mrem/year

$R_s$ = monitor reading per mrem/year to the skin.

$$= C \div (\overline{X/Q} \sum_i (L_i + 1.1\ M_i)Q_i) \quad (5)$$

$L_i$ = skin dose factor due to beta emissions from radionuclide i (mrem/year per $\mu Ci/m^3$) from Table 2.1-1.

1.1 = mrem skin dose per mrad air dose.

$M_i$ = air dose factor due to gamma emissions from radionuclide i (mrad/year per $\mu Ci/m^3$) from Table 2.1-1.

2.1.2 AUXILIARY BUILDING VENT STACK NO. 2 (EMERGENCY)

MONITOR: ORE-5471

Auxiliary Building Vent Stack No. 2 is used during abnormal or accident conditions. Therefore, this monitor serves no routine function. When necessary, a monitor setpoint would be determined following the methodology of Section 2.1.1.

### 2.1.3 GASEOUS RADWASTE SYSTEM, REACTOR CONTAINMENT BUILDING PURGE, AND AIR ROOM PURGE

Monitors: ORE-0907, 1RE-5377, 2RE-6277, 1RE-5385, 2RE-6285

The Gaseous Radwaste System, Reactor Containment Building Purge, and Air Room Purge are gaseous sources which discharge to release pathways which are continuously monitored. Although these sources discharge to a release pathway which is equipped with a final monitor, due to the significance of these sources, the methodology for calculating setpoints is presented. Sampling and analyses are completed and setpoints determined prior to release. These setpoints must take into account simultaneous release pathways; the combined allocation factors for contributing pathway monitors must not exceed the allocation factor for the final release pathway monitor to which they contribute.

Downstream monitors must also take into consideration the combinations of source terms for the particular release pathway.

#### 2.1.3.1 Gaseous Radwaste System

Monitor: ORE-0907

The Gaseous Radwaste System releases exhaust through Auxiliary Building Vent Stack No. 1, therefore, the Gaseous Radwaste monitor is not the final monitor in this release pathway. However, because of the significance of this release pathway and because the Auxiliary Building Vent Stack No. 1 monitor setpoint would have to accommodate the Gaseous Radwaste release, the setpoint methodology for this monitor is presented.

The methodology presented in Section 2.1.1 applies to this monitor with the following exceptions:

$$R_t = r_t = C \div (\overline{X/Q} \sum_i K_i q_i) \qquad (6)$$

C = monitor response of the Gaseous Radwaste System monitor for radionuclide concentrations to be discharged (sample taken and analyzed prior to discharge).

$\overline{X/Q} = (\overline{X/Q})_M$; see Section 2.1.1.

$q_i$ = rate of release of noble gas radionuclide i (μCi/sec) from the Waste Gas Decay System, determined by multiplying the expected release rate by the concentration of radionuclide i.

$$R_s = r_s = C \div [\overline{X/Q} \sum_i (L_i + 1.1 M_i) q_i] \qquad (7)$$

$F_B$ = a selected value less than the allocation factor for the monitor serving the final release pathway to which the particular source discharges, Auxiliary Building Vent Stack No. 1.

When releases are to be made from the Gaseous Radwaste System, it will be necessary to redetermine the setpoint for the Auxiliary Building Vent Stack No. 1 monitor (0RE-5470) which is downstream from the Gaseous Radwaste monitor (0RE-0907).

Calculation of this setpoint is accomplished by applying the methodology of Section 2.1.1 with the following exceptions:

A new source term, $(Q_i)_{AG}$, is determined which includes the routine Auxiliary Building Vent Stack No. 1 source term, $Q_i$, (based on sample results from TS Table 4.11-2) combined with the Gaseous Radwaste tank source term planned for release, $q_i$, as follows:

$$(Q_i)_{AG} = Q_i + q_i \qquad (8)$$

C = monitor reading corresponding to the concentration resulting from the combined release.

2.1.3.2 Reactor Containment Building Purge System

This section pertains to purges associated with plant shutdown.

Containment purge is a release which discharges to the Reactor Containment Building Ventilation Exhaust System. There is no separate monitor for containment purge releases; purge releases are monitored by the Reactor Containment Building Ventilation monitor (1RE-5377 or 2RE-6277).

When containment purge releases are to be made, setpoints for the Reactor Containment Building Ventilation System monitors must be redetermined to account for the additional source term associated with the purge.

The methodology presented in Section 2.1.1 applies to redetermining the setpoint for this monitor with the following exceptions:

A new source term, $(Q_i)_{CP}$, is determined which includes the routine Reactor Containment Building Ventilation System source term, $Q_i$, (based on sample

results from TS Table 4.11-2) combined with the Containment Purge source term, $q_i$, as follows:

$$(Q_i)_{CP} = Q_i + q_i \tag{9}$$

C = monitor reading corresponding to the concentration resulting from the combined release.

2.1.3.3 Air Room Purge System

Monitors: 1RE-5385 or 2RE-6285

Air Room Purge discharges are released to the Reactor Containment Building Ventilation System; therefore, the Air Room Purge monitor is not the final monitor in this release pathway. However, since this is an additional contributor to the Containment Building Ventilation System discharge pathway, and because the Containment Building Ventilation System monitor would have to accommodate the Air Room Purge release, the setpoint methodology for this monitor is presented.

The Air Room Exhaust System is utilized also to perform operational containment purge. When used for this purpose, the air concentration of radioactivity and the source term used to determine the setpoint for the Air Room Exhaust System monitor must include the concentration and source term associated with the operational containment purge.

The methodology presented in Section 2.1.1 applies to this monitor with the following exceptions:

$$R_t = r_t = C \div (\overline{X/Q} \sum_i K_i q_i) \quad (10)$$

C = monitor response of the Air Room Purge System monitor for radionuclide concentrations to be discharged (sample taken and analyzed prior to discharge)

$\overline{X/Q} = (\overline{X/Q})_M$; see Section 2.1.1

$q_i$ = rate of release of noble gas radionuclide i (μCi/sec) from the Air Room Purge System; determined by multiplying the flow rate from the Air Room Purge by the concentration of radionuclide i.

$$R_s = r_s = C \div [\overline{X/Q} \sum_i (L_i + 1.1\ M_i) q_i] \quad (11)$$

$F_B$ = a selected value less than the allocation factor for the monitor serving the Reactor Containment Building Vent.

When releases are to be made from the Air Room Purge System, it will be necessary to redetermine the setpoint for the Reactor Containment Building Ventilation monitor (1RE-5377 or 2RE-6277) which is downstream from the Air Room Purge monitor (1RE-5385 or 2RE-6285).

Calculation of this setpoint is accomplished by applying the methodology of Section 2.1.1 with the following exceptions:

A new source term, $(Q_i)_{CR}$, is determined which includes the routine Containment Building Ventilation source term, $Q_i$, (based on sample results

from TS Table 4.11-2) combined with the source term for the Air Room Volume and/or the Operational Containment Purge planned for release, $q_i$, as follows:

$$(Q_i)_{CR} = Q_i + q_i \qquad (12)$$

C = monitor reading corresponding to the concentration resulting from the combined release.

### 2.1.4 CONSIDERATION OF BACKGROUND AND MONITOR RESPONSE ADJUSTMENTS IN ESTABLISHING GASEOUS MONITOR SETPOINTS

The calculated setpoint concentration, $C_s$, establishes the base value for the monitor setpoint. However, in establishing the actual monitor setpoint for a particular monitor, background radiation levels and monitor response adjustments must be considered.

Contributions to background radiation levels may include ambient background, plant environmental background at monitor locations when plant is in shutdown status, plant environmental background at monitor location when plant is at power, and internal background of monitor due to contamination of sample chamber. Normally, the actual monitor setpoint includes the calculated setpoint value plus background. Background levels must be controlled such that radioactivity levels in the effluent stream being monitored can be accurately assessed at or below the calculated setpoint value.

Monitor response adjustments may be necessary to assure that monitor readout accurately reflects radioactivity levels in the monitored effluent stream. Monitor adjustments (monitor setting) may be based on monitor calibrations, monitor calibration data supplied by the monitor vendor, or by operational

data which correlates monitor response to sample analyses associated with actual effluent releases. At the Midland Plant the monitor response adjustment which correlates actual monitor response to monitor response expected, based on associated sample analyses, is referred to as the gain factor.

## TABLE 2.1-1

Dose Factors for Exposure to a Semi-Infinite Cloud of Noble Gases*

| Nuclide | γ-Body***(K) | β-Skin***(L) | γ-Air**(M) | β-Air**(N) |
|---|---|---|---|---|
| Kr-85m | 1.17E+03**** | 1.46E+03 | 1.23E+03 | 1.97E+03 |
| Kr-85 | 1.61E+01 | 1.34E+03 | 1.72E+01 | 1.95E+03 |
| Kr-87 | 5.92E+03 | 9.73E+03 | 6.17E+03 | 1.03E+04 |
| Kr-88 | 1.47E+04 | 2.37E+03 | 1.52E+04 | 2.93E+03 |
| Kr-89 | 1.66E+04 | 1.01E+04 | 1.73E+04 | 1.06E+04 |
| Kr-90 | 1.56E+04 | 7.29E+03 | 1.63E+04 | 7.83E+03 |
| Xe-131m | 9.15E+01 | 4.76E+02 | 1.56E+02 | 1.11E+03 |
| Xe-133m | 2.51E+02 | 9.94E+02 | 3.27E+02 | 1.48E+03 |
| Xe-133 | 2.94E+02 | 3.06E+02 | 3.53E+02 | 1.05E+03 |
| Xe-135m | 3.12E+03 | 7.11E+02 | 3.36E+03 | 7.39E+02 |
| Xe-135 | 1.81E+03 | 1.86E+03 | 1.92E+03 | 2.46E+03 |
| Xe-137 | 1.42E+03 | 1.22E+04 | 1.51E+03 | 1.27E+04 |
| Xe-138 | 8.83E+03 | 4.13E+03 | 9.21E+03 | 4.75E+03 |
| Ar-41 | 8.84E+03 | 2.69E+03 | 9.30E+03 | 3.28E+03 |

*Values taken from Reference 3, Table B-1.

** $\frac{\text{mrad-m}^3}{\mu\text{Ci-yr}}$

*** $\frac{\text{mrem-m}^3}{\mu\text{Ci-yr}}$

****1.17E+03 = $1.17 \times 10^3$

## 2.2 GASEOUS EFFLUENT DOSE RATE AND DOSE CALCULATIONS

### 2.2.1 SITE BOUNDARY DOSE RATES

#### 2.2.1.a Dose Rates Due to Noble Gases

For the purpose of implementation of TS 3.11.2.1(a), the dose rate at or beyond the site boundary due to noble gases shall be calculated as follows:

$D_t$ = total body dose rate at time of release (mrem/year).

$$= [(\overline{X/Q})_M \sum_i K_i (Q_i)_M] + [(\overline{X/Q})_G \sum_i K_i (Q_i)_G] \qquad (13)$$

$D_s$ = skin dose rate at time of release (mrem/year).

$$= [(\overline{X/Q})_M \sum_i (L_i + 1.1\ M_i)(Q_i)_M] + [(\overline{X/Q})_G \sum_i (L_i + 1.1\ M_i)(Q_i)_G] \qquad (14)$$

NOTE: Terms defined previously in Section 2.1.1.

In the event of simultaneous releases, dose rates shall be summed to assure that dose rate limits are not exceeded.

#### 2.2.1.b Dose Rates Due to Radioiodines, Tritium, and Particulates

Organ dose rates due to inhalation of radioiodines, tritium, and all radioactive materials in particulate form with half-lives greater than 8 days, will be calculated for the purpose of implementation of TS 3.11.2.1(b) as follows:

$D_o$ = organ dose rate at time of release (mrem/year).

$$= [(\overline{X/Q})_M \sum_i P_{io}(Q_i')_M] + [(\overline{X/Q})_G \sum_i P_{io}(Q_i')_G]$$

where

$\overline{X/Q}$ = controlling sector annual average relative concentration at the site boundary for the appropriate pathway.

= $(\overline{X/Q})_M$ = mixed-mode; applies to Reactor Containment Building Ventilation (including Containment Purge and Air Room Purge) and Auxiliary Building Stack (including Gaseous Radwaste System).

= $2.74 \times 10^{-6}$ sec/m$^3$ in the NNE sector.

= $(\overline{X/Q})_G$ = ground-level; applies to Condenser Air Ejectors.

= $2.55 \times 10^{-5}$ sec/m$^3$ in the NNE sector.

$P_{io}$ = organ dose parameter for organ o and radionuclide i, (mrem/year per µCi/m$^3$) for inhalation determined as follows:

$$P_{io} = K'(BR)\ DF_{io} \qquad (16)$$

where

K' = constant of unit conversion, $10^6$ pCi/µCi.

BR = breathing rate for child age group.

= 3700 $m^3$/year (Table 2.2-10 from Reference 3).

$DF_{io}$ = inhalation pathway dose factor for child age group for organ o and radionuclide i (from Table 2.2-2).

$Q'_i$ = release rate of non-noble gas radionuclide i (μCi/sec) for the type of release under consideration.

= $(Q'_i)_M$ = mixed-mode release type.

= $(Q'_i)_G$ = ground-level release type.

NOTE: In order to assure that potential dose rates (pre-release) to an organ due to radioiodine, tritium, and particulates in simultaneous gaseous releases from the site do not exceed 1500 mrem/year as specified in TS 3.11.2.1(b), potential organ dose rate, $D_o$, must be limited as follows:

$$D_o \div (F_B \times F_S) \leq 1500 \text{ mrem/year} \quad (17)$$

$F_B$ and $F_S$ are assigned the same values as were used in Section 2.1 for the release source pathway under consideration. To further assure that dose rate limits were not exceeded (post-release), dose rates from simultaneous releases shall be summed.

## 2.2.2 AIR DOSE AND DOSE TO INDIVIDUAL

### 2.2.2.a Air Dose

For the purpose of implementation of TS 3.11.2.2 and TS 3.11.2.4, the air dose at or beyond the site boundary shall be determined as follows:

$D_\gamma$ = air dose due to gamma emissions from noble gases (mrad).

$$= 3.17 \times 10^{-8} \left[\sum_i M_i \, (\overline{X/Q})_M \, (\tilde{Q}_i)_M + \sum_i M_i \, (\overline{X/Q})_G (\tilde{Q}_i)_G\right] \quad (18)$$

where

$3.17 \times 10^{-8}$ = the fraction of one year per one second.

$\tilde{Q}_i$ = cumulative release of noble gas radionuclide i over the period of interest (μCi) for the type of release under consideration.

= $(\tilde{Q}_i)_M$ = mixed-mode release type.

= $(\tilde{Q}_i)_G$ = ground-level release type.

$M_i$ = defined in Section 2.1.1.

$(\overline{X/Q})_M = 2.74 \times 10^{-6}$ sec/m$^3$ in the NNE sector.

$(\overline{X/Q})_G = 2.55 \times 10^{-5}$ sec/m$^3$ in the NNE sector.

$D_\beta$ = air dose due to beta emissions from noble gases (mrad).

$$= 3.17 \times 10^{-8} \left[\sum_i N_i \, (\overline{X/Q})_M \, (\tilde{Q}_i)_M + \sum_i N_i \, (\overline{X/Q})_G (\tilde{Q}_i)_G\right] \quad (19)$$

$N_i$ = air dose factor due to beta emissions from noble gas radionuclide i (mrad/year per $\mu Ci/m^3$ from Table 2.1-1).

2.2.2.b Dose To An Individual

Dose to an individual from radioiodines, tritium, and radioactive materials in particulate form will be calculated for the purpose of implementation of TS 3.11.2.3 and TS 3.11.2.4 as follows:

$D_j$ = dose to an organ of an individual from radioiodines, tritium, and radionuclides in particulate form (mrem)

$$= 3.17 \times 10^{-8} \sum_p [(W'_p \sum_i R_{aipj} \tilde{Q}'_i)] \qquad (20)$$

where

$3.17 \times 10^{-8}$ = fraction of one year per one second.

$W'_p$ = pathway - dependent relative concentration or relative deposition for unrestricted areas at the controlling receptor, defined as follows:

= $(\overline{X/Q'})$ = annual average relative concentration for location of controlling (critical) receptor for inhalation and all tritium pathways only. (For all tritium pathways, the $Q_i$ source term is limited to tritium.)

= $(\overline{X/Q'})_M$ = $4.15 \times 10^{-8}$ $sec/m^3$ in the ESE sector for inhalation and all tritium pathways for mixed-mode release type.

$= (\overline{X/Q'})_G = 8.41 \times 10^{-8}$ sec/m$^3$ in the ESE sector for inhalation and all tritium pathways for ground-level release type.

$= \overline{D/Q'}$ = annual average relative deposition for location of controlling (critical) receptor for pathways other than inhalation or tritium.

$= (\overline{D/Q'})_M = 6.01 \times 10^{-10}$ m$^{-2}$ in the ESE sector for pathways other than inhalation or tritium for mixed-mode release type.

$= (\overline{D/Q'})_G = 7.84 \times 10^{-10}$ m$^{-2}$ in the ESE sector for pathways other than inhalation or tritium for ground-level release type.

NOTE: At the Midland Plant, the Unit 1 Condenser Air Ejector and the Unit 2 Condenser Air Ejector are ground-level releases; all other releases are mixed-mode.

$\tilde{Q}'_i$ = cumulative release of radioiodines, tritium, or material in particulate form for radionuclide i over the period of interest (μCi), for the type of release under consideration.

$= (\tilde{Q}'_i)_M$ = mixed-mode release type.

$= (\tilde{Q}'_i)_G$ = ground-level release type.

$R_{aipj}$ = pathway-specific, individual age-specific, organ dose factor for radionuclide i, pathway p, organ j, and individual age group a. The controlling individual age group and the dose pathways are determined through the Land Use Census for the site. $R_{aipj}$ is determined as follows:

NOTE: At the Midland Plant the controlling receptor is an infant. The dose pathways are inhalation, ground-plane, and grass-goat-milk.

Inhalation Pathway Factor

$$R_{aipj} = K'(BR)_a \, (DFA_{ij})_a \text{ mrem/year per } \mu Ci/m^3 \qquad (21)$$

where

K' = constant of unit conversion, $10^6$ pCi/µCi.

$(BR)_a$ = the breathing rate for a particular age group a, in $m^3$/year from Table 2.2-10 (infant = 1400).

$(DFA_{ij})_a$ = the inhalation dose factor for ith radionuclide for the receptor in age group a, in mrem/pCi from Tables 2.2-1 through 2.2-4 (infant, Table 2.2-1).

Ground-Plane Pathway Factor

$$R_{aipj} = K'K''(SF)(DFG_{ij})((1 - e^{-\lambda_i t})/\lambda_i)(m^2 \text{ mrem/year per } \mu Ci/sec) \qquad (22)$$

where

K' = constant of unit conversion, $10^6$ pCi/µCi.

K" = constant of unit conversion, 8760 hr/year.

SF = shielding factor, 0.7 (dimensionless).

$DFG_{ij}$ = ground-plane dose conversion factor for radionuclide i (same for all age groups) (mrem/hr per $pCi/m^2$) from Table 2.2-9.

$\lambda_i$ = decay constant for radionuclide i, in $sec^{-1}$.

t = exposure time, $4.73 \times 10^8$ sec (15 years).

Grass-Goat-Milk Pathway Factor

$$R_{aipj} = K' \frac{Q_F(U_{ap})}{\lambda_i + \lambda_w} F_m(r)(DFL_{ij})_a \left[\frac{f_p f_s}{Y_p} + \frac{(1 - f_p f_s)\, e^{-\lambda_i t_h}}{Y_s}\right] e^{-\lambda_i t_f} \quad (23)$$

($m^2$ mrem/year per µCi/sec)

where

NOTE: Midland Plant site-specific values are included in parentheses following each definition.

K' = a constant of unit conversion, $10^6$ pCi/µCi.

$Q_F$ = the goat's consumption rate, in kg/day (wet weight).
(6)

$U_{ap}$ = the receptor's milk consumption rate for age group a, in liters/year from Table 2.2-10.
(infant - 330)

$Y_p$ = the agricultural productivity by unit area of pasture feed grass, in $kg/m^2$.
(0.26)

$Y_s$ = the agricultural productivity by unit area of stored feed, in $kg/m^2$.
(0.52)

$F_m$ = the stable element transfer coefficients, in days/liter.
(see Table 2.2-11)

r = fraction of deposited activity retained on feed grass.
(1.0 for radioiodines; 0.2 for particulates)

$(DFL_{ij})_a$ = the organ ingestion dose factor for the ith radionuclide for the receptor in age group a, in mrem/pCi from Tables 2.2-5 through 2.2-8.
(infant - Table 2.2-5)

$\lambda_i$ = the decay constant for the ith radionuclide, in $sec^{-1}$.

$\lambda_w$ = the decay constant for removal of activity on leaf and plant surfaces by weathering, $5.73 \times 10^{-7}$ $sec^{-1}$ (corresponding to a 14-day half-life).

$t_f$ = the transport time from pasture to goat, to milk, to receptor, in sec.

