

CONSUMERS POWER COMPANY  
BIG ROCK POINT PLANT  
DRAFT OFFSITE DOSE CALCULATION MANUAL  
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## 1. Gaseous Effluents

### 1.1 Alarm/Trip Setpoints

Specification 3.11.2.1 requires that the dose rate in unrestricted areas due to gaseous effluents from the site shall be limited at all times to the following values:

1. 500 mrem/y to the total body and 3,000 mrem/y to the skin from noble gases.
2. 1,500 mrem/y to any organ from radioiodines and particulates.

Specification 3.3.3.10 requires gaseous effluent monitors to have alarm/trip setpoints to ensure that the above dose rates are not exceeded. This section of the ODCM describes the methodology that will be used to determine these setpoints.

The methodology for determining alarm/trip setpoints is divided into two major parts. The first consists of backcalculating from a dose rate to a release rate limit, in  $\mu\text{Ci/s}$ , for each nuclide and release point. The second consists of using the release rate limits to determine the physical settings on the monitors.

#### 1.1.1 Release Rate Limit Methodology - $\mu\text{Ci/s}$

##### Step 1

The first step involves calculating a dose rate based on the design objective source term mix used in Appendix I licensing calculations. Historical meteorological data used in licensing are also used in this calculation. Doses are determined for (1) noble gases and (2) iodines and particulates. Depending on the pathway involved, either air concentrations or ground concentrations are calculated.

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- A. Equations and assumptions for calculating doses from noble gases are as follows:

Assumptions

1. Doses to be calculated are total body and skin.
2. Exposure pathway is submersion within a cloud of noble gases.
3. Noble gas radionuclide mix is based on the historically observed source term given in Table 1.1.
4. Basic radionuclide data are given in Table 1.2.
5. All releases are treated as elevated.
6. Meteorological data are expressed as a joint-frequency distribution of wind speed, wind direction, and atmospheric stability for the period (Table 1.3).
7. Raw meteorological data consist of wind speed and direction measurements at 256 ft and temperatures at 50 ft and 250 ft.
8. Dose is to be evaluated at the offsite exposure point where maximum concentrations are expected to exist.
9. Potential maximum-exposure points are identified in Table 1.4.
10. A semi-infinite cloud model is used.
11. credit is taken for shielding by residence (factor of 0.7).
12. Plume depletion and radioactive decay are considered.
13. A sector-average dispersion equation is used.
14. The wind speed classes that are used are as follows:

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<u>Wind Speed Number</u>	<u>Range (m/s)</u>	<u>Midpoint (m/s)</u>
1	<0.3	0.13
2	0.3-0.6	0.45
3	0.7-1.5	1.10
4	1.6-2.4	1.99
5	2.5-3.3	2.80
6	3.4-5.5	4.45
7	5.6-8.2	6.91
8	>10.9	13.00

15. The stability classes that will be used are the standard A through G classifications. The stability classes 1-7 will correspond to A=1, B=2, . . . , G=7.
16. Terrain effects are not considered.

#### Equations

To calculate the dose for any one of the 16 potential maximum-exposure points, the following equations are used.

For determining the air concentration of any radionuclide:

$$X_i = \sum_{j=1}^9 \sum_{k=1}^7 \left( \frac{z}{z_0} \right)^{1/2} \frac{f_{jk} Q_i}{\sigma_{zk} u_j (2-x/n)} \exp \left( -\lambda_i \frac{x}{u_j} \right) \quad (1.1)$$

where

$X_i$  = air concentration of radionuclide  $i$ ,  $\mu\text{Ci}/\text{m}^3$

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

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$Q_1$  = average release rate of radionuclide 1,  $\mu\text{Ci/s}$ .

$p$  = fraction of radionuclide remaining in plume.

$\sigma_{zk}$  = vertical dispersion coefficient for stability  
class k (m)

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

$x$  = downwind distance, m.

$n$  = number of sectors, 16.

$\lambda_1$  = radioactive decay coefficient of radionuclide 1,  $\text{s}^{-1}$ .

$2\pi x/n$  = sector width at point of interest, m.

For determining the total body dose rate

$$D_{TB} = \sum_1 X_1 DFB_1 \quad (1.2)$$

where

$D_{TB}$  = total body dose rate, mrem/y.

$X_1$  = air concentration of radionuclide 1,  $\mu\text{Ci/m}^3$ .

$DFB_1$  = total body dose factor due to gamma radiation, mrem/y  
per  $\mu\text{Ci/m}^3$  (Table 1.5).

For determining the skin dose rate

$$D_s = \sum_1 X_1 [DFS_1 + 1.11 DFY_1] \quad (1.3)$$

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where

$D_s$  = skin dose rate, mrem/y.

$X_1$  = air concentration of radionuclide 1,  $\mu\text{Ci}/\text{m}^3$ .

$\text{DFS}_1$  = skin dose factor due to beta radiation, mrem/y per  $\mu\text{Ci}/\text{m}^3$  (Table 1.5).

1.11 = the average ratio of tissue to air energy absorption coefficients, mrem/mrad.

$\text{DFY}_1$  = gamma-to-air dose factor for radionuclide 1, mrad/y per  $\mu\text{Ci}/\text{m}^3$  (Table 1.5).

B. Equations and assumptions for calculating doses from radioiodines and particulates are as follows:

Assumptions

1. Dose is to be calculated for the critical organ, thyroid, and the critical age groups, infant (milk) and child (green, leafy vegetables).
2. Exposure pathways from iodines and particulates are milk ingestion, ground contamination, green leafy vegetables from home gardens, and inhalation.
3. The radioiodine and particulate mix is based on the historically observed source term given in Table 1.1.
4. Basic radionuclide data are given in Table 1.2.
5. All releases are treated as elevated.
6. Annual average  $\chi/Q$ 's are given in Table 1.3.
7. Raw meteorological data for elevated releases consist of wind speed and direction measurements at 256' and temperature measurements at 50' and 250'.
8. Dose is to be evaluated at the potential offsite exposure points where maximum doses to man are expected to exist.
9. Real cow, goat and garden locations are considered.
10. Potential maximum exposure points (Table 1.4) considered are the nearest cow, goat and home garden locations in each sector.

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11. Terrain effects are not considered.
12. Building wake effects on effluent dispersion are considered.
13. Plume depletion and radioactive decay are considered for air-concentration calculations.
14. Radioactive decay is considered for ground-concentration calculations.
15. Deposition is calculated based on the curves given in Figure 1.1.
16. Milk cows and goats obtain 100% of their food from pasture grass May through October of each year.
17. Credit is taken for shielding by residence (factor of 0.7).

#### Equations

To calculate the dose for any one of the potential maximum-exposure points, the following equations are used.

##### 1. Inhalation -

Equation for calculating air concentration,  $\chi$ , is the same as in the Noble Gas Section, 1.1.1.A.

For determining the organ dose rate:

$$D_I = 1 \times 10^6 \sum_i \chi_i DFI_i ER \quad (1.4)$$

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where:

$D_I$  = Organ dose rate due to inhalation, mrem/y.

$\chi_i$  = air concentration of radionuclide i,  $\mu\text{Ci}/\text{m}^3$ .

$\text{DFI}_i$  = inhalation dose factor, mrem/pCi (Table 1.7).

BR = breathing rate  $1400 \text{ m}^3/\text{y}$ , infant;  $3700 \text{ m}^3/\text{y}$ , child; or  $8000 \text{ m}^3/\text{y}$  adult.

$1 \times 10^6$  = pCi/ $\mu\text{Ci}$  conversion factor.

## 2. Ground Contamination

For determining the ground concentration of any nuclide:

$$C_i = 3.15 \times 10^7 \sum_{k=1}^7 \frac{f_k Q_i \text{DR}}{(2\pi x/n) \lambda_i} [1 - \exp -(\lambda_i t_b)] \quad (1.5)$$

where

$C_i$  = ground concentration of radionuclide i,  $\mu\text{Ci}/\text{m}^3$ .

$k$  = stability class.

$f_k$  = joint relative frequency of occurrence of winds in stability class  $k$  blowing toward this exposure point, expressed as a fraction.

$Q_i$  = average release rate of radionuclide i,  $\mu\text{Ci}/\text{s}$ .

DR = relative deposition rate,  $\text{m}^{-1}$  (Figure 1.1 for  $\text{DR}/2\pi\chi$ ).

$x$  = downwind distance, m.

$n$  = number of sectors, 16.

$2x/n$  = sector width at point of interest, m.

$\lambda_i$  = radioactive decay coefficient of radionuclide i,  $\text{y}^{-1}$ .

$t_b$  = time for buildup of radionuclides on the ground, 35y.

$3.15 \times 10^7$  = s/y conversion factor.

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For determining the total body or organ dose rate from ground contamination:

$$D_G = (8,760)(1 \times 10^6) \sum_1 G_1 DFC_1 \quad (1.6)$$

where:

$D_G$  = dose rate due to ground contamination, mrem/y.

$G_1$  = ground concentration of radionuclide 1,  $\mu\text{Ci}/\text{m}^2$ .

$DFC_1$  = dose factor for standing on contaminated ground, mrem/h per  $\text{pCi}/\text{m}^2$  (Table 1.8).

8,760 = occupation time, h/y.

$1 \times 10^6$  =  $\text{pCi}/\mu\text{Ci}$  conversion factor.

### 3. Milk Ingestion

For determining the concentration of any nuclide (except C-14 and H-3) in and on vegetation:

$$CV_1 = 3,600 \sum_{k=1}^7 \frac{f_k Q_1 DR}{(2\pi x/n)} \left( \frac{r[1-\exp(-\lambda_{E1} t_e)]}{Y_v \lambda_{E1}} + \frac{B_{iv} [1-\exp(-\lambda_1 t_b)]}{P \lambda_1} \right) \quad (1.7)$$

where:

$CV_1$  = concentration of radionuclide 1 in and on vegetation,  $\mu\text{Ci}/\text{kg}$ .

$k$  = stability class.

$f_k$  = frequency of this stability class and wind direction combination, expressed as a fraction.

$Q_1$  = average release rate of radionuclide 1,  $\mu\text{Ci}/\text{s}$ .

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DR = relative deposition rate,  $m^{-2}$  (Figure 1.1).

x = downwind distance, m.

n = number of sectors, 16.

$2\pi x/n$  = sector width at point of interest, m.

r = fraction of deposited activity retained on vegetation  
(1.0 for iodines, 0.2 for particulates).

$\lambda_{Ei}$  = effective removal rate constant,  $\lambda_{Ei} = \lambda_i + \lambda_w$ , where  $\lambda_i$  is the radioactive decay coefficient,  $h^{-1}$ , and  $\lambda_w$  is a measure of physical loss by weathering ( $\lambda_w = .0021 h^{-1}$ ),

$\tau_e$  = period over which deposition occurs, 720 h.

$Y_v$  = agricultural yield,  $0.7 kg/m^2$ .

$B_{iv}$  = transfer factor from soil to vegetation of radionuclide i (Table 1.9).

$\lambda_i$  = radioactive decay coefficient of radionuclide i,  $h^{-1}$ .

$\tau_b$  = time for buildup of radionuclides on the ground,  $3.07 \times 10^5$  h (35y).

P = effective surface density of soil,  $240 kg/m^2$ .

3,600 = s/h conversion factor.

For determining the concentration of C-14 in vegetation:

$$CV_{14} = 1 \times 10^3 X_{14} (0.11/0.16) \quad (1.8)$$

where

$CV_{14}$  = concentration of C-14 in vegetation,  $\mu Ci/kg$ .

$X_{14}$  = air concentration of C-14,  $\mu Ci/m^3$ .

0.11 = fraction of total plant mass that is natural carbon.

0.16 = concentration of natural carbon in the atmosphere,  
 $g/m^3$ .

