

OFFSITE DOSE CALCULATION MANUAL

FOR

DUKE POWER NUCLEAR STATIONS

8003200 403

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(Later)

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## INTRODUCTION

The Offsite Dose Calculation Manual provides the methodology and parameters to be used in the calculation of off-site doses due to radioactive liquid and gaseous effluents to assure compliance with the dose limitations of the Technical Specifications. These dose limitations assure that:

- 1) the concentration of radioactive liquid effluents from the site to the unrestricted area will be limited to the concentration levels of 10CFR20, Appendix B, Table II;
- 2) the exposures to any individual from radioactive liquid effluents will not result in doses greater than the design objectives of 10CFR50, Appendix I;
- 3) the dose rate at any time at the site boundary from radioactive gaseous effluents will be limited to the annual dose limits of 10CFR20 for unrestricted areas; and
- 4) the exposure to any individual from radioactive gaseous effluents will not result in doses greater than the design objectives of 10CFR50, Appendix I.

The methodology used to assure compliance with the dose limitations described above shall also be used to prepare the radioactive liquid and gaseous effluent reports required by the Technical Specifications. To assure compliance with 40CFR190 when twice the design objectives of 10CFR50, Appendix I are exceeded, the methodology and parameters to be used in calculating the off-site dose to any individual resulting from the entire fuel cycle except mining and waste management facilities are provided in this Manual.

The Manual also provides the methodology and parameters to be used in the calculation of radioactive liquid and gaseous effluent monitoring instrumentation alarm/trip setpoints to assure compliance with the concentration and dose rate limitations of the Technical Specifications. Changes to the methodology and parameters used in this Manual shall be reviewed by a qualified reviewer(s) and approved by the Station Manager and Nuclear Safety Review Board prior to implementation. Changes to this Manual shall be submitted to the Nuclear Regulatory Commission within 90 days of the date the change was made effective by inclusion in the Monthly Operating Report to comply with the Technical Specifications.

This Manual does not replace any station implementing procedures.

## 1.0 RELEASE RATE CALCULATIONS

The release rate calculations presented in the following sections are site release limits. Sites containing two or more units shall administratively control releases to assure that the release rate calculations limit releases as stated in the Technical Specifications. Administrative controls could limit the number of releases occurring at one time or apportion the release rate between the units.

### 1.1 LIQUID EFFLUENTS

To comply with Technical Specifications and to assure that the concentration of radioactive liquid effluents from the site to the unrestricted area is limited to the concentrations of 10CFR20, Appendix B, Table II, Column 2, the following release rate calculation shall be performed:

$$f \leq F \div (\sigma \sum_{i=1}^n \frac{C_i}{MPC_i})$$

where:

$C_i$  = The concentration of radionuclide, 'i', in undiluted liquid effluent, in  $\mu\text{Ci}/\text{ml}$ .

$MPC_i$  = the concentration of radionuclide, 'i', from 10CFR20, Appendix B, Table II, Column 2, in  $\mu\text{Ci}/\text{ml}$ .

$f$  = the undiluted effluent flow from the tank, in gpm.

$F$  = the dilution flow from the site discharge structure to unrestricted area receiving waters, in gpm.

$\sigma$  = recirculation factor at equilibrium.

### 1.2 GASEOUS EFFLUENTS

In order to comply with the Technical Specifications and to assure that the dose rate, at any time, in the unrestricted area due to radioactive materials released in gaseous effluents from the site is limited to  $<500$  mrem/yr to the total body and  $<3000$  mrem/yr to the skin for the noble gases and is limited to  $\leq 1500$  mrem/yr to any organ for all radioiodine and for all radioactive materials in particulates form and radionuclides other than noble gases with half lives greater than 8 days, the following release rate calculations shall be performed. These calculations, when solved for 'f', i.e. flowrate, are the release rates for noble gases and for radioiodines, particulates and other radionuclides with half-lives greater than 8 days. The most conservative of release rates calculated shall control the release rate.

#### 1.2.1 Noble Gases

$$\sum_i K_i \times [(\bar{x}/\bar{Q})Q_i] \sim <500 \text{ mrem/yr}, \text{ and}$$

$$\sum_i (L_i + 1.1 M_i) [(\overline{\chi/Q}) \tilde{Q}_i] < 3000 \text{ mrem/yr}$$

where:

$K_i$  = The total body dose factor due to gamma emissions for each identified noble gas radionuclide, in mrem/yr per  $\mu\text{Ci}/\text{m}^3$  from Table 1.2-1.

$L_i$  = The skin dose factor due to beta emissions for each identified noble gas radionuclide, in mrem/yr per  $\mu\text{Ci}/\text{m}^3$  from Table 1.2-1.

$M_i$  = The air dose factor due to gamma emissions for each identified noble gas radionuclide, in mrad/yr per  $\mu\text{Ci}/\text{m}^3$  from Table 1.2-1 (unit conversion constant of 1.1 mrem/mrad converts air dose to skin dose).

$P_i$  = The dose parameter for radionuclides other than noble gases for the inhalation pathway, in mrem/yr per  $\mu\text{Ci}/\text{m}^3$  and for the food and ground plane pathways in  $\text{m}^2$  (mrem/yr) per  $\mu\text{Ci}/\text{sec}$  from Table 1.2-2. The dose factors are based on the critical individual organ and most restrictive age group (child or infant).

$\tilde{Q}_i$  = The release rate of radionuclides, 'i', in gaseous effluent from all release points at the site, in  $\mu\text{Ci/sec}$ .

$(\overline{\chi/Q})$  = The highest calculated annual average dispersion parameter for any area at or beyond the unrestricted area boundary.

$W$  = The highest calculated annual average dispersion parameter for estimating the dose to an individual at the controlling location.

$$\tilde{Q}_i = k_1 C_i f \div k_2 = 4.72E+2 C_i f$$

where:

$C_i$  = the concentration of radionuclide, 'i', in undiluted gaseous effluent, in  $\mu\text{Ci/ml}$ .

$f$  = the undiluted effluent flow, in cfm.

$k_1$  = conversion factor,  $2.83E4 \text{ ml/ft}^3$ .

$k_2$  = conversion factor,  $6E1 \text{ sec/min}$ .

### 1.2.2 Radioiodines, Particulates, and Others

$$\sum_i P_i [W \tilde{Q}_i] < 1500 \text{ mrem/yr}$$

where the terms are as defined above.

TABLE 1.2-1  
(1 of 1)  
DOSE FACTORS FOR NOBLE GASES AND DAUGHTERS\*

Radionuclide	Total Body Dose Factor $K_i$ (mrem/yr per $\mu\text{Ci}/\text{m}^3$ )	Skin Dose Factor $L_i$ (mrem/yr per $\mu\text{Ci}/\text{m}^3$ )	Gamma Air Dose Factor $M_i$ (mrad/yr per $\mu\text{Ci}/\text{m}^3$ )	Beta Air Dose Factor $N_i$ (mrad/yr per $\mu\text{Ci}/\text{m}^3$ )
Kr-83m	7.56E-02**	---	1.93E+01	2.66E+02
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

\*The listed dose factors are for radionuclides that may be detected in gaseous effluents.  
\*\* $7.56E-02 = 7.56 \times 10^{-2}$ .

TABLE 1.2-2  
(1 of 1)  
DOSE PARAMETERS FOR RADIOIODINES AND RADIOACTIVE  
PARTICULATE, GASEOUS EFFLUENTS\*

P(I), DOSE PARAMETERS FOR RADIOIODINES AND RADIOACTIVE PARTICULATES IN GASEOUS EFFLUENTS

Radionuclide	Pathways		Radionuclide	Pathways	
	Inhalation (mrem/yr per μCi/m <sup>3</sup> )	Milk and Ground (m <sup>2</sup> . mrem/yr per μCi/sec)		Inhalation (mrem/yr per μCi/m <sup>3</sup> )	Milk and Ground (m <sup>2</sup> . mrem/yr per μCi/sec)
I-3**	6.5E+02	2.4E+03	RU 103	1.8E+04	1.6E+08
C-14**	2.6E+04	3.2E+06	RU 106	1.6E+05	3.0E+08
P-32	2.0E+06	1.6E+11	AG 110M	3.3E+04	1.5E+10
CR-51	3.6E+02	1.1E+07	CD 115M	7.0E+04	5.2E+07
MN-54	2.5E+04	1.1E+09	SN 123	2.9E+05	3.7E+09
FE-55	2.0E+04	1.1E+08	SN 126	1.2E+06	1.1E+10
FE-59	2.4E+04	7.2E+08	SB 124	5.9E+04	1.4E+09
CO-58	1.1E+04	5.8E+08	SB 125	1.5E+04	9.1E+08
CO-60	3.2E+04	4.6E+09	TE 127M	3.8E+04	1.0E+09
NI-63	3.4E+05	3.0E+10	TE 129M	3.2E+04	1.3E+09
ZN-65	6.3E+04	1.8E+10	CS 134	7.0E+05	5.6E+10
RB-86	1.9E+05	2.1E+10	CS 136	1.3E+05	5.7E+09
SR-89	4.0E+05	1.1E+10	CS 137	6.1E+05	5.0E+10
SR-90	4.1E+07	1.0E+11	BA 140	5.6E+04	2.0E+08
Y-91	7.0E+04	5.9E+06	CE 141	2.2E+04	3.2E+07
ZR-95	2.2E+04	3.5E+08	CE 144	1.5E+05	1.6E+08
NB-95	1.3E+04	3.8E+08	I-131	1.5E+07	1.0E+12
MO-99	2.6E+02	3.2E+08	I-133	3.6E+06	9.6E+09

\*If SR-90 analysis is performed, use P(I) given in I-131 for unidentified components. If SR-90 and I-131 analyses are performed, use P(I) given in CS-137 for unidentified components. If SR-90, I-131, and CS-137 analyses are performed, use P(I) given in ZN-65 for unidentified components.

\*\*For tritium, the units of dose parameters are mrem/yr per μCi/m<sup>3</sup> for all pathways, and they must be multiplied by X/Q in Specification 3.11.2.1.B.

## 2.0 RADIATION MONITORING SETPOINTS

Effluent radiation monitor alarm/trip setpoints shall be determined using the calculations presented in the following sections. The calculations define the relationships between the measured effluent activity, the maximum allowable effluent activity, the effluent flowrate, and the dilution available in the restricted area (as defined for effluent releases in the Technical Specifications) which must be controlled to assure that the instantaneous release rate is not exceeded.

The setpoints shall be determined for those monitors listed in the appropriate tables of the Technical Specifications.

### 2.1 LIQUID MONITORS

The following equation shall be used to calculate liquid radiation monitor setpoints:

$$\frac{Cf}{F + f} \leq MPC$$

where:

MPC = the effluent concentration limit implementing 10CFR20 for the site, in  $\mu\text{Ci}/\text{ml}$ .

C = the radioactivity concentration in  $\mu\text{Ci}/\text{ml}$ , in the effluent line prior to dilution and subsequent release, which may be the setpoint and, if so, represents a value which, if exceeded, would result in concentrations exceeding the limits of 10CFR20 in the unrestricted area.

f = the flow measured at the radiation monitor location in gpm.

F = the dilution water flow as measured prior to the release point in gpm.

(Note that if no dilution is provided, C  $\leq$  MPC. Also, note that when (F) is large compared to (f), then F + f  $\approx$  F.)

### 2.2 GAS MONITORS

The following equation shall be used to calculate noble gas radiation monitor setpoints based on Xe-133:

$$K_i (\overline{\chi/Q}) \tilde{Q}_i < 500$$
$$\tilde{Q}_i = 4.72E+2 C f \text{ (See Section 1.2.1)}$$

where:

C = the gross activity in undiluted effluent, in  $\mu\text{Ci}/\text{ml}$ .

f = the flow from the tank or building and varies for various release sources, in cfm.

$K_i$  = from Table 1.2-1 for Xe-133, 2.94E-2 mrem/yr per  $\mu\text{Ci}/\text{m}^3$ .

$(\bar{\chi}/Q)$  = the highest calculated annual average dispersion parameter for any area at or beyond the unrestricted area boundary for long term releases.