$(1.73 \times 10^5)$

$t_h$ = the transport time from pasture to harvest, to goat, to milk, to receptor, in sec.

$(7.78 \times 10^6)$

$f_p$ = fraction of the year that the goat is on pasture (dimensionless).

(1)

$f_s$ = fraction of the goat feed that is pasture grass while the goat is on pasture (dimensionless).

(1)

For tritium in milk, the grass-goat-milk pathway factor is a special case due to the fact that the concentration of tritium in milk is based on airborne concentration rather than deposition:

$$R_{aipj} = K'K'''F_m Q_F U_{ap} (DFL_{ij})_a \, [0.75(0.5/H)] \text{ (mrem/year per } \mu\text{Ci/m}^3) \quad (24)$$

where

$K'''$ = a constant of unit conversion, $10^3$ gm/kg.

$H$ = absolute humidity of the atmosphere, in $gm/m^3$.

(8)

0.75 = the fraction of total feed that is water.

0.5 = the ratio of the specific activity of the feed grass water to the atmospheric water.

Other parameters and values are given above.

2.2.2.c Dose Calculations to Support Other Specific Technical Specifications

For the purpose of implementing TS 6.9.1.12 dose calculations may be performed using the above equations with the substitution of average relative concentrations and relative depositions for the period of the report and the appropriate pathway receptor dose factors ($R_{aipj}$). (Values for $R_{aipj}$ are determined in accordance with Section 2.2.2.d.)

For the purpose of implementing TS 6.9.1.8, dose calculations may be performed using the above equations with the substitution of the relative concentrations (X/Q) and relative depositions (D/Q) which are concurrent with actual releases and the appropriate pathway receptor dose factors ($R_{aijp}$). (Values for $R_{aijp}$ are determined in accordance with Section 2.2.2.d.)

For the purpose of implementing TS 3/4.12.2, dose calculations may be performed using the above equations substituting the appropriate pathway receptor dose factors ($R_{aipj}$) and the appropriate relative concentrations and relative depositions for the location(s) of interest. Annual average relative concentrations and relative depositions may be used for these calculations. (Values for $R_{aijp}$ are determined in accordance with Section 2.2.2.d.)

2.2.2.d Additional Pathway Dose Factors

For the purpose of implementing TS 6.9.1.12, 16.6.9.1.8 or 3/4.12.2, it may be necessary to calculate individual doses due to gaseous releases via exposure pathways other than ground-plane, inhalation, and grass-goat-milk pathways presented in Section 2.2.2.b. Methodology for calculating doses due to gaseous releases via the grass-cow-milk, grass-cow-meat, and the vegetation pathway is the same as was presented in Section 2.2.2.b. However, $R_{aipj}$ is pathway-dependent and is calculated for the remaining pathways as follows:

Grass-Cow-Milk Pathway Factor

$$R_{aipj} = K' \frac{Q_F (U_{ap})}{\lambda_i + \lambda_w} F_m(r)(DFL_{ij})_a \left[\frac{f_p f_s}{Y_p} + \frac{(1 - f_p f_s)\, e^{-\lambda_i t_h}}{Y_s}\right] e^{-\lambda_i t_f} \quad (25)$$

($m^2$ mrem/year per μCi/sec)

where

NOTE: Midland Plant site-specific values are included in parentheses following each definition.

$K'$ = a constant of unit conversion, $10^6$ pCi/μCi.

$Q_F$ = the cow's consumption rate, in kg/day (wet weight). (50)

$U_{ap}$ = the receptor's milk consumption rate for age group a, in liters/year from Table 2.2-10.

$Y_p$ = the agricultural productivity by unit area of pasture feed grass, in $kg/m^2$.

(0.26)

$Y_s$ = the agricultural productivity by unit area of stored feed, in $kg/m^2$.

(0.52)

$F_m$ = the stable element transfer coefficients, in days/liter.

(see Table 2.2-11)

r = fraction of deposited activity retained on feed grass.

(1.0 for radioiodines, 0.2 for particulates)

$(DFL_{ij})_a$ = the organ ingestion dose factor for the ith radionuclide for the receptor in age group a, in mrem/pCi from Tables 2.2-5 through 2.2-8.

(Tables 2.2-5 through 2.2-8)

$\lambda_i$ = the decay constant for the ith radionuclide, in $sec^{-1}$.

$\lambda_w$ = the decay constant for removal of activity on leaf and plant surfaces by weathering, $5.73 \times 10^{-7}$ $sec^{-1}$ (corresponding to a 14-day half-life).

$t_f$ = the transport time from pasture to cow, to milk, to receptor, in sec.

$(1.73 \times 10^5)$

$t_h$ = the transport time from pasture, to harvest, to cow, to milk, to receptor, in sec.

($7.78 \times 10^6$)

$f_p$ = fraction of the year that the cow is on pasture (dimensionless).

(1)

$f_s$ = fraction of the cow feed that is pasture grass while the cow is on pasture (dimensionless).

(0.25)

For tritium in milk, the grass-cow-milk pathway factor is a special case due to the fact that the concentration of tritium in milk is based on airborne concentration rather than deposition:

$$R_{aipj} = K'K'''F_m Q_F U_{ap} (DFL_{ij})_a \, [0.75(0.5/H)] \text{ (mrem/year per } \mu Ci/m^3) \qquad (26)$$

where

K''' = a constant of unit conversion, $10^3$ gm/kg.

H = absolute humidity of the atmosphere, in gm/$m^3$.

(8)

0.75 = the fraction of total feed that is water.

0.5 = the ratio of the specific activity of the feed grass water to the atmospheric water.

Other parameters and values are given above.

Grass-Cow-Meat Pathway Factor

$$R_{aipj} = K' \frac{Q_F(U_{ap})}{\lambda_i + \lambda_w} F_f(r)(DFL_{ij})_a \left[\frac{f_p f_s}{Y_p} + \frac{(1 - f_p f_s)\, e^{-\lambda_i t_h}}{Y_s}\right] e^{-\lambda_i t_f} \qquad (27)$$

($m^2$ mrem/year per μCi/sec)

where

NOTE: Midland Plant site-specific values are included in parentheses following each definition.

$K'$ = a constant of unit conversion, $10^6$ pCi/μCi.

$Q_F$ = the cow's consumption rate, in kg/day (wet weight).
(50)

$U_{ap}$ = the receptor's meat consumption rate for age group a, in kg/year from Table 2.2-10.

$Y_p$ = the agricultural productivity by unit area of pasture feed grass, in $kg/m^2$.
(0.26)

$Y_s$ = the agricultural productivity by unit area of stored feed, in $kg/m^2$.
(0.52)

$F_f$ = the stable element transfer coefficients, in days/kg.
(see Table 2.2-11)

$r$ = fraction of deposited activity retained on feed grass.
(1.0 for radioiodines, 0.2 for particulates)

$(DFL_{ij})_a$ = the organ ingestion dose factor for the ith radionuclide for the receptor in age group a, in mrem/pCi from Tables 2.2-5 through 2.2-8.
(Tables 2.2-5 through 2.2-8)

$\lambda_i$ = the decay constant for the ith radionuclide, in $sec^{-1}$.

$\lambda_w$ = the decay constant for removal of activity on leaf and plant surfaces by weathering, $5.73 \times 10^{-7}$ $sec^{-1}$ (corresponding to a 14-day half-life).

$t_f$ = the transport time from pasture to cow, to meat, to receptor, in sec.
($1.73 \times 10^6$)

$t_h$ = the transport time from pasture, to harvest, to cow, to meat, to receptor, in sec.
($7.78 \times 10^6$)

$f_p$ = fraction of the year that the cow is on pasture (dimensionless).
(1)

$f_s$ = fraction of the cow feed that is pasture grass while the cow is on pasture (dimensionless).
(0.25)

For tritium in meat, the grass-cow-meat pathway factor is a special case due to the fact that the concentration of tritium in meat is based on airborne concentration rather than deposition:

$$R_{aipj} = K'K'''F_f Q_F U_{ap} (DFL_{ij})_a \; [0.75(0.5/H)] \text{ (mrem/year per } \mu Ci/m^3) \qquad (28)$$

where

K''' = a constant of unit conversion, $10^3$ gm/kg.

H = absolute humidity of the atmosphere, in $gm/m^3$. (8)

0.75 = the fraction of total feed that is water.

0.5 = the ratio of the specific activity of the feed grass water to the atmospheric water.

Other parameters and values are given above.

Vegetation Pathway Factor

$$R_{aipj} = K' \frac{r}{Y_v(\lambda_i + \lambda_w)} (DFL_{ij})_a \; [U_{a\ell} f_\ell e^{-\lambda_i t_\ell} + U_{as} f_g e^{-\lambda_i t_h}] \qquad (29)$$

where

NOTE: Midland Plant site-specific values are included in parentheses following each definition.

K' = a constant of unit conversion, $10^6$ pCi/μCi.

$U_{a\ell}$ = the consumption rate of fresh leafy vegetation by the receptor in age group a, in kg/year.
(Table 2.2-10)

$U_{as}$ = the consumption rate of stored vegetation by the receptor in age group a, in kg/year.
(Table 2.2-10)

$f_{\ell}$ = the fraction of the annual intake of fresh leafy vegetation grown locally.
(1.0)

$f_g$ = the fraction of the annual intake of strored vegetation grown locally.
(0.76)

$t_{\ell}$ = the average time between harvest of leafy vegetation and its consumption, in sec.
($8.6 \times 10^4$)

$t_h$ = the average time between harvest of stored vegetation and its consumption, in sec.
($5.18 \times 10^6$)

$Y_v$ = the vegetation area density, in $kg/m^2$.
(2.4; adjusted in accordance with Table 11.3-25, Footnote 4, Reference 5)

$(DFL_{ij})_a$ = the organ ingestion dose factor for the ith radionuclide for the receptor in age group a, in mrem/pCi from Tables 2.2-5 through 2.2-8.
(Tables 2.2-5 through 2.2-8)

$\lambda_i$ = the decay constant for the ith radionuclide, in $sec^{-1}$.

$\lambda_w$ = the decay constant for removal of activity on leaf and plant surfaces by weathering, $5.73 \times 10^{-7}$ $sec^{-1}$ (corresponding to a 14-day half-life).

For tritium in vegetation, the vegetation pathway factor is a special case to the fact that the concentration of tritium in vegetation is based on airborne concentration rather than deposition:

$$R_{aipj} = K'K'''(U_{a\ell}f_\ell + U_{as}f_g)\,(DFL_{ij})_a\,[0.75(0.5/H)] \quad (30)$$

(mrem/year per $\mu Ci/m^3$)

where

$K'''$ = a constant of unit conversion, $10^3$ gm/kg.

$H$ = absolute humidity of the atmosphere, in $gm/m^3$.
(8)

0.75 = the fraction of total vegetation that is water.

0.5 = the ratio of the specific activity of the vegetation water to the atmospheric water.

Other parameters and values are given above.

## TABLE 2.2-1

Inhalation Dose Factors for Infants*
(Mrem per PCI Inhaled)
Page 1 of 3

| 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.[illegible] |
| Fe-55 | 1.41E-05 | 8.39E-06 | 2.38E-06 | No Data | No Data | 6.21E-05 | 7.[illegible] |
| Fe-59 | 9.69E-06 | 1.68E-05 | 6.77E-06 | No Data | No Data | 7.25E-04 | 1.[illegible] |
| Co-58 | No Data | 8.71E-07 | 1.30E-06 | No Data | No Data | 5.55E-04 | 7.95E-[illegible] |
| 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 | LT E-24 |
| Br-84 | No Data | No Data | 2.86E-07 | No Data | No Data | No Data | LT E-24 |
| Br-85 | No Data | No Data | 1.46E-08 | No Data | No Data | No Data | LT E-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 |

*Reference 3, Table E-10

Inhalation Dose Factors for Infants
(Mrem per PCI Inhaled)


| Nuclide | Bone | Liver | T Body | Thyroid | Kidney | Lung | GI-LLI |
|---|---|---|---|---|---|---|---|
| Y-93 | 1.07E-07 | No Data | 2.91E-09 | No Data | No Data | 5.46E-05 | 1.19E-04 |
| Zr-95 | 8.24E-05 | 1.99E-05 | 1.45E-05 | No Data | 2.22E-05 | 1.25E-03 | 1.55E-05 |
| Zr-97 | 1.07E-07 | 1.83E-08 | 8.36E-09 | No Data | 1.85E-08 | 7.88E-05 | 1.00E-04 |
| Nb-95 | 1.12E-05 | 4.59E-06 | 2.70E-06 | No Data | 3.37E-06 | 3.42E-04 | 9.05E-06 |
| Mo-99 | No Data | 1.18E-07 | 2.31E-08 | No Data | 1.89E-07 | 9.63E-05 | 3.48E-05 |
| Tc-99M | 9.98E-13 | 2.06E-12 | 2.66E-11 | No Data | 2.22E-11 | 5.79E-07 | 1.45E-06 |
| Tc-101 | 4.65E-14 | 5.88E-14 | 5.80E-13 | No Data | 6.99E-13 | 4.17E-07 | 6.03E-07 |
| Ru-103 | 1.44E-06 | No Data | 4.85E-07 | No Data | 3.03E-06 | 3.94E-04 | 1.15E-05 |
| Ru-105 | 8.74E-10 | No Data | 2.93E-10 | No Data | 6.42E-10 | 1.12E-05 | 3.46E-05 |
| Ru-106 | 6.20E-05 | No Data | 7.77E-06 | No Data | 7.61E-05 | 8.26E-03 | 1.17E-04 |
| 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 |

TABLE 2.2-1 (continued)

Inhalation Dose Factors for Infants
(Mrem per PCI Inhaled)
Page 3 of 3

| Nuclide | Bone | Liver | T Body | Thyroid | Kidney | Lung | GI-LLI |
|---|---|---|---|---|---|---|---|
| La-142 | 7.36E-10 | 2.69E-10 | 6.46E-11 | No Data | No Data | 5.87E-06 | 4.25E-05 |
| Ce-141 | 1.98E-05 | 1.19E-05 | 1.42E-06 | No Data | 3.75E-06 | 3.69E-04 | 1.54E-05 |
| Ce-143 | 2.09E-07 | 1.38E-07 | 1.58E-08 | No Data | 4.03E-08 | 8.30E-05 | 3.55E-05 |
| Ce-144 | 2.28E-03 | 8.65E-04 | 1.26E-04 | No Data | 3.84E-04 | 7.03E-03 | 1.06E-04 |
| Pr-143 | 1.00E-05 | 3.74E-06 | 4.99E-07 | No Data | 1.41E-06 | 3.09E-04 | 2.66E-05 |
| Pr-144 | 3.42E-11 | 1.32E-11 | 1.72E-12 | No Data | 4.80E-12 | 1.15E-06 | 3.06E-06 |
| Nd-147 | 5.67E-06 | 5.81E-06 | 3.57E-07 | No Data | 2.25E-06 | 2.30E-04 | 2.23E-05 |
| W-187 | 9.26E-09 | 6.44E-09 | 2.23E-09 | No Data | No Data | 2.83E-05 | 2.54E-05 |
| Np-239 | 2.65E-07 | 2.37E-08 | 1.34E-08 | No Data | 4.73E-08 | 4.25E-05 | 1.78E-05 |

TABLE 2.2-2

Inhalation Dose Factors for Children*
(Mrem per PCI Inhaled)
Page 1 of 3

| Nuclide | Bone | Liver | T Body | Thyroid | Kidney | Lung | GI-LLI |
|---|---|---|---|---|---|---|---|
| H-3 | No Data | 3.04E-07 | 3.04E-07 | 3.04E-07 | 3.04E-07 | 3.04E-07 | 3.04E-07 |
| C-14 | 9.70E-06 | 1.82E-06 | 1.82E-06 | 1.82E-06 | 1.82E-06 | 1.82E-06 | 1.82E-06 |
| Na-24 | 4.35E-06 | 4.35E-06 | 4.35E-06 | 4.35E-06 | 4.35E-06 | 4.35E-06 | 4.35E-06 |
| P-32 | 7.04E-04 | 3.09E-05 | 2.67E-05 | No Data | No Data | No Data | 1.14E-05 |
| Cr-51 | No Data | No Data | 4.17E-08 | 2.31E-08 | 6.57E-09 | 4.59E-06 | 2.93E-07 |
| Mn-54 | No Data | 1.16E-05 | 2.57E-06 | No Data | 2.71E-06 | 4.26E-04 | 6.19E-06 |
| Mn-56 | No Data | 4.48E-10 | 8.43E-11 | No Data | 4.52E-10 | 3.55E-06 | 3.33E-05 |
| Fe-55 | 1.28E-05 | 6.80E-06 | 2.10E-06 | No Data | No Data | 3.00E-05 | 7.75E-07 |
| Fe-59 | 5.59E-06 | 9.04E-06 | 4.51E-06 | No Data | No Data | 3.43E-04 | 1.91E-05 |
| Co-58 | No Data | 4.79E-07 | 8.55E-07 | No Data | No Data | 2.99E-04 | 9.29E-06 |
| Co-60 | No Data | 3.55E-06 | 6.12E-06 | No Data | No Data | 1.91E-03 | 2.60E-05 |
| Ni-63 | 2.22E-04 | 1.25E-05 | 7.56E-06 | No Data | No Data | 7.43E-05 | 1.71E-06 |
| Ni-65 | 8.08E-10 | 7.99E-11 | 4.44E-11 | No Data | No Data | 2.21E-06 | 2.27E-05 |
| Cu-64 | No Data | 5.39E-10 | 2.90E-10 | No Data | 1.63E-09 | 2.59E-06 | 9.92E-06 |
| Zn-65 | 1.15E-05 | 3.06E-05 | 1.90E-05 | No Data | 1.93E-05 | 2.69E-04 | 4.41E-06 |
| Zn-69 | 1.81E-11 | 2.61E-11 | 2.41E-12 | No Data | 1.58E-11 | 3.84E-07 | 2.75E-06 |
| Br-83 | No Data | No Data | 1.28E-07 | No Data | No Data | No Data | LT E-24 |
| Br-84 | No Data | No Data | 1.48E-07 | No Data | No Data | No Data | LT E-24 |
| Br-85 | No Data | No Data | 6.84E-09 | No Data | No Data | No Data | LT E-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 |

*Reference 3, Table E-9

## TABLE 2.2-2 (continued)

Inhalation Dose Factors for Children
(Mrem per PCI Inhaled)


| Nuclide | Bone | Liver | T Body | Thyroid | Kidney | Lung | GI-LLI |
|---|---|---|---|---|---|---|---|
| Y-93 | 5.04E-08 | No Data | 1.38E-09 | No Data | No Data | 2.01E-05 | 1.05E-04 |
| Zr-95 | 5.13E-05 | 1.13E-05 | 1.00E-05 | No Data | 1.61E-05 | 6.03E-04 | 1.65E-05 |
| Zr-97 | 5.07E-08 | 7.34E-09 | 4.32E-09 | No Data | 1.05E-08 | 3.06E-05 | 9.49E-05 |
| Nb-95 | 6.35E-06 | 2.48E-06 | 1.77E-06 | No Data | 2.33E-06 | 1.66E-04 | 1.00E-05 |
| Mo-99 | No Data | 4.66E-08 | 1.15E-08 | No Data | 1.06E-07 | 3.66E-05 | 3.42E-05 |
| Tc-99M | 4.81E-13 | 9.41E-13 | 1.56E-11 | No Data | 1.37E-11 | 2.57E-07 | 1.30E-06 |
| Tc-101 | 2.19E-14 | 2.30E-14 | 2.91E-13 | No Data | 3.92E-13 | 1.58E-07 | 4.41E-09 |
| Ru-103 | 7.55E-07 | No Data | 2.90E-07 | No Data | 1.90E-06 | 1.79E-04 | 1.21E-05 |
| Ru-105 | 4.13E-10 | No Data | 1.50E-10 | No Data | 3.63E-10 | 4.30E-06 | 2.69E-05 |
| Ru-106 | 3.68E-05 | No Data | 4.57E-06 | No Data | 4.97E-05 | 3.87E-03 | 1.16E-04 |
| 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-07 | 5.56E-05 | 8.32E-05 |
| Te-131 | 5.87E-12 | 2.28E-12 | 1.78E-12 | 4.59E-12 | 1.59E-11 | 5.55E-07 | 3.60E-07 |
| Te-132 | 1.30E-07 | 7.36E-08 | 7.12E-08 | 8.58E-08 | 4.79E-07 | 1.02E-04 | 3.72E-05 |
| I-130 | 2.21E-06 | 4.43E-06 | 2.28E-06 | 4.99E-04 | 6.61E-06 | 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 |