$1 \times 10^3$  = g/kg conversion factor.

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For determining the concentration of H-3 in vegetation:

$$CV_T = 1 \times 10^3 X_T (0.75)(0.5/H) \quad (1.9)$$

where

$CV_T$  = concentration of H-3 in vegetation,  $\mu\text{Ci}/\text{kg}$ .

$X_T$  = air concentration of H-3,  $\text{Ci}/\text{m}^3$ .

0.75 = fraction of total plant mass that is water.

0.5 = ratio of tritium concentration in plant water to tritium concentration in atmospheric water.

H = absolute humidity of the atmosphere,  $\text{g}/\text{m}^3$ .

$1 \times 10^3$  = g/kg conversion factor.

For determining the concentration of any nuclide in cow's or goat's milk:

$$C_i^m = CV_i FM_i Q_f \exp(-\lambda_i t_f) \quad (1.10)$$

where

$C_i^m$  = concentration of radionuclide i (including C-14 and H-3) in milk,  $\mu\text{Ci}/\text{l}$ .

$CV_i$  = concentration of radionuclide i in and on vegetation,  $\mu\text{Ci}/\text{kg}$ .

$FM_i$  = transfer factor from feed to milk for radionuclide i, d/l (Table 1.6).

$Q_f$  = amount of feed consumed by the milk animal per day, kg/d.

$\lambda_i$  = radioactive decay coefficient of radionuclide i,  $\text{d}^{-1}$ .

$t_f$  = transport time of activity from feed to milk to receptor, 2 days.

For determining the organ dose rate from ingestion of green leafy vegetables and milk:

$$D = 1 \times 10^6 \sum_i C_i^m DF_i \text{ UM} \quad (1.11)$$

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where

- D = Organ dose rate due to ingestion, mrem/y.  
 $CM_i$  = concentration of radionuclide i in vegetables or milk,  $\mu\text{Ci/Kg}$   
 (or liters)  
 $DFG_i$  = ingestion dose factor, mrem/pCi (Table 1.7).  
 UM = ingestion rate for milk, 330 l/y; for vegetables 26 Kg/yr (child),  
 no ingestion by infant.  
 $1 \times 10^6$  = pCi/ $\mu\text{Ci}$  conversion factor.

#### 4. Organ Dose Rates

For determining the total thyroid dose rate from iodines and particulates:

$$D = D_I + D_G + D_M + D_V \quad (1.12)$$

where

- D = total organ dose rate, mrem/y.  
 $D_I$  = dose rate due to inhalation, mrem/y.  
 $D_G$  = dose rate due to ground contamination, mrem/y.  
 $D_M$  = dose rate due to milk ingestion, mrem/y.  
 $D_V$  = dose rate due to vegetable ingestion, mrem/y.  
 The maximum organ dose rate, maximum total body dose rate, and maximum skin dose rate calculated in this step will be used in step 2.

#### 5. Design Basis Quantities

The design basis quantity of a radionuclide emitted to the atmosphere is the amount of that nuclide, when released in one year, which would result in a dose not exceeding any of the following:

- a) 20 millirad beta dose in air at ground level beyond the site boundary from noble gas
- b) 10 millirad gamma dose in air at ground level beyond the site boundary from noble gas
- c) 15 millirem to any organ of an individual from iodines and particulates
- d) 15 millirem to skin of an individual from noble gas
- e) 5 millirem to the total body of an individual from noble gas

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Design basis quantities (Ci) are calculated by dividing the dose limits (a through e, above) by the appropriate dose calculated in step 1; the result then is multiplied by the amount of radionuclide (Ci) used to calculate the doses of step 1, as listed in Table 1.1:

$$DBQ = \frac{D_{AI}}{D_c} (C_c)$$

where

- $D_{AI}$  = Appendix I dose limit (mrem or mrad)
- $D_c$  = Calculated dose from step 1 (mrem or mrad)
- $C_c$  = Quantity of nuclide resulting in dose  $D_c$  (Ci) and
- DBQ = Design Basis Quantity (Ci)

Design Basis Quantities for radionuclide released to the atmosphere are given in Table 1.9.

The inverse of the ratio  $C_c/D_c$  in the above equation (i.e.  $D_c/C_c$ ) is a useful value, since it represents the dose per unit quantity of each nuclide released. Use of the  $D_c/C_c$  ratio in monthly evaluation of offsite dose is discussed in section 1.2. Values of  $D_c/C_c$  are given in Table 1.9.

### Step 2

The dose rate limits of interest for setpoints (10CFR20) are

Total body = 500 mrem/y

Skin = 3,000 mrem/y

Maximum Organ = 1,500 mrem/y

Dividing the above limits by the appropriate dose calculated in step 1 yields a useful ratio.

$$\frac{\text{Dose limit}}{\text{Dose step 1}} = R$$

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This ratio, R, represents how far above or below the guidelines the step 1 calculation was. Multiplying the original source term by R will give release rates that should correspond to the dose limits given above.

Appropriate release rate limits in  $\mu\text{Ci/s}$  for each nuclide will be provided for use in establishing monitor setpoints. The setpoint for each gaseous effluent monitor is established using plant instructions. Release rate limit, principal gamma emitter, geometry and detector efficiency are combined to give an equivalent setpoint in counts per minute (cpm). An added safety factor is applied if necessary to account for radionuclides not detected by the monitor, variations in flow rates, or monitor background fluctuations. The physical and technical description, location and identification number for each gaseous radiation detector is contained in plant documentation.

#### 1.2 Monthly Dose Calculations

Dose calculations will be performed monthly to determine compliance with specifications. These specifications require that the dose rate in unrestricted areas due to gaseous effluents from each reactor at the site shall be limited to the following values:

For noble gases,

1. During any calendar quarter, 5 mrad to air and 2.5 mrem to an individual for gamma radiation and 10 mrad to air and 7.5 millirem to skin of an individual for beta radiation.
2. During any calendar year, 10 mrad to air and 5 mrem to an individual for gamma radiation, 20 mrad to air and 15 millirem to skin of an individual for beta radiation.

For iodines and particulates,

1. During any calendar quarter, 7.5 mrem to any organ.
2. During any calendar year, 15 mrem to any organ.

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This section of the ODCM describes the methodology that will be used to perform these monthly calculations.

Doses will first be calculated by a simplified conservative approach (step 1). If these exceed the specification limits, more realistic calculations will be performed (step 2.)

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### Step 1

Doses will be calculated using the methodology described in this step. The method utilizes a limiting dose concept such that the limiting dose for each nuclide is summed with the limiting dose for each other nuclide, regardless if such sum is physically possible.

As such, the method is highly conservative and significantly overestimates dose. If limits appear to be exceeded by this method, step 2 (a concise method, but requiring computer support) will be performed.

### Assumptions

1. All assumptions of Section 1.1 are utilized
2. Limiting doses for each gaseous nuclide are summed, regardless of limiting decay mode (gamma or beta)
3. Limiting doses for each particulate and iodine nuclide are summed, regardless of dose point location, exposure pathway or organ affected.
4. Doses are summed for detected nuclides such that all nuclides which contribute greater than 10% individually or 25% in aggregate, to the released radioactivity, are included in the dose calculation.

### Equations

For determining gaseous effluent dose:

$$D_G = \sum_0^i A_{iG} (D_c/C_c)_{iG} < 5 \text{ millirad/quarter, } 10 \text{ mrad/yr}$$

where

$D_G$  = Dose from gaseous effluents (mrad)

$A_{iG}$  = Quantity of gaseous nuclide  $i$  released (Ci)

$(D_c/C_c)_{iG}$  = Dose per Ci factor for gaseous nuclide  $i$  (mrad/Ci)

The limit for this mixture is conservatively taken as that for gamma exposure (5 mrem/quarter, 10 mrem/year) although as indicated in Table 1.9, a majority of the gaseous effluents are beta-limiting and on an individual basis have the higher limit of 10 millirem/quarter and 20 millirem/year.

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For determining iodine and particulate dose to organs:

$$D_{PI} = \sum_0^i A_{PIi} (D_c/C_c)_{PIi} < 7.5 \text{ mrem/q, } 15 \text{ mrem/y}$$

where

$D_{PI}$  = Dose from particulates and iodines (mrem)

$A_{PIi}$  = Quantity of particulate or iodine nuclide  $i$  released (Ci)

$(D_c/C_c)_{PIi}$  = Dose per Ci factor for particulate or iodine nuclide  $i$  (mrad/Ci)

### Step 2.

This methodology is to be used if the highly conservative calculations in step 1 yield doses that appear to exceed applicable limits.

Doses for released particulates, iodines and noble gasses will be determined by use of the NRC GASPAR computer code. The computer run will utilize the most recently compiled joint frequency meteorological data available for the appropriate interval (not less than a calendar quarter; normally an annual average) and will reflect demographic and land use information from the land use survey generated in the most recent prior year. Where appropriate, seasonal adjustments will be applied to obtain realistic dose estimates since both recreational and agricultural activities can vary greatly in relation to season of the year.

An alternative to GASPAR for offsite dose calculation is use of the General Office Control Center Emergency offsite dose calculation program. This system allows evaluation of dose under the actual meteorological conditions present at the time of release. It is anticipated that the system may be used if major short-term releases are made under conditions which depart significantly from mean annual conditions.

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### 1.3 Gaseous Radwaste Treatment System Operation

Gaseous radwaste treatment consists solely of a 30-minute decay line for condenser air ejector exhaust. This system shall be maintained and operated to keep releases ALARA. Figure 1.2 diagrams Big Rock Point gaseous emission discharge paths.

#### 1.3.1 Dose Calculations

Doses will be calculated monthly using the methodology described in Section 1.2.

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## 2. Liquid Effluents

### 2.1 Concentration

#### 2.1.1 RETS Requirement

Specification 3.9.2 of the Radiological Effluent Technical Specifications (RETS) requires that the concentration of radioactive material released at any time from the site to unrestricted areas shall be limited to the Maximum Permissible Concentration (MPC) specified in 10CFR20, Appendix B, Table II, Column 2 for nuclides other than dissolved or entrained noble gases. For dissolved or entrained noble gases, the concentration shall be limited to  $2 \times 10^{-4}$   $\mu\text{Ci/ml}$  total activity. To ensure compliance, the following approach will be used for each release.

#### 2.1.2 Prerelease Analysis

Most tanks will be recirculated through two volume changes prior to sampling for release to the environment to ensure that a representative sample is obtained. The appropriate recirculation time for those tanks too large to provide two volume changes will be the time that the suspended particulate concentration reaches steady state. A one-time test or prior sampling data may be used to determine appropriate recirculation time.

Prior to release, a grab sample will be analyzed for each release, and the concentration of each radionuclide determined.

$$C_j = \sum_{i=1}^n C_i \quad (2.1)$$

where:

$C_j$  = total concentration in the liquid effluent at release point  $j$ ,  $\mu\text{Ci/ml}$ .

$C_i$  = concentration of radionuclide  $i$ ,  $\mu\text{Ci/ml}$ .

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### 2.1.3 MPC-Sum of the Ratios

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

$$R_j = \frac{C_A}{MPC_A} + \frac{C_B}{MPC_B} + \dots + \frac{C_i}{MPC_i} \dots + \frac{C_n}{MPC_n} \quad (2.2)$$

where:

$C_i$  = undiluted effluent concentration of radionuclide i, as determined in Section 2.1.2,  $\mu\text{Ci/ml}$ .

$MPC_i$  = the MPC of radionuclide i, as specified in Section 2.1.1,  $\mu\text{Ci/ml}$ .

$R_j$  = the sum of the ratios for release point j.