### 3.0      DOSE CALCULATIONS

#### 3.1      DOSE MODELS FOR MAXIMUM EXPOSED INDIVIDUAL

##### 3.1.1      Liquid Effluents

Of the possible exposure pathways in the aquatic environment, only two contribute significantly to the total dose; these pathways are ingestion of potable water and aquatic foods. The dose contributions, from these pathways, for measured quantities of radioactive materials identified in liquid effluents released to unrestricted areas shall be calculated for the maximum exposed individual in each age group using:

$$D_{at} = \sum_i [A_{ait} \sum_{\ell=1}^m \Delta t_{\ell} C_{il} F_{\ell}]$$

where:

$D_{at}$  = the cumulative dose commitment to the total body or any organ,  $t$ , for an individual of age group,  $a$ , from the liquid effluent for the total time period  $\sum_{\ell=1}^m \Delta t_{\ell}$ , in mrem.

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

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

$F_{\ell}$  = the near field average dilution factor for  $C_{il}$  during any liquid effluent release where:

$$F_{\ell} = \frac{f\sigma}{F + f}$$

where:

$\sigma$  = recirculation factor at equilibrium

$f$  = liquid radwaste flow, in gpm.

$F$  = dilution flow, in gpm.

$A_{ait}$  = the site related ingestion dose commitment factor for an individual of age group,  $a$ , to the total body or any organ, ' $t$ ', for each identified principal gamma and beta emitter, mrem/hr per  $\mu\text{Ci}/\text{ml}$ .

$$A_{ait} = 1.14E5 (U_{aw}/D_w + U_{af}BF_i)DF_{ait}$$

where:

$$1.14E5 = 10^6 \text{ pCi}/\mu\text{Ci} \times 10^3 \text{ ml/kg} \div 8760 \text{ hr/yr.}$$

$U_{aw}$  = Water consumption by age group, l/yr.

infant	330
child	510
teen	510
adult	730

$D_w$  = Dilution factor from the near field area to the potable water intake.

$U_{af}$  = fish consumption by age group, kg/yr.

infant	--
child	6.9
teen	16
adult	21

$BF_i$  = Bioaccumulation factor for radionuclide, 'i', in fish, pCi/kg per pCi/l, from Table 3.1-1.

$DF_{ait}$  = Dose conversion factor for radionuclide, 'i', by age group in pre-selected organ,  $\tau$ , in mrem/pCi, from Tables 3.1-2, 3.1-3, 3.1-4, and 3.1-5, respectively.

### 3.1.2 Gaseous Effluents

The dose contributions from measured quantities of radioactive materials identified in gaseous effluent released to unrestricted areas shall be calculated for the maximum exposed individual using the following equations:

#### 3.1.2.1 Noble Gases

For gamma radiation:

$$D_\gamma = 3.17 \times 10^{-8} \sum_{i=1}^{\infty} M_i [(\bar{Q}/\bar{Q}) Q_i]$$

For beta radiation:

$$D_\beta = 3.17 \times 10^{-8} \sum_{i=1}^{\infty} N_i [(\bar{Q}/\bar{Q}) Q_i]$$

where:

$3.17 \times 10^{-8}$  = The inverse of the number of seconds in a year.

$M_i$  = The air dose factor due to gamma emissions for each identified noble gas radionuclide, in mrad/yr per  $\mu\text{Ci}/\text{m}^3$  from Table 1.2-1.

$N_i$  = The air dose factor due to beta emissions for each identified noble gas radionuclide, in mrad/yr per  $\mu\text{Ci}/\text{m}^3$  from Table 1.2-1.

$(\bar{Q}/\bar{Q})$  = The highest calculated annual average relative concentration for any area at or beyond the unrestricted area boundary.

$\sim Q_i$  = The release of noble gas radionuclides, 'i', in gaseous effluents, in  $\mu\text{Ci}$ .

### 3.1.2.2 Radioiodines, Particulates, and Others

These calculations apply to all radioiodines, radioactive materials in particulate form and radionuclides other than noble gases with half-lives greater than 8 days:

$$D = 3.17 \times 10^{-8} \sum_i^{\sim} R_i [WQ_i]$$

where:

$3.17 \times 10^{-8}$  = The inverse of the number of seconds in a year.

$\sim$

$Q_i$  = The release of radioiodines, radioactive materials in particulate form and radionuclides other than noble gases in gaseous effluents, 'i', in  $\mu\text{Ci}$ . Releases shall be cumulative over the calendar quarter or year as appropriate.

$W$  = The annual average dispersion or deposition parameter for estimating the dose to an individual at the controlling location.

$W = (\bar{X}/\bar{Q})$  for the inhalation pathway, in  $\text{sec}/\text{m}^3$ .

$W = (\bar{D}/\bar{Q})$  for the food and ground plane pathways, in  $\text{meters}^{-2}$ .

$R_i$  = The dose factor for each identified radionuclide, 'i', in  $\text{m}^2$  ( $\text{mrem}/\text{yr}$ ) per  $\mu\text{Ci}/\text{sec}$  or  $\text{mrem}/\text{yr}$  per  $\mu\text{Ci}/\text{m}^3$ .

$$R_i = R_i^I [\chi/Q] + R_i^G [D/Q] + R_i^C [D/Q, \chi/Q] + R_i^M [D/Q, \chi/Q] + R_i^V [D/Q, \chi/Q]$$

where:

Inhalation Pathway Factor,  $R_i^I [\chi/Q]$

$$R_i^I [\chi/Q] = K' (BR)_a (DFA_i)_a (\text{mrem}/\text{yr} \text{ per } \mu\text{Ci}/\text{m}^3)$$

where:

$K'$  = a constant of unit conversion,  $10^6 \text{ pCi}/\mu\text{Ci}$ .

$(BR)_a$  = the breathing rate of the receptor of age group (a), in  $\text{m}^3/\text{yr}$ .

The breathing rates  $(BR)_a$  for the various age groups are tabulated below, as given in Regulatory Guide 1.109.

<u>Age Group (a)</u>	<u>Breathing Rate (<math>\text{m}^3/\text{yr}</math>)</u>
Infant	1400
Child	3700
Teen	8000
Adult	8000

$(DFA_{i,a})$  = the maximum organ inhalation dose factor the receptor of age group (a) for the ith radionuclide, in mrem/pCi. The total body is considered as an organ in the selection of  $(DFA_{i,a})$ . See Tables 3.1-6, 3.1-7, 3.1-8, and 3.1-9.

Inhalation dose factors  $(DFA_i)$  for the various age groups are given in Tables 3.1-6, 3.1-7, 3.1-8, and 3.1-9 (taken from Regulatory Guide 1.109 (Rev.1)).

Ground Plane Pathway Factor,  $R_i^G$  [D/Q]

$$R_i^G \text{ [D/Q]} = K' K'' (SF) DFG_i [(1 - e^{-\lambda_i t}) / \lambda_i] \text{ (m}^2 \cdot \text{ mrem/yr per } \mu\text{Ci/sec)}$$

where:

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

$K''$  = a constant of unit conversion, 8760 hr/year.

$\lambda_i$  = the decay constant for the ith radionuclide, sec<sup>-1</sup>.

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

$DFG_i$  = the ground plane dose conversion factor for the ith radionuclide (mrem/hr per pCi/m<sup>2</sup>).

$SF$  = the shielding factor (dimensionless), 0.7 (Regulatory Guide 1.109 (Rev. 1)).

Ground plane dose conversion factors,  $DFG$ , are found in Table 3.1-10.

Grass-Cow-Milk Pathway Factor,  $R_i^C$  [D/Q]

$$R_i^C \text{ [D/Q]} = K' E \frac{Q_F (U_{ap})}{\lambda_i + \lambda_w} F_m(r) (DFL_i)_a \left[ \frac{f_p f_s}{Y_p} + \frac{(1-f_p f_s)e^{-\lambda_i t_h}}{Y_s} \right] e^{-\lambda_i t_f}$$

$$\text{ (m}^2 \cdot \text{ mrem/yr per } \mu\text{Ci/sec})$$

where:

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

$Q_F$  = the cow's consumption rate, in kg/day (wet weight), 50 (Regulatory Guide 1.109 (Rev. 1)).

$U_{ap}$  = the receptor's milk consumption rate for age (a), in liters/yr.

$U_{ap}$ (liters/yr)	- Infant	330
	- Child	330
	- Teen	400
	- Adult	310 (Regulatory Guide 1.109 (Rev. 1))

- $Y_p$  = the agricultural productivity by unit area of pasture feed grass, in  $\text{kg/m}^2$ , 0.7.  
 $Y_s$  = the agricultural productivity by unit area of stored feed, in  $\text{kg/m}^2$ , 2.0.  
 $F_m$  = the stable element transfer coefficients, in days/liter, Table 3.1-11.  
 $r$  = fraction of deposited activity retained on cow's feed grass,  $r = 1$  for radioiodine and  $r = 0.2$  for particulates (Regulatory Guide 1.109).  
 $(DFL_{i,a})$  = the maximum organ ingestion dose factor for the ith radionuclide for the receptor in age group 'a', in  $\text{mrem/pCi}$ . See Tables 3.1-2, 3.1-3, 3.1-4, and 3.1-5.  
 $\lambda_i$  = the decay constant for the ith radionuclide, in  $\text{sec}^{-1}$ .  
 $\lambda_w$  = the decay constant for removal of activity on leaf and plant surfaces by weathering,  $5.73 \times 10^{-7} \text{ sec}^{-1}$  (corresponding to a 14 day half-life).  
 $t_f$  = the transport time from pasture to cow, to milk, to receptor, in sec,  $1.73 \times 10^5$  (2 days).  
 $t_h$  = the transport time from pasture, to harvest, to cow, to milk, to receptor, in sec,  $7.78 \times 10^6$  (90 days).  
 $f_p$  = fraction of the year that the cow is on pasture (dimensionless), 1.0.  
 $f_s$  = fraction of the cow feed that is pasture grass while the cow is on pasture (dimensionless), 1.0.  
 $E$  = an adjustment fraction which accounts for the fraction of radionuclides in elemental form which contribute dose for this pathway,  $E = 0.5$  for radioiodine,  $E = 1.0$  for all others.

The concentration of tritium in milk is based on the airborne concentration rather than the deposition. Therefore, the  $R_i^C$  is based on  $[\chi/Q]$ :

$$R_i^C [\chi/Q] = K' K'' F_m Q_F U_{ap} (DFL_{i,a}) [0.75(0.5/H)] (\text{mrem/yr per } \mu\text{Ci/m}^3)$$

where:

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

$H$  = absolute humidity of the atmosphere,  $8 \text{ gm/m}^3$ , (Regulatory Guide 1.109)

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.

### Grass-Cow-Meat Pathway Factor, $R_i^M[D/Q]$

The integrated concentration in meat follows in a similar manner to the development for the milk pathway, therefore:

$$R_i^M[D/Q] = K' \frac{Q_F(U_{ap})}{\lambda_i + \lambda_w} F_f(r)(DFL_i)_a \left[ \frac{f_f s}{Y_p} + \frac{(1-f_f s)e^{-\lambda_i t_h}}{Y_s} \right] e^{-\lambda_i t_f}$$

(m<sup>2</sup> · mrem/yr per  $\mu$ Ci/sec)

where:

$F_f$  = the stable element transfer coefficients, in days/kg, Table 3.1-11.

$U_{ap}$  = the receptor's meat consumption rate for age (a), in kg/yr.

$U_{ap}$ (kg/yr)	- Infant	0
	- Child	41
	- Teen	65
	- Adult	110 Taken from Regulatory Guide 1.109 (Rev. 1).

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

$t_h$  = the transport time from crop field to receptor, in sec.

The concentration of tritium in meat is based on its airborne concentration rather than the deposition. Therefore, the  $R_i^M$  is based on  $[x/Q]$ :

$$R_i^M[x/Q] = K' K'' F_f Q_F U_{ap} (DFL_i)_a [0.75(0.5/H)] (\text{mrem/yr per } \mu\text{Ci/m}^3)$$

where all terms are defined above.