## TABLE 2.2-2 (continued)

Inhalation Dose Factors for Children
(Mrem per PCI Inhaled)


| Nuclide | Bone | Liver | T Body | Thyroid | Kidney | Lung | GI-LLI |
|---|---|---|---|---|---|---|---|
| La-142 | 3.50E-10 | 1.11E-10 | 3.49E-11 | No Data | No Data | 2.35E-06 | 2.05E-05 |
| Ce-141 | 1.06E-05 | 5.28E-06 | 7.83E-07 | No Data | 2.31E-06 | 1.47E-04 | 1.53E-05 |
| Ce-143 | 9.89E-08 | 5.37E-08 | 7.77E-09 | No Data | 2.26E-08 | 3.12E-05 | 3.44E-05 |
| Ce-144 | 1.83E-03 | 5.72E-04 | 9.77E-05 | No Data | 3.17E-04 | 3.23E-03 | 1.05E-04 |
| Pr-143 | 4.99E-06 | 1.50E-06 | 2.47E-07 | No Data | 8.11E-07 | 1.17E-04 | 2.63E-05 |
| Pr-144 | 1.61E-11 | 4.99E-12 | 8.10E-13 | No Data | 2.64E-12 | 4.23E-07 | 5.32E-08 |
| Nd-147 | 2.92E-06 | 2.36E-06 | 1.84E-07 | No Data | 1.30E-06 | 8.87E-05 | 2.22E-05 |
| W-187 | 4.41E-09 | 2.61E-09 | 1.17E-09 | No Data | No Data | 1.11E-05 | 2.46E-05 |
| Np-239 | 1.26E-07 | 9.04E-09 | 6.35E-09 | No Data | 2.63E-08 | 1.57E-05 | 1.73E-05 |

TABLE 2.2-3

Inhalation Dose Factors for Teenagers*
(Mrem per PCI Inhaled)
Page 1 of 3

| 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 | 1.68E-04 | 1.1[illegible] |
| Co-60 | No Data | 1.89E-06 | 2.48E-06 | No Data | No Data | 1.09E-03 | 3.[illegible] |
| Ni-63 | 7.25E-05 | 5.43E-06 | 2.47E-06 | No Data | No Data | 3.84E-05 | [illegible] |
| Ni-65 | 2.73E-10 | 3.66E-11 | 1.59E-11 | No Data | No Data | 1.17E-06 | [illegible] |
| Cu-64 | No Data | 2.54E-10 | 1.06E-10 | No Data | 8.01E-10 | 1.39E-06 | 7.[illegible] |
| 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 | LT E-24 |
| Br-84 | No Data | No Data | 5.41E-08 | No Data | No Data | No Data | LT E-24 |
| Br-85 | No Data | No Data | 2.29E-09 | No Data | No Data | No Data | LT E-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 |

*Reference 3, Table E-8

TABLE 2.2-3 (continued)

Inhalation Dose Factors for Teenagers
(Mrem per PCI Inhaled)
Page 2 of 3

| Nuclide | Bone | Liver | T Body | Thyroid | Kidney | Lung | GI-LLI |
|---|---|---|---|---|---|---|---|
| Y-93 | 1.69E-08 | No Data | 4.65E-10 | No Data | No Data | 1.04E-05 | 7.24E-05 |
| Zr-95 | 1.82E-05 | 5.73E-06 | 3.94E-06 | No Data | 8.42E-06 | 3.36E-04 | 1.86E-05 |
| Zr-97 | 1.72E-08 | 3.40E-09 | 1.57E-09 | No Data | 5.15E-09 | 1.62E-05 | 7.88E-05 |
| Nb-95 | 2.32E-06 | 1.29E-06 | 7.08E-07 | No Data | 1.25E-06 | 9.39E-05 | 1.21E-05 |
| Mo-99 | No Data | 2.11E-08 | 4.03E-09 | No Data | 5.14E-08 | 1.92E-05 | 3.36E-05 |
| Tc-99M | 1.73E-13 | 4.83E-13 | 6.24E-12 | No Data | 7.20E-12 | 1.44E-07 | 7.66E-07 |
| Tc-101 | 7.40E-15 | 1.05E-14 | 1.03E-13 | No Data | 1.90E-13 | 8.34E-08 | 1.09E-16 |
| Ru-103 | 2.63E-07 | No Data | 1.12E-07 | No Data | 9.29E-07 | 9.79E-05 | 1.36E-05 |
| Ru-105 | 1.40E-10 | No Data | 5.42E-11 | No Data | 1.76E-10 | 2.27E-06 | 1.13E-05 |
| Ru-106 | 1.23E-05 | No Data | 1.55E-06 | No Data | 2.38E-05 | 2.01E-03 | 1.20E-04 |
| 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 |

TABLE 2.2-3 (continued)

Inhalation Dose Factors for Teenagers
(Mrem per PCI Inhaled)
Page 3 of 3

| Nuclide | Bone | Liver | T Body | Thyroid | Kidney | Lung | GI-LLI |
|---|---|---|---|---|---|---|---|
| La-142 | 1.20E-10 | 5.31E-11 | 1.32E-11 | No Data | No Data | 1.27E-06 | 1.50E-06 |
| Ce-141 | 3.55E-06 | 2.37E-06 | 2.71E-07 | No Data | 1.11E-06 | 7.67E-05 | 1.58E-05 |
| Ce-143 | 3.32E-08 | 2.42E-08 | 2.70E-09 | No Data | 1.08E-08 | 1.63E-05 | 3.19E-05 |
| Ce-144 | 6.11E-04 | 2.53E-04 | 3.28E-05 | No Data | 1.51E-04 | 1.67E-03 | 1.08E-04 |
| Pr-143 | 1.67E-06 | 6.64E-07 | 8.28E-08 | No Data | 3.86E-07 | 6.04E-05 | 2.67E-05 |
| Pr-144 | 5.37E-12 | 2.20E-12 | 2.72E-13 | No Data | 1.26E-12 | 2.19E-07 | 2.94E-14 |
| Nd-147 | 9.83E-07 | 1.07E-06 | 6.41E-08 | No Data | 6.28E-07 | 4.65E-05 | 2.28E-05 |
| W-187 | 1.50E-09 | 1.22E-09 | 4.29E-10 | No Data | No Data | 5.92E-06 | 2.21E-05 |
| Np-239 | 4.23E-08 | 3.99E-09 | 2.21E-09 | No Data | 1.25E-08 | 8.11E-06 | 1.65E-05 |

## TABLE 2.2-4

Inhalation Dose Factors for Adults*
(Mrem per PCI Inhaled)
Page 1 of 3

| Nuclide | Bone | Liver | T Body | Thyroid | Kidney | Lung | GI-LLI |
|---|---|---|---|---|---|---|---|
| H-3 | No Data | 1.58E-07 | 1.58E-07 | 1.58E-07 | 1.58E-07 | 1.58E-07 | 1.58E-07 |
| C-14 | 2.27E-06 | 4.26E-07 | 4.26E-07 | 4.26E-07 | 4.26E-07 | 4.26E-07 | 4.26E-07 |
| Na-24 | 1.28E-06 | 1.28E-06 | 1.28E-06 | 1.28E-06 | 1.28E-06 | 1.28E-06 | 1.28E-06 |
| P-32 | 1.65E-04 | 9.64E-06 | 6.26E-06 | No Data | No Data | No Data | 1.08E-05 |
| Cr-51 | No Data | No Data | 1.25E-08 | 7.44E-09 | 2.85E-09 | 1.80E-06 | 4.15E-07 |
| Mn-54 | No Data | 4.95E-06 | 7.87E-07 | No Data | 1.23E-06 | 1.75E-04 | 9.67E-06 |
| Mn-56 | No Data | 1.55E-10 | 2.29E-11 | No Data | 1.63E-10 | 1.18E-06 | 2.53E-06 |
| Fe-55 | 3.07E-06 | 2.12E-06 | 4.93E-07 | No Data | No Data | 9.01E-06 | 7.54E-07 |
| Fe-59 | 1.47E-06 | 3.47E-06 | 1.32E-06 | No Data | No Data | 1.27E-04 | 2.35E-05 |
| Co-58 | No Data | 1.98E-07 | 2.59E-07 | No Data | No Data | 1.16E-04 | 1.33E-05 |
| Co-60 | No Data | 1.44E-06 | 1.85E-06 | No Data | No Data | 7.46E-04 | 3.56E-05 |
| Ni-63 | 5.40E-05 | 3.93E-06 | 1.81E-06 | No Data | No Data | 2.23E-05 | 1.67E-06 |
| Ni-65 | 1.92E-10 | 2.62E-11 | 1.14E-11 | No Data | No Data | 7.00E-07 | 1.54E-06 |
| Cu-64 | No Data | 1.83E-10 | 7.69E-11 | No Data | 5.78E-10 | 8.48E-07 | 6.12E-06 |
| Zn-65 | 4.05E-06 | 1.29E-05 | 5.82E-06 | No Data | 8.62E-06 | 1.08E-04 | 6.68E-06 |
| Zn-69 | 4.23E-12 | 8.14E-12 | 5.65E-13 | No Data | 5.27E-12 | 1.15E-07 | 2.04E-09 |
| Br-83 | No Data | No Data | 3.01E-08 | No Data | No Data | No Data | 2.90E-08 |
| Br-84 | No Data | No Data | 3.91E-08 | No Data | No Data | No Data | 2.05E-13 |
| Br-85 | No Data | No Data | 1.60E-09 | No Data | No Data | No Data | LT E-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 |

*Reference 3, Table E-7

## TABLE 2.2-4 (continued)

Inhalation Dose Factors for Adults
(Mrem per PCI Inhaled)
Page 2 of 3

| Nuclide | Bone | Liver | T Body | Thyroid | Kidney | Lung | GI-LLI |
|---|---|---|---|---|---|---|---|
| Y-93 | 1.18E-08 | No Data | 3.26E-10 | No Data | No Data | 6.06E-06 | 5.27E-05 |
| Zr-95 | 1.34E-05 | 4.30E-06 | 2.91E-06 | No Data | 6.77E-06 | 2.21E-04 | 1.88E-05 |
| Zr-97 | 1.21E-08 | 2.45E-09 | 1.13E-09 | No Data | 3.71E-09 | 9.84E-06 | 6.54E-05 |
| Nb-95 | 1.76E-06 | 9.77E-07 | 5.26E-07 | No Data | 9.67E-07 | 6.31E-05 | 1.30E-05 |
| Mo-99 | No Data | 1.51E-08 | 2.87E-09 | No Data | 3.64E-08 | 1.14E-05 | 3.10E-05 |
| Tc-99M | 1.29E-13 | 3.64E-13 | 4.63E-12 | No Data | 5.52E-12 | 9.55E-08 | 5.20E-07 |
| Tc-101 | 5.22E-15 | 7.52E-15 | 7.38E-14 | No Data | 1.35E-13 | 4.99E-08 | 1.36E-21 |
| Ru-103 | 1.91E-07 | No Data | 8.23E-08 | No Data | 7.29E-07 | 6.31E-05 | 1.38E-05 |
| Ru-105 | 9.88E-11 | No Data | 3.89E-11 | No Data | 1.27E-10 | 1.37E-06 | 6.02E-06 |
| Ru-106 | 8.64E-06 | No Data | 1.09E-06 | No Data | 1.67E-05 | 1.17E-03 | 1.14E-04 |
| 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-08 | 7.76E-08 | 4.05E-08 | No Data | 6.00E-08 | 6.07E-09 | 2.33E-13 |
| Ba-139 | 1.17E-10 | 8.32E-14 | 3.42E-12 | No Data | 7.78E-14 | 4.70E-07 | 1.12E-07 |
| Ba-140 | 4.88E-06 | 6.13E-09 | 3.21E-07 | No Data | 2.09E-09 | 1.59E-04 | 2.73E-05 |
| Ba-141 | 1.25E-11 | 9.41E-15 | 4.20E-13 | No Data | 8.75E-15 | 2.42E-07 | 1.45E-17 |
| Ba-142 | 3.29E-12 | 3.38E-15 | 2.07E-13 | No Data | 2.86E-15 | 1.49E-07 | 1.96E-26 |
| La-140 | 4.30E-08 | 2.17E-08 | 5.73E-09 | No Data | No Data | 1.70E-05 | 5.73E-05 |

## TABLE 2.2-4 (continued)

Inhalation Dose Factors for Adults
(Mrem per PCI Inhaled)
Page 3 of 3

| Nuclide | Bone | Liver | T Body | Thyroid | Kidney | Lung | GI-LLI |
|---|---|---|---|---|---|---|---|
| La-142 | 8.54E-11 | 3.88E-11 | 9.65E-12 | No Data | No Data | 7.91E-07 | 2.64E-07 |
| Ce-141 | 2.49E-06 | 1.69E-06 | 1.91E-07 | No Data | 7.83E-07 | 4.52E-05 | 1.50E-05 |
| Ce-143 | 2.33E-08 | 1.72E-08 | 1.91E-09 | No Data | 7.60E-09 | 9.97E-06 | 2.83E-05 |
| Ce-144 | 4.29E-04 | 1.79E-04 | 2.30E-05 | No Data | 1.06E-04 | 9.72E-04 | 1.02E-04 |
| Pr-143 | 1.17E-06 | 4.69E-07 | 5.80E-08 | No Data | 2.70E-07 | 3.51E-05 | 2.50E-05 |
| Pr-144 | 3.76E-12 | 1.56E-12 | 1.91E-13 | No Data | 8.81E-13 | 1.27E-07 | 2.69E-18 |
| Nd-147 | 6.59E-07 | 7.62E-07 | 4.56E-08 | No Data | 4.45E-07 | 2.76E-05 | 2.16E-05 |
| W-187 | 1.06E-09 | 8.85E-10 | 3.10E-10 | No Data | No Data | 3.63E-06 | 1.94E-05 |
| Np-239 | 2.87E-08 | 2.82E-09 | 1.55E-09 | No Data | 8.75E-09 | 4.70E-06 | 1.49E-05 |

TABLE 2.2-5

Ingestion Dose Factors for Infants*
(Mrem per PCI Ingested)
Page 1 of 3

| Nuclide | Bone | Liver | T Body | Thyroid | Kidney | Lung | GI-LLI |
|---|---|---|---|---|---|---|---|
| H-3 | No Data | 3.08E-07 | 3.08E-07 | 3.08E-07 | 3.08E-07 | 3.08E-07 | 3.08E-07 |
| C-14 | 2.37E-05 | 5.06E-06 | 5.06E-06 | 5.06E-06 | 5.06E-06 | 5.06E-06 | 5.06E-06 |
| Na-24 | 1.01E-05 | 1.01E-05 | 1.01E-05 | 1.01E-05 | 1.01E-05 | 1.01E-05 | 1.01E-05 |
| P-32 | 1.70E-03 | 1.00E-04 | 6.59E-05 | No Data | No Data | No Data | 2.30E-05 |
| Cr-51 | No Data | No Data | 1.41E-08 | 9.20E-09 | 2.01E-09 | 1.79E-08 | 4.11E-07 |
| Mn-54 | No Data | 1.99E-05 | 4.51E-06 | No Data | 4.41E-06 | No Data | 7.31E-06 |
| Mn-56 | No Data | 8.18E-07 | 1.41E-07 | No Data | 7.03E-07 | No Data | 7.43E-05 |
| Fe-55 | 1.39E-05 | 8.98E-06 | 2.40E-06 | No Data | No Data | 4.39E-06 | 1.14E-06 |
| Fe-59 | 3.08E-05 | 5.38E-05 | 2.12E-05 | No Data | No Data | 1.59E-05 | 2.57E-05 |
| Co-58 | No Data | 3.60E-06 | 8.98E-06 | No Data | No Data | No Data | 8.97E-06 |
| Co-60 | No Data | 1.08E-05 | 2.55E-05 | No Data | No Data | No Data | 2.57E-05 |
| Ni-63 | 6.34E-04 | 3.92E-05 | 2.20E-05 | No Data | No Data | No Data | 1.95E-06 |
| Ni-65 | 4.70E-06 | 5.32E-07 | 2.42E-07 | No Data | No Data | No Data | 4.05E-05 |
| Cu-64 | No Data | 6.09E-07 | 2.82E-07 | No Data | 1.03E-06 | No Data | 1.25E-05 |
| Zn-65 | 1.84E-05 | 6.31E-05 | 2.91E-05 | No Data | 3.06E-05 | No Data | 5.33E-05 |
| Zn-69 | 9.33E-08 | 1.68E-07 | 1.25E-08 | No Data | 6.98E-08 | No Data | 1.37E-05 |
| Br-83 | No Data | No Data | 3.63E-07 | No Data | No Data | No Data | LT E-24 |
| Br-84 | No Data | No Data | 3.82E-07 | No Data | No Data | No Data | LT E-24 |
| Br-85 | No Data | No Data | 1.94E-08 | No Data | No Data | No Data | LT E-24 |
| Rb-86 | No Data | 1.70E-04 | 8.40E-05 | No Data | No Data | No Data | 4.35E-06 |
| Rb-88 | No Data | 4.98E-07 | 2.73E-07 | No Data | No Data | No Data | 4.85E-07 |
| Rb-89 | No Data | 2.86E-07 | 1.97E-07 | No Data | No Data | No Data | 9.74E-08 |
| Sr-89 | 2.51E-03 | No Data | 7.20E-05 | No Data | No Data | No Data | 5.16E-05 |
| Sr-90 | 1.85E-02 | No Data | 4.71E-03 | No Data | No Data | No Data | 2.31E-04 |
| Sr-91 | 5.00E-05 | No Data | 1.81E-06 | No Data | No Data | No Data | 5.92E-05 |
| Sr-92 | 1.92E-05 | No Data | 7.13E-07 | No Data | No Data | No Data | 2.07E-04 |
| Y-90 | 8.69E-08 | No Data | 2.33E-09 | No Data | No Data | No Data | 1.20E-04 |
| Y-91M | 8.10E-10 | No Data | 2.76E-11 | No Data | No Data | No Data | 2.70E-06 |
| Y-91 | 1.13E-06 | No Data | 3.01E-08 | No Data | No Data | No Data | 8.10E-05 |
| Y-92 | 7.65E-09 | No Data | 2.15E-10 | No Data | No Data | No Data | 1.46E-04 |

*Reference 3, Table E-14

TABLE 2.2-5 (continued)

Ingestion Dose Factors for Infants
(Mrem per PCI Ingested)
Page 2 of 3

| Nuclide | Bone | Liver | T Body | Thyroid | Kidney | Lung | GI-LLI |
|---|---|---|---|---|---|---|---|
| Y-93 | 2.43E-08 | No Data | 6.62E-10 | No Data | No Data | No Data | 1.92E-04 |
| Zr-95 | 2.06E-07 | 5.02E-08 | 3.56E-08 | No Data | 5.41E-08 | No Data | 2.50E-05 |
| Zr-97 | 1.48E-08 | 2.54E-09 | 1.16E-09 | No Data | 2.56E-09 | No Data | 1.62E-04 |
| Nb-95 | 4.20E-08 | 1.73E-08 | 1.00E-08 | No Data | 1.24E-08 | No Data | 1.46E-05 |
| Mo-99 | No Data | 3.40E-05 | 6.63E-06 | No Data | 5.08E-05 | No Data | 1.12E-05 |
| Tc-99M | 1.92E-09 | 3.96E-09 | 5.10E-08 | No Data | 4.26E-08 | 2.07E-09 | 1.15E-06 |
| Tc-101 | 2.27E-09 | 2.86E-09 | 2.83E-08 | No Data | 3.40E-08 | 1.56E-09 | 4.86E-07 |
| Ru-103 | 1.48E-06 | No Data | 4.95E-07 | No Data | 3.08E-06 | No Data | 1.80E-05 |
| Ru-105 | 1.36E-07 | No Data | 4.58E-08 | No Data | 1.00E-06 | No Data | 5.41E-05 |
| Ru-106 | 2.41E-05 | No Data | 3.01E-06 | No Data | 2.85E-05 | No Data | 1.83E-04 |
| Ag-110M | 9.96E-07 | 7.27E-07 | 4.81E-07 | No Data | 1.04E-06 | No Data | 3.77E-05 |
| Te-125M | 2.33E-05 | 7.79E-06 | 3.15E-06 | 7.84E-06 | No Data | No Data | 1.11E-05 |
| Te-127M | 5.85E-05 | 1.94E-05 | 7.08E-06 | 1.69E-05 | 1.44E-04 | No Data | 2.36E-05 |
| Te-127 | 1.00E-06 | 3.35E-07 | 2.15E-07 | 8.14E-07 | 2.44E-06 | No Data | 2.10E-05 |
| Te-129M | 1.00E-04 | 3.43E-05 | 1.54E-05 | 3.84E-05 | 2.50E-04 | No Data | 5.97E-05 |
| Te-129 | 2.84E-07 | 9.79E-08 | 6.63E-08 | 2.38E-07 | 7.07E-07 | No Data | 2.27E-05 |
| Te-131M | 1.52E-05 | 6.12E-06 | 5.05E-06 | 1.24E-05 | 4.21E-05 | No Data | 1.03E-04 |
| Te-131 | 1.76E-07 | 6.50E-08 | 4.94E-08 | 1.57E-07 | 4.50E-07 | No Data | 7.11E-06 |
| Te-132 | 2.08E-05 | 1.03E-05 | 9.61E-06 | 1.52E-05 | 6.44E-05 | No Data | 3.81E-05 |
| I-130 | 6.00E-06 | 1.32E-05 | 5.30E-06 | 1.48E-03 | 1.45E-05 | No Data | 2.83E-06 |
| I-131 | 3.59E-05 | 4.23E-05 | 1.86E-05 | 1.39E-02 | 4.94E-05 | No Data | 1.51E-06 |
| I-132 | 1.66E-06 | 3.37E-06 | 1.20E-06 | 1.58E-04 | 3.76E-06 | No Data | 2.73E-06 |
| I-133 | 1.25E-05 | 1.82E-05 | 5.33E-06 | 3.31E-03 | 2.14E-05 | No Data | 3.08E-06 |
| I-134 | 8.69E-07 | 1.78E-06 | 6.33E-07 | 4.15E-05 | 1.99E-06 | No Data | 1.84E-06 |
| I-135 | 3.64E-06 | 7.24E-06 | 2.64E-06 | 6.49E-04 | 8.07E-06 | No Data | 2.62E-06 |
| Cs-134 | 3.77E-04 | 7.03E-04 | 7.10E-05 | No Data | 1.81E-04 | 7.42E-05 | 1.91E-06 |
| Cs-136 | 4.59E-05 | 1.35E-04 | 5.04E-05 | No Data | 5.38E-05 | 1.10E-05 | 2.05E-06 |
| Cs-137 | 5.22E-04 | 6.11E-04 | 4.33E-05 | No Data | 1.64E-04 | 6.64E-05 | 1.91E-06 |
| Cs-138 | 4.81E-07 | 7.82E-07 | 3.79E-07 | No Data | 3.90E-07 | 6.09E-08 | 1.25E-06 |
| Ba-139 | 8.81E-07 | 5.84E-10 | 2.55E-08 | No Data | 3.51E-10 | 3.54E-10 | 5.58E-05 |