The sum of the ratios at the discharge to the lake must be  $\leq 1$  due to the releases from any or all concurrent releases. The following relationship will assure this criterion is met:

$$f_1(R_1-1) + f_2(R_2-1) + f_3(R_3-1) + f_4(R_4-1) \leq F \quad (2.3)$$

where:

$f_1, f_2, f_3, f_4$  = The effluent flow rate (gallons/minute) for the respective releases, determined by plant personnel.

$R_1, R_2, R_3, R_4$  = the sum of the ratios of the respective releases as determined by Equation 2.2.

$F$  = minimum required dilution flow rate.

## 2.2 Instrument Setpoints

### 2.2.1 Setpoint Determination

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The setpoint for each liquid effluent monitor will be established using plant instructions. Concentration, flow rate, dilution, principal gamma emitter, geometry and detector efficiency are combined to give an equivalent setpoint in counts per minute (cpm). The physical and technical description, location and identification number for each liquid effluent radiation detector is contained in plant documentation.

The respective alarm/trip setpoints at each release point will be set such that the sum of the ratios at each point, as calculated by Equation 2.2, will not be exceeded. The  $R_j$  is directly related to the total concentration calculated by Equation 2.1. An increase in the concentration would indicate an increase in the respective  $R_j$ . A large increase would cause the limits specified in Section 2.1.1 to be exceeded. The minimum alarm/trip setpoint value is equal to the release concentration, but for ease of operation it may be desired that the setpoint(s) be set above the effluent concentration ( $C_j$ ). That is,

$$S_j = b_j \times C_j \quad (2.4)$$

Liquid effluent flow paths and release points are indicated in Figure 2.2.

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### 2.2.2 Post-Release Analysis

A post-release analysis will be done using actual release data to ensure that the limits specified in Section 2.1.1 were not exceeded.

A composite list of concentrations ( $C_i$ ), by isotope, will be used with the actual liquid radwaste ( $f$ ) and dilution ( $F$ ) flow rates (or volumes) during the release. The data will be substituted into Equation 2.3 to demonstrate compliance with the limits in Section 2.1.1. This data and setpoints will be recorded in auditable records by plant personnel.

## 2.3 Dose

### 2.3.1 RETS Requirement

Specification 3.9.1 of the Radiological Effluent Technical Specification (RETS) requires that the quantity of radionuclides released be limited such that the dose or dose commitment to an individual from radioactive materials in liquid effluents released to unrestricted areas from each reactor (see Figure 2.2.) will not exceed:

- a. During any calendar quarter 1.5 mrem to the total body and 5 mrem to any organ, and
- b. During any calendar year 3 mrem to the total body and 10 mrem to any organ.

To ensure compliance, quantities of activity of each radionuclide released will be summed for each release and accumulated for each quarter as follows:

### 2.3.2 Release Analysis

Calculations shall be performed for each batch release, and weekly for continuous releases according to the formula  $\sum A_i/C_i \leq 0.5$

where  $A_i$  = cumulative quarterly activity of nuclide  $i$  identified in liquid release ( $C_i$ )

$C_i$  = Design objective annual quantity of radionuclide  $i$  from Table 2.2.

Radionuclides may be omitted from the summation if they fall under the criteria of allowed omission specified by Note 5 to Appendix B, 10CFR20.

Values for the design basis quantities ( $C_i$ ), and the dose per Curie ( $D_c/C_c$ )<sub>iL</sub> for each nuclide  $i$  shown in Table 2.2, were calculated as follows:

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### 2.3.2.1 Water Ingestion

The dose to an individual from ingestion of water is described by the following equation.

$$D_j = \sum_{i=1}^i (DCF)_{ij} \times I_i \text{ rem} \quad (2.11)$$

where:

$D_j$  = dose for the  $j^{\text{th}}$  organ from radionuclides released rem.

$j$  = the organ of interest (thyroid or total body).

$DCF_{ij}$  = adult ingestion dose commitment factor for the  $j^{\text{th}}$  organ from the  $i^{\text{th}}$  radionuclide rem/ $\mu\text{Ci}$ , see attached as Table 2.1.

$I_i$  = activity ingested of the  $i^{\text{th}}$  radionuclide,  $\mu\text{Ci}$ .

$I_i$  is described by

$$I_i = \frac{(A_i)(V)(365)}{1000d} \mu\text{Ci} \quad (2.12)$$

where:

365 = days per year

$A_i$  = annual activity released of  $i^{\text{th}}$  radionuclide  $\mu\text{Ci}$ .

$V$  = average rate of water consumption (730 ml/d ICRP 23, p. 358)

$d$  = dilution water flow for year

1000 = dispersion factor from discharge to nearest drinking water supply.

The dose equation then becomes

$$D_j = \frac{266}{d} \sum_{i=1}^i (DCF)_{ij} \times A_i \text{ mrem} \quad (2.13)$$

### 2.3.2.2 Fish Ingestion

The dose to an individual from the consumption of fish is described by Equation 2.13. In this case the activity ingested of the  $j^{\text{th}}$  radionuclide ( $I_i$ ) is described by

$$I_i = \frac{A_i B_i F}{15d}, \mu\text{Ci} \quad (2.14)$$

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where:

$A_i$  = Annual released of  $i^{\text{th}}$  radionuclide,  $\mu\text{Ci}$

$B_i$  = Fish concentration factor of  $i^{\text{th}}$  radionuclide  $\frac{\mu\text{Ci}/\text{FM}}{\mu\text{Ci}/\text{ml}}$ ,  
see Table 2.0.

$F$  = Amount of fish eaten per day (57.5 gm)

$15$  = Dispersion factor from discharge to fish exposure point

$d$  = dilution water flow, year to date (ml)

$t$  = Days to date of release (to adjust  $F$  for period of calculation)

The dose equation then becomes:

$$D_g = \frac{3.8 t}{d} \sum_{i=1}^i A_i \times B_i \times \text{DCF}_i \text{ mrem} \quad (2.15)$$

### 2.3.3 Annual Analysis

A complete analysis utilizing the NRC computer code LADTAP with the total source release will be done annually in conjunction with the annual environmental report. This analysis will provide estimates of dose to the total body and various organs in addition to thyroid considered in the method of Section 2.3.2. The following approach is utilized in LADTAP: The dose to the  $j^{\text{th}}$  organ from  $m$  radionuclides,  $D_j$ , is described by

$$D_j = \sum_{i=1}^m D_{ij}, \text{ rem} \quad (2.16)$$

$$= \sum_{i=1}^m (\text{DCF})_{ij} \times I_i, \text{ rem} \quad (2.17)$$

where:

$D_{ij}$  = dose to the  $j^{\text{th}}$  organ from the  $i^{\text{th}}$  radionuclide, rem.

$j$  = the organ of interest (bone, GI tract, thyroid, or total body).

$(\text{DCF})_{ij}$  = adult ingestion dose commitment factor for the  $j^{\text{th}}$  organ from the  $i^{\text{th}}$  radionuclide,  $\text{rem}/\mu\text{Ci}$ , see Table 2.1.

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$I_i$  = activity ingested of the  $i^{\text{th}}$  radionuclide,  $\mu\text{Ci}$

$I_i$  for water ingestion is described by

$$I_i = \frac{A_i V \tau}{u d}, \mu\text{Ci} \quad (2.18)$$

and for fish ingestion  $I_i$  is described by

$$I_i = \frac{A_i B_i F \tau}{u d}, \mu\text{Ci} \quad (2.19)$$

where

$A_i$  = activity released of  $j^{\text{th}}$  radionuclide during the year,  $\mu\text{Ci}$

$V$  = average rate of water consumption (730 ml/d).

$\tau$  = number of days during the year (365 d)

$u$  = dispersion factor from point of discharge to point of exposure.

$d$  = dilution water volume (ml)

$B_i$  = fish concentration factor of the  $i^{\text{th}}$  radionuclide,  $\frac{\mu\text{Ci/gm}}{\mu\text{Ci/ml}}$

$F$  = amount of fish eaten per day (57.5 gm)

#### 2.4 Operability of Liquid Radwaste Equipment

Specification 3.9.5 of the Radiological Effluent Technical Specifications requires that the liquid radwaste system be used to reduce the radioactive materials in liquid wastes prior to their discharge (by recycle or shipment for disposal) whenever liquid effluent releases to unrestricted areas (see Figure 2.1) would exceed Specification 3.9.1. Maintaining the cumulative fraction of allowable release for each batch release and weekly for continuous releases assures compliance with this requirement.

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TABLE 1.1  
 BIG ROCK POINT  
 AIRBORNE RELEASES

<u>Nuclide</u>	<u>Release (Ci/yr)</u>	<u>Comment</u>
I 131	4.07(-2)	From 23rd Semi-Annual Operating Report as adjusted to 80 percent capacity factor. ↓ From 23rd Semi-Annual Operating Report as adjusted to 80 percent capacity factor. ↓ From 23rd Semi-Annual Operating Report. ↓
I 133	6.09(-2)	
I 135	4.08(-1)	
Cs 134	7.34(-2)	
Cs 137	3.37(-2)	
BaLa 140	3.20(-2)	
Mn 54	9.29(-4)	
Co 60	5.60(-3)	
Co 58	1.50(-4)	
Xe 138	1.35(+4)	
Kr 87	1.45(+4)	
Kr 88	1.03(+4)	
Kr 85m	4.69(+3)	
Xe 135	1.99(+4)	
Xe 133	9.56(+3)	
Xe 140	3.74(+1)	
Kr 90	4.56(+2)	
Xe 139	6.76(+2)	
Kr 89	1.01(+3)	
Xe 137	1.76(+3)	
Xe 135m	3.78(+3)	
Kr 83m	2.44(+3)	
Xe 133m	3.65(+2)	
Xe 131m	3.74(+1)	
Kr 85	2.55(+2)	
N 13	1.90(+3)	
H 3	7.39(0)	From 23rd Semi-Annual Operating Report.
C 14	9.5(0)	NUREG-0016
Ar 41	2.5(+1)	NUREG-0016

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TABLE 1.2 BASIC RADIONUCLIDE DATA