### Vegetation Pathway Factor, $R_i^V[D/Q]$

The integrated concentration in vegetation consumed by man follows the expression developed in the derivation of the milk factor. Man is considered to consume two types of vegetation (fresh and stored) that differs only in the time period between harvest and consumption, therefore:

$$R_i^V[D/Q] = K' \left[ \frac{(r)}{Y_v(\lambda_i + \lambda_w)} \right] (DFL_i)_a \left[ U_a^L f_L e^{-\lambda_i t_L} + U_a^S f_g e^{-\lambda_i t_h} \right]$$

(m<sup>2</sup> · mrem/yr per  $\mu$ Ci/sec)

where:

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

$U_a^L$  = the consumption rate of fresh leafy vegetation by the receptor in age group (a), in kg/yr.

$U_a^L$ = (kg/nr)	- Infant	0
	- Child	26
	- Teen	42
	- Adult	64

$U_a^S$  = the consumption rate of stored vegetation by the receptor in age group (a), in kg/yr.

$U_a^S$ = (kg/yr)	- Infant	0
	- Child	520
	- Teen	630
	- Adult	520

$f_L$  = the fraction of the annual intake of fresh leafy vegetation grown locally.

$f_g$  = the fraction of the annual intake of stored vegetation grown locally.

$t_L$  = the average time between harvest of leafy vegetation and its consumption, in seconds,  $8.6 \times 10^4$  (1 day).

$t_h$  = the average time between harvest of stored vegetation and its consumption, in seconds,  $5.18 \times 10^6$  (60 days).

$\gamma_v$  = the vegetation area density, 2.0 kg/m<sup>2</sup>.

and all other factors are previously defined.

The concentration of tritium in vegetation is based on the airborne concentration rather than the deposition. Therefore, the  $R_i^V$  is based on [ $\chi/Q$ ]:

$$R_i^V[\chi/Q] = K'K''' \left[ U_a^L f_L + U_a^S f_g \right] (DFL_i)_a [0.75(0.5/H)] (\text{mrem/yr per } \mu\text{Ci/m}^3).$$

All terms defined previously.

### 3.1.3 Direct Radiation

Direct radiation is that radiation from confined sources and does not include any external component from radioactive effluents. The point kernel method has been used to calculate offsite dose rates from radioactive materials stored in the refueling water storage tanks and reactor makeup water storage tanks. Dose calculations using this method performed for Duke Nuclear Stations indicate direct radiation doses are much less than 1 mrem/yr. and, therefore, negligible contributions to either individual or population doses. Direct radiation doses will not be calculated routinely.

### 3.2 SIMPLIFIED DOSE ESTIMATES

To estimate the cumulative dose contributions to the maximum exposed individual for 31 day dose calculations, the calculations presented in Section 3.1 can be simplified. The simplified calculations would be for an individual in the critical population using only data for the critical pathway and critical radionuclide(s). Critical populations, critical pathways, and critical radionuclides have been determined for each Duke Nuclear Station from the dose calculations performed to evaluate compliance with Appendix I to 10CFR50.

Simplified 31-day dose calculations are presented in the section on site specific information.

### 3.3 FUEL CYCLE CALCULATIONS

In accordance with the requirements of 40CFR190, the annual dose commitment to any member of the general public shall be calculated to assure that doses are limited to 25 millirems to the total body or any organ with the exception of the thyroid which is limited to 75 millirems. In accordance with the requirements of the Technical Specifications, the annual dose commitment shall also be calculated any time that one of the quarterly dose limits of the Technical Specifications is exceeded; these annual dose commitments may not just be calculated for the calendar year.

The "Uranium fuel cycle" is defined in 40CFR Part 190.02(b) as:

"Uranium fuel cycle means the operations of milling or uranium ore, chemical conversion of uranium, isotopic enrichment of uranium, fabrication of uranium fuel, generation of electricity by a light-water-cooled nuclear power plant using uranium fuel, and reprocessing of spent uranium fuel, to the extent that these directly support the production of electrical power for public use utilizing nuclear energy, but excludes mining operations, operations at waste disposal sites, transportation of any radioactive material in support of these operations, and the reuse of recovered non-uranium special nuclear and by-product materials from the cycle."

Based on this definition of the fuel cycle and the information in 10CFR51 Table S-3 and WASH-1248, the radiological impact of the following operations has been assessed for Duke Nuclear Stations:

#### 3.3.1 Milling

No milling operations occur within fifty miles of any Duke Nuclear Station. The increment of dose from milling operations to any individual within fifty miles of any Duke Nuclear Station is negligible.

#### 3.3.2 Conversion

No uranium hexafluoride production occurs within fifty miles of any Duke Nuclear Station. The increment of dose from UF<sub>6</sub> production to any individual within fifty miles of any Duke Nuclear Station is negligible.

#### 3.3.3 Enrichment

No uranium enrichment operations occur within fifty miles of any Duke Nuclear Station. The increment of dose from enrichment operations to any individual within fifty miles of any Duke Nuclear Station is negligible.

#### 3.3.4 Fuel Fabrication

No fuel fabrication operations occur within fifty miles of any Duke Nuclear Station. The increment of dose from fabrication operations to any individual within fifty miles of any Duke Nuclear Station is negligible.

### 3.3.5 Nuclear Power Production

The production of electricity for public use using light-water-cooled nuclear power stations results in increments of dose to individuals within fifty miles of any station due to liquid and gaseous effluent releases and direct radiation or skyshine. The increments of dose resulting from liquid and gaseous effluent releases will be calculated using the methodology presented in Sections 3.1.1 and 3.1.2. The dose from direct radiation, skyshine, and radiation from the station storage facilities has been estimated using conservative assumptions (see Section 3.1.3), the estimates of this dose will be presented in the section on site specific information.

In certain situations more than one nuclear power station site may contribute to the doses to be considered in making fuel cycle dose assessments in accordance with 40CFR190. Situations involving more than one station will be presented in the section on site specific information.

### 3.3.6 Fuel Reprocessing

No fuel reprocessing operations occur within fifty miles of any Duke Nuclear Station. The increment of dose from reprocessing operations to any individual within fifty miles of any Duke Nuclear Station is negligible.

To summarize, only dose increments from nuclear power production operations (Section 3.3.5) need be considered in calculations to demonstrate compliance with the requirements of 40CFR190.

## 3.4 POPULATION DOSES

To comply with the reporting requirements of the semiannual effluent summary, significant population dose contributions from all receiving-water-related pathways, from gaseous effluents to a distance of 50 miles from the site, and from direct radiation from the station should be calculated. A significant dose contribution is defined as 10 percent or more of total dose.

### 3.4.1 Liquid Effluents

As stated in Section 3.1.1 of the possible exposure pathways in the aquatic environment, only two contribute significantly to the total dose; these pathways are ingestion of potable water and aquatic foods. The dose contributions from these pathways, for measured quantities of radioactive materials identified in liquid effluents released to unrestricted areas, shall be calculated for the exposed population using:

$$D_t^P = 0.001 \sum_d P_d \sum_a \sum_i [A_{it} \sum_{l=1}^m \Delta t_l C_{il} F_l]$$

where:

$D_t^P$  = the population dose commitment to the total body or any organ,  $\tau$ , from

the liquid effluent for the total time period  $\sum_{l=1}^m \Delta t_l$ , in man-rem.

**IMAGE EVALUATION  
TEST TARGET (MT-3)**



**MICROCOPY RESOLUTION TEST CHART**

0.001 = conversion from millirem to rem.

$P_d$  = exposed population in region d.

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

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

$F_\ell$  = the near field average dilution factor for  $C_{il}$  during any liquid effluent release where:

$$F_\ell = \frac{f\sigma}{F + f}$$

where:

c = recirculation factor at equilibrium

f = liquid radwaste flow, in gpm

F = dilution flow, in gpm.

$A_{ait}$  = the site related ingestion dose commitment factor for an individual of age group, a, to the total body or any organ,  $\tau$ , for each identified principal gamma and beta emitter, mrem/hr per  $\mu\text{Ci}/\text{ml}$ .

$$A_{ait} = 1.14E5 (U_{aw}/D_w + U_{af}BF_i)DF_{ait}$$

where:

$$1.14E5 = 10^6 \text{ pCi}/\mu\text{Ci} \times 10^3 \text{ ml/kg} \div 8760 \text{ hr/yr.}$$

$U_{aw}$  = water consumption by age group,  $\text{z/yr}$ .

infant	0
child	260
teen	260
adult	370

$D_w$  = dilution factor from the near field area to the potable water intake.

$U_{af}$  = fish consumption by age group,  $\text{kg/yr}$ .

infant	0
child	2.2
teen	5.2
adult	6.9

$BF_i$  = bioaccumulation factor for radionuclide, i, in fish,  $\text{pCi/kg}$  per  $\text{pCi}/\ell$ , from Table 3.1-1.

$DF_{ait}$  = dose conversion factor for radionuclide, i, by age group in pre-selected organ,  $\tau$ , in mrem/pCi, from Tables 3.1-2, 3.1-3, 3.1-4, and 3.1-5, respectively.

### 3.4.2 Gaseous Effluents

The dose contributions to the exposed population from measured quantities of radioactive materials identified in gaseous effluents released to unrestricted areas shall be calculated by sectors using the methodology in the following sections. The 50-mile region should be divided 160 subregions formed by sectors centered on the 16 compass points and annuli at distances 1, 2, 3, 4, 5, 10, 20, 30, 40, and 50 miles from the center of the facility.

#### 3.4.2.1 Noble Gases

For gamma radiation:

$$D_{\gamma}^P = 3.17E-11 \sum_d P_d \sum_i M_i [\overline{X/Q} \tilde{Q}_i]$$

For beta radiation:

$$D_{\beta}^P = 3.17E-11 \sum_d P_d \sum_i N_i [\overline{X/Q} \tilde{Q}_i]$$

where:

3.17E-11 = The inverse of the number of seconds in a year times the conversion of millirems to rems.

$P_d$  = population in subregion d

$M_i$  = The air dose factor due to gamma emissions for each identified noble gas radionuclide, in mrad/yr per  $\mu\text{Ci}/\text{m}^3$  from Table 1.2.1.

$N_i$  = The air dose factor due to beta emissions for each identified noble gas radionuclide, in mrad/yr per  $\mu\text{Ci}/\text{m}^3$  from Table 1.2-1.

$(\overline{X/Q})$  = The highest calculated annual average dispersion parameter for any area at or beyond the unrestricted area boundary.

$\tilde{Q}_i$  = The release of noble gas radionuclides, 'i', in gaseous effluents, in  $\mu\text{Ci}$ .

#### 3.4.2.2 Radioiodines, Particulates, and Others

These calculations apply to all radioiodines, radioactive materials in particulate form and radionuclides other than noble gases with half-lives greater than 8 days:

$$D^P = 3.17E-11 \sum_d P_d \sum_i f_d R_i [\overline{WQ} \tilde{Q}_i]$$

where:

3.17E-11 = The inverse of the number of seconds in a year times the conversion from millirems to rems.

$P_d$  = The population in subregion d

$f_d$  = The fraction of the population in subregion d that is in age group a.

$\bar{Q}_i$  = The release of radioiodines, radioactive materials in particulate form and radionuclides other than noble gases in gaseous effluents, 'i', in  $\mu\text{Ci}$ . Releases shall be cumulative over the calendar quarter or year as appropriate.

$w$  = The annual average dispersion or deposition parameter for estimating the dose to an individual at the controlling location

$$w = (\bar{X}/\bar{Q}) \text{ for the inhalation pathway, in sec/m}^3$$

$$w = (\bar{D}/\bar{Q}) \text{ for the food and ground plane pathways, in meters, } ^{-2}$$

$R_i$  = The dose factor for each identified radionuclide, 'i', in  $\text{m}^2$  ( $\text{mrem}/\text{yr}$ ) per  $\mu\text{Ci/sec}$  or  $\text{mrem}/\text{yr}$  per  $\mu\text{Ci/m}^3$ .

$$R_i = R_i^I [\chi/Q] + R_i^G [D/Q] + R_i^C [D/Q, \chi/Q] + [D/Q, \chi/Q] + R_i^V [D/Q, \chi/Q]$$

where:

Inhalation Pathway Factor,  $R_i^I [\chi/Q]$

$$R_i^I [\chi/Q] = K' (BR)_a (\text{mrem}/\text{yr} \text{ per } \mu\text{Ci/m}^3)$$

where:

$K'$  = a constant of unit conversion,  $10^6 \text{ pCi}/\mu\text{Ci}$ .