TABLE 2.2-5 (continued)

Ingestion Dose Factors for Infants
(Mrem per PCI Ingested)
Page 3 of 3

| Nuclide | Bone | Liver | T Body | Thyroid | Kidney | Lung | GI-LLI |
|---|---|---|---|---|---|---|---|
| Ba-140 | 1.71E-04 | 1.71E-07 | 8.81E-06 | No Data | 4.06E-08 | 1.05E-07 | 4.20E-05 |
| Ba-141 | 4.25E-07 | 2.91E-10 | 1.34E-08 | No Data | 1.75E-10 | 1.77E-10 | 5.19E-06 |
| Ba-142 | 1.84E-07 | 1.53E-10 | 9.06E-09 | No Data | 8.81E-11 | 9.26E-11 | 7.59E-07 |
| La-140 | 2.11E-08 | 8.32E-09 | 2.14E-09 | No Data | No Data | No Data | 9.77E-05 |
| La-142 | 1.10E-09 | 4.04E-10 | 9.67E-11 | No Data | No Data | No Data | 6.86E-05 |
| Ce-141 | 7.87E-08 | 4.80E-08 | 5.65E-09 | No Data | 1.48E-08 | No Data | 2.48E-05 |
| Ce-143 | 1.48E-08 | 9.82E-06 | 1.12E-09 | No Data | 2.86E-09 | No Data | 5.73E-05 |
| Ce-144 | 2.98E-06 | 1.22E-06 | 1.67E-07 | No Data | 4.93E-07 | No Data | 1.71E-04 |
| Pr-143 | 8.13E-08 | 3.04E-08 | 4.03E-09 | No Data | 1.13E-08 | No Data | 4.29E-05 |
| Pr-144 | 2.74E-10 | 1.06E-10 | 1.38E-11 | No Data | 3.84E-11 | No Data | 4.93E-06 |
| Nd-147 | 5.53E-08 | 5.68E-08 | 3.48E-09 | No Data | 2.19E-08 | No Data | 3.60E-0[illegible] |
| W-187 | 9.03E-07 | 6.28E-07 | 2.17E-07 | No Data | No Data | No Data | 3.69E-05 |
| Np-239 | 1.11E-08 | 9.93E-10 | 5.61E-10 | No Data | 1.98E-09 | No Data | 2.87E-05 |

TABLE 2.2-6

Ingestion Dose Factors for Children*
(Mrem per PCI Ingested)
Page 1 of 3

| Nuclide | Bone | Liver | T Body | Thyroid | Kidney | Lung | GI-LLI |
|---|---|---|---|---|---|---|---|
| H-3 | No Data | 2.03E-07 | 2.03E-07 | 2.03E-07 | 2.03E-07 | 2.03E-07 | 2.03E-07 |
| C-14 | 1.21E-05 | 2.42E-06 | 2.42E-06 | 2.42E-06 | 2.42E-06 | 2.42E-06 | 2.42E-06 |
| Na-24 | 5.80E-06 | 5.80E-06 | 5.80E-06 | 5.80E-06 | 5.80E-06 | 5.80E-06 | 5.80E-06 |
| P-32 | 8.25E-04 | 3.86E-05 | 3.18E-05 | No Data | No Data | No Data | 2.28E-05 |
| Cr-51 | No Data | No Data | 8.90E-09 | 4.94E-09 | 1.35E-09 | 9.02E-09 | 4.72E-07 |
| Mn-54 | No Data | 1.07E-05 | 2.85E-06 | No Data | 3.00E-06 | No Data | 8.98E-06 |
| Mn-56 | No Data | 3.34E-07 | 7.54E-08 | No Data | 4.04E-07 | No Data | 4.84E-05 |
| Fe-55 | 1.15E-05 | 6.10E-06 | 1.89E-06 | No Data | No Data | 3.45E-06 | 1.13E-06 |
| Fe-59 | 1.65E-05 | 2.67E-05 | 1.33E-05 | No Data | No Data | 7.74E-06 | 2.78E-05 |
| Co-58 | No Data | 1.80E-06 | 5.51E-06 | No Data | No Data | No Data | 1.05E-05 |
| Co-60 | No Data | 5.29E-06 | 1.56E-05 | No Data | No Data | No Data | 2.93E-05 |
| Ni-63 | 5.38E-04 | 2.88E-05 | 1.83E-05 | No Data | No Data | No Data | 1.94E-06 |
| Ni-65 | 2.22E-06 | 2.09E-07 | 1.22E-07 | No Data | No Data | No Data | 2.56E-05 |
| Cu-64 | No Data | 2.45E-07 | 1.48E-07 | No Data | 5.92E-07 | No Data | 1.15E-05 |
| Zn-65 | 1.37E-05 | 3.65E-05 | 2.27E-05 | No Data | 2.30E-05 | No Data | 6.41E-06 |
| Zn-69 | 4.38E-08 | 6.33E-08 | 5.85E-09 | No Data | 3.84E-08 | No Data | 3.99E-06 |
| Br-83 | No Data | No Data | 1.71E-07 | No Data | No Data | No Data | LT E-24 |
| Br-84 | No Data | No Data | 1.98E-07 | No Data | No Data | No Data | LT E-24 |
| Br-85 | No Data | No Data | 9.12E-09 | No Data | No Data | No Data | LT E-24 |
| Rb-86 | No Data | 6.70E-05 | 4.12E-05 | No Data | No Data | No Data | 4.31E-06 |
| Rb-88 | No Data | 1.90E-07 | 1.32E-07 | No Data | No Data | No Data | 9.32E-09 |
| Rb-89 | No Data | 1.17E-07 | 1.04E-07 | No Data | No Data | No Data | 1.02E-09 |
| Sr-89 | 1.32E-03 | No Data | 3.77E-05 | No Data | No Data | No Data | 5.11E-05 |
| Sr-90 | 1.70E-02 | No Data | 4.31E-03 | No Data | No Data | No Data | 2.29E-04 |
| Sr-91 | 2.40E-05 | No Data | 9.06E-07 | No Data | No Data | No Data | 5.30E-05 |
| Sr-92 | 9.03E-06 | No Data | 3.62E-07 | No Data | No Data | No Data | 1.71E-04 |
| Y-90 | 4.11E-08 | No Data | 1.10E-09 | No Data | No Data | No Data | 1.17E-04 |
| Y-91M | 3.82E-10 | No Data | 1.39E-11 | No Data | No Data | No Data | 7.48E-07 |
| Y-91 | 6.02E-07 | No Data | 1.61E-08 | No Data | No Data | No Data | 8.02E-05 |
| Y-92 | 3.60E-09 | No Data | 1.03E-10 | No Data | No Data | No Data | 1.04E-04 |

*Reference 3, Table E-13

TABLE 2.2-6 (continued)

Ingestion Dose Factors for Children
(Mrem per PCI Ingested)
Page 2 of 3

| Nuclide | Bone | Liver | T Body | Thyroid | Kidney | Lung | GI-LLI |
|---|---|---|---|---|---|---|---|
| Y-93 | 1.14E-08 | No Data | 3.13E-10 | No Data | No Data | No Data | 1.70E-04 |
| Zr-95 | 1.16E-07 | 2.55E-08 | 2.27E-08 | No Data | 3.65E-08 | No Data | 2.66E-05 |
| Zr-97 | 6.99E-09 | 1.01E-09 | 5.96E-10 | No Data | 1.45E-09 | No Data | 1.53E-04 |
| Nb-95 | 2.25E-08 | 8.76E-09 | 6.26E-09 | No Data | 8.23E-09 | No Data | 1.62E-05 |
| Mo-99 | No Data | 1.33E-05 | 3.29E-06 | No Data | 2.84E-05 | No Data | 1.10E-05 |
| Tc-99M | 9.23E-10 | 1.81E-09 | 3.00E-08 | No Data | 2.63E-08 | 9.19E-10 | 1.03E-06 |
| Tc-101 | 1.07E-09 | 1.12E-09 | 1.42E-08 | No Data | 1.91E-08 | 5.92E-10 | 3.56E-09 |
| Ru-103 | 7.31E-07 | No Data | 2.81E-07 | No Data | 1.84E-06 | No Data | 1.89E-05 |
| Ru-105 | 6.45E-08 | No Data | 2.34E-08 | No Data | 5.67E-07 | No Data | 4.21E-05 |
| Ru-106 | 1.17E-05 | No Data | 1.46E-06 | No Data | 1.58E-05 | No Data | 1.82E-04 |
| Ag-110M | 5.39E-07 | 3.64E-07 | 2.91E-07 | No Data | 6.78E-07 | No Data | 4.33E-05 |
| Te-125M | 1.14E-05 | 3.09E-06 | 1.52E-06 | 3.20E-06 | No Data | No Data | 1.10E-05 |
| Te-127M | 2.89E-05 | 7.78E-06 | 3.43E-06 | 6.91E-06 | 8.24E-05 | No Data | 2.34E-05 |
| Te-127 | 4.71E-07 | 1.27E-07 | 1.01E-07 | 3.26E-07 | 1.34E-06 | No Data | 1.84E-05 |
| Te-129M | 4.87E-05 | 1.36E-05 | 7.56E-06 | 1.57E-05 | 1.43E-04 | No Data | 5.94E-05 |
| Te-129 | 1.34E-07 | 3.74E-08 | 3.18E-08 | 9.56E-08 | 3.92E-07 | No Data | 8.34E-06 |
| Te-131M | 7.20E-06 | 2.49E-06 | 2.65E-06 | 5.12E-06 | 2.41E-05 | No Data | 1.01E-04 |
| Te-131 | 8.30E-08 | 2.53E-08 | 2.47E-08 | 6.35E-08 | 2.51E-07 | No Data | 4.36E-07 |
| Te-132 | 1.01E-05 | 4.47E-06 | 5.40E-06 | 6.51E-06 | 4.15E-05 | No Data | 4.50E-05 |
| I-130 | 2.92E-06 | 5.90E-06 | 3.04E-06 | 6.50E-04 | 8.82E-06 | No Data | 2.76E-06 |
| I-131 | 1.72E-05 | 1.73E-05 | 9.83E-06 | 5.72E-03 | 2.84E-05 | No Data | 1.54E-06 |
| I-132 | 8.00E-07 | 1.47E-06 | 6.76E-07 | 6.82E-05 | 2.25E-06 | No Data | 1.73E-06 |
| I-133 | 5.92E-06 | 7.32E-06 | 2.77E-06 | 1.36E-03 | 1.22E-05 | No Data | 2.95E-06 |
| I-134 | 4.19E-07 | 7.78E-07 | 3.58E-07 | 1.79E-05 | 1.19E-06 | No Data | 5.16E-07 |
| I-135 | 1.75E-06 | 3.15E-06 | 1.49E-06 | 2.79E-04 | 4.83E-06 | No Data | 2.40E-06 |
| Cs-134 | 2.34E-04 | 3.84E-04 | 8.10E-05 | No Data | 1.19E-04 | 4.27E-05 | 2.07E-06 |
| Cs-136 | 2.35E-05 | 6.46E-05 | 4.18E-05 | No Data | 3.44E-05 | 5.13E-06 | 2.27E-06 |
| Cs-137 | 3.27E-04 | 3.13E-04 | 4.62E-05 | No Data | 1.02E-04 | 3.67E-05 | 1.96E-06 |
| Cs-138 | 2.28E-07 | 3.17E-07 | 2.01E-07 | No Data | 2.23E-07 | 2.40E-08 | 1.46E-07 |
| Ba-139 | 4.14E-07 | 2.21E-10 | 1.20E-08 | No Data | 1.93E-10 | 1.30E-10 | 2.39E-05 |
| Ba-140 | 8.31E-05 | 7.28E-08 | 4.85E-06 | No Data | 2.37E-08 | 4.34E-08 | 4.21E-05 |
| Ba-141 | 2.00E-07 | 1.12E-10 | 6.51E-09 | No Data | 9.69E-11 | 6.58E-10 | 1.14E-07 |
| Ba-142 | 8.74E-08 | 6.29E-11 | 4.88E-09 | No Data | 5.09E-11 | 3.70E-11 | 1.14E-09 |

TABLE 2.2-6 (continued)

Ingestion Dose Factors for Children
(Mrem per PCI Ingested)
Page 3 of 3

| Nuclide | Bone | Liver | T Body | Thyroid | Kidney | Lung | GI-LLI |
|---|---|---|---|---|---|---|---|
| La-140 | 1.01E-08 | 3.53E-09 | 1.19E-09 | No Data | No Data | No Data | 9.84E-05 |
| La-142 | 5.24E-10 | 1.67E-10 | 5.23E-11 | No Data | No Data | No Data | 3.31E-05 |
| Ce-141 | 3.97E-08 | 1.98E-08 | 2.94E-09 | No Data | 8.68E-09 | No Data | 2.47E-05 |
| Ce-143 | 6.99E-09 | 3.79E-06 | 5.49E-10 | No Data | 1.59E-09 | No Data | 5.55E-05 |
| Ce-144 | 2.08E-06 | 6.52E-07 | 1.11E-07 | No Data | 3.61E-07 | No Data | 1.70E-04 |
| Pr-143 | 3.93E-08 | 1.18E-08 | 1.95E-09 | No Data | 6.39E-09 | No Data | 4.24E-05 |
| Pr-144 | 1.29E-10 | 3.99E-11 | 6.49E-12 | No Data | 2.11E-11 | No Data | 8.59E-08 |
| Nd-147 | 2.79E-08 | 2.26E-08 | 1.75E-09 | No Data | 1.24E-08 | No Data | 3.58E-05 |
| W-187 | 4.29E-07 | 2.54E-07 | 1.14E-07 | No Data | No Data | No Data | 3.57E-05 |
| Np-239 | 5.25E-09 | 3.77E-10 | 2.65E-10 | No Data | 1.09E-09 | No Data | 2.79E-05 |

## TABLE 2.2-7

Ingestion Dose Factors for Teenagers*
(Mrem per PCI Ingested)
Page 1 of 3

| Nuclide | Bone | Liver | T Body | Thyroid | Kidney | Lung | GI-LLI |
|---|---|---|---|---|---|---|---|
| H-3 | No Data | 1.06E-07 | 1.06E-07 | 1.06E-07 | 1.06E-07 | 1.06E-07 | 1.06E-07 |
| C-14 | 4.06E-06 | 8.12E-07 | 8.12E-07 | 8.12E-07 | 8.12E-07 | 8.12E-07 | 8.12E-07 |
| Na-2[illegible] | 2.30E-06 | 2.30E-06 | 2.30E-06 | 2.30E-06 | 2.30E-06 | 2.30E-06 | 2.30E-06 |
| P-32 | 2.76E-04 | 1.71E-05 | 1.07E-05 | No Data | No Data | No Data | 2.32E-05 |
| Cr-51 | No Data | No Data | 3.60E.09 | 2.00E-09 | 7.89E-10 | 5.14E-09 | 6.05E-07 |
| Mn-54 | No Data | 5.90E-06 | 1.17E-06 | No Data | 1.76E-06 | No Data | 1.21E-05 |
| Mn-56 | No Data | 1.58E-07 | 2.81E-08 | No Data | 2.00E-07 | No Data | 1.04E-05 |
| Fe-55 | 3.78E-06 | 2.68F-06 | 6.25E-07 | No Data | No Data | 1.70E-06 | 1.16E-06 |
| Fe-59 | 5.87E-06 | 1.37E-05 | 5.29E-06 | No Data | No Data | 4.32E-06 | 3.24E-05 |
| Co-58 | No Data | 9.72E-07 | 2.24E-06 | No Data | No Data | No Data | 1.34E-0[illegible] |
| Co-60 | No Data | 2.81E-06 | 6.33E-06 | No Data | No Data | No Data | 3.66E[illegible] |
| Ni-63 | 1.77E-04 | 1.25E-05 | 6.00E-06 | No Data | No Data | No Data | 1.99E-[illegible] |
| Ni-65 | 7.49E-07 | 9.57E-08 | 4.36E-08 | No Data | No Data | No Data | 5.19E-06 |
| Cu-64 | No Data | 1.15E-07 | 5.41E-08 | No Data | 2.91E-07 | No Data | 8.92E-06 |
| Zn-65 | 5.76E-06 | 2.00E-05 | 9.33E-06 | No Data | 1.28E-05 | No Data | 8.47E-06 |
| Zn-69 | 1.47E-08 | 2.80E-08 | 1.96E-09 | No Data | 1.83E-08 | No Data | 5.16E-08 |
| Br-83 | No Data | No Data | 5.74E-08 | No Data | No Data | No Data | LT E-24 |
| Br-84 | No Data | No Data | 7.22E-08 | No Data | No Data | No Data | LT E-24 |
| Br-85 | No Data | No Data | 3.05E-09 | No Data | No Data | No Data | LT E-24 |
| Rb-86 | No Data | 2.98E-05 | 1.40E-05 | No Data | No Data | No Data | 4.41E-06 |
| Rb-88 | No Data | 8.52E-08 | 4.54E-08 | No Data | No Data | No Data | 7.30E-15 |
| Rb-89 | No Data | 5.50E-08 | 3.89E-08 | No Data | No Data | No Data | 8.43E-17 |
| Sr-89 | 4.40E-04 | No Data | 1.26E-05 | No Data | No Data | No Data | 5.24E-05 |
| Sr-90 | 8.30E-03 | No Data | 2.05E-03 | No Data | No Data | No Data | 2.33E-04 |
| Sr-91 | 8.07E-06 | No Data | 3.21E-07 | No Data | No Data | No Data | 3.66E-05 |
| Sr-92 | 3.05E-06 | No Data | 1.30E-07 | No Data | No Data | No Data | 7.77E-05 |
| Y-90 | 1.37E-08 | No Data | 3.69E-10 | No Data | No Data | No Data | 1.13E-04 |
| Y-91M | 1.29E-10 | No Data | 4.93E-12 | No Data | No Data | No Data | 6.09E-09 |
| Y-91 | 2.01E-07 | No Data | 5.39E-09 | No Data | No Data | No Data | 8.24E-05 |
| Y-92 | 1.21E-09 | No Data | 3.50E-11 | No Data | No Data | No Data | 3.32E-05 |