NUCLIDE	HALF-LIFE (DAYS)	EMITTED RADIATION	Y	C	HPA (MEV/DIS)	GAMMA (MEV/DIS)	WASH (1/S)	
1 TRITIUM	101	4.44E-03	1.74E-04	2	1	5.64E-03	0.0	2.86E-07
2 C-14	604	2.04E-04	3.44E-12	2	1	5.17E-02	0.0	0.0
3 A-13	702	6.94E-03	1.16E-03	2	1	4.41E-01	1.02E-00	1.00E-02
4 C-19	804	3.36E-04	2.34E-02	2	1	1.02E-00	1.05E-00	1.00E-02
5 F-18	902	7.42E-02	1.04E-04	2	1	2.11E-01	4.48E-01	1.00E-04
6 NA-24	1104	5.33E-01	1.27E-05	3	1	5.55E-01	4.12E-00	1.00E-04
7 P-32	1504	1.43E-01	5.41E-07	5	1	6.44E-01	0.0	1.00E-04
8 AR-41	1805	7.61E-02	1.05E-04	2	1	3.53E-01	1.24E-00	0.0
9 CH-51	2405	2.78E-01	2.89E-07	5	1	3.75E-03	3.24E-02	1.00E-04
10 KA-54	2508	3.02E-02	2.65E-06	5	1	4.17E-03	4.30E-01	1.00E-04
11 MA-56	2509	1.07E-01	7.50E-05	5	1	7.47E-01	1.74E-00	1.00E-04
12 FE-59	2604	4.50E-01	1.74E-07	5	1	1.16E-01	1.14E-00	1.00E-04
13 CO-58	2706	7.12E-01	1.12E-07	5	1	2.05E-01	5.74E-01	1.00E-04
14 CO-60	2708	1.92E-02	4.18E-05	5	1	4.06E-02	2.50E-00	1.00E-04
15 ZA-69M	3007	5.75E-01	1.34E-05	5	1	0.0	4.15E-00	1.00E-04
16 ZA-69	3006	3.96E-02	2.02E-04	5	1	3.14E-01	0.0	1.00E-04
17 BR-84	3516	2.21E-02	3.62E-04	2	1	1.25E-00	1.44E-00	1.00E-04
18 BR-85	3518	2.04E-03	3.26E-03	2	2	1.04E-00	8.40E-01	1.00E-04
19 KR-85M	3611	1.52E-01	4.32E-05	1	2	2.53E-01	1.54E-01	1.00E-11
20 KR-85	3610	3.92E-02	2.04E-09	1	1	2.51E-01	2.21E-03	1.00E-11
21 KR-87	3612	5.28E-02	1.52E-04	1	1	1.32E-00	7.94E-01	1.00E-11
22 KR-88	3613	1.17E-01	6.86E-05	1	1	3.75E-01	1.96E-00	1.00E-11
23 KR-89	3614	2.21E-02	3.62E-03	1	1	1.23E-00	2.05E-00	1.00E-11
24 RB-88	3713	1.24E-02	6.47E-04	3	1	2.06E-00	6.26E-01	1.00E-04
25 RB-89	3714	1.07E-02	7.50E-04	5	1	0.0	2.40E-00	1.00E-04
26 SR-89	3802	5.20E-01	1.54E-07	5	1	5.73E-01	1.26E-04	2.67E-07
27 SR-90	3810	1.02E-04	7.79E-10	5	1	1.46E-01	0.0	2.67E-07
28 SR-91	3811	4.03E-01	1.94E-05	5	2	6.50E-01	6.95E-01	2.67E-07
29 SR-92	3812	1.12E-01	7.10E-05	5	1	1.45E-01	1.24E-00	2.67E-07
30 SR-93	3813	5.56E-02	1.44E-03	5	1	1.61E-00	6.26E-01	2.67E-07
31 Y-90	3916	2.67E-00	3.00E-06	5	1	9.36E-01	0.0	1.00E-04
32 Y-91M	3915	3.47E-02	2.31E-04	5	1	0.0	5.56E-01	1.00E-04
33 Y-91	3916	5.89E-01	1.34E-07	5	1	6.04E-01	3.61E-03	1.00E-04
34 Y-92	3920	1.47E-01	5.46E-05	5	1	1.44E-00	2.50E-01	1.00E-04
35 Y-93	3921	4.25E-01	1.87E-05	5	1	1.17E-00	4.94E-02	1.00E-04
36 ZR-95	4014	6.50E-01	1.23E-07	5	2	1.20E-01	7.35E-01	1.00E-04
37 NB-95M	4115	3.75E-00	2.14E-06	5	1	2.85E-01	5.27E-02	1.00E-04
38 NB-95	4114	3.50E-01	2.24E-07	5	1	4.50E-02	7.64E-01	1.00E-04
39 MO-99	4208	2.74E-00	2.87E-06	5	2	3.44E-01	1.62E-01	1.00E-04
40 TC-99M	4314	2.50E-01	3.21E-05	5	1	4.06E-03	1.43E-01	1.00E-04
41 TC-99	4313	7.74E-07	1.04E-12	5	1	4.34E-02	0.0	1.00E-04
42 TC-104	4320	1.25E-02	6.42E-04	5	1	0.0	0.0	1.00E-04
43 RU-106	4407	3.67E-02	2.15E-08	5	1	1.01E-02	0.0	1.00E-04
44 TE-132	5223	3.24E-00	2.48E-06	5	1	1.00E-01	2.05E-01	1.00E-04
45 I-129	5315	6.21E-09	1.24E-13	3	1	4.02E-02	3.77E-03	5.00E-06
46 I-131	5317	8.05E-00	9.46E-07	3	2	1.44E-01	3.81E-01	5.00E-06
47 NI-131	15317	8.05E-00	9.46E-07	2	2	1.44E-01	7.11E-01	5.00E-06
48 I-132	5318	9.56E-02	8.37E-05	3	1	5.14E-01	2.34E-00	5.00E-06
49 NI-132	15318	9.56E-02	8.37E-05	4	1	5.14E-01	2.34E-00	5.00E-06
50 I-133	5319	8.75E-01	4.17E-06	3	2	4.06E-01	6.10E-01	5.00E-06
51 NI-133	15319	8.75E-01	4.17E-06	4	2	4.06E-01	6.10E-01	5.00E-06
52 I-134	5320	3.41E-02	2.22E-04	3	1	6.10E-01	2.54E-00	5.00E-06
53 NI-134	15320	3.41E-02	2.22E-04	4	1	6.10E-01	2.54E-00	5.00E-06
54 I-135	5321	2.74E-01	2.47E-05	3	2	3.64E-01	1.46E-00	5.00E-06
55 NI-135	15321	2.74E-01	2.47E-05	4	2	3.64E-01	1.56E-00	5.00E-06
56 ZE-131M	5412	1.14E-01	6.40E-07	1	1	1.43E-01	2.01E-02	1.00E-11
57 ZE-132M	5414	2.26E-00	3.55E-06	1	1	1.40E-01	4.16E-02	1.00E-11
58 ZE-132	5413	5.27E-00	1.52E-06	1	1	1.35E-01	4.54E-02	1.00E-11
59 ZE-135M	5416	1.04E-02	7.43E-04	1	1	4.50E-02	4.32E-01	1.00E-11
60 ZE-135	5415	3.82E-01	2.09E-05	1	1	3.17E-01	2.47E-01	1.00E-11
61 ZE-137	5417	2.71E-02	2.96E-03	1	1	1.64E-00	1.54E-01	1.00E-11
62 ZE-138	5414	1.14E-02	6.40E-04	1	1	6.04E-01	1.14E-00	1.00E-11
63 CS-134	5510	7.44E-02	1.07E-06	5	1	1.57E-01	1.04E-00	1.00E-04
64 CS-135	5512	1.10E-09	7.24E-15	5	1	5.74E-02	0.0	1.00E-04
65 CS-136	5514	1.20E-01	4.17E-07	5	1	1.01E-01	2.20E-00	1.00E-04
66 CS-137	5515	1.10E-04	7.24E-10	5	1	2.52E-01	5.47E-01	1.00E-04
67 CS-138	5516	2.24E-02	3.54E-04	5	1	1.23E-00	2.40E-00	1.00E-04
68 BA-139	5615	5.74E-02	1.34E-04	5	1	6.54E-01	5.05E-02	1.00E-04
69 BA-140	5616	1.21E-01	4.27E-07	5	1	3.15E-01	1.04E-01	1.00E-04
70 LA-140	5715	1.64E-00	4.77E-06	5	1	5.40E-01	2.11E-00	1.00E-04
71 CE-144	5415	2.44E-02	2.47E-04	5	1	4.17E-02	3.24E-02	1.00E-04
72 PH-143	5412	1.34E-01	5.40E-07	5	1	3.14E-01	0.0	1.00E-04
73 PO-144	5513	1.34E-02	4.17E-05	5	1	1.01E-01	2.20E-00	1.00E-04

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TABLE 1.3  
 BIG ROCK POINT  
 (2/9/61-2/8/63)  
 X/O VALUES (UNDELETED) ASSOCIATED WITH A  
 RELEASE FROM THE 240 FT STACK\*

Sector Affected	Downwind Distance (mi)									
	805	2414	4023	5633	7242	12070	24140	40234	56327	72420
H	2.1-08	1.4-07	9.5-08	6.4-08	4.9-08	2.5-08	1.2-08	6.8-09	4.6-09	3.4-09
HNE	1.1-08	8.5-08	5.9-08	4.0-08	3.1-08	1.7-08	6.4-09	3.3-09	2.1-09	1.5-09
HE	7.6-09	7.3-08	5.3-08	3.7-08	2.9-08	1.7-08	6.7-09	3.4-09	2.2-09	1.6-09
E/NE	1.3-08	1.0-07	7.7-08	5.1-08	3.8-08	2.1-08	7.1-09	3.6-09	2.3-09	1.7-09
E	2.7-08	2.5-07	1.7-07	9.2-08	6.2-08	2.4-08	9.0-09	4.5-09	2.9-09	2.1-09
ESE	4.8-08	2.2-07	1.0-07	5.3-08	3.4-08	1.3-08	4.9-09	2.5-09	1.6-09	1.1-09
SE	7.9-08	1.9-07	9.7-08	4.9-08	3.1-08	1.3-08	4.7-09	2.3-09	1.5-09	1.1-09
SSE	1.0-07	1.9-07	9.2-08	5.8-08	3.6-08	1.4-08	5.3-09	2.7-09	1.7-09	1.2-09
S	7.0-08	1.2-07	8.3-08	5.0-08	3.5-08	1.7-08	5.5-09	2.6-09	1.7-09	1.2-09
SSW	3.8-08	9.4-08	5.8-08	3.8-08	2.9-08	1.5-08	5.3-09	2.7-09	1.8-09	1.2-09
SW	3.2-08	7.6-08	6.6-08	3.7-08	2.6-08	1.3-08	4.7-09	2.1-09	1.4-09	1.0-09
WSW	1.2-08	7.8-08	5.7-08	3.9-08	3.0-08	1.6-08	7.3-09	4.0-09	2.7-09	1.3-09
W	8.3-09	1.4-07	1.1-07	7.9-08	6.1-08	3.3-08	1.6-08	8.9-09	4.1-09	3.0-09
WNW	3.8-09	6.0-08	4.8-08	3.4-08	2.7-08	1.5-08	7.5-09	4.5-09	3.1-09	2.3-09
NW	4.7-09	5.8-08	4.4-08	3.0-08	2.4-08	1.3-08	6.1-09	3.4-09	2.3-09	1.7-09
NNW	6.5-09	6.4-08	4.7-08	3.2-08	2.5-08	1.3-08	6.2-09	3.5-09	2.4-09	1.8-09

\*These values include open terrain adjustment factors, -8 units are sec/m<sup>3</sup>; abbreviation, eg. 2.1-08 is 2.1 x 10<sup>-8</sup>

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TABLE 1 .4

BIG ROCK POINT PLANT

LOCATION CHART FOR ITEMS<sup>(1)</sup> IMPORTANT TO  
CALCULATION OF DOSES TO INDIVIDUALS

Sector <sup>(2)</sup>	DISTANCE (MILES)				
	<u>0 - 1</u>	<u>1 - 2</u>	<u>2 - 3</u>	<u>3 - 4</u>	<u>4 - 5</u>
ENE	-----	-----	R, V (2.5)	R, V	-----
E	-----	R, V(1.3)	R, V	C (3.5) G (3.25) M (3.75) R, V	R, V
ESE	-----	R, V(1.3)	M (2.5) R, V C (2.25)	R, V	R, V
SE	-----	M (1.75) R, V(1.6) C (1.75)	C (2.25) R, V G (3.0)	R, V	R, V
SSE	-----	R, V(1.6)	M (2.25) R, V	R, V C (3.5)	C (4) R, V
S	-----	R, V(1.5)	R, V	R, V	-----
SSW	-----	R, V(1.5) G (1.5)	R, V	R, V	-----
SW	-----	-----	R, V(2.5)	R, V	R, V
WSW	-----	-----	R, V(2.75)	-----	-----
W	-----	-----	-----	-----	-----

(1) C = cow )  
G = goat )  
M = meat animal)

R = residence )  
V = vegetable garden)

Numbers in parentheses are distances in miles from reactor.

A vegetable garden is assumed at each residence. For purposes of calculations, beyond 2 miles, a residence may be located in sector annulus at location of highest calculated dose. Therefore, distances are not given.