$(BR)_a$  = the breathing rate of the receptor of age group (a), in  $\text{m}^3/\text{yr}$ .

The breathing rates (BR)<sub>a</sub> for the various age groups are tabulated below, as given in Regulatory Guide 1.109.

<u>Age Group (a)</u>	<u>Breathing Rate (<math>\text{m}^3/\text{yr}</math>)</u>
Infant	1400
Child	3700
Teen	8000
Adult	8000

$(DFA_{i,a})$  : the maximum organ inhalation dose factor the receptor of age group (a) for the ith radionuclide, in  $\text{mrem}/\text{pCi}$ . The total body is considered as an organ in the selection of  $(DF_{i,a})$ . See Tables 3.1-6, 3.1-7, 3.1-8, and 3.1-9.

Inhalation dose factors  $(DFA_i)$  for the various age groups are given in Tables 3.1-6, 3.1-7, 3.1-8, and 3.1-9<sup>a</sup> (taken from Regulatory Guide 1.109 (Rev. 1)).

Ground Plane Pathway Factor,  $R_i^G$  [D/Q]

$$R_i^G \text{ [D/Q]} = K' K'' (SF) DFG_i [1 - e^{-\lambda_i t}] \text{ (m}^2 \cdot \text{ mrem/yr per } \mu\text{Ci/sec)}$$

where:

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

$K''$  = a constant of unit conversion, 8760 hr/year.

$\lambda_i$  = the decay constant for the ith radionuclide, sec<sup>-1</sup>.

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

$DFG_i$  = the ground plane dose conversion factor for the ith radionuclide (mrem/hr per pCi/m<sup>2</sup>).

SF = the shielding factor (dimensionless), 0.7 (Regulatory Guide 1.109 (Rev. 1)).

\* Ground plane dose conversion factors, DFG, are found in Table 3.1-10.

Grass-Cow-Milk Pathway Factor,  $R_i^C$  [D/Q]

$$R_i^C \text{ [D/Q]} = K' E \frac{Q_F(U_{ap})}{\lambda_i + \lambda_w} F_m(r)(DFL_i)_a \left[ \frac{f_p f_s}{Y_p} + \frac{(1-f_p f_s)e^{-\lambda_i t_h}}{Y_s} \right] e^{-\lambda_i t_f}$$

$(\text{m}^2 \cdot \text{ mrem/yr per } \mu\text{Ci/sec})$

where:

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

$Q_F$  = the cow's consumption rate, in kg/day (wet weight), 50 Regulatory Guide 1.109 (Rev. 1).

$U_{ap}$  = the receptor's milk consumption rate for age (a), in liters/yr.

$U_{ap}$ = (liters/yr)	- Infant	330
	- Child	170
	- Teen	200
	- Adult	110 (Regulatory Guide 1.109 (Rev. 1))

$Y_p$  = the agricultural productivity by unit area of pasture feed grass, in kg/m<sup>2</sup>, 0.7.

$Y_s$  = the agricultural productivity by unit area of stored feed, in kg/m<sup>2</sup>, 2.0.

$F_m$  = the stable element transfer coefficients, in days/liter, Table 3.1-11.

$r$  = fraction of deposited activity retained on cow's feed grass,  $r = 1$  for radioiodine and  $r = 0.2$  for particulates (Regulatory Guide 1.109).

- $(DFL_i)_a$  = the maximum organ ingestion dose factor for the ith radionuclide for the receptor in age group 'a', in mrem/pCi. See Tables 3.1-2, 3.1-3, 3.1-4, and 3.1-5.
- $\lambda_i$  = the decay constant for the ith radionuclide, in sec<sup>-1</sup>.
- $\lambda_w$  = the decay constant for removal of activity on leaf and plant surfaces by weathering,  $5.73 \times 10^{-7}$  sec<sup>-1</sup> (corresponding to a 14 day half-life).
- $t_f$  = the transport time from pasture to cow, to milk, to receptor, in sec,  $1.73 \times 10^5$  (2 days).
- $f_g$  = the transport time for pasture, to harvest, to cow, to milk, to receptor, in sec,  $7.78 \times 10^6$  (90 days).
- $f_p$  = fraction of the year that the cow is on pasture (dimensionless), 1.0.
- $f_s$  = fraction of the cow feed that is pasture grass while the cow is on pasture (dimensionless), 1.0.
- E = an adjustment fraction which accounts for the fraction of radionuclides in elemental form which contribute dose for this pathway. E = 0.5 for radioiodine, E = 1.0 for all others.

The concentration of tritium in milk is based on the airborne concentration rather than the deposition. Therefore, the  $R_i^C$  is based on  $[\chi/Q]$ :

$$R_i^C [\chi/Q] = K' K'' F_m Q_F U_p (DFL_i)_a [0.75(0.5/H)] \text{ (mrem/yr per } \mu\text{Ci/m}^3)$$

where:

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

H = absolute humidity of the atmosphere,  $8 \text{ gm/m}^3$ , (Regulatory Guide 1.109)

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.

#### Grass-Cow-Meat Pathway Factor, $R_i^M [D/Q]$

The integrated concentration in meat follows in a similar manner to the development for the milk pathway, therefore:

$$R_i^M [D/Q] = K' \frac{Q_F (U_p)}{\lambda_i + \lambda_w} F_f(r) (DFL_i)_a \left[ \frac{f_p f_s}{Y_p} + \frac{(1-f_p f_s)e^{-\lambda_i t_h}}{Y_s} \right] e^{-\lambda_i t_f} \\ (\text{m}^2 \cdot \text{mrem/yr per } \mu\text{Ci/sec})$$

where:

$F_f$  = the stable element transfer coefficients, in days/kg, Table 3.1-11.

$U_{ap}$  = the receptor's meat consumption rate for age (a), in kg/yr.

$U_{ap}$ (kg/yr)	- Infant	0
	- Child	37
	- Teen	59
	- Adult	95 Taken from Regulatory Guide 1.109 (Rev. 1).

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

$t_h$  = the transport time from crop field to receptor, in sec.

The concentration of tritium in meat is based on its airborne concentration rather than the deposition. Therefore, the  $R_i^M$  is based on  $[\chi/Q]$ :

$$R_i^M[\chi/Q] = K' K'' F_f Q U_{ap} (DFL_i)_a [0.75(0.5/H)] \text{ (mrem/yr per } \mu\text{Ci/m}^3\text{)}$$

where all terms are defined above.

#### Vegetation Pathway Factor, $R_i^V[D/Q]$

The integrated concentration in vegetation consumed by man follows the expression developed in the derivation of the milk factor. Man is considered to consume two types of vegetation (fresh and stored) that differs only in the time period between harvest and consumption, therefore:

$$R_i^V[D/Q] = K' \frac{(r)}{Y_v(\lambda_i + \lambda_w)} (DFL_i)_a \left[ U_a^L f L e^{-\lambda_i t_L} + U_a^S f g e^{-\lambda_i t_h} \right] \text{ (m}^2 \cdot \text{ mrem/yr per } \mu\text{Ci/sec)}$$

where:

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

$U_a^L$  = the consumption rate of fresh leafy vegetation by the receptor in age group (a), in kg/yr.

$U_a^L$ = (kg/hr)	- Infant	0
	- Child	26
	- Teen	42
	- Adult	64

$U_a^S$  = the consumption rate of stored vegetation by the receptor in age group (a), in kg/yr.

$U_a^S$ = (kg/yr)	- Infant	0
	- Child	200
	- Teen	240
	- Adult	190

$f_L$  = the fraction of the annual intake of fresh leafy vegetation grown locally.

$f_g$  = the fraction of the annual intake of stored vegetation grown locally.

$t_L$  = the average time between harvest of leafy vegetation and its consumption,  
in seconds,  $8.6 \times 10^4$  (1 day).

$t_h$  = the average time between harvest of stored vegetation and its consumption,  
in seconds,  $5.18 \times 10^6$  (60 days).

$Y_v$  = the vegetation area density,  $2.0 \text{ kg/m}^2$ .

and all other factors are previously defined.

The concentration of tritium in vegetation is based on the airborne concentration rather than the deposition. Therefore, the  $R_i^V$  is based on  $[X/Q]$ :

$$R_i^V[X/Q] = K'K'' \left[ U_a^L f_L + U_a^S f_g \right] (DFL_i)_a [0.75 (0.5/H)] (\text{mrem/yr per } \mu\text{Ci/m}^3)$$

All terms defined previously.

#### 5.4.3 Direct Radiation

Direct radiation exposure contributions to the dose of either the maximum exposed individual or to the population within 50 miles of any Duke Nuclear Station are negligible using the point kernel method of evaluating offsite dose rates from radioactive material stored outside buildings in the refueling water storage tanks and reactor makeup water storage tanks. Direct radiaiton doses will not be routinely evaluated.

TABLE 3.1-1\*

(1 of 1)

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BIOACCUMULATION FACTORS TO BE USED IN THE ABSENCE OF SITE-SPECIFIC DATA

(pCi/kg per pCi/liter)

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<u>ELEMENT</u>	<u>FRESHWATER</u>	
	<u>FISH</u>	<u>INVERTEBRATE</u>
H	9.0E-01	9.0E-01
C	4.6E-03	9.1E-03
Na	1.0E-02	2.0E 02
P	1.0E 05	2.0E 04
Cr	2.0E 02	2.0E 03
Mn	4.0E 02	9.0E 04
Fe	1.0E 02	3.2E 03
Co	5.0E 01	2.0E 02
Ni	1.0E 02	1.0E 02
Cu	5.0E 01	4.0E 02
Zn	2.0E 03	1.0E 04
Br	4.2E 02	3.3E 02
Rb	2.0E 03	1.0E 03
Sr	3.0E 01	1.0E 02
Y	2.5E 01	1.0E 03
Zr	3.3E 00	6.7E 00
Nb	3.0E 04	1.0E 02
Mo	1.0E 01	1.0E 01
Tc	1.5E 01	5.0E 00
Ru	1.0E 01	3.0E 02
Rh	1.0E 01	3.0E 02
Te	4.0E 02	6.1E 03
I	1.5E 01	5.0E 00
Cs	2.0E 03	1.0E 03
Ba	4.0E 00	2.0E 02
La	2.5E 01	1.0E 03
Ce	1.0E 00	1.0E 03
Pr	2.5E 01	1.0E 03
Nd	2.5E 01	1.0E 03
W	1.2E 03	1.0E 01
Np	1.0E 01	4.0E 02

\* Table taken from Regulatory Guide 1.109 (Rev.1)

TABLE 3.3-1

(1 of 1)

TABLE 3.1-2  
(1 of 3)  
INGESTION DOSE FACTORS FOR ADULTS  
(MREM PER PCI INGESTED)

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						
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	0.96E-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
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

TABLE 3.1-2  
(1 of 3)

TABLE 3.1-2  
(2 of 3)  
INGESTION DOSE FACTORS FOR ADULTS  
(MREM PER PCI INGESTED)

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
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-04	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
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 3.1-2  
(2 of 3)

TABLE 3.1-2  
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 INGESTION DOSE FACTORS FOR ADULTS  
 (MREM PER PCI INGESTED)

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LI
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-06	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

TABLE 3.1-2  
 (3 of 3)

TABLE 3.1-3\*  
 (1 of 3)  
 INGESTION DOSE FACTORS FOR TEENAGER  
 (MREM PER PCI INGESTED)