*Reference 3, Table E-12

## TABLE 2.2-7 (continued)

Ingestion Dose Factors for Teenagers
(Mrem per PCi Ingested)
Page 2 of 3

| Nuclide | Bone | Liver | T Body | Thyroid | Kidney | Lung | GI-LLI |
|---|---|---|---|---|---|---|---|
| Y-93 | 3.83E-09 | No Data | 1.05E-10 | No Data | No Data | No Data | 1.17E-04 |
| Zr-95 | 4.12E-08 | 1.30E-08 | 8.94E-09 | No Data | 1.91E-08 | No Data | 3.00E-05 |
| Zr-97 | 2.37E-09 | 4.69E-10 | 2.16E-10 | No Data | 7.11E-10 | No Data | 1.27E-04 |
| Nb-95 | 8.22E-09 | 4.56E-09 | 2.51E-09 | No Data | 4.42E-09 | No Data | 1.95E-05 |
| Mo-99 | No Data | 6.03E-06 | 1.15E-06 | No Data | 1.38E-05 | No Data | 1.08E-05 |
| Tc-99M | 3.32E-10 | 9.26E-10 | 1.20E-08 | No Data | 1.38E-08 | 5.14E-10 | 6.08E-07 |
| Tc-101 | 3.60E-10 | 5.12E-10 | 5.03E-09 | No Data | 9.26E-09 | 3.12E-10 | 8.75E-17 |
| Ru-103 | 2.55E-07 | No Data | 1.09E-07 | No Data | 8.99E-07 | No Data | 2.13E-05 |
| Ru-105 | 2.18E-08 | No Data | 8.46E-09 | No Data | 2.75E-07 | No Data | 1.76E-05 |
| Ru-106 | 3.92E-06 | No Data | 4.94E-07 | No Data | 7.56E-06 | No Data | 1.88E-04 |
| Ag-110M | 2.05E-07 | 1.94E-07 | 1.18E-07 | No Data | 3.70E-07 | No Data | 5.45E-05 |
| Te-125M | 3.83E-06 | 1.38E-06 | 5.12E-07 | 1.07E-06 | No Data | No Data | 1.13E-05 |
| Te-127M | 9.67E-06 | 3.43E-06 | 1.15E-06 | 2.30E-06 | 3.92E-05 | No Data | 2.41E-05 |
| Te-127 | 1.58E-07 | 5.60E-08 | 3.40E-08 | 1.09E-07 | 6.40E-07 | No Data | 1.22E-05 |
| Te-129M | 1.63E-05 | 6.05E-06 | 2.58E-06 | 5.26E-06 | 6.82E-05 | No Data | 6.12E-05 |
| Te-129 | 4.48E-08 | 1.67E-08 | 1.09E-08 | 3.20E-08 | 1.88E-07 | No Data | 2.45E-07 |
| Te-131M | 2.44E-06 | 1.17E-06 | 9.76E-07 | 1.76E-06 | 1.22E-05 | No Data | 9.39E-05 |
| Te-131 | 2.79E-08 | 1.15E-08 | 8.72E-09 | 2.15E-08 | 1.22E-07 | No Data | 2.29E-09 |
| Te-132 | 3.49E-06 | 2.21E-06 | 2.08E-06 | 2.33E-06 | 2.12E-05 | No Data | 7.00E-05 |
| I-130 | 1.03E-06 | 2.98E-06 | 1.19E-06 | 2.43E-04 | 4.59E-06 | No Data | 2.29E-06 |
| I-131 | 5.85E-06 | 8.19E-06 | 4.40E-06 | 2.39E-03 | 1.41E-05 | No Data | 1.62E-06 |
| I-132 | 2.79E-07 | 7.30E-07 | 2.62E-07 | 2.46E-05 | 1.15E-06 | No Data | 3.18E-07 |
| I-133 | 2.01E-06 | 3.41E-06 | 1.04E-06 | 4.76E-04 | 5.98E-06 | No Data | 2.58E-06 |
| I-134 | 1.46E-07 | 3.87E-07 | 1.39E-07 | 6.45E-06 | 6.10E-07 | No Data | 5.10E-09 |
| I-135 | 6.10E-07 | 1.57E-06 | 5.82E-07 | 1.01E-04 | 2.48E-06 | No Data | 1.74E-06 |
| Cs-134 | 8.37E-05 | 1.97E-04 | 9.14E-05 | No Data | 6.26E-05 | 2.39E-05 | 2.45E-06 |
| Cs-136 | 8.59E-06 | 3.38E-05 | 2.27E-05 | No Data | 1.84E-05 | 2.90E-06 | 2.72E-06 |
| Cs-137 | 1.12E-04 | 1.49E-04 | 5.19E-05 | No Data | 5.07E-05 | 1.97E-05 | 2.12E-06 |
| Cs-138 | 7.76E-08 | 1.49E-07 | 7.45E-08 | No Data | 1.10E-07 | 1.28E-08 | 6.76E-11 |
| Ba-139 | 1.39E-07 | 9.78E-11 | 4.05E-09 | No Data | 9.22E-11 | 6.74E-11 | 1.24E-06 |

## TABLE 2.2-7 (continued)

Ingestion Dose Factors for Teenagers
(Mrem per PCI Ingested)
Page 3 of 3

| Nuclide | Bone | Liver | T Body | Thyroid | Kidney | Lung | GI-LLI |
|---|---|---|---|---|---|---|---|
| Ba-140 | 2.84E-05 | 3.48E-08 | 1.83E-06 | No Data | 1.18E-08 | 2.34E-08 | 4.38E-05 |
| Ba-141 | 6.71E-08 | 5.01E-11 | 2.24E-09 | No Data | 4.65E-11 | 3.43E-11 | 1.43E-13 |
| Ba-142 | 2.99E-08 | 2.99E-11 | 1.84E-09 | No Data | 2.53E-11 | 1.99E-11 | 9.18E-20 |
| La-140 | 3.48E-09 | 1.71E-09 | 4.55E-10 | No Data | No Data | No Data | 9.82E-05 |
| La-142 | 1.79E-10 | 7.95E-11 | 1.98E-11 | No Data | No Data | No Data | 2.42E-06 |
| Ce-141 | 1.33E-08 | 8.88E-09 | 1.02E-09 | No Data | 4.18E-09 | No Data | 2.54E-05 |
| Ce-143 | 2.35E-09 | 1.71E-06 | 1.91E-10 | No Data | 7.67E-10 | No Data | 5.14E-05 |
| Ce-144 | 6.96E-07 | 2.88E-07 | 3.74E-08 | No Data | 1.72E-07 | No Data | 1.75E-04 |
| Pr-143 | 1.31E-08 | 5.23E-09 | 6.52E-10 | No Data | 3.04E-09 | No Data | 4.31E-05 |
| Pr-144 | 4.30E-11 | 1.76E-11 | 2.18E-12 | No Data | 1.01E-11 | No Data | 4.74E-14 |
| Nd-147 | 9.38E-09 | 1.02E-08 | 6.11E-10 | No Data | 5.99E-09 | No Data | 3.68E-05 |
| W-187 | 1.46E-07 | 1.19E-07 | 4.17E-08 | No Data | No Data | No Data | 3.22E-05 |
| Np-239 | 1.76E-09 | 1.66E-10 | 9.22E-11 | No Data | 5.21E-10 | No Data | 2.67E-05 |

TABLE 2.2-8

Ingestion Dose Factors for Adults*
(Mrem per PCI Ingested)
Page 1 of 3

| Nuclide | Bone | Liver | T Body | Thyroid | Kidney | Lung | GI-LLI |
|---|---|---|---|---|---|---|---|
| H-3 | No Data | 1.05E-07 | 1.05E-07 | 1.05E-07 | 1.05E-07 | 1.05E-07 | 1.05E-07 |
| C-14 | 2.84E-06 | 5.68E-07 | 5.68E-07 | 5.68E-07 | 5.68E-07 | 5.68E-07 | 5.68E-07 |
| Na-24 | 1.70E-06 | 1.70E-06 | 1.70E-06 | 1.70E-06 | 1.70E-06 | 1.70E-06 | 1.70E-06 |
| P-32 | 1.93E-04 | 1.20E-05 | 7.46E-06 | No Data | No Data | No Data | 2.17E-05 |
| Cr-51 | No Data | No Data | 2.66E-09 | 1.59E-09 | 5.86E-10 | 3.53E-09 | 6.69E-07 |
| Mn-54 | No Data | 4.57E-06 | 8.72E-07 | No Data | 1.36E-06 | No Data | 1.40E-05 |
| Mn-56 | No Data | 1.15E-07 | 2.04E-08 | No Data | 1.46E-07 | No Data | 3.67E-06 |
| Fe-55 | 2.75E-06 | 1.90E-06 | 4.43E-07 | No Data | No Data | 1.06E-06 | 1.09E-06 |
| Fe-59 | 4.34E-06 | 1.02E-05 | 3.91E-06 | No Data | No Data | 2.85E-06 | 3.40E-05 |
| Co-58 | No Data | 7.45E-07 | 1.67E-06 | No Data | No Data | No Data | 1.51E-05 |
| Co-60 | No Data | 2.14E-06 | 4.72E-06 | No Data | No Data | No Data | 4.02E-05 |
| Ni-63 | 1.30E-04 | 9.01E-06 | 4.36E-06 | No Data | No Data | No Data | 1.88E-06 |
| Ni-65 | 5.28E-07 | 6.86E-08 | 3.13E-08 | No Data | No Data | No Data | 1.74E-06 |
| Cu-64 | No Data | 8.33E-08 | 3.91E-08 | No Data | 2.10E-07 | No Data | 7.10E-06 |
| Zn-65 | 4.84E-06 | 1.54E-05 | 6.96E-06 | No Data | 1.03E-05 | No Data | 9.70E-06 |
| Zn-69 | 1.03E-08 | 1.97E-08 | 1.37E-09 | No Data | 1.28E-08 | No Data | 2.96E-09 |
| Br-83 | No Data | No Data | 4.02E-08 | No Data | No Data | No Data | 5.79E-08 |
| Br-84 | No Data | No Data | 5.21E-08 | No Data | No Data | No Data | 4.09E-13 |
| Br-85 | No Data | No Data | 2.14E-09 | No Data | No Data | No Data | LT E-24 |
| Rb-86 | No Data | 2.11E-05 | 9.83E-06 | No Data | No Data | No Data | 4.16E-06 |
| Rb-88 | No Data | 6.05E-08 | 3.21E-08 | No Data | No Data | No Data | 8.36E-19 |
| Rb-89 | No Data | 4.01E-08 | 2.82E-08 | No Data | No Data | No Data | 2.33E-21 |
| Sr-89 | 3.08E-04 | No Data | 8.84E-06 | No Data | No Data | No Data | 4.94E-05 |
| Sr-90 | 7.58E-03 | No Data | 1.86E-03 | No Data | No Data | No Data | 2.19E-04 |
| Sr-91 | 5.67E-06 | No Data | 2.29E-07 | No Data | No Data | No Data | 2.70E-05 |
| Sr-92 | 2.15E-06 | No Data | 9.30E-08 | No Data | No Data | No Data | 4.26E-05 |
| Y-90 | 9.62E-09 | No Data | 2.58E-10 | No Data | No Data | No Data | 1.02E-04 |
| Y-91M | 9.09E-11 | No Data | 3.52E-12 | No Data | No Data | No Data | 2.67E-10 |
| Y-91 | 1.41E-07 | No Data | 3.77E-09 | No Data | No Data | No Data | 7.76E-05 |
| Y-92 | 8.45E-10 | No Data | 2.47E-11 | No Data | No Data | No Data | 1.48E-05 |

*Reference 3, Table E-11

TABLE 2.2-8 (continued)

Ingestion Dose Factors for Adults
(Mrem per PCI Ingested)
Page 2 of 3

| Nuclide | Bone | Liver | T Body | Thyroid | Kidney | Lung | GI-LLI |
|---|---|---|---|---|---|---|---|
| Y-93 | 2.68E-09 | No Data | 7.40E-11 | No Data | No Data | No Data | 8.50E-05 |
| Zr-95 | 3.04E-08 | 9.75E-09 | 6.60E-09 | No Data | 1.53E-08 | No Data | 3.09E-05 |
| Zr-97 | 1.68E-09 | 3.39E-10 | 1.55E-10 | No Data | 5.12E-10 | No Data | 1.05E-04 |
| Nb-95 | 6.22E-09 | 3.46E-09 | 1.86E-09 | No Data | 3.42E-09 | No Data | 2.10E-05 |
| Mo-99 | No Data | 4.31E-06 | 8.20E-07 | No Data | 9.76E-06 | No Data | 9.99E-06 |
| Tc-99M | 2.47E-10 | 6.98E-10 | 8.89E-09 | No Data | 1.06E-08 | 3.42E-10 | 4.13E-07 |
| Tc-101 | 2.54E-10 | 3.66E-10 | 3.59E-09 | No Data | 6.59E-09 | 1.87E-10 | 1.10E-21 |
| Ru-103 | 1.85E-07 | No Data | 7.97E-08 | No Data | 7.06E-07 | No Data | 2.16E-05 |
| Ru-105 | 1.54E-08 | No Data | 6.08E-09 | No Data | 1.99E-07 | No Data | 9.42E-06 |
| Ru-106 | 2.75E-06 | No Data | 3.48E-07 | No Data | 5.31E-06 | No Data | 1.78E-04 |
| Ag-110M | 1.60E-07 | 1.48E-07 | 8.79E-08 | No Data | 2.91E-07 | No Data | 6.04E-05 |
| Te-125M | 2.68E-06 | 9.71E-07 | 3.59E-07 | 8.06E-07 | 1.09E-05 | No Data | 1.07E-05 |
| Te-127M | 6.77E-06 | 2.42E-06 | 8.25E-07 | 1.73E-06 | 2.75E-05 | No Data | 2.27E-05 |
| Te-127 | 1.10E-07 | 3.95E-08 | 2.38E-08 | 8.15E-08 | 4.48E-07 | No Data | 8.68E-06 |
| Te-129M | 1.15E-05 | 4.29E-06 | 1.82E-06 | 3.95E-06 | 4.80E-05 | No Data | 5.79E-05 |
| Te-129 | 3.14E-08 | 1.18E-08 | 7.65E-09 | 2.41E-08 | 1.32E-07 | No Data | 2.37E-08 |
| Te-131M | 1.73E-06 | 8.46E-07 | 7.05E-07 | 1.34E-06 | 8.57E-06 | No Data | 8.40E-05 |
| Te-131 | 1.97E-08 | 8.23E-09 | 6.22E-09 | 1.62E-08 | 8.63E-08 | No Data | 2.79E-09 |
| Te-132 | 2.52E-06 | 1.63E-06 | 1.53E-06 | 1.80E-06 | 1.57E-05 | No Data | 7.71E-05 |
| I-130 | 7.56E-07 | 2.23E-06 | 8.80E-07 | 1.89E-04 | 3.48E-06 | No Data | 1.92E-06 |
| I-131 | 4.16E-06 | 5.95E-06 | 3.41E-06 | 1.95E-03 | 1.02E-05 | No Data | 1.57E-06 |
| I-132 | 2.03E-07 | 5.43E-07 | 1.90E-07 | 1.90E-05 | 8.65E-07 | No Data | 1.02E-07 |
| I-133 | 1.42E-06 | 2.47E-06 | 7.53E-07 | 3.63E-04 | 4.31E-06 | No Data | 2.22E-06 |
| I-134 | 1.06E-07 | 2.88E-07 | 1.03E-07 | 4.99E-06 | 4.58E-07 | No Data | 2.51E-10 |
| I-135 | 4.43E-07 | 1.16E-06 | 4.28E-07 | 7.65E-05 | 1.86E-06 | No Data | 1.31E-06 |
| Cs-134 | 6.22E-05 | 1.48E-04 | 1.21E-04 | No Data | 4.79E-05 | 1.59E-05 | 2.59E-06 |
| Cs-136 | 6.51E-06 | 2.57E-05 | 1.85E-05 | No Data | 1.43E-05 | 1.96E-06 | 2.92E-06 |
| Cs-137 | 7.97E-05 | 1.09E-04 | 7.14E-05 | No Data | 3.70E-05 | 1.23E-05 | 2.11E-06 |
| Cs-138 | 5.52E-08 | 1.09E-07 | 5.40E-08 | No Data | 8.01E-08 | 7.91E-09 | 4.65E-13 |
| Ba-139 | 9.70E-08 | 6.91E-11 | 2.84E-09 | No Data | 6.46E-11 | 3.92E-11 | 1.72E-07 |
| Ba-140 | 2.03E-05 | 2.55E-08 | 1.33E-06 | No Data | 8.67E-09 | 1.46E-08 | 4.18E-05 |
| Ba-141 | 4.71E-08 | 3.56E-11 | 1.59E-09 | No Data | 3.31E-11 | 2.02E-11 | 2.22E-17 |
| Ba-142 | 2.13E-08 | 2.19E-11 | 1.34E-09 | No Data | 1.85E-11 | 1.24E-11 | 3.00E-26 |

TABLE 2.2-8 (continued)

Ingestion Dose Factors for Adults
(Mrem per PCI Ingested)
Page 3 of 3

| Nuclide | Bone | Liver | T Body | Thyroid | Kidney | Lung | GI-LLI |
|---|---|---|---|---|---|---|---|
| La-140 | 2.50E-09 | 1.26E-09 | 3.33E-10 | No Data | No Data | No Data | 9.25E-05 |
| La-142 | 1.28E-10 | 5.82E-11 | 1.45E-11 | No Data | No Data | No Data | 4.25E-07 |
| Ce-141 | 9.36E-09 | 6.33E-09 | 7.18E-10 | No Data | 2.94E-09 | No Data | 2.42E-05 |
| Ce-143 | 1.65E-09 | 1.22E-06 | 1.35E-10 | No Data | 5.37E-10 | No Data | 4.56E-05 |
| Ce-144 | 4.88E-07 | 2.04E-07 | 2.62E-08 | No Data | 1.21E-07 | No Data | 1.65E-04 |
| Pr-143 | 9.20E-09 | 3.69E-09 | 4.56E-10 | No Data | 2.13E-09 | No Data | 4.03E-05 |
| Pr-144 | 3.01E-11 | 1.25E-11 | 1.53E-12 | No Data | 7.05E-12 | No Data | 4.33E-18 |
| Nd-147 | 6.29E-09 | 7.27E-09 | 4.35E-10 | No Data | 4.25E-09 | No Data | 3.49E-05 |
| W-187 | 1.03E-07 | 8.61E-08 | 3.01E-08 | No Data | No Data | No Data | 2.82E-05 |
| Np-239 | 1.19E-09 | 1.17E-10 | 6.45E-11 | No Data | 3.65E-10 | No Data | 2.40E-05 |

TABLE 2.2-9

External Dose Factors for Standing on Contaminated Ground*
(mrem/hr per pCi/$m^2$)
Page 1 of 3

| Element | Total Body | Skin |
|---|---|---|
| H-3 | 0.0 | 0.0 |
| C-14 | 0.0 | 0.0 |
| Na-24 | 2.50E-08 | 2.90E-08 |
| P-32 | 0.0 | 0.0 |
| Cr-51 | 2.20E-10 | 2.60E-10 |
| Mn-54 | 5.80E-09 | 6.80E-09 |
| Mn-56 | 1.10E-08 | 1.30E-08 |
| Fe-55 | 0.0 | 0.0 |
| Fe-59 | 8.00E-09 | 9.40E-09 |
| Co-58 | 7.00E-09 | 8.20E-09 |
| Co-60 | 1.70E-08 | 2.00E-08 |
| Ni-63 | 0.0 | 0.0 |
| Ni-65 | 3.70E-09 | 4.30E-09 |
| Cu-64 | 1.50E-09 | 1.70E-09 |
| Zn-65 | 4.00E-09 | 4.60E-09 |
| Zn-69 | 0.0 | 0.0 |
| Br-83 | 6.40E-11 | 9.30E-11 |
| Br-84 | 1.20E-08 | 1.40E-08 |
| Br-85 | 0.0 | 0.0 |
| Rb-86 | 6.30E-10 | 7.20E-10 |
| Rb-88 | 3.50E-09 | 4.00E-09 |
| Rb-89 | 1.50E-08 | 1.80E-08 |
| Sr-89 | 5.60E-13 | 6.50E-13 |
| Sr-91 | 7.10E-09 | 8.30E-09 |
| Sr-92 | 9.00E-09 | 1.00E-08 |
| Y-90 | 2.20E-12 | 2.60E-12 |
| Y-91M | 3.80E-09 | 4.40E-09 |
| Y-91 | 2.40E-11 | 2.70E-11 |
| Y-92 | 1.60E-09 | 1.90E-09 |
| Y-93 | 5.70E-10 | 7.80E-10 |

*Reference 3, Table E-6

TABLE 2.2-9 (continued)

External Dose Factors for Standing on Contaminated Ground*
(mrem/hr per $pCi/m^2$)
Page 2 of 3

| Element | Total Body | Skin |
|---|---|---|
| Zr-95 | 5.00E-09 | 5.80E-09 |
| Zr-97 | 5.50E-09 | 6.40E-09 |
| Nb-95 | 5.10E-09 | 6.00E-09 |
| Mo-99 | 1.90E-09 | 2.20E-09 |
| Tc-99M | 9.60E-10 | 1.10E-09 |
| Tc-101 | 2.70E-09 | 3.00E-09 |
| Ru-103 | 3.60E-09 | 4.20E-09 |
| Ru-105 | 4.50E-09 | 5.10E-09 |
| Ru-106 | 1.50E-09 | 1.80E-09 |
| Ag-110M | 1.80E-08 | 2.10E-08 |
| Te-125M | 3.50E-11 | 4.80E-11 |
| Te-127M | 1.10E-12 | 1.30E-12 |
| Te-127 | 1.00E-11 | 1.10E-11 |
| Te-129M | 7.70E-10 | 9.00E-10 |
| Te-129 | 7.10E-10 | 8.40E-10 |
| Te-131M | 8.40E-09 | 9.90E-09 |
| Te-131 | 2.20E-09 | 2.60E-06 |
| Te-132 | 1.70E-09 | 2.00E-09 |
| I-130 | 1.40E-08 | 1.70E-08 |
| I-131 | 2.80E-09 | 3.40E-09 |
| I-132 | 1.70E-08 | 2.00E-08 |
| I-133 | 3.70E-09 | 4.50E-09 |
| I-134 | 1.60E-08 | 1.90E-08 |
| I-135 | 1.20E-08 | 1.40E-08 |
| Cs-134 | 1.20E-08 | 1.40E-08 |
| Cs-136 | 1.50E-08 | 1.70E-08 |
| Cs-137 | 4.20E-09 | 4.90E-09 |
| Cs-138 | 2.10E-08 | 2.40E-08 |
| Ba-139 | 2.40E-09 | 2.70E-09 |
| Ba-140 | 2.10E-09 | 2.40E-09 |
| Ba-141 | 4.30E-09 | 4.90E-09 |
| Ba-142 | 7.90E-09 | 9.00E-09 |
| La-140 | 1.50E-08 | 1.70E-08 |