(2) Sectors not listed are entirely over water out to 5 miles or more.

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TABLE 1.4

BIG ROCK POINT PLANT  
CURRENT LOCATIONS OF MAXIMUM DOSE

<u>NO</u>	<u>DISTANCE (MILES)</u>	<u>DIRECTION</u>	<u>DESCRIPTION</u>	<u>NORMAL X/Q (s/m<sup>3</sup>)</u>	<u>DEPOSITION D/Q (l/m<sup>2</sup>)</u>
1	1.25	E	Max residence, garden	$2.98 \times 10^{-7}$	$2.48 \times 10^{-9}$
2	1.75	SE	Max milk cow	$1.65 \times 10^{-7}$	$1.03 \times 10^{-9}$
3	1.5	SSW	Max milk goat	$9.4 \times 10^{-8}$	$5.8 \times 10^{-10}$
4	1.75	SE	Max meat animal	$1.38 \times 10^{-7}$	$9.67 \times 10^{-10}$

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TABLE 1.5

DOSE FACTORS FOR SUBMERSION IN NOBLE GASES

	<u>DFB<sup>1</sup></u>	<u>DFY<sup>2</sup></u>	<u>DFS<sup>1</sup></u>	<u>DFE<sup>2</sup></u>
Kr-85m	1.17(+3) <sup>3</sup>	1.21(+3)	1.46(+3)	3.86(+3)
Kr-85	1.61(+1)	1.69(+1)	1.34(+3)	3.83(+3)
Kr-87	5.92(+3)	6.05(+3)	9.73(+3)	2.01(+4)
Kr-88	1.47(+4)	1.50(+4)	2.37(+3)	5.72(+3)
Kr-89	1.66(+4)	1.59(+4)	1.01(+4)	1.88(+4)
Xe-131m	9.15(+1)	1.53(+2)	4.76(+2)	2.18(+3)
Xe-133m	2.51(+2)	3.17(+2)	9.94(+2)	2.90(+3)
Xe-133	2.94(+2)	3.46(+2)	3.06(+2)	2.06(+3)
Xe-135m	3.12(+3)	3.50(+3)	7.11(+2)	1.45(+3)
Xe-135	1.81(+3)	1.88(+3)	1.86(+3)	4.84(+3)
Xe-137	1.42(+3)	1.48(+3)	1.22(+4)	2.50(+4)
Xe-138	8.83(+3)	9.00(+3)	4.13(+3)	9.25(+3)
Ar-41	8.84(+3)	9.76(+3)	2.69(+3)	5.54(+3)

1. mrem/y per  $\mu\text{Ci}/\text{m}^3$ .

2. mrad/y per  $\mu\text{Ci}/\text{m}^3$ .

3.  $1.17(+3) = 1.17 \times 10^3$ .

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TABLE 1.6

## STABLE ELEMENT TRANSFER DATA

ELEMENT	$F_m$ - MILK (COW)	$F_m$ - MILK (GOAT)	$F_f$ - MEAT
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-02	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

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TABLE 1.7  
 INHALATION DOSE FACTORS FOR INFANT  
 (MREM PER PCI INHALED)

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NUCLIDE	BONE	LIVER	T. BODY	THYROID	KIDNEY	LUNG	GI-LLI
H 3	NO DATA	4.62E-07	4.62E-07	4.62E-07	4.62E-07	4.62E-07	4.62E-07
C 14	1.89E-05	3.79E-06	3.79E-06	3.79E-06	3.79E-06	3.79E-06	3.79E-06
NA 24	7.54E-06	7.54E-06	7.54E-06	7.54E-06	7.54E-06	7.54E-06	7.54E-06
P 32	1.45E-03	8.03E-05	5.53E-05	NO DATA	NO DATA	NO DATA	1.15E-05
CR 51	NO DATA	NO DATA	6.39E-08	4.11E-08	9.45E-09	9.17E-06	2.55E-07
MN 54	NO DATA	1.81E-05	3.56E-06	NO DATA	3.56E-06	7.14E-04	5.04E-06
MN 56	NO DATA	1.10E-09	1.58E-10	NO DATA	7.86E-10	8.95E-06	5.12E-05
FE 55	1.41E-05	8.39E-06	2.38E-06	NO DATA	NO DATA	6.21E-05	7.82E-07
FE 59	9.69E-06	1.68E-05	6.77E-06	NO DATA	NO DATA	7.25E-04	1.77E-05
CO 58	NO DATA	8.71E-07	1.30E-06	NO DATA	NO DATA	5.55E-04	7.95E-06
CO 60	NO DATA	5.73E-06	8.41E-06	NO DATA	NO DATA	3.22E-03	2.28E-05
NI 63	2.42E-04	1.46E-05	8.29E-06	NO DATA	NO DATA	1.49E-04	1.73E-06
NI 65	1.71E-09	2.03E-10	8.79E-11	NO DATA	NO DATA	5.80E-06	3.58E-05
CU 64	NO DATA	1.34E-09	5.53E-10	NO DATA	2.84E-09	6.64E-06	1.07E-05
ZN 65	1.38E-05	4.47E-05	2.22E-05	NO DATA	2.32E-05	4.62E-04	3.07E-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
KR 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

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TABLE 1.7 CONT'D  
 INHALATION DOSE FACTORS FOR INFANT  
 (MREM PER PCI INHALED)

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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
TC101	4.65E-14	5.98E-14	5.80E-13	NO DATA	6.99E-13	4.17E-07	6.03E-07
RU103	1.44E-06	NO DATA	4.85E-07	NO DATA	3.03E-06	3.94E-04	1.15E-05
RU105	8.74E-10	NO DATA	2.93E-10	NO DATA	6.42E-10	1.12E-05	3.46E-05
RU106	6.20E-05	NO DATA	7.77E-06	NO DATA	7.61E-05	8.26E-03	1.17E-04
AG110M	7.13E-06	5.16E-06	3.57E-06	NO DATA	7.80E-06	2.62E-03	2.36E-05
TE125M	3.40E-06	1.42E-06	4.70E-07	1.16E-06	NO DATA	3.19E-04	9.22E-06
TE127M	1.19E-05	4.93E-06	1.48E-06	3.48E-06	2.69E-05	9.37E-04	1.95E-05
TE127	1.59E-09	6.81E-10	3.47E-10	1.32E-09	3.47E-09	7.39E-06	1.74E-05
TE129M	1.01E-05	4.35E-06	1.59E-06	3.91E-06	2.27E-05	1.20E-03	4.93E-05
TE129	5.63E-11	2.48E-11	1.34E-11	4.82E-11	1.25E-10	2.14E-06	1.88E-05
TE131M	7.62E-08	3.93E-08	2.59E-08	6.38E-08	1.89E-07	1.42E-04	8.51E-05
TE131	1.24E-11	5.87E-12	3.57E-12	1.13E-11	2.85E-11	1.47E-06	5.87E-06
TE132	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	9.71E-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	1.99E-06	4.97E-04	6.05E-06	NO DATA	1.31E-06
CS134	2.83E-04	5.02E-04	5.32E-05	NO DATA	1.36E-04	5.69E-05	9.53E-07
CS136	3.45E-05	9.61E-05	3.78E-05	NO DATA	4.03E-05	8.40E-06	1.02E-06
CS137	3.92E-04	4.37E-04	3.25E-05	NO DATA	1.23E-04	5.09E-05	9.53E-07
CS138	3.61E-07	5.58E-07	2.84E-07	NO DATA	2.93E-07	4.67E-08	6.26E-07
BA139	1.06E-09	7.03E-13	3.07E-11	NO DATA	4.73E-13	4.25E-06	3.64E-05

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TABLE 1.7 CONT'D  
 INHALATION DOSE FACTORS FOR INFANT  
 (MREM PER PCI INHALED)

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NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
HA140	4.00E-05	4.00E-08	2.07E-06	NO DATA	9.59E-09	1.14E-03	2.74E-05
HA141	1.12E-10	7.70E-14	3.55E-12	NO DATA	4.64E-14	2.12E-06	3.39E-06
HA142	2.84E-11	2.36E-14	1.40E-12	NO DATA	1.36E-14	1.11E-06	4.95E-07
LA140	3.61E-07	1.43E-07	3.68E-08	NO DATA	NO DATA	1.20E-04	6.06E-05
LA142	7.36E-10	2.69E-10	6.46E-11	NO DATA	NO DATA	5.67E-06	4.25E-05
CE141	1.98E-05	1.19E-05	1.42E-06	NO DATA	3.75E-06	3.69E-04	1.54E-05
CE143	2.09E-07	1.78E-07	1.59E-08	NO DATA	4.03E-08	8.30E-05	3.55E-05
CE144	2.28E-03	8.05E-04	1.26E-04	NO DATA	3.84E-04	7.03E-03	1.06E-04
PR143	1.00E-05	3.74E-06	4.99E-07	NO DATA	1.41E-06	3.09E-04	2.66E-05
PR144	3.42E-11	1.32E-11	1.72E-12	NO DATA	4.90E-12	1.15E-06	3.06E-06
ND147	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
NP239	2.65E-07	2.37E-08	1.34E-08	NO DATA	4.73E-08	4.25E-05	1.78E-05

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TABLE 1.7  
 INHALATION DOSE FACTORS FOR CHILD  
 (MREM PER PCI INHALED)

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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	4.77E-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
HR 83	NO DATA	NO DATA	1.28E-07	NO DATA	NO DATA	NO DATA	LT E-24
UR 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
KB 86	NO DATA	5.36E-05	3.09E-05	NO DATA	NO DATA	NO DATA	2.16E-06
RP 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	7.85E-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
SP 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 91 <sup>m</sup>	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

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TABLE 1.7 CONT'D  
 INHALATION DOSE FACTORS FOR CHILD  
 (MFEM PER PCI INHALED)

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NUCLIDE	BONE	LIVER	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-06	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
TC101	2.19E-14	2.30E-14	2.91E-13	NO DATA	3.92E-13	1.58E-07	4.41E-09
RU103	7.55E-07	NO DATA	2.90E-07	NO DATA	1.70E-06	1.79E-04	1.21E-05
RU105	4.13E-10	NO DATA	1.50E-10	NO DATA	3.63E-10	4.30E-06	2.69E-05
RU106	3.68E-05	NO DATA	4.57E-06	NO DATA	4.97E-05	3.87E-03	1.16E-04
AG110M	4.56E-06	3.08E-06	2.47E-06	NO DATA	5.74E-06	1.48E-03	2.71E-05
TE125M	1.82E-06	6.29E-07	2.47E-07	5.20E-07	NO DATA	1.29E-04	9.13E-06
TE127M	6.72E-06	2.31E-06	8.16E-07	1.64E-06	1.72E-05	4.00E-04	1.93E-05
TE127	7.49E-10	2.57E-10	1.65E-10	5.30E-10	1.91E-09	2.71E-06	1.52E-05
TE127M	5.19E-06	1.85E-06	8.22E-07	1.71E-06	1.36E-05	4.76E-04	4.91E-05
TE129	2.64E-11	9.45E-12	6.44E-12	1.93E-11	6.94E-11	7.93E-07	6.89E-06
TE131M	3.63E-08	1.60E-08	1.37E-08	2.64E-08	1.08E-07	5.56E-05	8.52E-05
TE131	5.87E-12	2.28E-12	1.78E-12	4.59E-12	1.59E-11	5.55E-07	3.60E-07
TE132	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
CS134	1.76E-04	2.74E-04	6.07E-05	NO DATA	8.93E-05	3.27E-05	1.04E-06
CS136	1.76E-05	4.62E-05	3.14E-05	NO DATA	2.58E-05	3.93E-06	1.13E-06
CS137	2.45E-04	2.23E-04	3.47E-05	NO DATA	7.63E-05	2.81E-05	9.78E-07
CS138	1.71E-07	2.27E-07	1.50E-07	NO DATA	1.68E-07	1.84E-08	7.29E-08
RA139	4.98E-10	2.66E-13	1.45E-11	NO DATA	2.33E-13	1.56E-06	1.56E-05