NUCLIDE	BONE	LIVER	T. BODY	THYROID	KIDNEY	LUNG	GI-LI
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	9.12E-07	8.12E-07	8.12E-07	8.12E-07	8.12E-07	8.12E-07
NA 24	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 _	1.58E-07	2.81E-08	NO DATA	2.00E-07	NO DATA	1.04E-05
FE 55	3.78E-06	2.68E-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-05
CO 60	NO DATA	2.81E-06	6.33E-06	NO DATA	NO DATA	NO DATA	3.66E-05
NI 63	1.77E-04	1.25E-05	6.00E-06	NO DATA	NO DATA	NO DATA	1.99E-06
NI 65	7.49E-07	9.57E-08	4.36E-08	NO DATA	NO DATA	NO DATA	5.19E-07
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

\*Taken from Regulatory Guide 1.109 (Rev. 1)

TABLE 3.1-3  
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TABLE 3.1-3 (cont'd)  
(2 of 3)  
INGESTION DOSE FACTORS FOR TEENAGER  
(MREM PER PCI INGESTED)

NUCLIDE	BONE	LIVER	T. BODY	THYROID	KIDNEY	LUNG	GI-LI
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
TC101	3.60E-10	5.12E-10	5.03E-09	NO DATA	9.26E-09	3.12E-11	8.75E-18
RU103	2.55E-07	NO DATA	1.09E-07	NO DATA	8.99E-07	NO DATA	2.13E-05
RU105	2.18E-08	NO DATA	8.46E-09	NO DATA	2.75E-07	NO DATA	1.76E-05
RU106	3.92E-06	NO DATA	4.94E-07	NO DATA	7.56E-06	NO DATA	1.88E-04
AG110M	2.05E-07	1.94E-07	1.18E-07	NO DATA	3.70E-07	NO DATA	5.45E-05
TE125M	3.83E-06	1.38E-06	5.12E-07	1.07E-06	NO DATA	NO DATA	1.13E-05
TE127M	9.67E-06	3.43E-06	1.15E-06	2.30E-06	3.92E-05	NO DATA	2.41E-05
TE127	1.58E-07	5.60E-08	3.40E-08	1.09E-07	6.40E-07	NO DATA	1.22E-05
TE129M	1.63E-05	6.05E-06	2.58E-06	5.26E-06	6.82E-05	NO DATA	6.12E-05
TE129	4.48E-08	1.67E-08	1.09E-08	3.20E-08	1.88E-07	NO DATA	2.45E-07
TE131M	2.44E-06	1.17E-06	9.76E-07	1.76E-06	1.22E-05	NO DATA	9.39E-05
TE131	2.79E-08	1.15E-08	8.72E-09	2.15E-08	1.22E-07	NO DATA	2.29E-09
TE132	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
CS134	8.37E-05	1.97E-04	9.14E-05	NO DATA	6.26E-05	2.39E-05	2.45E-06
CS136	8.59E-06	3.38E-05	2.27E-05	NO DATA	1.84E-05	2.90E-06	2.72E-06
CS137	1.12E-04	1.49E-04	5.19E-05	NO DATA	5.07E-05	1.97E-05	2.12E-06
CS138	7.76E-08	1.49E-07	7.45E-08	NO DATA	1.10E-07	1.28E-08	6.76E-11
BA139	1.39E-07	9.78E-11	4.05E-09	NO DATA	9.22E-11	6.74E-11	1.24E-06

TABLE 3.1-3  
(2 of 3)

TABLE 3.1-3 (cont'd)  
 (3 of 3)  
 INGESTION DOSE FACTORS FOR TEENAGER  
 (MREM PER PCI INGESTED)

NUCLIDE	BONE	LIVER	T. BODY	THYROID	KIDNEY	LUNG	GI-LLI
BA140	2.84E-05	3.48E-08	1.83E-06	NO DATA	1.18E-08	2.34E-08	4.18E-05
BA141	6.71E-08	5.01E-11	2.24E-08	NO DATA	4.65E-11	3.43E-11	1.43E-13
BA142	2.99E-08	2.99E-11	1.84E-09	NO DATA	2.53E-11	1.99E-11	9.18E-20
LA140	3.48E-09	1.71E-09	4.55E-10	NO DATA	NO DATA	NO DATA	9.82E-05
LA142	1.79E-10	7.95E-11	1.98E-11	NO DATA	NO DATA	NO DATA	2.42E-06
CE141	1.33E-08	8.88E-09	1.02E-09	NO DATA	4.18E-09	NO DATA	2.54E-05
CE143	2.35E-09	1.71E-06	1.91E-10	NO DATA	7.67E-10	NO DATA	5.14E-05
CD144	6.96E-07	2.88E-07	3.74E-08	NO DATA	1.72E-07	NO DATA	1.75E-04
PR143	1.31E-08	5.23E-09	6.52E-10	NO DATA	3.04E-09	NO DATA	4.31E-05
PR144	4.30E-11	1.76E-11	2.18E-12	NO DATA	1.01E-11	NO DATA	4.74E-14
ND147	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
NP239	1.76E-09	1.66E-10	9.22E-11	NO DATA	5.21E-10	NO DATA	2.67E-05

TABLE 3.1-3  
 (3 of 3)

TABLE 3.1-4\*  
 (1 of 3)  
 INGESTION DOSE FACTORS FOR CHILD  
 (MREM PER PCI INGESTED)

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						
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
CP 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
BR 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

\*Taken from Regulatory Guide 1.109 (Rev. 1).

TABLE 3.1-4  
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TABLE 3.1-4 (cont'd)  
 (2 of 3)  
 INGESTION DOSE FACTORS FOR CHILD  
 (MREM PER PCI INGESTED)

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
TC101	1.07E-09	1.12E-09	1.42E-08	NO DATA	1.91E-08	5.92E-10	3.56E-09
RU103	7.31E-07	NO DATA	2.81E-07	NO DATA	1.84E-06	NO DATA	1.89E-05
RU105	6.45E-08	NO DATA	2.34E-08	NO DATA	5.67E-07	NO DATA	4.21E-05
RU106	1.17E-05	NO DATA	1.46E-06	NO DATA	1.58E-05	NO DATA	1.82E-04
AG110M	5.39E-07	3.84E-07	2.91E-07	NO DATA	6.78E-07	NO DATA	4.33E-05
TE125M	1.14E-05	3.09E-06	1.52E-06	3.20E-06	NO DATA	NO DATA	1.10E-05
TE127M	2.89E-05	7.78E-06	3.43E-06	6.91E-06	8.24E-05	NO DATA	2.34E-05
TE127	4.71E-07	1.27E-07	1.01E-07	3.26E-07	1.34E-06	NO DATA	1.84E-05
TE129M	4.87E-05	1.36E-05	7.56E-06	1.57E-05	1.43E-04	NO DATA	5.94E-05
TE129	1.34E-07	3.74E-08	3.18E-08	9.56E-08	3.92E-07	NO DATA	8.34E-06
TE131M	7.20E-06	2.49E-06	2.65E-06	5.12E-06	2.41E-05	NO DATA	1.01E-04
TE131	8.30E-08	2.53E-08	2.47E-08	6.35E-08	2.51E-07	NO DATA	4.36E-07
TE132	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
CS134	2.34E-04	3.84E-04	8.10E-05	NO DATA	1.19E-04	4.27E-05	2.07E-06
CS136	2.35E-05	6.46E-05	4.18E-05	NO DATA	3.44E-05	5.13E-06	2.27E-06
CS137	3.27E-04	3.13E-04	4.62E-05	NO DATA	1.02E-04	3.67E-05	1.96E-06
CS138	2.28E-07	3.17E-07	2.01E-07	NO DATA	2.23E-07	2.40E-08	1.46E-07
BA139	4.14E-07	2.21E-10	1.20E-08	NO DATA	1.93E-10	1.30E-10	2.39E-05

TABLE 3.1-4  
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TABLE 3.1-4  
 (3 of 3)  
 INGESTION DOSE FACTORS FOR CHILD  
 (MREM PER PCI INGESTED)

NUCLIDE	BONE	LIVER	T. BODY	THYROID	KIDNEY	LUNG	GI-LLI
BA140	8.31E-05	7.28E-08	4.85E-06	NO DATA	2.37E-08	4.34E-08	4.21E-05
BA141	2.00E-07	1.12E-10	6.51E-09	NO DATA	9.69E-11	6.58E-10	1.14E-07
BA142	8.74E-08	6.29E-11	4.88E-09	NO DATA	5.09E-11	3.70E-11	1.14E-09
LA140	1.01E-08	3.53E-09	1.19E-09	NO DATA	NO DATA	NO DATA	9.84E-05
LA142	5.24E-10	1.67E-10	5.23E-11	NO DATA	NO DATA	NO DATA	3.31E-05
CE141	3.97E-08	1.98E-08	2.94E-09	NO DATA	8.68E-09	NO DATA	2.47E-05
CE143	6.99E-09	3.79E-06	5.49E-10	NO DATA	1.59E-09	NO DATA	5.55E-05
CE144	2.08E-06	6.52E-07	1.11E-07	NO DATA	3.61E-07	NO DATA	1.70E-04
PR143	3.93E-08	1.18E-08	1.95E-09	NO DATA	6.39E-09	NO DATA	4.24E-05
PR144	1.29E-10	3.99E-11	6.49E-12	NO DATA	2.11E-11	NO DATA	8.59E-08
ND147	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
NP239	5.25E-09	3.77E-10	2.65E-10	NO DATA	1.09E-09	NO DATA	2.79E-05

TABLE 3.1-4  
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TABLE 3.1-5\*  
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 INGESTION DOSE FACTORS FOR INFANT  
 (MREM PER PCI INGESTED)

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						
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	8.93E-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
* 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

\*Taken from Regulatory Guide 1.109 (Rev. 1)

TABLE 3.1-5  
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TABLE 3.1-5  
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 INGESTION DOSE FACTORS FOR INFANT  
 (MREM PER PCI INGESTED)

NUCLIDE	BONE	LIVER	T. BODY	THYROID	KIDNEY	LUNG	GI-LI
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
TC101	2.27E-09	2.86E-09	2.83E-08	NO DATA	3.40E-08	1.56E-09	4.86E-07
RU103	1.48E-06	NO DATA	4.95E-07	NO DATA	3.08E-06	NO DATA	1.80E-05
RU105	1.36E-07	NO DATA	4.58E-08	NO DATA	1.00E-06	NO DATA	5.41E-05
RU106	2.41E-05	NO DATA	3.01E-06	NO DATA	2.85E-05	NO DATA	1.83E-04
AG110M	9.96E-07	7.27E-07	4.81E-07	NO DATA	1.04E-06	NO DATA	3.77E-05
TE125M	2.33E-05	7.79E-06	3.15E-06	7.84E-06	NO DATA	NO DATA	1.11E-05
TE127M	5.85E-05	1.94E-05	7.08E-06	1.69E-05	1.44E-04	NO DATA	2.36E-05
TE127	1.00E-06	3.35E-07	2.15E-07	8.14E-07	2.44E-06	NO DATA	2.10E-05
TE129M	1.00E-04	3.43E-05	1.54E-05	3.84E-05	2.50E-04	NO DATA	5.97E-05
TE129	2.84E-07	9.79E-08	6.63E-08	2.38E-07	7.07E-07	NO DATA	2.27E-05
TE131M	1.52E-05	6.12E-06	5.05E-06	1.24E-05	4.21E-05	NO DATA	1.03E-04
TE131	1.76E-07	6.50E-08	4.94E-08	1.57E-07	4.50E-07	NO DATA	7.11E-06
TE132	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-07	NO DATA	2.73E-06
I 133	1.25E-05	1.82E-05	5.32E-06	3.31E-03	2.14E-05	NO DATA	3.08E-06
I 134	8.69E-07	1.78E-06	6.35E-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
CS134	3.77E-04	7.03E-04	7.10E-05	NO DATA	1.81E-04	7.42E-05	1.91E-06
CS136	4.59E-05	1.35E-04	5.04E-05	NO DATA	5.38E-05	1.10E-05	2.05E-06
CS137	5.22E-04	6.11E-04	4.33E-05	NO DATA	1.64E-04	6.64E-05	1.91E-06
CS138	4.81E-07	7.82E-07	3.79E-07	NO DATA	3.90E-07	6.09E-08	1.25E-06
BA139	8.81E-07	5.84E-10	2.55E-08	NO DATA	3.51E-10	3.54E-10	5.58E-05