TABLE 2.2-9 (continued)

External Dose Factors for Standing on Contaminated Ground*
(mrem/hr per $pCi/m^2$)
Page 3 of 3

| Element | Total Body | Skin |
|---|---|---|
| La-142 | 1.50E-08 | 1.80E-08 |
| Ce-141 | 5.50E-10 | 6.20E-10 |
| Ce-143 | 2.20E-09 | 2.50E-09 |
| Ce-144 | 3.20E-10 | 3.70E-10 |
| Pr-143 | 0.0 | 0.0 |
| Pr-144 | 2.00E-10 | 2.30E-10 |
| Nd-147 | 1.00E-09 | 1.20E-09 |
| W-187 | 3.10E-09 | 3.60E-09 |
| Np-239 | 9.50E-10 | 1.10E-09 |

## TABLE 2.2-10

Individual Usage Factors*

| | Infant | Child | Teenager | Adult |
|---|---|---|---|---|
| Milk Consumption Rate, $U_{ap}$ (liters/year) | 330 | 330 | 400 | 310 |
| Meat Consumption Rate, $U_{ap}$ (kg/year) | 0 | 41 | 65 | 110 |
| Fresh Leafy Vegetation Consumption Rate, $U_{a\ell}$ (kg/year) | 0 | 26 | 42 | 64 |
| Stored Vegetation Consumption Rate, $U_{as}$ (kg/year) | 0 | 520 | 630 | 520 |
| Breathing Rate, $(BR)_a$ ($m^3$/year) | 1400 | 3700 | 8000 | 8000 |

*Reference 3, Table E-5

TABLE 2.2-11

Stable Element Transfer Data*

| Element | $F_m$ - Milk (Cow) (days/liter) | $F_m$ - Milk (Goat) (days/liter) | $F_f$ - Meat (days/kg) |
|---|---|---|---|
| H | 1.0E-02 | 1.7E-01 | 1.2E-02 |
| C | 1.2E-02 | 1.0E-01 | 3.1E-02 |
| Na | 4.0E-02 | 4.0E-02 | 3.0E-02 |
| P | 2.5E-02 | 2.5E-01 | 4.6E-02 |
| Cr | 2.2E-03 | 2.2E-03 | 2.4E-03 |
| Mn | 2.5E-04 | 2.5E-04 | 8.0E-04 |
| Fe | 1.2E-03 | 1.3E-04 | 4.0E-02 |
| Co | 1.0E-03 | 1.0E-03 | 1.3E-02 |
| Ni | 6.7E-03 | 6.7E-03 | 5.3E-02 |
| Cu | 1.4E-02 | 1.3E-02 | 8.0E-03 |
| Zn | 3.9E-02 | 3.9E-02 | 3.0E-02 |
| Rb | 3.0E-02 | 3.0E-02 | 3.1E-02 |
| Sr | 8.0E-04 | 1.4E-02 | 6.0E-04 |
| Y | 1.0E-05 | 1.0E-05 | 4.6E-03 |
| Zr | 5.0E-06 | 5.0E-06 | 3.4E-02 |
| Nb | 2.5E-03 | 2.5E-03 | 2.8E-01 |
| Mo | 7.5E-03 | 7.5E-03 | 8.0E-03 |
| Tc | 2.5E-02 | 2.5E-02 | 4.0E-01 |
| Ru | 1.0E-06 | 1.0E-06 | 4.0E-01 |
| Rh | 1.0E-02 | 1.0E-02 | 1.5E-03 |
| Ag | 5.0E-02 | 5.0E-02 | 1.7E-02 |
| Te | 1.0E-03 | 1.0E-03 | 7.7E-02 |
| I | 6.0E-03 | 6.0E-02 | 2.9E-03 |
| Cs | 1.2E-02 | 3.0E-01 | 4.0E-03 |
| Ba | 4.0E-04 | 4.0E-04 | 3.2E-03 |
| La | 5.0E-06 | 5.0E-06 | 2.0E-04 |
| Ce | 1.0E-04 | 1.0E-04 | 1.2E-03 |
| Pr | 5.0E-06 | 5.0E-06 | 4.7E-03 |
| Nd | 5.0E-06 | 5.0E-06 | 3.3E-03 |
| W | 5.0E-04 | 5.0E-04 | 1.3E-03 |
| Np | 5.0E-06 | 5.0E-06 | 2.0E-04 |

*Reference 3, Table E-1

## TABLE 2.2-12

Controlling Receptors, Locations, and Pathways*

(For Dose Calculations required by Technical Specifications 4.11.2.4.1, 6.9.1.8, 6.9.1.12, and 3.12.2)

| Sector | Distance (Miles) | Pathway | Age Group |
|---|---|---|---|
| N | 1.52 | Vegetation | Child |
| NNE | 1.40 | Vegetation | Child |
| NE | 1.29 | Vegetation | Child |
| ENE | 3.96 | Grass/cow/milk | Infant |
| E | 3.37 | Grass/cow/milk | Infant |
| ESE | 5.00 | Grass/goat/milk | Infant |
| SE | 3.96 | Grass/cow/milk | Infant |
| SSE | 2.50 | Vegetation | Child |
| S | 1.25 | Vegetation | Child |
| SSW | 1.29 | Vegetation | Child |
| SW | 1.02 | Vegetation | Child |
| WSW | 0.80 | Vegetation | Child |
| W | 0.87 | Vegetation | Child |
| WNW | 1.40 | Vegetation | Child |
| NW | 2.10 | Vegetation | Child |
| NNW | 1.86 | Vegetation | Child |

*Reference 5

## TABLE 2.2-13

Relative Concentrations and Relative Depositions*

(For Technical Specifications 3.11.2.3, 3.11.2.4, 6.9.1.12, and 3.12.2)

| Sector | Ground Release X/Q | Ground Release D/Q | Mixed-Mode Release X/Q | Mixed-Mode Release D/Q | Distance (Miles) |
|---|---|---|---|---|---|
| N | 1.39E-6 | 1.08E-8 | 2.38E-7 | 3.35E-9 | 1.52 |
| NNE | 1.50E-6 | 1.31E-8 | 3.21E-7 | 4.85E-9 | 1.40 |
| NE | 1.79E-6 | 1.50E-8 | 4.17E-7 | 5.81E-9 | 1.29 |
| ENE | 1.80E-7 | 1.50E-9 | 7.32E-8 | 9.95E-10 | 3.96 |
| E | 3.26E-7 | 2.02E-9 | 8.99E-8 | 1.28E-9 | [illegible] |
| ESE | 8.41E-8 | 7.84E-10 | 4.15E-8 | 6.01E-10 | [illegible] |
| SE | 1.00E-7 | 1.05E-9 | 5.01E-8 | 8.31E-10 | 3.96 |
| SSE | 1.51E-7 | 1.75E-9 | 8.18E-8 | 1.24E-9 | 2.50 |
| S | 3.96E-7 | 5.10E-9 | 1.52E-7 | 2.49E-9 | 1.25 |
| SSW | 3.79E-7 | 4.76E-9 | 1.42E-7 | 2.50E-9 | 1.29 |
| SW | 7.86E-7 | 9.70E-9 | 2.43E-7 | 4.55E-9 | 1.02 |
| WSW | 2.52E-6 | 2.61E-8 | 5.65E-7 | 9.81E-9 | 0.80 |
| W | 1.83E-6 | 1.59E-8 | 2.38E-7 | 4.97E-9 | 0.87 |
| WNW | 8.10E-7 | 5.36E-9 | 1.48E-7 | 1.82E-9 | 1.40 |
| NW | 4.76E-7 | 3.33E-9 | 8.26E-8 | 1.07E-9 | 2.10 |
| NNW | 7.00E-7 | 5.22E-9 | 1.09E-7 | 1.52E-9 | 1.86 |

*Reference 5

## 2.3 DEFINITIONS OF GASEOUS EFFLUENTS PARAMETERS

| Term | Definition | Section of Initial Use |
|---|---|---|
| BR | = breathing rate for child age group (3700 $m^3$/year) from Table 2.2-10. | 2.2.1.b |
| $(BR)_a$ | = breathing rate for a particular age group a ($m^3$/year) from Table 2.2-10. | 2.2.2.b |
| C | = monitor reading of a noble gas monitor corresponding to associated sample radionuclide concentrations (μCi/cc). | 2.1.1 |
| $C_S$ | = monitor reading of the noble gas monitor at the alarm setpoint for the release pathway under consideration (μCi/cc). | 2.1.1 |
| $D_j$ | = dose to an organ of an individual from radioiodines, tritium, and radionuclides in particulate form with half-lives greater than eight days (mrem). | 2.2.2.b |
| $D_o$ | = organ dose rate at time of release (mrem/year). | 2.2.1.b |
| $D_s$ | = skin dose rate at time of release (mrem/year). | 2.2.1.a |

## 2.3 DEFINITIONS OF GASEOUS EFFLUENTS PARAMETERS (Continued)

| Term | Definition | Section of Initial Use |
|---|---|---|
| $D_t$ | = total body dose rate at time of release (mrem/year). | 2.2.1.a |
| $D_\beta$ | = air dose due to beta emissions from noble gases (mrad). | 2.2.2.a |
| $D_\gamma$ | = air dose due to gamma emissions from noble gases (mrad). | 2.2.2.a |
| $D_{TB}$ | = limiting dose rate to the total body of an individual in an unrestricted area (500 mrem/year). | 2.1.1 |
| $D_{ss}$ | = limiting dose rate to the skin of an individual in an unrestricted area (3000 mrem/year). | 2.1.1 |
| $DF_{io}$ | = inhalation pathway dose factor for child age group for organ o and radionuclide i (mrem/pCi inhaled) from Table 2.2-2. | 2.2.1.b |
| D/Q | = relative deposition concurrent with actual release ($m^{-2}$). | 2.2.2.c |
| $\overline{D/Q'}$ | = annual average relative deposition for location of controlling (critical) receptor for pathways other than inhalation or tritium ($m^{-2}$). | 2.2.2.b |

2.3 DEFINITIONS OF GASEOUS EFFLUENTS PARAMETERS (Continued)

| Term | Definition | Section of Initial Use |
|---|---|---|
| $(\overline{D/Q'})_G$ | = annual average relative deposition for location of controlling (critical) receptor for pathways other than inhalation of tritium for a mixed mode release type ($m^{-2}$) | 2.2.2.b |
| $(\overline{D/Q'})_M$ | = annual average relative deposition for location of controlling (critical) receptor for pathways other than inhalation or tritium for a ground-level release type ($m^{-2}$). | 2.2.2.b |
| $(DFA_{ij})_a$ | = the inhalation dose factor for the ith radionucldie for the receptor in age group a (mrem/pCi) from Tables 2.2-1 through 2.2-4. | 2.2.2.b |
| $DFG_{ij}$ | = ground-plane dose conversion factor for radionuclide i (same for all age groups) (mrem/hr per pCi/$m^2$) from Table 2.2-9. | 2.2.2.b |
| $(DFL_{ij})_a$ | = the organ ingestion dose factor for the ith radionuclide for the receptor in age group a (mrem/pCi) from Tables 2.2-5 through 2.2-8. | 2.2.2.b |
| $F_B$ | = administrative allocation factor for gaseous effluent pathways (dimensionless). | 2.1.1 |

## 2.3 DEFINITIONS OF GASEOUS EFFLUENTS PARAMETERS (Continued)

| Term | Definition | Section of Initial Use |
|---|---|---|
| $F_f$ | = the stable element transfer coefficient (days/kg) from Table 2.2-11. | 2.2.2.d |
| $F_m$ | = the stable element transfer coefficient (days/liter) from Table 2.2-11. | 2.2.2.d |
| $F_s$ | = safety factor; a conservative factor applied to each noble gas monitor to compensate for statistical fluctuations and errors of measurement (dimensionless). | 2.1.1 |
| $f_g$ | = fraction of annual intake of stored vegetation grown locally (dimensionless). | 2.2.2.d |
| $f_p$ | = fraction of the year that the cow is on pasture (dimensionless). | 2.2.2.b |
| $f_s$ | = fraction of the cow feed that is on pasture while the cow is on pasture (dimensionless). | 2.2.2.b |
| $f_\ell$ | = fraction of the annual intake of fresh leafy vegetation grown locally (dimensionless). | 2.2.2.d |
| H | = absolute humidity of the atmopshere ($gm/m^3$). | 2.2.2.b |

## 2.3 DEFINITIONS OF GASEOUS EFFLUENTS PARAMETERS (Continued)

| Term | Definition | Section of Initial Use |
|---|---|---|
| K' | = constant of unit conversion, $10^6$ pCi/μCi. | 2.2.1.b |
| K" | = constant of unit conversion, 8760 hr/year. | 2.2.2.b |
| K'" | = constant of unit conversion, $10^3$ gm/$m^3$. | 2.2.2.b |
| $K_i$ | = total body dose factor due to gamma emissions from radionuclide i (mrem/year per μCi/$m^3$) from Table 2.1-1. | 2.1.1 |
| $L_i$ | = skin dose factor due to beta emissions from radionuclide i (mrem/year per μCi/$m^3$) from Table 2.1-1. | 2.1.1 |
| $M_i$ | = air dose factor due to gamma emissions from radionuclide i (mrad/year per μCi/$m^3$) from Table 2.1-1. | 2.1.1 |
| $N_i$ | = air dose factor due to beta emissions from noble gas radionuclide i (mrad/year per μCi/$m^3$) from Table 2.1-1. | 2.2.2.a |

## 2.3 DEFINITIONS OF GASEOUS EFFLUENTS PARAMETERS (Continued)

| Term | Definition | Section of Initial Use |
| --- | --- | --- |
| $P_{io}$ | = organ dose parameter for organ o and radionuclide i (mrem/year per μCi/$m^3$ for inhalation and all tritium pathways); ($m^2$-mrem/year per μCi/sec for other pathways). | 2.2.1.b |
| $Q_F$ | = cow's or goat's consumption rate (kg/day) (net weight). | 2.2.2.b |
| $Q_i$ | = rate of release of noble gas radionuclide i (μCi/sec). | 2.1 |
| $(Q_i)_G$ | = rate of release of noble gas radionuclide i for a ground-level release type (μCi/sec). | 2.1.1 |
| $(Q_i)_M$ | = rate of release of noble gas radionuclide i for a mixed-mode release type (μCi/sec). | 2.1.1 |
| $(Q'_i)$ | = release rate of non-noble gas radionuclide i (μCi/sec). | 2.2.1.b |
| $(Q'_i)_G$ | = release rate of non-noble gas radionuclide i for a ground-level release type (μCi/sec). | 2.2.1.b |

## 2.3 DEFINITIONS OF GASEOUS EFFLUENTS PARAMETERS (Continued)

| Term | Definition | Section of Initial Use |
|---|---|---|
| $(Q'_i)_M$ | = release rate of non-noble gas radionuclide i for a mixed mode release type (μCi/sec). | 2.2.1.b |
| $\tilde{Q}_i$ | = cumulative release of noble gas radionuclide i over the period of interest (μCi). | 2.2.2.a |
| $(\tilde{Q}_i)_G$ | = cumulative release of noble gas radionuclide i over the period of interest for a ground-level release type (μCi). | 2.2.2.a |
| $(\tilde{Q}_i)_M$ | = cumulative release of noble gas radionuclide i over the period of interest for a mixed-mode release type (μCi). | |
| $\tilde{Q}'_i$ | = cumulative release of radioiodines, tritium, or material in particulate form for radionuclide i over the period of interest (μCi). | 2.2.2.b |
| $(\tilde{Q}'_i)_G$ | = cumulative release of radioiodines, tritium, or material in particulate form radionuclide for over the period of interest for a mixed-mode release type (μCi). | 2.2.2.b |

2.3 DEFINITIONS OF GASEOUS EFFLUENTS PARAMETERS (Continued)

| Term | Definition | Section of Initial Use |
|---|---|---|
| $(\tilde{Q}'_i)_M$ | = cumulative release of radioiodines, tritium, or material in particulate form for radionuclide i over the period of interest for a ground-level release type (μCi). | 2.2.2.b |
| $(Q_i)_{AG}$ | = release rate of radionuclide i for the combined source terms of routine Auxiliary Building Vent Stack No. 1 plus the Gaseous Radwaste Tank (μCi/sec). | 2.1.3.1 |
| $(Q_i)_{CP}$ | = release rate of radionuclide i for the combined source terms of routine Reactor Containment Ventilation System plus Containment Purge (μCi/sec). | 2.1.3.2 |
| $(Q_i)_{CR}$ | = release rate of radionuclide i for the combined source terms of routine Containment Building Ventilation System plus Air Room Volume and/or Operational Containment Purge (μCi/sec). | 2.1.3.3 |
| $q_i$ | = rate of release of noble gas radionuclide i from the particular Containment Purge, Air Room Purge, or Gaseous Radwaste System (μCi/sec). | 2.1.3.1 |
| $R_s$ | = monitor reading per mrem/year to the skin. | 2.1.1 |

2.3 DEFINITIONS OF GASEOUS EFFLUENTS PARAMETERS (Continued)

| Term | Definition | Section of Initial Use |
|---|---|---|
| $R_t$ | = monitor reading per mrem/year to the total body. | 2.1.1 |
| $R_{aipj}$ | = dose factor for age group a, radionuclide i, pathway p, and organ j (mrem/year per $\mu Ci/m^3$ or $m^2$-mrem/year per $\mu Ci/sec$). | 2.2.2.b |
| r | = fraction of deposited activity retained on feed grass (dimensionless) (1.0 for radioiodines; 0.2 for particulates). | 2.2.2.b |
| $r_s$ | = monitor reading per mrem/year to the skin for the Gaseous Radwaste System, Containment Purge, or Air Room Purge. | 2.1.3.1 |
| $r_t$ | = monitor reading per mrem/year to the total body for the Gaseous Radwaste System, Containment Purge, or Air Room Purge. | 2.1.3.1 |
| SF | = shielding factor, 0.7 (dimensionless). | 2.2.2.b |
| t | = exposure time, $4.73 \times 10^8$ sec (15 years). | 2.2.2.b |
| $t_f$ | = transport time from pasture to goat, to milk, to receptor (sec). | 2.2.2.b |

## 2.3 DEFINITIONS OF GASEOUS EFFLUENTS PARAMETERS (Continued)

| Term | Definition | Section of Initial Use |
|---|---|---|
| $t_h$ | = transport time from pasture to harvest, to goat, to milk, to receptor (sec). | 2.2.2.b |
| $t_\ell$ | = average time between harvest of leafy vegetation and its consumption (sec). | 2.2.2.c |
| $U_{ap}$ | = receptor's milk or meat consumption rate for age group a (liters/year) from Table 2.2-10. | 2.2.2.b |
| $U_{as}$ | = consumption rate of stored vegetation by the receptor in age group a (kg/year) from Table 2.2-10. | 2.2.2.c |
| $U_{a\ell}$ | = consumption rate of fresh leafy vegetation by the receptor in age group a (kg/year) from Table 2.2-10. | 2.2.2.c |
| $W'_p$ | = pathway-dependent relative concentration or relative deposition for unrestricted areas of the controlling receptor ($sec/m^3$ or $m^{-2}$). | 2.2.2.b |
| X/Q | = relative concentration concurrent with actual release ($sec/m^3$). | 2.2.2.c |

## 2.3 DEFINITIONS OF GASEOUS EFFLUENTS PARAMETERS (Continued)

| Term | Definition | Section of Initial Use |
|---|---|---|
| $\overline{X/Q}$ | = highest annual average relative concentration at or beyond the site boundary (sec/m$^3$). | 2.1.1 |
| $(\overline{X/Q})_G$ | = highest annual average relative concentration for a ground-level release type (sec/m$^3$). | 2.1.1 |
| $(\overline{X/Q})_M$ | = highest annual average concentration for a mixed-mode release type (sec/m$^3$). | 2.1.1 |
| $(\overline{X/Q'})$ | = annual average relative concentration for location of controlling (critical) receptor for inhalation and all tritium pathways (sec/m$^3$). | 2.2.2.b |
| $(\overline{X/Q'})_G$ | = annual average relative concentration for location of controlling (critical) receptor for inhalation and all tritium pathways for a ground-level release type (sec/m$^3$). | 2.2.2.b |
| $(\overline{X/Q'})_M$ | = annual average relative concentration for location of controlling (critical) receptor for inhalation and all tritium pathways for a mixed-mode release type (sec/m$^3$). | 2.2.2.b |
| $Y_p$ | = agricultural productivity by unit area of pasture feed grass (kg/m$^2$). | 2.2.2.b |

## 2.3 DEFINITIONS OF GASEOUS EFFLUENTS PARAMETERS (Continued)

| Term | Definition | Section of Initial Use |
|---|---|---|
| $Y_s$ | = agricultural productivity by unit area of stored feed ($kg/m^2$). | 2.2.2.b |
| $Y_v$ | = vegetation area density ($kg/m^2$). | 2.2.2.d |
| $\lambda_i$ | = decay constant for the ith radionuclide ($sec^{-1}$). | 2.2.2.b |
| $\lambda_w$ | = decay constant for removal of activity on leaf and plant surfaces by weathering ($5.73 \times 10^{-7}$ $sec^{-1}$) (corresponding to a 14 day half-life). | 2.2.2.b |

## 2.4 GASEOUS RADWASTE TREATMENT SYSTEM

Figures 2.4-1, 2.4-2 and 2.4-3 present minimum OPERABLE Gaseous Radwaste Treatment System and Ventilation System.