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TABLE 1.7 : CONT'D  
 INHALATION DOSE FACTORS FOR CHILD  
 (MREM PER PCI INHALED)

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NUCLIDE	BONE	LIVER	T. BODY	THYROID	KIDNEY	LUNG	GI-LLI
BA140	2.00E-05	1.75E-08	1.17E-06	NO DATA	5.71E-09	4.71E-04	2.75E-05
BA141	5.29E-11	2.95E-14	1.72E-12	NO DATA	2.56E-14	7.89E-07	7.44E-08
BA142	1.35E-11	9.73E-15	7.54E-13	NO DATA	7.97E-15	4.44E-07	7.41E-10
LA140	1.74E-07	6.08E-0	2.04E-08	NO DATA	NO DATA	4.94E-05	6.10E-05
LA142	3.50E-10	1.11E-10	3.49E-11	NO DATA	NO DATA	2.35E-06	2.05E-05
CE141	1.06E-05	5.28E-06	7.83E-07	NO DATA	2.31E-06	1.47E-04	1.53E-05
CE143	9.89E-08	5.37E-08	7.77E-09	NO DATA	2.26E-08	3.12E-05	3.44E-05
CE144	1.83E-03	5.72E-04	9.77E-05	NO DATA	3.17E-04	3.23E-03	1.05E-04
PR143	4.95E-06	1.50E-06	2.47E-07	NO DATA	8.11E-07	1.17E-04	2.63E-05
PR144	1.61E-11	4.99E-12	8.10E-13	NO DATA	2.64E-12	4.23E-07	5.32E-08
ND147	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
NP239	1.26E-07	9.04E-09	6.35E-09	NO DATA	2.63E-08	1.57E-05	1.73E-05

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TABLE 1.7  
 INHALATION DOSE FACTORS FOR ADULTS  
 (MREM PER PCI INHALED)  
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NUCLIDE	BONE	LIVER	T.ROCY	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
VA 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	9.5E-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
RE 86	NO DATA	1.69E-05	7.37E-06	NO DATA	NO DATA	NO DATA	2.08E-06
RD 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

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TABLE 1.7 CONT'D  
 INHALATION DOSE FACTORS FOR ADULTS  
 (MREM PER PCI INHALED)

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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
NO 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
TC101	5.22E-15	7.52E-15	7.38E-14	NO DATA	1.35E-13	4.99E-08	1.36E-21
RU103	1.91E-07	NO DATA	8.23E-08	NO DATA	7.29E-07	6.31E-05	1.38E-05
RU105	9.88E-11	NO DATA	3.89E-11	NO DATA	1.27E-10	1.37E-06	6.02E-06
RU106	8.44E-06	NO DATA	1.07E-06	NO DATA	1.67E-05	1.17E-03	1.14E-04
AG110M	1.35E-06	1.25E-06	7.43E-07	NO DATA	2.46E-06	5.79E-04	3.78E-05
TE125M	4.27E-07	1.98E-07	5.84E-08	1.31E-07	1.55E-06	3.92E-05	8.83E-06
TE127M	1.58E-06	7.21E-07	1.96E-07	4.11E-07	5.72E-06	1.20E-04	1.87E-05
TE127	1.75E-10	8.03E-11	3.87E-11	1.32E-10	6.37E-10	8.14E-07	7.17E-06
TE129M	1.22E-06	5.64E-07	1.98E-07	4.30E-07	4.57E-06	1.45E-04	4.79E-05
TE129	6.22E-12	2.99E-12	1.55E-12	4.87E-12	2.34E-11	2.42E-07	1.96E-08
TE131M	8.74E-09	5.45E-09	3.63E-09	6.88E-09	3.86E-08	1.82E-05	6.95E-05
TF131	1.39E-12	7.44E-13	4.49E-13	1.17E-12	5.46E-12	1.74E-07	2.30E-09
TE132	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
CS134	4.66E-05	1.06E-04	9.10E-05	NO DATA	3.59E-05	1.22E-05	1.30E-06
CS136	4.88E-06	1.83E-05	1.38E-05	NO DATA	1.07E-05	1.50E-06	1.46E-06
CS137	5.98E-05	7.76E-05	5.35E-05	NO DATA	2.78E-05	9.40E-06	1.05E-06
CS138	4.14E-08	7.76E-08	4.05E-08	NO DATA	6.00E-08	6.07E-09	2.33E-13
BA139	1.17E-10	8.32E-14	3.42E-12	NO DATA	7.78E-14	4.70E-07	1.12E-07

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TABLE 1.7 CONT'D  
 INHALATION DOSE FACTORS FOR ADULTS  
 (MREM PER PCI INHALED)

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NUCLIDE	BONE	LIVER	T. BODY	THYROID	KIDNEY	LUNG	GI-LLI
RA140	4.88E-06	6.13E-09	3.21E-07	NO DATA	2.09E-09	1.59E-04	2.73E-05
RA141	1.25E-11	9.41E-15	4.20E-13	NO DATA	8.75E-15	2.42E-07	1.45E-17
RA142	3.29E-12	3.38E-15	2.07E-13	NO DATA	2.86E-15	1.49E-07	1.96E-26
LA140	4.30E-08	2.17E-08	5.73E-09	NO DATA	NO DATA	1.70E-05	5.73E-05
LA142	8.54E-11	3.88E-11	9.65E-12	NO DATA	NO DATA	7.91E-07	2.64E-07
CE141	2.49E-06	1.69E-06	1.91E-07	NO DATA	7.83E-07	4.52E-05	1.50E-05
CE143	2.33E-08	1.72E-08	1.91E-09	NO DATA	7.60E-09	9.97E-06	2.83E-05
CE144	4.29E-04	1.79E-04	2.30E-05	NO DATA	1.06E-04	9.77E-04	1.02E-04
PR143	1.17E-06	4.69E-07	5.80E-08	NO DATA	2.70E-07	3.51E-05	2.50E-05
PR144	3.76E-12	1.56E-12	1.91E-13	NO DATA	8.91E-13	1.27E-07	2.69E-18
ND147	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
NP239	2.87E-08	2.82E-09	1.55E-09	NO DATA	8.75E-09	4.70E-06	1.49E-05

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TABLE 1.8

EXTERNAL DOSE FACTORS FOR STANDING ON CONTAMINATED GROUND(mrem/hr per pci/m<sup>2</sup>)

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
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

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TABLE 1.8 (Continued)

ELEMENT	TOTAL BODY	SKIN
Te-131M	8.40E-09	9.90E-09
Te-131	2.20E-09	2.60E-06
Te-132	1.70E-09	2.00E-09
I-130	1.40E-08	1.70E-08
I-131	2.80E-09	3.40E-09
I-132	1.70E-08	2.00E-08
I-133	3.70E-09	4.50E-09
I-134	1.60E-08	1.90E-08
I-135	1.20E-08	1.40E-08
Cs-134	1.20E-08	1.40E-08
Cs-136	1.50E-08	1.70E-08
Cs-137	4.20E-09	4.90E-09
Cs-138	2.10E-08	2.40E-08
Ba-139	2.40E-09	2.70E-09
Ba-140	2.10E-09	2.40E-09
Ba-141	4.30E-09	4.90E-09
Ba-142	7.90E-09	9.00E-09
La-140	1.50E-08	1.70E-08
La-142	1.50E-08	1.80E-08
Ce-141	5.50E-10	6.20E-10
Ce-143	2.20E-09	2.50E-09
Ce-144	3.20E-10	3.70E-10
Pr-143	0.0	0.0
Pr-144.	2.00E-10	2.30E-10
Nd-147	1.00E-09	1.20E-09
W-187	3.10E-09	3.60E-09
Np-239	9.50E-10	1.10E-09

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TABLE 1.9  
Stack Effluents

Design Objective Annual Quantities

<u>NUCLIDE</u>	<u>LIMITING ORGAN</u>	<u>DOSE CONVERSION FACTOR (mrem/Curie)</u>	<u>DESIGN OBJECTIVE ANNUAL QUANTITY Ci (Curies)</u>
I-131	Thyroid	7.44E+00	2.02E+00
I-133	Thyroid	1.29E-01	1.16E+02
Cs-134	Liver	2.49E+00	6.02E+00
Cs-137	Liver	2.39E+00	6.27E+00
Co-60	GI Tract	1.51E-01	9.93E+01
Mn-54	GI Tract	3.04E-01	4.93E+01
Co-58	GI Tract	2.87E-02	5.23E+02
C-14	GI Tract	6.24E-03	2.40E+03
Ba-140	Bone	2.08E-02	7.21E+02
Noble Gases <sup>(1)</sup>	Gamma Dose in Air	$\bar{E}$	2.30E+05

NOTE:

(1) The average gamma ray energy ( $\bar{E}$ ) for a diffusion mixture is 0.845 MeV for a pure U-235 fission spectrum.

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TABLE 2.0  
 BIOACCUMULATION FACTORS  
 (pCi/kg per pCi/liter)

<u>ELEMENT</u>	<u>FRESHWATER FISH</u>
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
FR	2.5E 01
NO	2.5E 01
W	1.2E 03
NP	1.0E 01

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TABLE 2.1

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## ADULT INGESTION DOSE FACTORS\*

(mrem/pCi ingested)

NUCLIDE	BONE	LIVER	T.ROCY	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	1.73E-04	1.20E-05	7.46E-06	NO DATA	NO DATA	NO DATA	2.17E-05
CR 51	NO DATA	NO DATA	2.60E-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	2.87E-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
Y 93	2.68E-09	NO DATA	7.40E-11	NO DATA	NO DATA	NO DATA	8.50E-05
ZR 95	3.04E-08	7.75E-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
IC101	2.54E-10	3.66E-10	3.59E-09	NO DATA	6.59E-09	1.87E-10	1.10E-21
RUI03	1.85E-07	NO DATA	7.97E-08	NO DATA	7.06E-07	NO DATA	2.16E-05
RUI05	1.54E-08	NO DATA	6.08E-09	NO DATA	1.99E-07	NO DATA	9.42E-06

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TABLE 2.1 (Continued)