TABLE 3.1-5  
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TABLE 3.1-5  
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 INGESTION DOSE FACTORS FOR INFANT  
 (MREM PER PCI INGESTED)

NUCLIDE	BONE	LIVER	T. BODY	THYROID	KIDNEY	LUNG	GI-LLI
BA140	1.71E-04	1.71E-07	8.81E-06	NO DATA	4.06E-08	1.05E-07	4.20E-05
BA141	4.25E-07	2.91E-10	1.34E-08	NO DATA	1.75E-10	1.77E-10	5.19E-06
BA142	1.84E-07	1.53E-10	9.06E-09	NO DATA	8.81E-11	9.26E-11	7.59E-07
LA140	2.11E-08	8.32E-09	2.14E-09	NO DATA	NO DATA	NO DATA	9.77E-05
LA142	1.10E-09	4.04E-10	9.67E-11	NO DATA	NO DATA	NO DATA	6.86E-05
CE141	7.87E-08	4.80E-08	5.65E-09	NO DATA	1.48E-08	NO DATA	2.48E-05
CE143	1.48E-08	9.82E-06	1.12E-09	NO DATA	2.86E-09	NO DATA	5.73E-05
CE144	2.98E-06	1.22E-06	1.67E-07	NO DATA	4.93E-07	NO DATA	1.71E-04
PR143	8.13E-08	3.04E-08	4.03E-09	NO DATA	1.13E-08	NO DATA	4.29E-05
PR144	2.74E-10	1.06E-10	1.38E-11	NO DATA	3.84E-11	NO DATA	4.93E-06
ND147	5.53E-08	5.68E-08	3.48E-09	NO DATA	2.19E-08	NO DATA	3.60E-05
W 187	9.03E-07	6.28E-07	2.17E-07	NO DATA	NO DATA	NO DATA	3.69E-05
NP239	1.11E-08	9.93E-10	5.61E-10	NO DATA	1.98E-09	NO DATA	2.87E-05

TABLE 3.1-5  
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TABLE 3.1-6\*  
 (1 of 3)  
 INHALATION DOSE FACTORS FOR ADULTS  
 (MREM PER PCI INHALED)

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	1.26E-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

\*Taken from Regulatory Guide 1.109 (Rev. 1)

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TABLE 3.1-6  
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INHALATION DOSE FACTORS FOR ADULTS  
(MREM PER PCI INHALED)

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-04	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

TABLE 3.1-6  
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TABLE 3.1-6  
 (3 of 3)  
 INHALATION DOSE FACTORS FOR ADULTS  
 (MREM PER PCI INHALED)

NUCLIDE	BONE	LIVER	T. BODY	THYROID	KIDNEY	LUNG	GI-LLI
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	9.14E-15	4.20E-13	NO DATA	8.75E-15	2.42E-07	1.45E-17
BA 142	3.29E-12	3.38E-15	2.07E-13	NO DATA	2.86E-15	1.49E-07	1.96E-26
LA 140	4.30E-08	2.17E-08	5.73E-09	NO DATA	NO DATA	1.70E-05	5.73E-05
LA 142	8.54E-11	3.88E-11	9.65E-12	NO DATA	NO DATA	7.91E-07	2.64E-07
CE 141	2.49E-06	1.69E-06	1.91E-07	NO DATA	7.83E-07	4.52E-05	1.50E-05
CE 143	2.33E-08	1.72E-08	1.91E-09	NO DATA	7.60E-09	9.97E-06	2.83E-05
CE 144	4.29E-04	1.79E-04	2.30E-05	NO DATA	1.06E-04	9.72E-04	1.02E-04
PR 143	1.17E-06	4.69E-07	5.80E-08	NO DATA	2.70E-07	3.51E-05	2.50E-05
PR 144	3.76E-12	1.56E-12	1.91E-13	NO DATA	8.81E-13	1.27E-07	2.69E-18
ND 147	6.59E-07	7.62E-07	4.56E-08	NO DATA	4.45E-07	2.76E-05	2.16E-05
W 187	1.06E-09	8.85E-10	3.10E-10	NO DATA	NO DATA	3.63E-06	1.94E-05
NP 239	2.87E-08	2.82E-09	1.55E-09	NO DATA	8.75E-09	4.70E-06	1.49E-05

TABLE 3.1-6  
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TABLE 3.1-7\*  
(1 of 3)  
INHALATION DOSE FACTORS FOR TEENAGER  
(MREM PER PCI INHALED)

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						
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	1.19E-05
CO 60	NO DATA	1.89E-06	2.48E-06	NO DATA	NO DATA	1.09E-03	3.24E-05
NI 63	7.25E-05	5.43E-06	2.47E-06	NO DATA	NO DATA	3.84E-05	1.77E-06
NI 65	2.73E-10	3.66E-11	1.59E-11	NO DATA	NO DATA	1.17E-06	4.59E-06
CU 64	NO DATA	2.54E-10	1.06E-10	NO DATA	8.01E-10	1.39E-06	7.68E-06
ZN 65	4.82E-06	1.67E-05	7.80E-06	NO DATA	1.08E-05	1.55E-04	5.83E-06
ZN 69	6.04E-12	1.15E-11	8.07E-13	NO DATA	7.53E-12	1.98E-07	3.56E-08
BR 83	NO DATA	NO DATA	4.30E-08	NO DATA	NO DATA	NO DATA	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

\*Taken from Regulatory Guide 1.109 (Rev. 1)

TABLE 3.1-7  
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TABLE 3.1-7  
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INHALATION DOSE FACTORS FOR TEENAGER  
(MREM PER PCI INHALED)

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	8.43E-06	3.36E-04	1.36E-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-07	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-02	NO DATA	1.55E-06	NO DATA	2.38E-05	2.01E-03	1.20E04
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	.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	.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

TABLE 3.1-7  
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TABLE 3.1-7  
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 INHALATION DOSE FACTORS FOR TEENAGER  
 (MREM PER PCI INHALED)

NUCLIDE	BONE	LIVER	T. BODY	THYROID	KIDNEY	LUNG	GI-LLI
BA 140	6.84E-06	8.38E-09	4.40E-07	NO DATA	2.85E-09	2.54E-04	2.86E-05
BA 141	1.78E-11	1.32E-14	5.93E-13	NO DATA	1.23E-14	4.11E-07	9.33E-14
BA 142	4.62E-12	4.63E-15	2.84E-13	NO DATA	3.92E-15	2.39E-07	5.99E-20
LA 140	5.99E-08	2.95E-08	7.82E-09	NO DATA	NO DATA	2.68E-05	6.09E-05
LA 142	1.20E-10	5.31E-11	1.32E-11	NO DATA	NO DATA	1.27E-06	1.50E-06
CE 141	3.55E-06	2.37E-06	2.71E-07	NO DATA	1.11E-06	7.67E-05	1.58E-05
CE 143	3.32E-08	2.42E-08	2.70E-09	NO DATA	1.08E-08	1.63E-05	3.19E-05
CE 144	6.11E-04	2.53E-04	3.28E-05	NO DATA	1.51E-04	1.67E-03	1.08E-04
PR 143	1.67E-06	6.64E-07	8.28E-08	NO DATA	3.86E-07	6.04E-05	2.67E-05
PR 144	5.37E-12	2.20E-12	2.72E-13	NO DATA	1.26E-12	2.19E-07	2.94E-14
ND 147	9.83E-07	1.07E-06	6.41E-08	NO DATA	6.28E-07	4.65E-05	2.28E-05
W 187	1.50E-09	1.22E-09	4.29E-10	NO DATA	NO DATA	5.92E-06	2.21E-05
NP 239	4.23E-08	3.99E-09	2.21E-09	NO DATA	1.25E-08	8.11E-06	1.65E-05

TABLE 3.1-7  
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TABLE 3.1-8\*  
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INHALATION DOSE FACTORS FOR CHILD  
(MREM PER PCI INHALED)

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-05	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	7.1E-06	4.26E-04	6.19E-06
MN 56	NO DATA	4.4E-10	8.43E-11	NO DATA	4.52E-10	3.55E-06	3.33E-05
FE 55	1.28E-05	6.00E-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

\*Taken From Regulatory Guide 1.109 (Rev. 1)

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TABLE 3.1-8  
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INHALATION DOSE FACTORS FOR CHILD  
(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
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	1.90E-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
TE129M	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	8.32E-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
BA139	4.98E-10	2.66E-13	1.45E-11	NO DATA	2.33E-13	1.56E-06	1.56E-05

TABLE 3.1-8  
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TABLE 3.1-8  
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 INHALATION DOSE FACTORS FOR CHILD  
 (MREM PER PCI INHALED)

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LII
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	7.87E-15	4.44E-07	7.41E-10
LA140	1.74E-07	6.08E-08	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	4.99E-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	4.42E-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

TABLE 3.1-8  
 (3 of 3)

TABLE 3.1-9\*  
(1 of 3)  
INHALATION DOSE FACTORS FOR INFANT  
(MREM PER PCI INHALED)

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LII
H 3	NO DATA	4.62E-07	4.62E-07	3.62E-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						
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	1.7 ^-09	2.03E-10	8.79E-11	NO DATA	NO DATA	5.80E-06	3.58E-05
CO 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

\*Taken from Regulatory Guide 1.109 (Rev. 1)

TABLE 3.1-9  
(1 of 3)

TABLE 3.1-9  
 (2 of 3)  
 INHALATION DOSE FACTORS FOR INFANT  
 (MREM PER PCI INHALED)

NUCLIDE	BONE	LIVER	T. BODY	THYROID	KIDNEY	LUNG	GI-LII
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	5.88E-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	2.68E-05	9.37E-04	1.95E-05
TE127	1.59E-09	6.81E-10	3.49E-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	9.91E-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
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	4.23E-13	4.25E-06	3.64E-05

TABLE 3.1-9  
 (2 of 3)

TABLE 3.1-9  
 (3 of 3)  
 INHALATION DOSE FACTORS FOR INFANT  
 (MREM PER PCI INHALED)

NUCLIDE	BONE	LIVER	T. BODY	THYROID	KIDNEY	LUNG	GI-LII
BA140	4.00E-05	4.00E-08	2.07E-06	NO DATA	9.59E-09	1.14E-03	2.74E-05
BA141	1.12E-10	7.70E-14	3.55E-12	NO DATA	4.64E-14	2.12E-06	3.39E-06
BA142	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	6.44E-11	NO DATA	NO DATA	5.87E-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	2.98E-07	1.38E-07	1.58E-08	NO DATA	4.03E-08	8.30E-05	3.55E-05
CE144	2.28E-03	8.65E-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	4.80E-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

TABLE 3.1-9  
 (3 of 3)

TABLE 3.1-10<sup>\*</sup>  
 (1 of 2)  
 EXTERNAL DOSE FACTORS FOR STANDING ON CONTAMINATED GROUND  
 (mrem/hr per pCi/m<sup>2</sup>)

<u>Element</u>	<u>Total Body</u>	<u>Skin</u>
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
Nr-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

\*Taken from Regulatory Guide 1.109 (Rev. 1)

TABLE 3.1-10  
 (1 of 2)

TABLE 3.1-10  
(2 of 2)  
EXTERNAL DOSE FACTORS FOR STANDING ON CONTAMINATED GROUND  
(mrem/hr per pCi/m<sup>2</sup>)

<u>Element</u>	<u>Total</u>	<u>Body</u>	<u>Skin</u>
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

Table 3.1-10  
(2 of 2)

TABLE 3.1-11\*  
(1 of 1)  
STABLE ELEMENT TRANSFER DATA

<u>Element</u>	$F_m$ (Cow) Milk (d/l)	$F_f$ Meat (d/kg)
H	1.0E-02	1.2E-02
C	1.2E-02	3.1E-02
Na	4.0E-02	3.0E-02
P	2.5E-02	4.6E-02
Cr	2.2E-03	2.4E-03
Mn	2.5E-04	8.0E-04
Fe	1.2E-03	4.0E-02
Co	1.0E-03	1.3E-02
Ni	6.7E-03	5.3E-02
Cu	1.4E-02	8.0E-03
Zn	3.9E-02	3.0E-02
Rb	3.0E-02	3.1E-02
Sr	8.0E-04	6.0E-04
Y	1.0E-05	4.6E-03
Zr	5.0E-06	3.4E-02
Nb	2.5E-03	2.8E-01
Mo	7.5E-03	8.0E-03
Tc	2.5E-02	4.0E-01
Ru	1.0E-06	4.0E-01
Rh	1.0E-02	1.5E-03
Ag	5.0E-02	1.7E-02
Te	1.0E-00	7.7E-02
I	6.0E-03 <sup>+</sup>	2.9E-03
Cs	1.2E-02	4.0E-03
Ba	4.0E-04	3.2E-03
La	5.0E-06	2.0E-04
Ce	1.0E-04	1.2E-03
Pr	5.0E-06	4.7E-03
Nd	5.0E-06	3.3E-03
W	5.0E-04	1.3E-03
Np	5.0E-06	2.0E-04

\*Taken from Regulatory Guide 1.109 (Rev. 1)

<sup>+</sup> $F_m$  for goat is 6.0E-2.