FIGURE 2.4-1

GASEOUS RADWASTE TREATMENT AND VENTILATION SYSTEMS

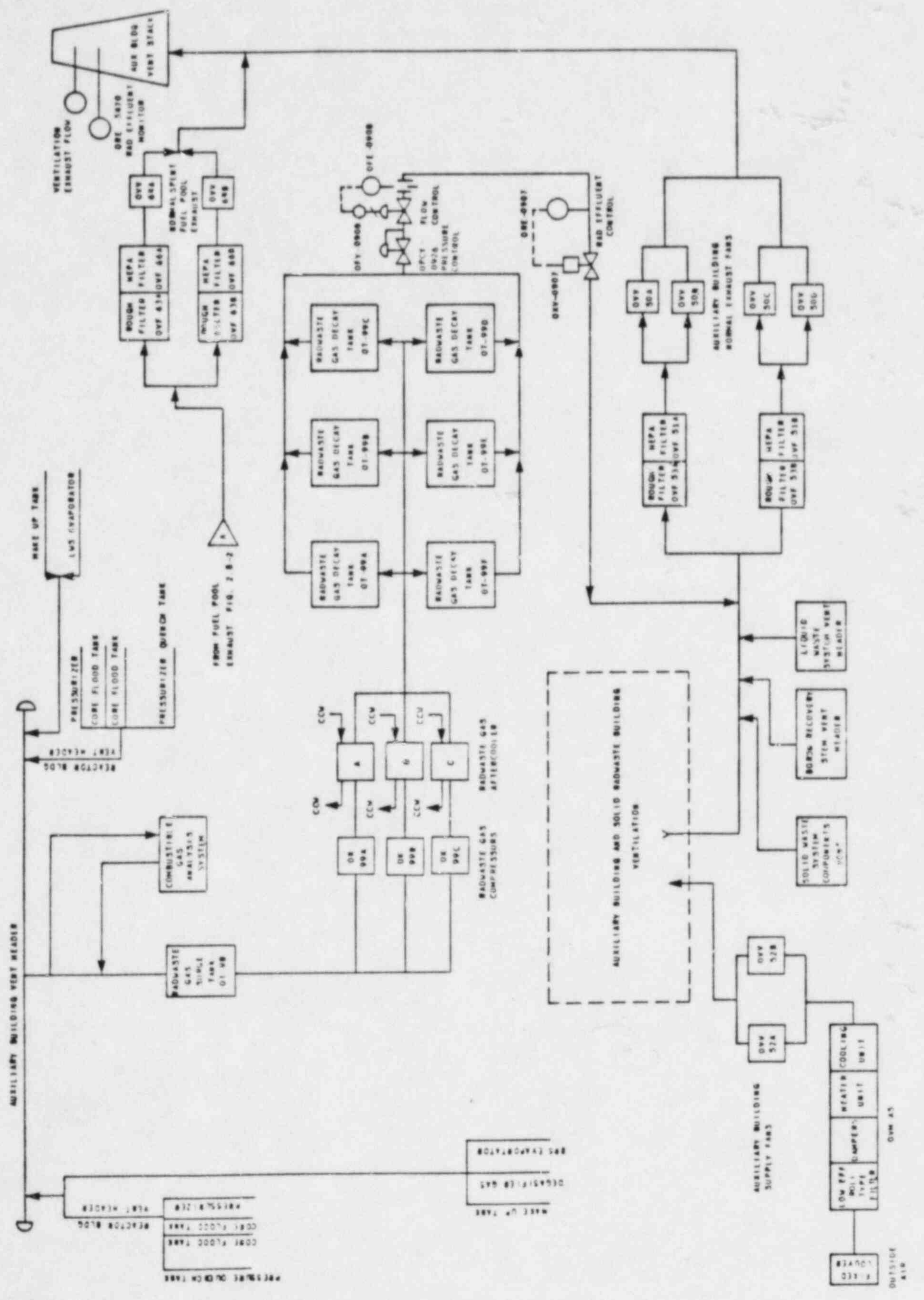


FIGURE 2.4-2

GASEOUS RADWASTE TREATMENT AND VENTILATION SYSTEMS

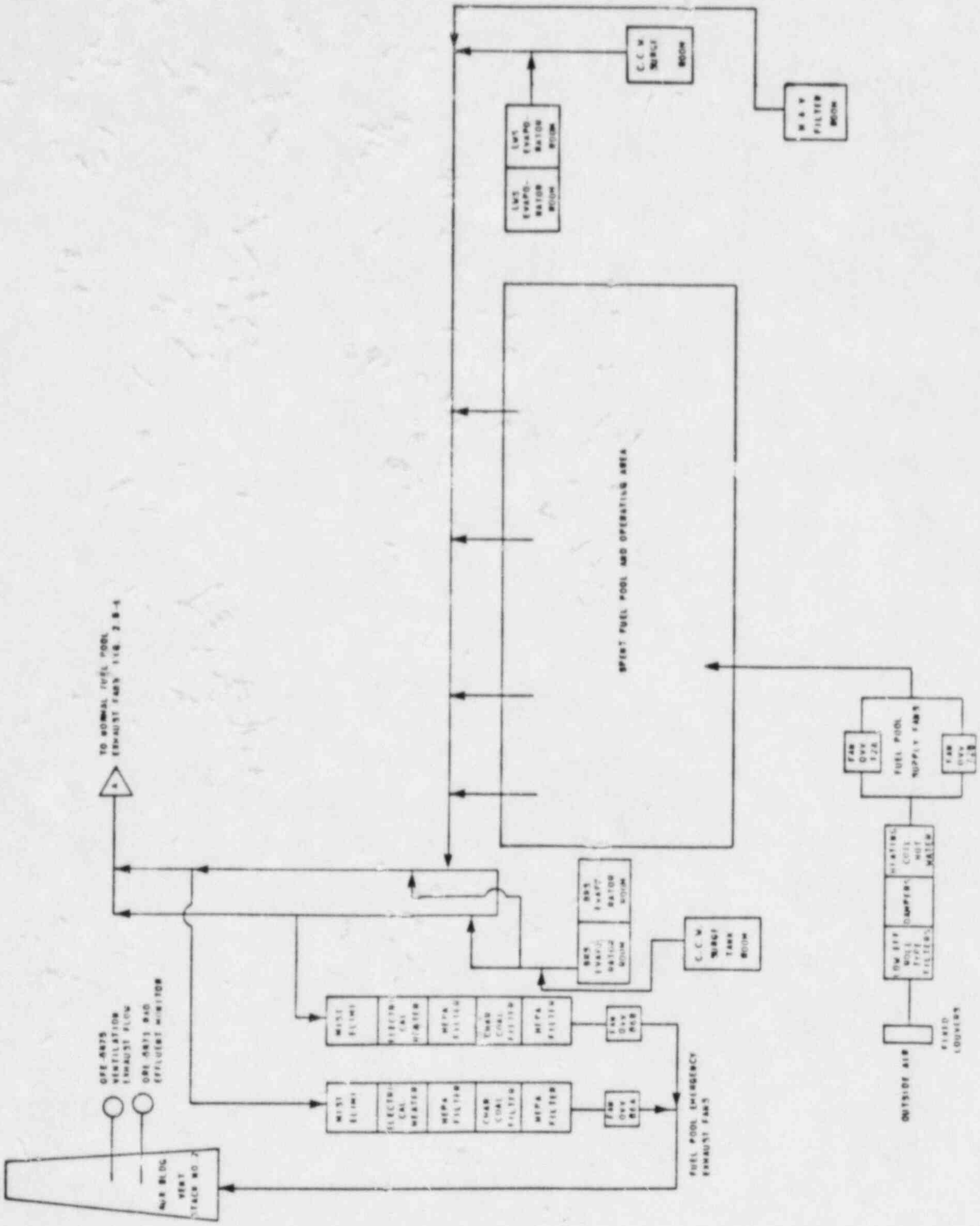
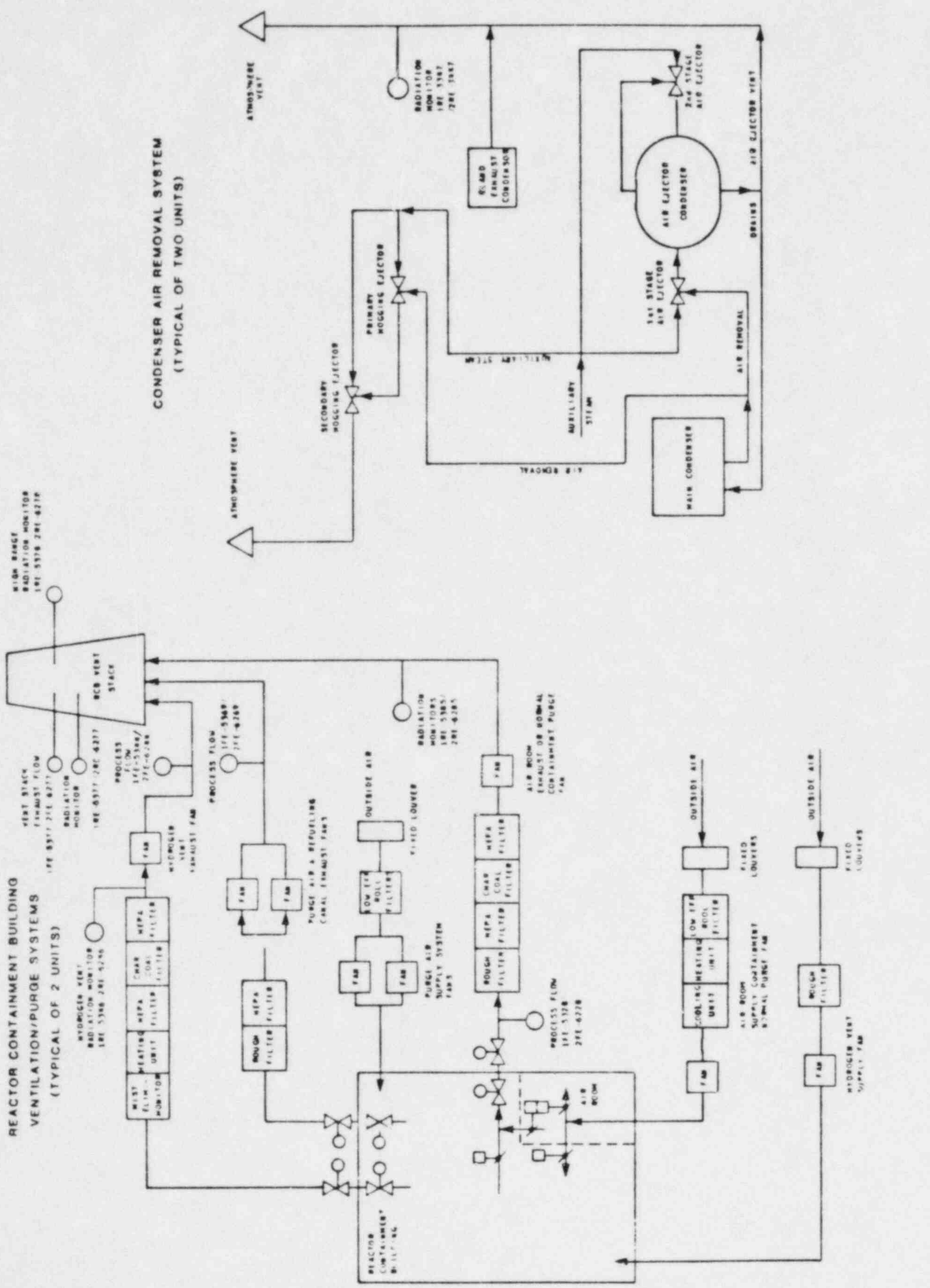


FIGURE 2.4-3

GASEOUS RADWASTE TREATMENT AND VENTILATION SYSTEMS



## 3.0 RADIOLOGICAL ENVIRONMENTAL MONITORING

Sampling locations as required in TS 3/4.12.1 are described in Table 3.0-1 and shown on the maps in Figures 3.0-1 and 3.0-2.

NOTE: For the purpose of implementing TS 3.12.2, sampling locations will be modified as required to reflect the findings of the Land Use Census.

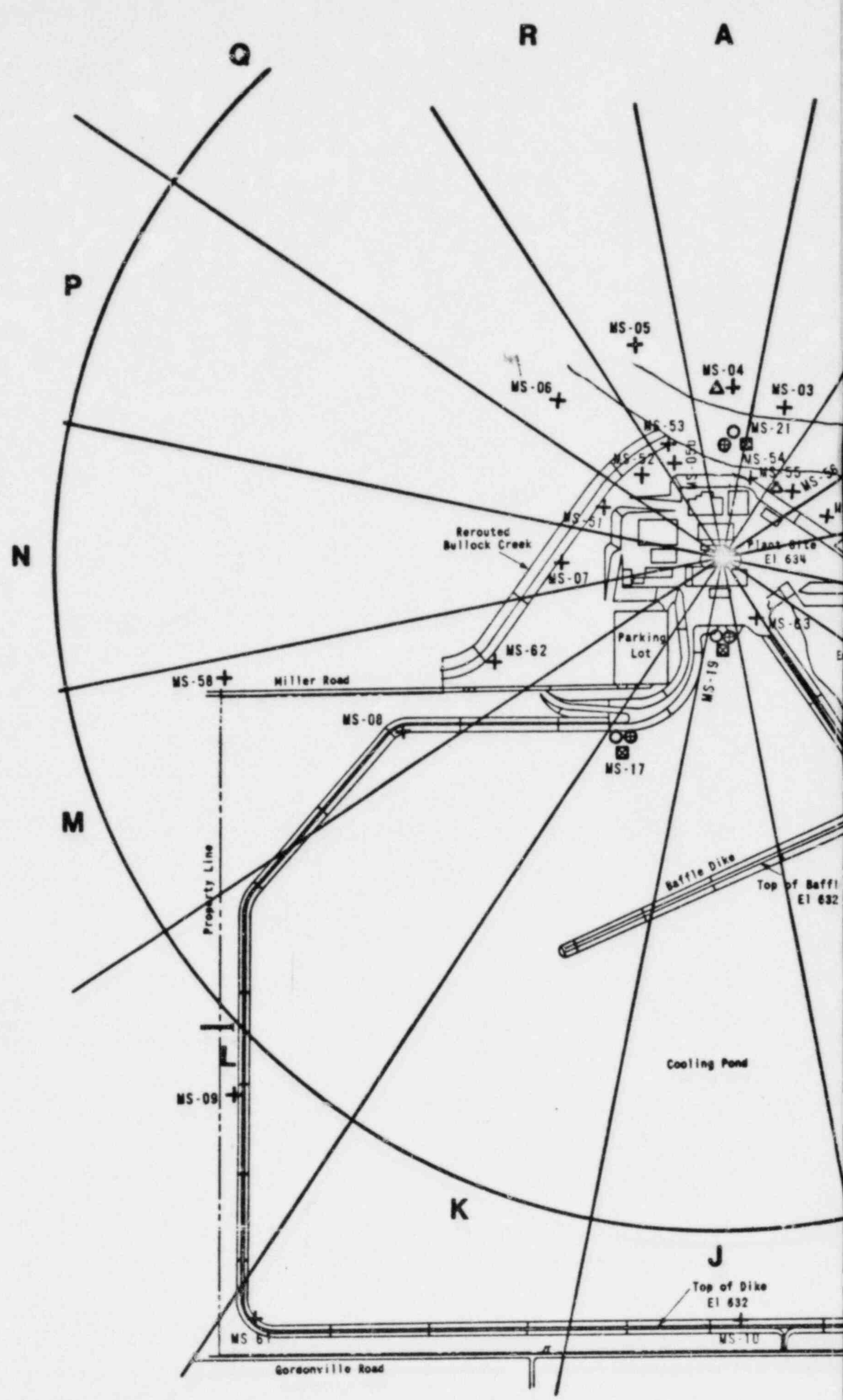
TABLE 3.0-1

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

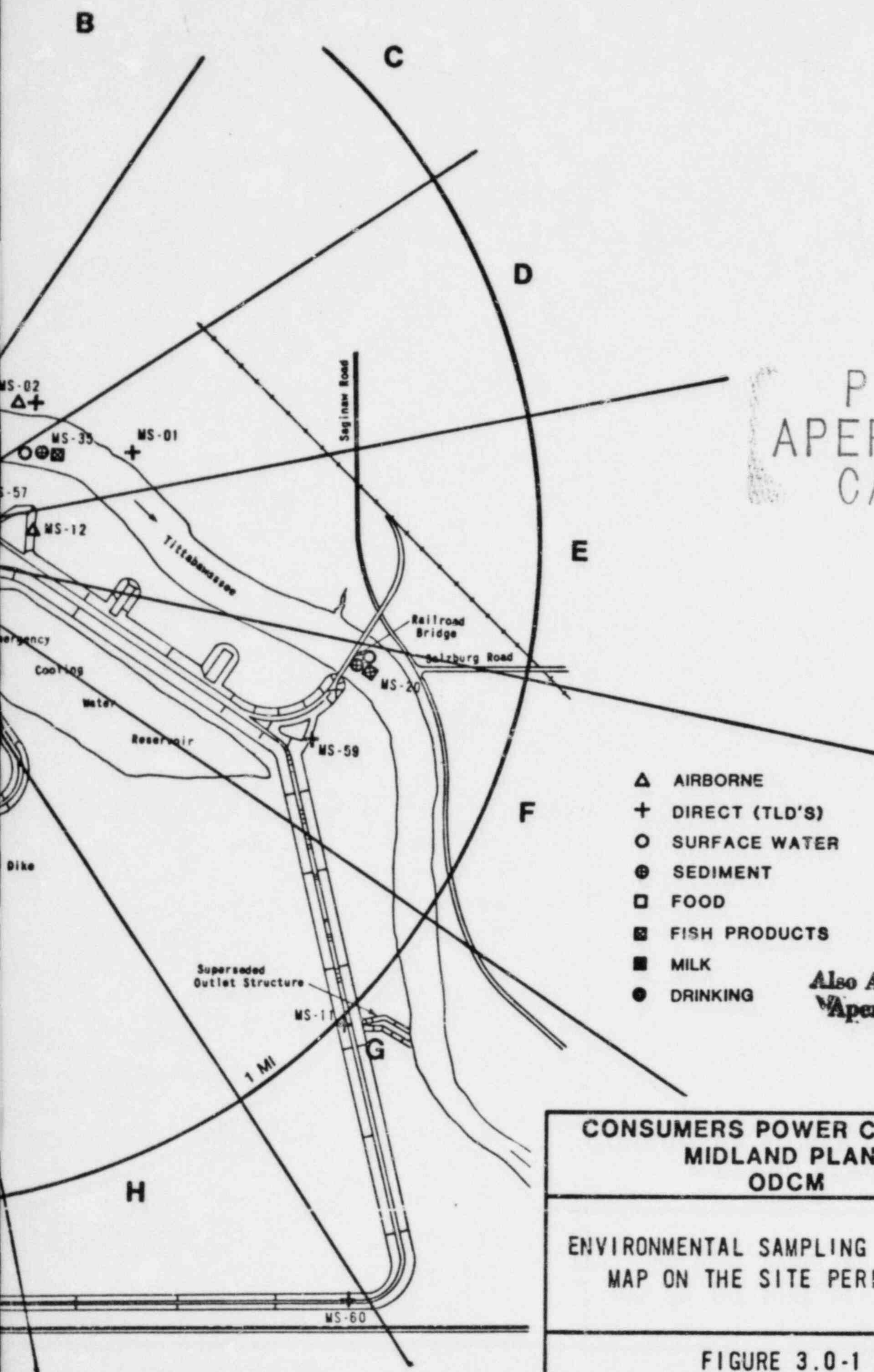
| Exposure Pathway and/or Sample | Number of Samples & Sample Locations | Sampling & Collection Frequency | Type & Frequency of Analysis |
|---|---|---|---|
| Airborne | | | |
| Radioiodine and Particulate | 5 - N, NE, E Sectors within 1000 meters<br>N Sector 2-3 miles<br>S Sector 10-20 miles | Continuous sampling at approximately 1 cfm with weekly collection. Sample size approximately 285 $m^3$. | Radioiodine cartridge: weekly for I-131. Particulate filter: Gross beta weekly, gamma isotopic quarterly on composites by location. |
| Direct Radiation | 40 Stations | Continuous dose accumulation by two (or more) thermo-luminescent dosimeters per location. | Gamma dose quarterly. |
| Waterborne | | | |
| Surface | 2 - Tittabawassee River upstream and downstream of the discharge. | Composite of weekly grab samples over a one-month period. | Gamma isotopic analysis monthly, tritium analysis quarterly. |
| Drinking | 2 - Midland and Bay City water supplies. | Composite sample over a one-month period. | Gross beta and gamma isotopic monthly, tritium analysis quarterly. |
| Aquatic | | | |
| Sediment | 2 - Vicinity of Intake and discharge. | Semiannual collection on the discharge side of the river. | Gamma isotopic analysis semiannually. |
| Ingestion | | | |
| Milk | 3 - ≤ 3 Miles(1) | At least once(2) per 31 days during the months May-October inclusive. | Gamma Isotopic including I-131 analysis of each sample. |
| Food Products | 3 - NE Quadrant < 3 miles<br>1 - S Sector 10-20 miles | Collection of broadleaf vegetation monthly during the third quarter, as available. | Gamma isotopic and I-131 on edible portion only. |
| Fish | 2 - Tittabawassee River upstream and downstream of discharge. | Semiannual collection as available. | Gamma isotopic on edible portion only. |

(1) If 3 samples are not available within 3 miles, will use nearest available 3 samples within 5 miles.