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NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
RU106	2.75E-06	NO DATA	3.48E-07	NO DATA	5.31E-06	NO DATA	1.78E-04
AG110M	1.60E-07	1.48E-07	8.79E-08	NO DATA	2.91E-07	NO DATA	6.04E-05
TE125M	2.68E-06	9.71E-07	3.57E-07	8.06E-07	1.09E-05	NO DATA	1.07E-05
TE127M	6.77E-06	2.42E-06	8.25E-07	1.73E-06	2.75E-05	NO DATA	2.27E-05
TE127	1.10E-07	3.95E-08	2.38E-08	8.15E-08	4.48E-07	NO DATA	8.68E-06
TE129M	1.15E-05	4.29E-06	1.82E-06	3.95E-06	4.80E-05	NO DATA	5.79E-05
TE129	3.14E-08	1.18E-08	7.65E-09	2.41E-08	1.32E-07	NO DATA	2.37E-08
TE131M	1.73E-06	8.46E-07	7.05E-07	1.34E-06	8.57E-06	NO DATA	8.40E-05
TE131	1.97E-08	8.23E-09	6.22E-09	1.62E-08	9.63E-08	NO DATA	2.79E-09
TE132	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	5.75E-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
CS134	6.22E-05	1.48E-04	1.21E-04	NO DATA	4.79E-05	1.59E-05	2.59E-06
CS136	6.51E-06	2.57E-05	1.85E-05	NO DATA	1.43E-05	1.96E-06	2.92E-06
CS137	7.97E-05	1.09E-04	7.14E-05	NO DATA	3.70E-05	1.23E-05	2.11E-06
CS138	5.52E-08	1.09E-07	5.40E-08	NO DATA	8.01E-08	7.91E-09	4.65E-13
BA139	9.70E-08	6.91E-11	2.84E-09	NO DATA	6.46E-11	3.92E-11	1.72E-07
BA140	2.03E-05	2.55E-08	1.33E-06	NO DATA	8.67E-09	1.46E-08	4.18E-05
BA141	4.71E-08	3.56E-11	1.59E-09	NO DATA	3.31E-11	2.02E-11	2.22E-17
BA142	2.13E-08	2.19E-11	1.34E-09	NO DATA	1.85E-11	1.24E-11	3.00E-26
LA140	2.50E-09	1.26E-09	3.33E-10	NO DATA	NO DATA	NO DATA	9.25E-05
LA142	1.28E-10	5.82E-11	1.45E-11	NO DATA	NO DATA	NO DATA	4.25E-07
CE141	9.36E-09	6.33E-09	7.18E-10	NO DATA	2.94E-09	NO DATA	2.42E-05
CE143	1.65E-09	1.22E-06	1.35E-10	NO DATA	5.37E-10	NO DATA	4.56E-05
CE144	4.88E-07	2.04E-07	2.62E-08	NO DATA	1.21E-07	NO DATA	1.65E-04
PR143	9.20E-09	3.69E-09	4.56E-10	NO DATA	2.13E-09	NO DATA	4.03E-05
PR144	3.01E-11	1.25E-11	1.53E-12	NO DATA	7.05E-12	NO DATA	4.33E-18
ND147	6.29E-09	7.27E-09	4.35E-10	NO DATA	4.25E-09	NO DATA	3.49E-05
W 197	1.03E-07	8.61E-08	3.01E-08	NO DATA	NO DATA	NO DATA	2.82E-05
NP239	1.19E-09	1.17E-10	6.45E-11	NO DATA	3.65E-10	NO DATA	2.40E-05

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TABLE 2.2  
Liquid Effluents

Design Objective Annual Quantity

<u>Nuclide</u>	<u>Limiting Organ</u>	<u>Dose Conversion Factor (mrem/Curie)</u>	<u>Design Objective Annual Quantity Ci (Curies)</u>
Cs-134	Total Body	3.62E+00	8.29E-01
Cs-137	Total Body	2.16E+00	1.39E+00
Cs-136	Total Body	4.01E+00	7.49E+00
Co-60	Total Body	2.99E-01	1.00E+01
Sr-89	Bone	1.70E-02	5.88E+02
Sr-90	Bone	1.64E-01	6.10E+01
Fe-55	GI Tract	1.41E-02	7.09E+02
Mn-54	GI	7.74E-02	1.29E+02
Zn-65	GI	2.73E-01	3.66E+02
Cr-51	GI	1.58E-03	6.32E+03
Ba-140	GI	2.50E-03	4.01E+03
La-140	GI	2.20E-02	4.55E+02
I-131	Thyroid	4.19E-01	2.39E+01
Co-58	GI Tract	1.13E-02	8.87E+02
H-3	Total Body	1.77E-06	1.69E+06

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D/Q

MS-1726  
APPENDIX 4 ANALYSIS

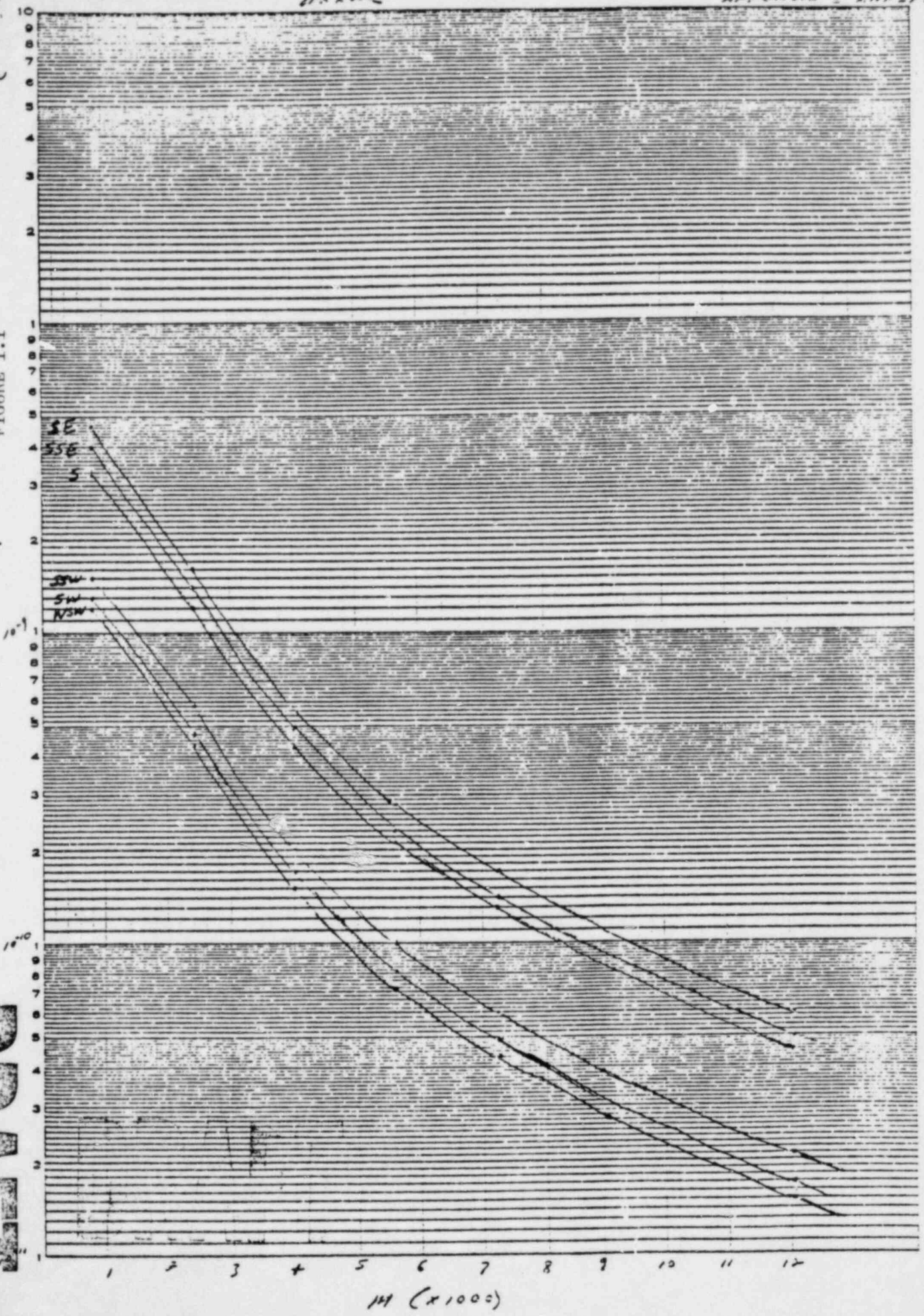
SE  
SSE  
S  
SSW  
SW  
WSW

DIETZGEN CORPORATION  
MADE IN U.S.A.

FIGURE 1.1

$D/Q$  ( $M^{-2}$ )

NO. 340-L410 DIETZGEN GRAPH PAPER  
SEMI-LOGARITHMIC  
4 CYCLES X 10 DIVISIONS PER INCH



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D/O - 3.2 206.8

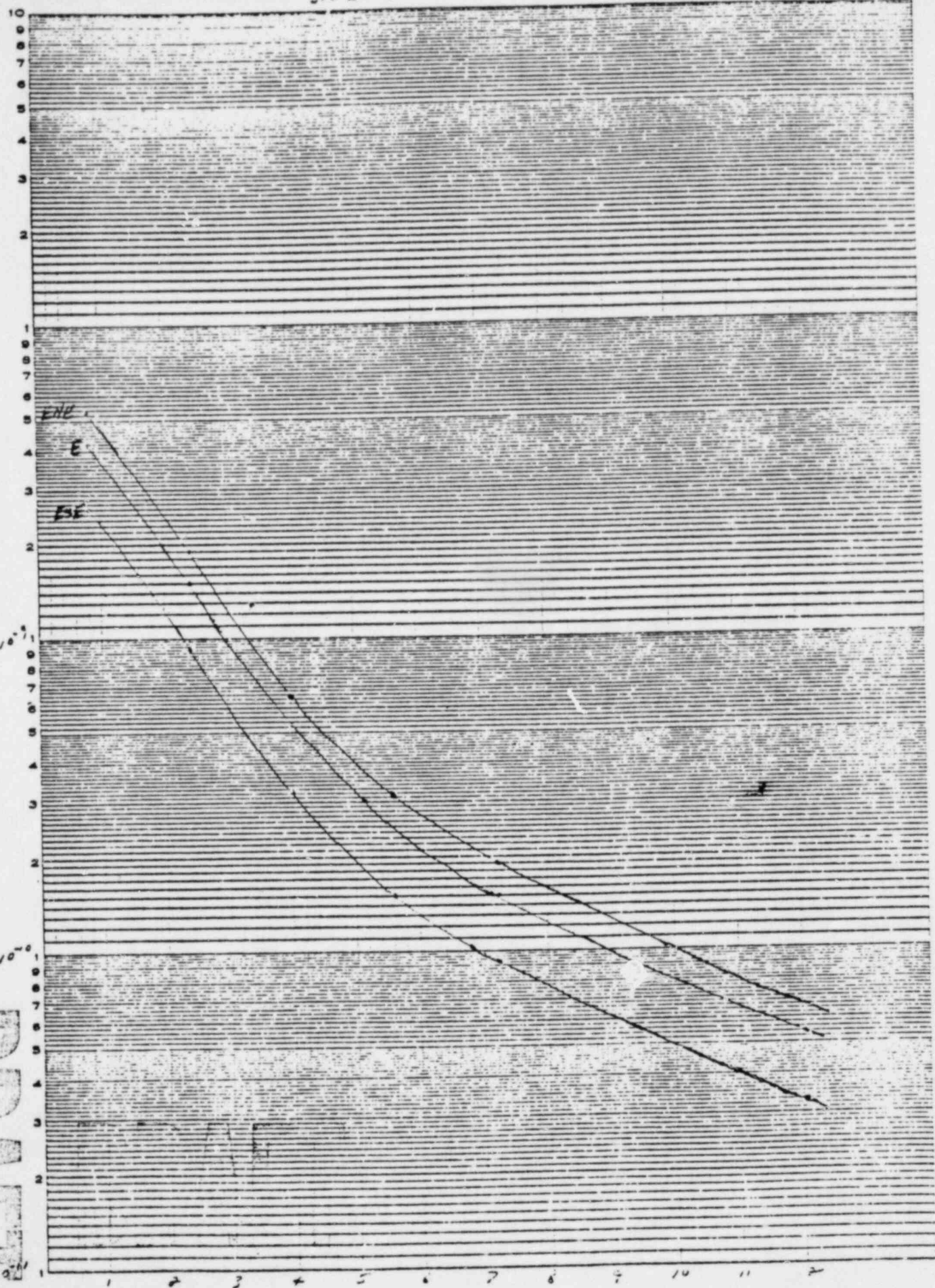
ENE  
E  
ESE

DIETZGEN CORPORATION  
MADE IN U.S.A.