TABLE 3.1-11  
(1 of 1)

APPENDIX B  
MCGUIRE NUCLEAR STATION  
SITE SPECIFIC INFORMATION

APPENDIX B - TABLE OF CONTENTS

	<u>Page</u>
B1.0 <u>MCGUIRE NUCLEAR STATION RADWASTE SYSTEMS</u>	B-1
B2.0 <u>RELEASE RATE CALCULATION</u>	B-4
B3.0 <u>RADIATION MONITOR SETPOINTS</u>	B-8
B4.0 <u>DOSE CALCULATIONS</u>	B-10
B5.0 <u>RADIOLOGICAL ENVIRONMENTAL MONITORING</u>	B-13

FIGURE B1-6  
(1 of 1)  
CENTRAL SCHEMATIC OF MRS LIQUID WASTE SYSTEMS

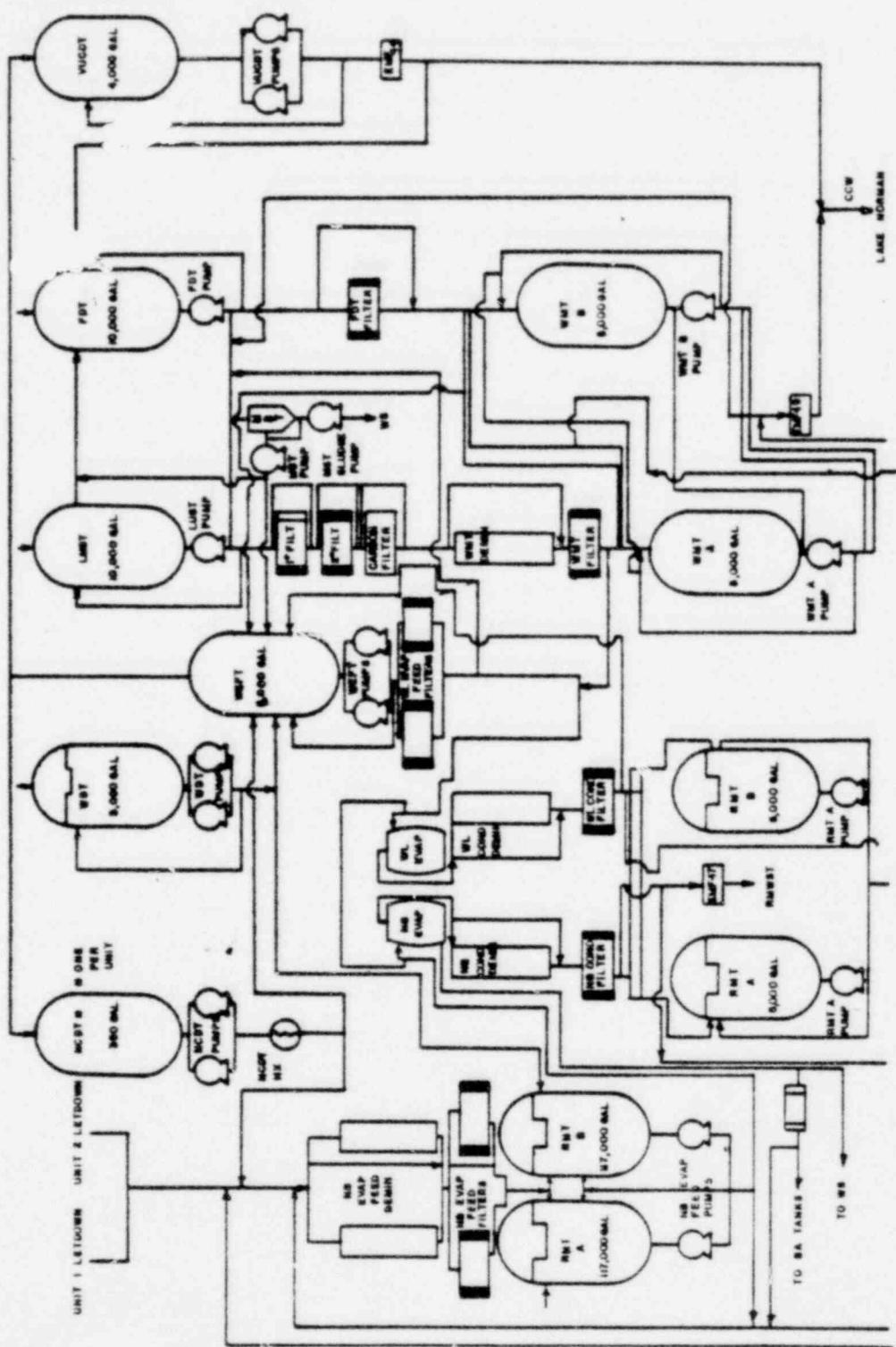


FIGURE B1.0-1  
(1 of 1)

## B1.2 GASEOUS RADWASTE SYSTEMS

The gaseous waste disposal system for McGuire is designed with the capability of processing the fission-product gases from contaminated reactor coolant fluids resulting from operation. The system shown schematically in Fig. B1.0-2 is designed to allow for the retention, through the plant lifetime, of all the gaseous fission products to be discharged from the reactor coolant system to the chemical and volume control system or the boron recycle system, to eliminate the need for intentional discharge of radioactive gases from the waste gas holdup tanks. Thus, the only unavoidable sources of low-level radioactive gaseous discharge to the environment will be from periodic purging operations of the containment, from the auxiliary building ventilation system, and through the secondary system air ejector. With respect to the former, the potential contamination is expected to arise from uncollectable reactor coolant leakage. With respect to the air ejector, the potential source of contamination will be from leakage of the reactor coolant to the secondary system through defects in steam generator tubes. The gaseous waste disposal system includes two waste gas compressors, two catalytic hydrogen recombiners, six gas decay storage tanks for use during normal power generation, and two gas decay storage tanks for use during shutdown and startup operations.

### B1.2.1 Gas Collection System

The gas collection system combines the waste hydrogen and fission gases from the volume control tanks and that from the boron recycle gas stripper evaporator produced during normal operation with the gas collected during the shutdown degasification (high percentage of nitrogen) and will cycle it through the catalytic recombiners to convert all the hydrogen to water. After the water vapor is removed, the resulting gas stream will be transferred from the recombiner into the gas decay tanks, where the accumulated activity may be contained in six approximately equal parts. From the decay tanks the gas will flow back to the compressor suction to complete the loop circuit.

### B1.2.2 Containment and Auxiliary Building Ventilation

Nonrecyclable reactor coolant leakage occurring either inside the containment or inside the auxiliary building will generate gasous activity. Gases resulting from leakage inside the containment will be retained until the containment is purged. The containment atmosphere will be circulated through a charcoal adsorber and a particulate filter prior to release to the atmosphere.

Gases resulting from leakage inside the auxiliary building are released, without further decay, to the atmosphere via the auxiliary building ventilation system. The ventilation exhaust from potentially contaminated areas in the auxiliary building is passed through charcoal adsorbers to reduce releases to the atmosphere.

### B1.2.3 Secondary Systems

When activity is in the secondary system, steam generator blowdown will be recycled through demineralizers to remove activity and the liquids will be removed by the ejector condenser prior to discharge to the unit vent.

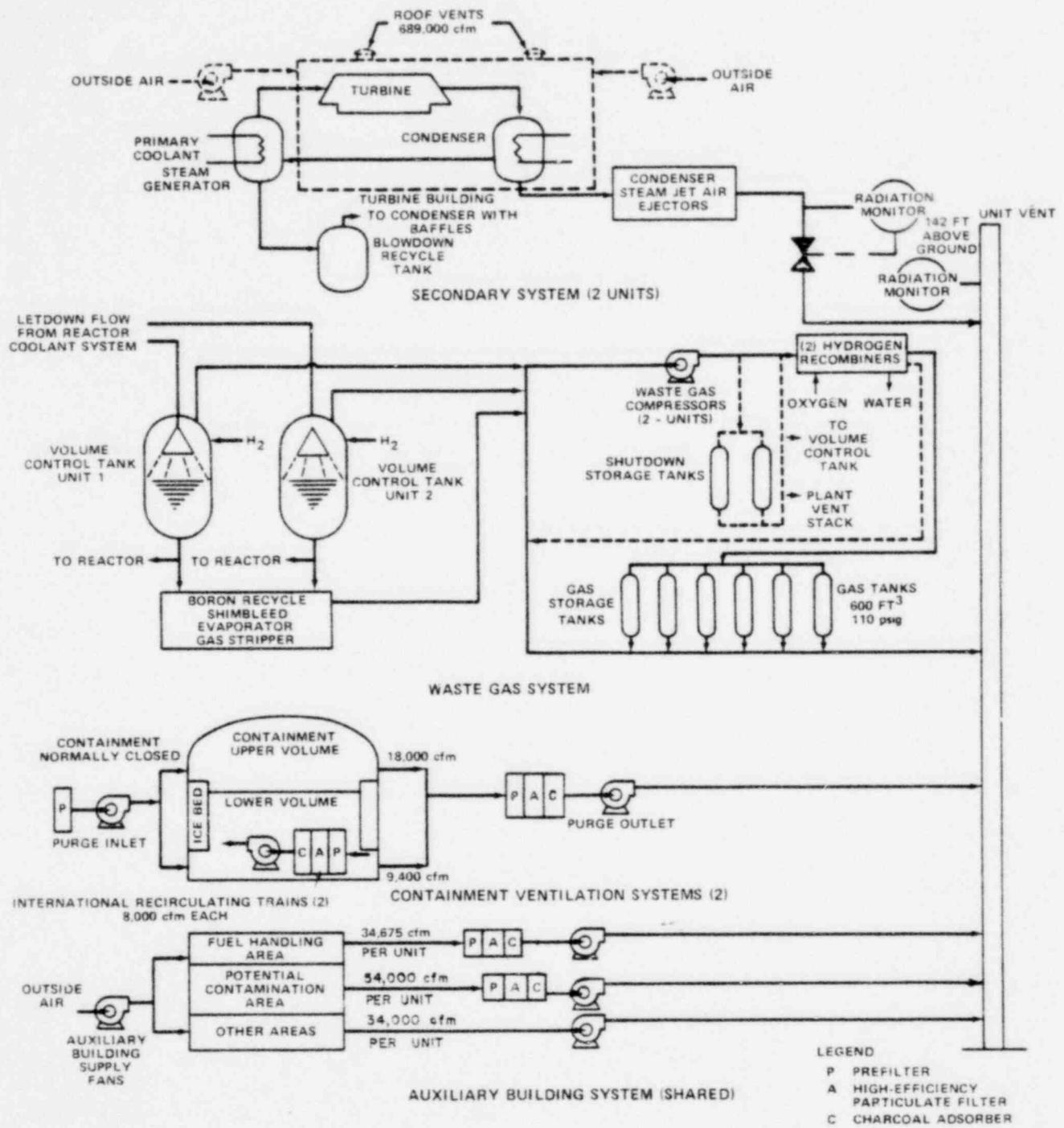


FIGURE B1.0-2. GASEOUS WASTE DISPOSAL AND VENTILATION SYSTEM  
(1 of 1)

Gland leak-off steam, which represents a minor source of activity, is routed to the gland condenser. The non-condensable gases are passed through a vent stack to the roof; the condensables are condensed and drained to the condensate storage tank.