(2) Milk monitoring is not required if the dose due to the broadleaf vegetation pathway is more limiting or the dose from the milk ingestion pathway is ≤ 1.0 mrem/year.



Q
R
A
P
N
M
L
K
J
MS-05
MS-04
MS-03
MS-06
MS-53
MS-21
MS-52
MS-54
MS-51
Rerouted Bullock Creek
MS-07
Plant Site El 634
MS-62
Parking Lot
MS-19
MS-58
Miller Road
MS-08
MS-17
Property Line
Baffle Dike
Cooling Pond
MS-09
Top of Dike El 632
MS 61
MS-10
Goresnville Road



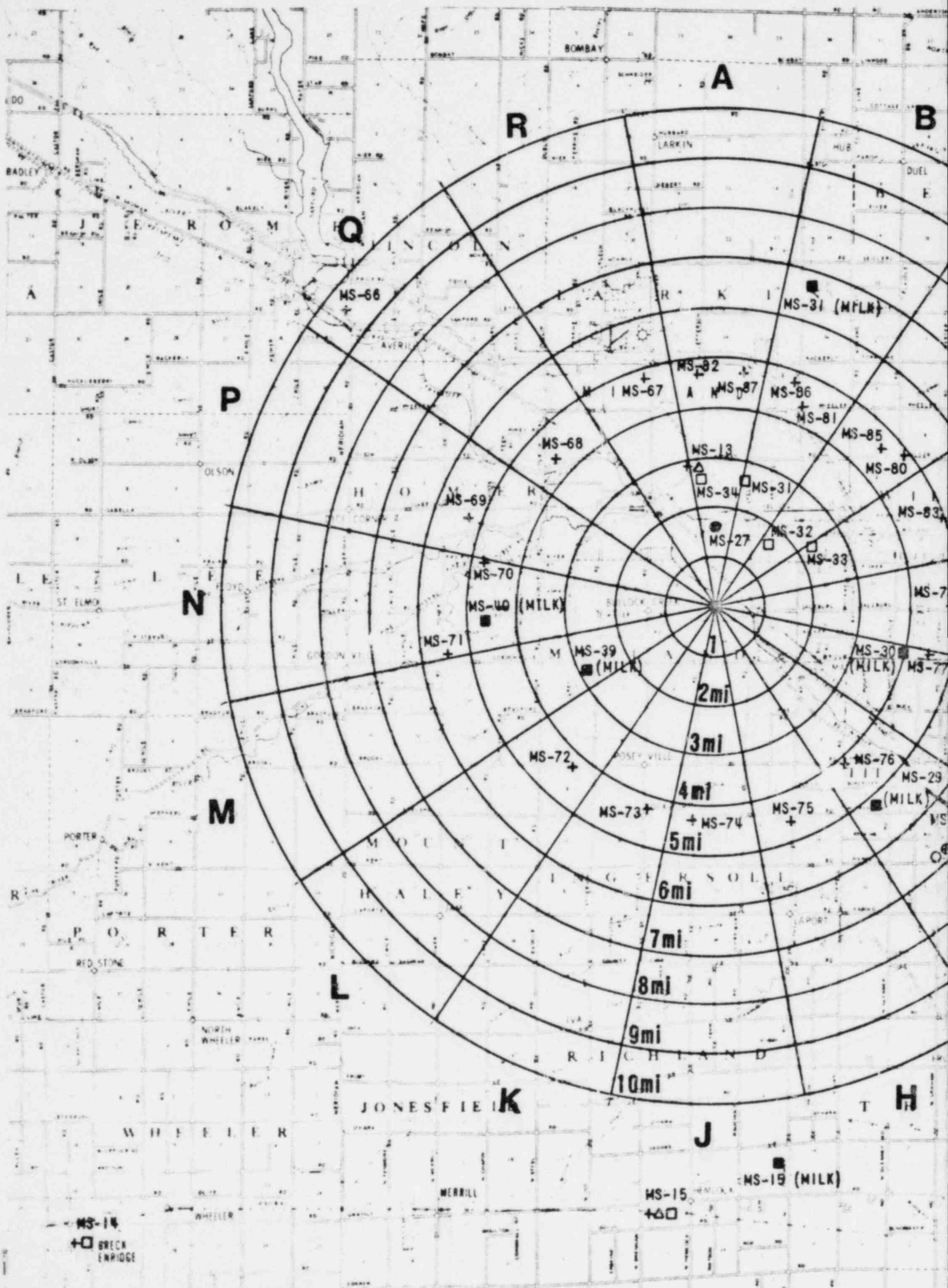

PRC APERTURE CARD

Also Available On Aperture Card

**CONSUMERS POWER COMPANY**
**MIDLAND PLANT**
**ODCM**

ENVIRONMENTAL SAMPLING LOCATION MAP ON THE SITE PERIPHERY

FIGURE 3.0-1



BOMBAY
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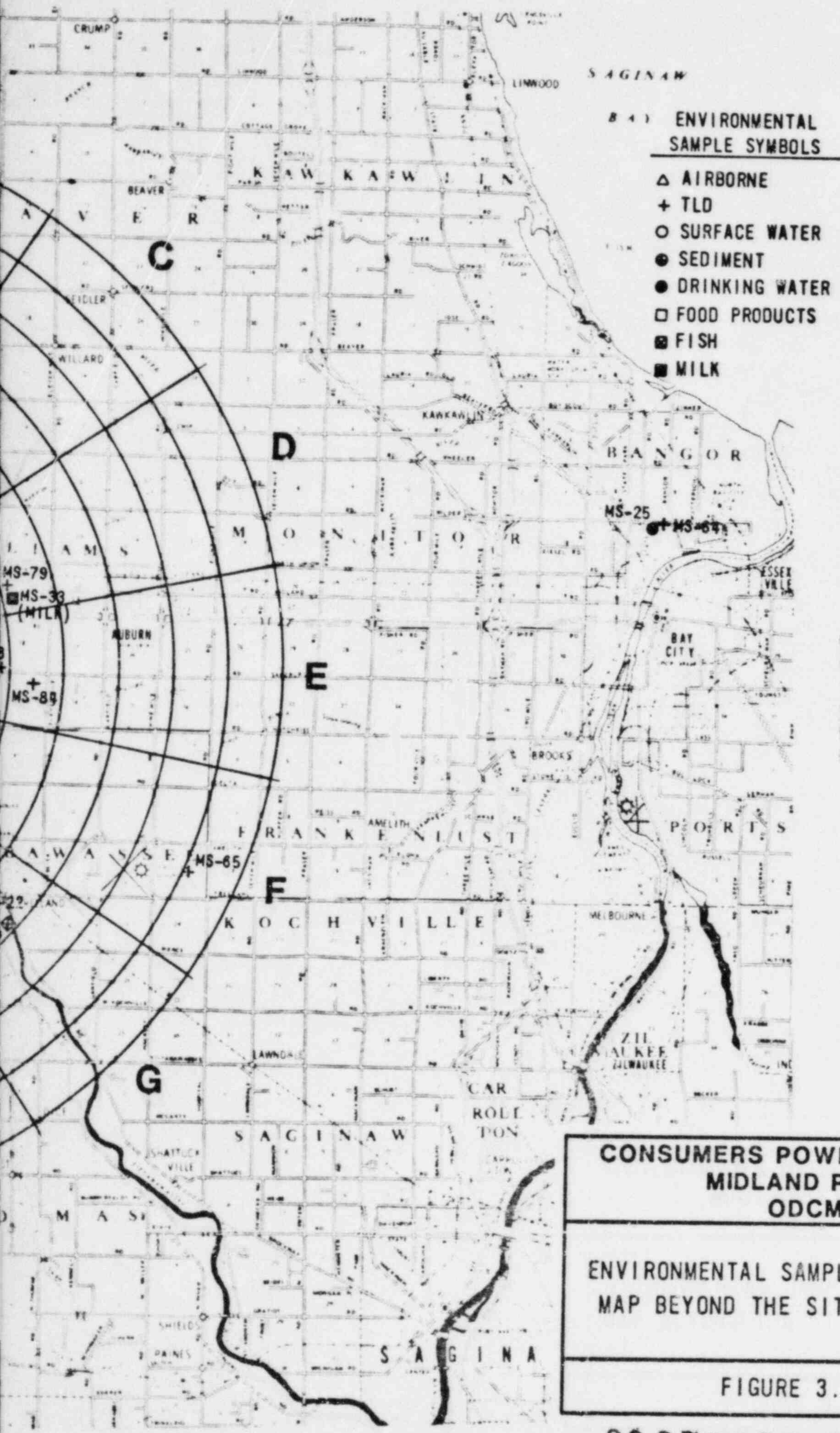
BADLEY
OLSON
ST. ELMO
PORTER
RED STONE
NORTH WHEELER
WHEELER
MERRILL
JONESFIEL
AVERILL
POSEY VILLE
LAPORT
IVA
MS-66
MS-31 (MILK)
MS-82
MS-67
MS-87
MS-86
MS-81
MS-85
MS-80
MS-68
MS-13
MS-34
MS-31
MS-69
MS-83
MS-27
MS-32
MS-33
MS-70
MS-40 (MILK)
MS-71
MS-39 (MILK)
MS-30 (MILK)
MS-77
MS-72
MS-76
MS-29 (MILK)
MS-73
MS-74
MS-75
MS-19 (MILK)
MS-15
MS-14
BRECK ENRIDGE
1
2mi
3mi
4mi
5mi
6mi
7mi
8mi
9mi
10mi




PRC APERTURE CARD

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**MIDLAND PLANT**
**ODCM**

ENVIRONMENTAL SAMPLING LOCATION MAP BEYOND THE SITE VICINITY

FIGURE 3.0-2

TABLE 3.0-2

Midland
Radiological Environmental
Monitoring Program Sample
Locations

| Number | Approximate Location | Samples |
|---|---|---|
| MS-01 | ~2400 ft ENE, power pole near SE corner of Dow perimeter fence | TLDs |
| MS-02 | ~1750 ft NE, 4th power pole E of corner in Dow perimeter fence | TLDs, Airborne |
| MS-03 | ~1350 ft NNE, instrument bracket on Dow tertiary feed pipe | TLDs |
| MS-04 | ~1350 ft N, power pole near N end of steam pipe bridge to Dow | TLDs, Airborne |
| MS-05 | ~2250 ft NNW, power pole near fork in road, S of Dow Bldg 1005 | TLDs |
| MS-05b | ~900 ft NNW of Mech Shop | TLDs |
| MS-06 | ~2500 ft NW, guard post on N Dow tertiary pond dike | TLDs |
| MS-07 | ~1200 ft W, base of site Meteorological tower | TLDs |
| MS-08 | ~2900 ft WSW, corner fence post near NW corner of pond dike | TLDs |
| MS-09 | ~5900 ft SW, corner fence post near where pond fence drops off dike, Wells #14 and #15 on SW pond dike | TLDs |
| MS-10 | ~6250 ft S, near Well #12 on S pond dike, Wells 11, 12 & 13 on S pond dike | TLDs |
| MS-11 | ~5400 ft SE, on rail of pond outlet structure on E pond dike | TLDs |
| MS-12 | ~1150 ft E, on SE leg of 138 kV transmission tower, Wells 1, 2 & 3 on the N pond Dike and the site dewatering discharge | TLDs, Airborne |

TABLE 3.0-2
(Contd)

| Number | Approximate Location | Samples |
|---|---|---|
| MS-13 | ~2.5 mi N, Ashman Circle Substation | TLDs, Arborne |
| MS-14 | ~18 mi SW, Breckenridge Substation (Vegetation G-15, G-14, G-13)* | TLDs, Vegetation |
| MS-15 | ~12 mi S, Hemlock Substation (Vegetation G-1, G-12)* (Milk-cow herd) | Vegetation Milk |
| MS-16 | TLD - QC Sample (Dummy floating location) | TLDs |
| MS-17 | SSE, Cooling Pond - Unit 1 & 2 Discharge Side | Surface water, Sediment, Fish |
| MS-18 | ESE, Cooling pond - Service Water Intake | Surface water, Sediment, Fish |
| MS-19 | S, Cooling pond - Circulating Water Intake | Surface water, Sediment, Fish |
| MS-20 | ESE, River - Railroad bridge | Surface water, Sediment, Fish |
| MS-21 | NNE, River - Makeup Screenhouse Intake | Surface water, Sediment, Fish |
| MS-22 | SE, River - Freeland Road Bridge | Surface water, Sediment, Fish |
| MS-23 | Presently not in use | |
| MS-24 | Presently not in use | |
| MS-25 | E, Bay City Drinking Water Supply, at Wilder Rd Service Center | Drinking Water |
| MS-26 | Drinking Water Supply, QC Sample | Drinking Water |
| MS-27 | N, Midland City Drinking Water Suppy at Washington St Service Center | Drinking Water, (TLDs Storage Area) |
| MS-28 | E Sector (May sample several locations, specify type of sample and exact location under Remarks) | Milk |

*Garden sample numbers

TABLE 3.0-2
(Contd)

| Number | Approximate Location | Samples |
|---|---|---|
| MS-29 | SE Sector (Milk - 2 goats) | Milk |
| MS-30 | ESE Sector (Milk - 1 cow) | Milk |
| MS-31 | NNE Sector (Vegetation G-4, G-7, and G-11)* (Milk - cow herd) | Milk, Vegetaton |
| MS-32 | NE Sector (Vegetation G-2, G-3)* | Vegetation |
| MS-33 | ENE Sector (Vegetation G-5, G-6)* (milk - 3 goats) | Milk, Vegetation |
| MS-34 | N Sector (Vegetation G-8, G-9, and G-10)* | Milk, Vegetation |
| MS-35 | NE, River - Plant Discharge | Surface water, Sediment, Fish |
| MS-36 | Presently not in use | |
| MS-37 | Presently not in use | |
| MS-38 | Presently not in use | |
| MS-39 | Presently not in use | |
| MS-40 | W Sector (Milk - 1 cow) | Milk |
| MS-41 | Presently not in use | |
| MS-42 | Presently not in use | |
| MS-43 | Presently not in use | |
| MS-44 | Presently not in use | |
| MS-45 | Presently not in use | |
| MS-46 | Surface water QC sample | |
| MS-47 | QC sample | |
| MS-48 | Vegetation QC sample | |
| MS-50 | Fish or sediment QC sample | |
| MS-51 | 1000' WNW/rear of equipment parking lot | TLD |

*Garden sample numbers

TABLE 3.0-2
(Contd)

| Number | Approximate Location | Samples |
|---|---|---|
| MS-52 | 1000' NW/steam bridge fence near Bullock Creek and Tittabawassee Rivers | TLD |
| MS-53 | 1000' NNW/just west of screenhouse | TLD |
| MS-54 | 800' N/near screenhouse | TLD |
| MS-55 | 900' NNE/near screenhouse | TLD |
| MS-56 | 1000' ENE/near screenhouse | TLD, Airborne |
| MS-57 | 1000' ENE/west of dump | TLD |
| MS-58 | 4200' WSW/guard house fence Main gate | TLD |
| MS-59 | 4000' ESE/railroad spur just off pond dike road | TLD |
| MS-60 | 6200' SSE/pond dike south of blowdow area | TLD |
| MS-61 | 1000' SSW/pond dike southwest corner of pond | TLD |
| MS-62 | 2000' WSW/guard parking lot fence near propane truck filling area | TLD |
| MS-63 | 600' SE/north end of baffle dike | TLD |
| MS-64 | 15-20 mi/Bay City Service Center parking lot, southwest corner | TLD |
| MS-65 | Tri-City airport, roof of FAA Building | TLD |
| MS-66 | Sanford DNR Station | TLD |
| MS-67 | 4 mi NNW/Larkin Substation, Eastman Road past Wheeler Road | TLD |
| MS-68 | 4 mi NW/4 mi north of Northwood Institute on W Main | TLD |
| MS-69 | 4 mi WNW/at Metro TV & Appliance on M-20 between Homer and Sandow | TLD |
| MS-70 | 4 mi W/corner of Pine River Road and Parrie | TLD |

TABLE 3.0-2
(Contd)

| Number | Approximate Location | Samples |
|---|---|---|
| MS-71 | 4.5 mi WSW/corner of Gordonville and Homwer Road | TLD |
| MS-72 | 4.5 mi SW/on Brooks in front of house #2242 | TLD |
| MS-73 | 4.8 mi SSW/Freeland x Poseyville Road | TLD |
| MS-74 | 4.5 mi S/corner of Freeland x Sasse | TLD |
| MS-75 | 4.8 mi SSE/corner of Freeland Road and Smith | TLD |
| MS-76 | 4.5 mi SE/corner of Brooks and Orr | TLD |
| MS-77 | 4.8 mi ESE/corner of Hotchkiss and M-47 | TLD |
| MS-78 | 4.2 mi E/corner of Carter and Salzburg | TLD |
| MS-79 | 4.2 mi ENE/corner of Carter and Midland Road | TLD |
| MS-80 | 4.3 mi NE/corner Wilder and Flajole | TLD |
| MS-81 | 4 mi NNE/corner of Waldo and Wheeler | TLD |
| MS-82 | 5 mi N/corner of Jefferson and Wackerly | TLD |
| MS-83 | 4.5 mi ENE/north on Carter next to railroad tracks | TLD |
| MS-84 | 4.6 mi E/one-half mi east past Carter on Salzburg | TLD |
| MS-85 | 4.1 mi NE/west of Flajole on Wilder | TLD |
| MS-86 | 4.5 mi NNE/Waldo 1/2 mi north of US-10 | TLD |
| MS-87 | 4.7 mi N/corner of Swede and US-10 | TLD |

Consumers Power Company

James W Cook
*Vice President - Projects, Engineering and Construction*

General Offices: 1945 West Parnall Road, Jackson, MI 49201 • (517) 788-0453

June 23, 1983

Harold R Denton, Director
Office of Nuclear Reactor Regulation
Division of Licensing
US Nuclear Regulatory Commission
Washington, DC 20555

MIDLAND ENERGY CENTER PROJECT
MIDLAND DOCKET NOS 50-329, 50-330
OFFSITE DOSE CALCULATION MODEL
FILE 0973/0505.20 SERIAL 22018

ENCLOSURES Sixty Copies of the Midland Plant Offsite Dose Calculation Manual

Enclosed are sixty (60) copies of Consumers Power Company's Midland Plant Offsite Dose Calculation Manual for NRC Staff review and approval. The Midland Plant Offsite Dose Calculation Manual is submitted pursuant to Section 3.6 of "The Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants," NUREG-0133.

James W. Cook

JWC/JMT/fms

CC RJCook, Midland Resident Inspector
DSHood, US NRC
DBMiller, Midland Construction (w/o)
DRHoffman, US NRC

A009
1/26

oc0483-1732a131

CONSUMERS POWER COMPANY
Midland Units 1 and 2
Docket No 50-329, 50-330

Letter Serial 22018 Dated June 23, 1983

At the request of the Commission and pursuant to the Atomic Energy Act of 1954, and the Energy Reorganization Act of 1974, as amended and the Commission's Rules and Regulations thereunder, Consumers Power Company submits the Midland Plant Offsite Dose Calculation Manual. This information is also submitted pursuant to Section 3.6 of NUREG-0133.

CONSUMERS POWER COMPANY

By JW Cook
J W Cook, Vice President
Projects, Engineering and Construction

Sworn and subscribed before me this 27 day of June 1983 .

Barbara P. Townsend
Notary Public
Jackson County, Michigan

My Commission Expires September 8, 1984

oc0483-1732a131