FIGURE 1.1

$D/Q (M^{-2})$

NO. 340-L410 DIETZGEN GRAPH PAPER  
SEMI-LOGARITHMIC  
4 CYCLES X 10 DIVISIONS PER INCH



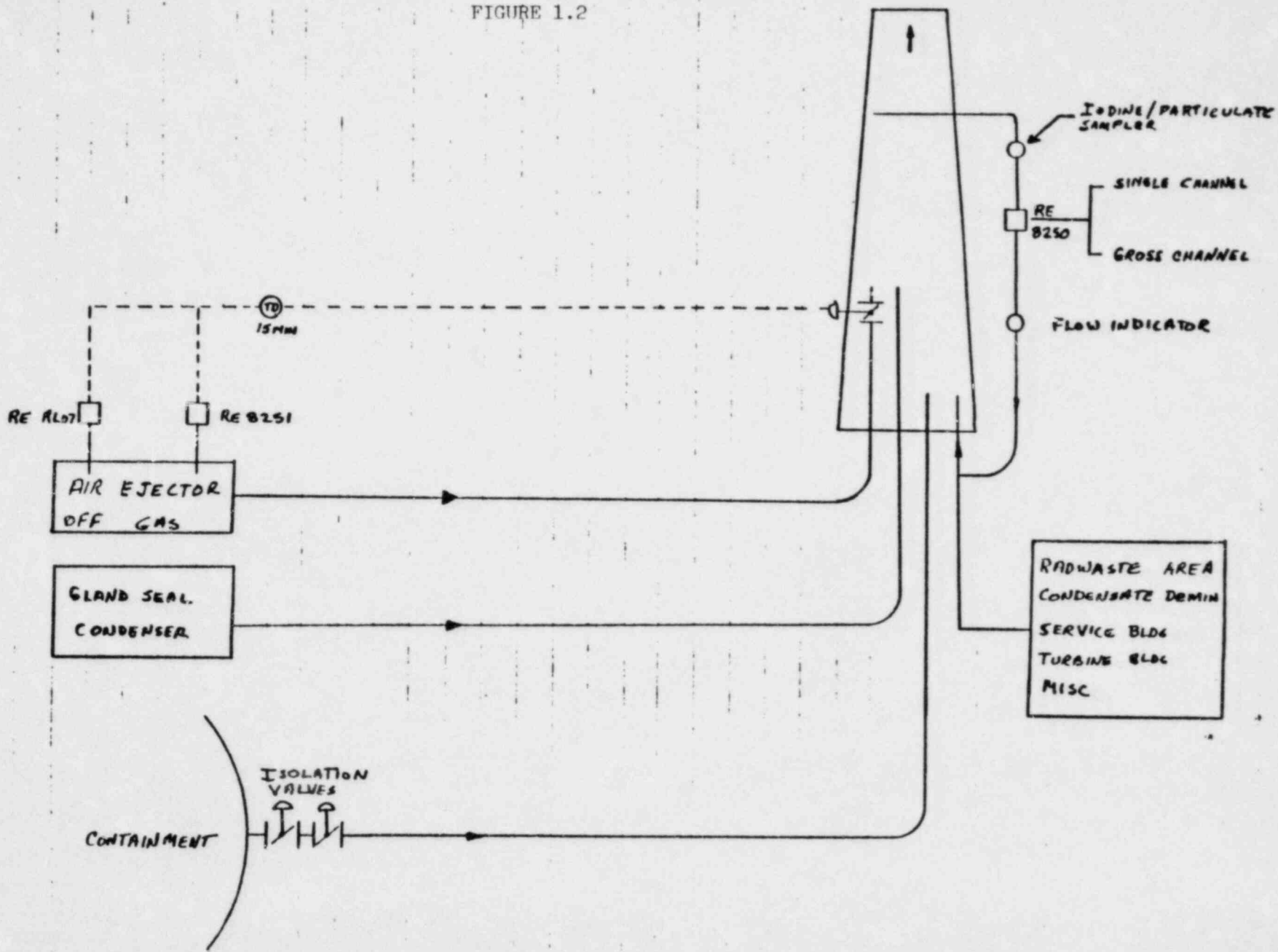
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10 (0.100)

# BIG ROCK POINT GASEOUS EFFLUENT FLOW PATHS

FIGURE 1.2

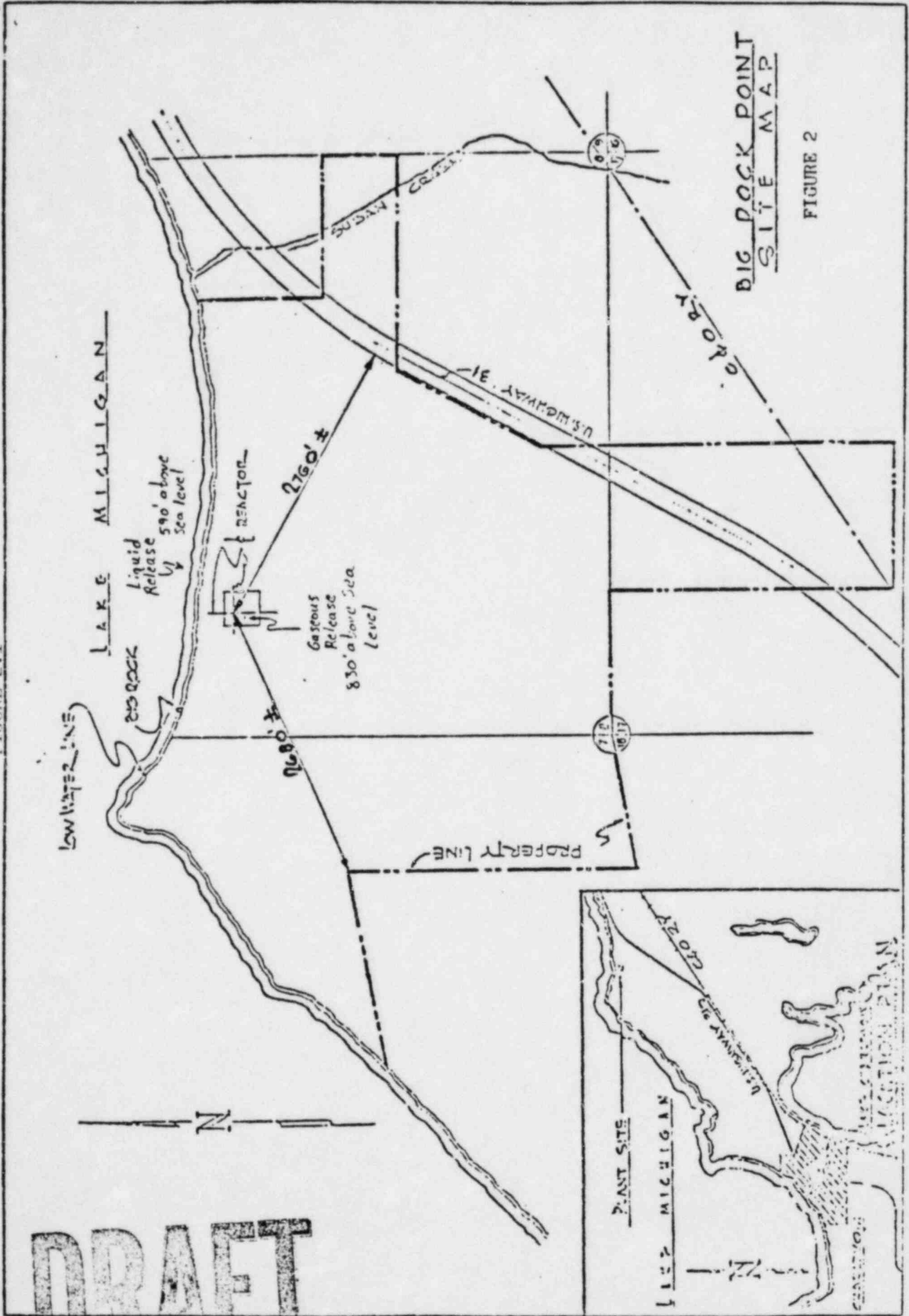


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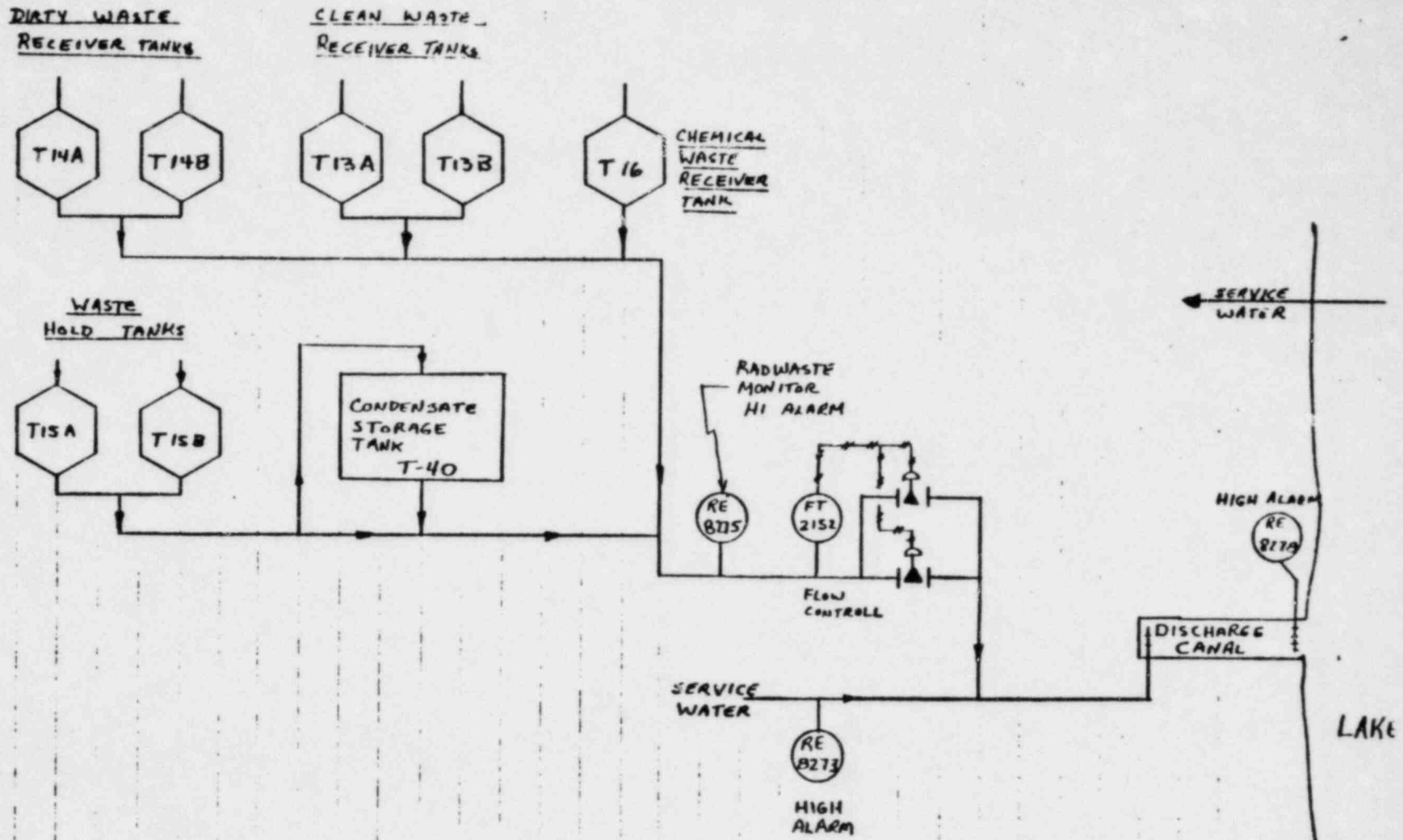
FIGURE 2.1



BIG DOCK POINT  
SITE MAP

FIGURE 2

FIGURE 2.2



BIG ROCK POINT - LIQUID RELEASE FLOWS

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