TABLE B1.0-1  
(1 of 2)  
ABBREVIATIONS

Systems:

KC - Component Cooling  
NB - Boron Recycle  
NC - Reactor Coolant  
ND - Residual Heat Removal  
NI - Safety Injection  
NR - Boron Thermal Regeneration  
NV - Chemical Volume and Control  
WC - Conventional Waste Water Treatment  
WG - Waste Gas  
WL - Liquid Waste Recycle  
WM - Liquid Waste Monitor and Disposal  
WS - Nuclear Solid Waste Disposal

Terms:

BOL - Beginning of Core Life  
BTRS - Boron Thermal Regeneration System  
CCW - Condenser Cooling Water  
CDT - Chemical Drain Tank  
ECST - Evaporator Concentrates Storage Tank  
EOL - End of Core Life  
FDT - Floor Drain Tank  
FWST - Fueling Water Storage Tank (formerly Refueling Water Storage Tank)  
LHST - Laundry and Hot Shower Tank  
MST - Mixing and Settling Tank  
NCDT - Reactor Coolant Drain Tank  
RBT - Resin Batching Tank  
RHT - Recycle Holdup Tank  
RMT - Recycle Monitor Tank  
RMWST - Reactor Makeup Water Storage Tank

TABLE B1.0-1  
(1 of 2)

TABLE B1.0-1

(2 of 2)

ABBREVIATIONS

SRST - Spent Resin Storage Tank

VUCDT - Ventilation Unit Condensate Drain Tank

WDT - Waste Drain Tank

WEFT - Waste Evaporator Feed Tank

WMT - Waste Monitor Tank

TABLE B1.0-1

(2 of 2)

## B2.0 RELEASE RATE CALCULATION

Generic release rate calculations are presented in Section 1.0; these calculations will be used to calculate release rates for McGuire Nuclear Station.

### B2.1 LIQUID RELEASE RATE CALCULATIONS

There are three potential release points at McGuire. Two of these release points, the waste liquid effluent line and the containment ventilation unit condensate effluent line, discharge into the condenser cooling water flow; the third possible release point is through the conventional waste water treatment system.

#### B2.1.1 Waste Liquid Effluent Line

To simplify calculations for the waste liquid effluent line, it is assumed that no activity above background is present in the containment ventilation unit condensate effluent. This assumption shall be confirmed by radiation monitoring measurements and by periodic analysis of the composite sample collected on that line. For the waste liquid effluent line, one of the following calculations shall be performed for discharge flow, in gpm, depending on the number of condenser cooling water pumps in service:

$$f_1 \leq 2.5E5 \div 2.5 (\sum_{i=1}^n \frac{C_i}{MPC_i}) \leq 1.0E5 \div (\sum_{i=1}^n \frac{C_i}{MPC_i})$$

$$f_2 \leq 5.0E5 \div 2.5 (\sum_{i=1}^n \frac{C_i}{MPC_i}) \leq 2.0E5 \div (\sum_{i=1}^n \frac{C_i}{MPC_i})$$

$$f_3 \leq 7.5E5 \div 2.5 (\sum_{i=1}^n \frac{C_i}{MPC_i}) \leq 3.0E5 \div (\sum_{i=1}^n \frac{C_i}{MPC_i})$$

$$f_4 \leq 1.0E6 \div 2.5 (\sum_{i=1}^n \frac{C_i}{MPC_i}) \leq 4.0E5 \div (\sum_{i=1}^n \frac{C_i}{MPC_i})$$

where:

$C_i$  = the concentration of radionuclide,  $i$ , in undiluted effluent as determined by laboratory analyses, in  $\mu\text{Ci}/\text{ml}$ .

$MPC_i$  = the concentration of radionuclide,  $i$ , from 10CFR20, Appendix B, Table II, Column 2. If radionuclide,  $i$ , is a dissolved noble gas, the  $MPC_i$ , =  $2E-4\mu\text{Ci}/\text{ml}$ .

$F$  = the dilution flow available depending on the number of condenser cooling water pumps in service, in gpm:

$F_1 = 2.5E5$  gpm

$F_2 = 5.0E5$  gpm

$F_3 = 7.5E5$  gpm

$F_4 = 1.0E6$  gpm

$\sigma$  = the recirculation factor at equilibrium is 2.5.

#### B2.1.2 Containment Ventilation Unit Condensate Effluent Line

As described in the preceding section, it is possible but unlikely that the containment ventilation unit condensate effluent line will contain measurable activity above background; it is assumed that no activity is present in the effluent until indicated by radiation monitoring measurements and by periodic analysis of the composite sample collected on that line. If measurable activity is present in the effluent, administrative controls shall be implemented to assure that release limits are not exceeded. See section on radiation monitoring alarm/trip setpoints.

#### B2.1.3 Conventional Waste Water Treatment System Effluent Line

The conventional waste water treatment system effluent is normally considered nonradioactive; that is, it is unlikely the effluent will contain measurable activity above background. It is assumed that no activity is present in the effluent until indicated by radiation monitoring measurements and by periodic analyses of the composite sample collected on that line. Radiation monitoring alarm/trip setpoints assure that release limits are not exceeded; see section on radiation monitoring alarm/trip setpoints.

### B2.2 GASEOUS RELEASE RATE CALCULATIONS

The unit vent is the release point for waste gas decay tanks, containment building purges, the condenser air ejector, and auxiliary building ventilation. The condenser air ejector effluent is normally considered nonradioactive; that is, it is unlikely the effluent will contain measurable activity above background. It is assumed that no activity is present in the effluent until indicated by radiation monitoring measurements and by analyses of periodic samples collected on that line. Radiation monitoring alarm/trip setpoints in conjunction with administrative controls assure that release limits are not exceeded; see section on radiation monitoring setpoints.

The following calculations, when solved for flowrate, are the release rates for noble gases and for radioiodines, particulates and other radionuclides with half-lives greater than 8 days; the most conservative of release rates calculated in B2.2.1 and B2.2.2 shall control the release rate for a single release point.

#### B2.2.1 Noble Gases

$$\sum_i \overline{K}_i \left[ \overline{(\chi/Q)Q_i} \right] \sim 500 \text{ mrem/yr, and}$$

$$\sum_i (L_i + 1.1 M_i) \overset{\sim}{[} (\overline{\chi/Q}) Q_i \overset{\sim}{] } < 3000 \text{ mrem/yr}$$

where the terms are defined below.

#### B2.2.2 Radioiodines, Particulates, and Others

$$\sum_i \overset{\sim}{P_i} [W \overset{\sim}{Q_i}] < 1500 \text{ mrem/yr}$$

where:

$K_i$  = The total body dose factor due to gamma emissions for each identified noble gas radionuclide, in mrem/yr per  $\mu\text{Ci}/\text{m}^3$  from Table 1.2-1.

$L_i$  = The skin dose factor due to beta emissions for each identified noble gas radionuclide, in mrem/yr per  $\mu\text{Ci}/\text{m}^3$  from Table 1.2-1.

$M_i$  = The air dose factor due to gamma emissions for each identified noble gas radionuclide, in mrad/yr per  $\mu\text{Ci}/\text{m}^3$  from Table 1.2-1 (unit conversion constant of 1.1 mrem/mrad converts air dose to skin dose).

$P_i$  = The dose parameter for radionuclides other than noble gases for the inhalation pathway, in mrem/yr per  $\mu\text{Ci}/\text{m}^3$  and for the food and ground plane pathways in  $\text{m}^2 \cdot (\text{mrem}/\text{yr})$  per  $\mu\text{Ci}/\text{sec}$  from Table 1.2-2. The dose factors are based on the critical individual organ and most restrictive age group (child or infant).

$\overset{\sim}{Q_i}$  = The release rate of radionuclides, i, in gaseous effluent from all release points at the site, in  $\mu\text{Ci}/\text{sec}$ .

$(\overline{\chi/Q})$  =  $2.6E-6 \text{ sec}/\text{m}^3$ . The highest calculated annual average relative concentration for any area at or beyond the unrestricted area boundary.

$W$  = The highest calculated annual average dispersion parameter for estimating the dose to an individual at the controlling location:

$W = 7.6E-8 \text{ sec}/\text{m}^3$ , for the inhalation pathway. The location is the unrestricted area in the SW sector.

$W = 2.0E-8 \text{ meter}^{-2}$ , for the food and ground plane pathways. The location is the unrestricted area boundary in the E sector (nearest residence, cow, and vegetable garden).

$\overset{\sim}{Q_i} = k_1 C_i f \div k_2 = 4.72E+2 C_i f$

where:

$C_i$  = the concentration of radionuclide, i, in undiluted gaseous effluent, in  $\mu\text{Ci}/\text{ml}$ .

$f$  = the undiluted effluent flow, in cfm

$k_1$  = conversion factor, 2.83E4 ml/ft<sup>3</sup>

$k_2$  = conversion factor, 6E1 sec/min

### B3.0 RADIATION MONITOR SETPOINTS

Using the generic calculations presented in Section 2.0, radiation monitoring setpoints are calculated for monitoring required by the Technical Specifications.

#### B3.1 LIQUID RADIATION MONITORS

##### B3.1.1 Waste Liquid Effluent Line

As described in Section B2.1.1 on release rate calculations for the waste liquid effluent, the release is controlled by limiting the flow rate of effluent from the station. Although the release rate is flow rate controlled, the radiation monitor setpoint shall be set to terminate the release if the effluent activity should exceed that determined by laboratory analyses and that used to calculate the release rate.

##### B3.1.2 Containment Ventilation Unit Condensate Effluent Line

As described in Section B2.1.2 on release rate calculations for the containment ventilation unit condensate effluent, it is possible but unlikely that the effluent will contain measurable activity above background. It is assumed that no activity is present in the effluent until indicated by radiation monitoring and by routine analyses of the composite sample collected on that line. Since the tank contents are discharged automatically, a maximum tank concentration, which also is the radiation monitor setpoint, is calculated to assure that release limits are not exceeded. The monitor setpoint and maximum tank concentration is:

$$c \leq \frac{MPC \times F}{\sigma f} \leq 1.25E-4 \text{ } \mu\text{Ci/ml}$$

where:

c = gross activity in undiluted effluent, in  $\mu\text{Ci/ml}$

f = the flow from the tank may vary from 0-100 gpm but, for this calculation, is assumed to be 100 gpm

C=MPC = 1E-7  $\mu\text{Ci/ml}$ , the MPC for an unidentified mixture

$\sigma$  = 2

F = the dilution flow may vary as described in B2.1.1, but is conservatively estimated at 2.5E+5 gpm, the minimum flow available

The above calculation determines the maximum setpoint for this release point; releases and/or setpoints may be administratively controlled to assure that release limits are not exceeded since more than one release source may be released to the condenser cooling water.

##### B3.1.3 Conventional Waste Water Treatment System Discharge Line

As described in Section B2.1.3 on release rate calculations for the conventional waste water treatment system effluent, the effluent is normally considered

non-radioactive; that is, it is unlikely the effluent will contain measurable activity above background. It is assumed that no activity is present in the effluent until indicated by radiation monitoring and by routein analysis of the composite sample collected on that line. Since the system discharges automatically, the maximum system concentration, which also is the radiation monitor setpoint, is calculated to assure compliance with 3.11.1.1. The monitor setpoint and maximum effluent concentration is:

$$c \leq \frac{MPC \times F}{\sigma f} \leq 3.6E-5 \mu\text{Ci}/\text{ml}$$

where:

c = the gross activity in undiluted effluent, in  $\mu\text{Ci}/\text{ml}$

f = the flow rate of undiluted effluent which may vary from 0-600 gpm, but is assumed to be 600 gpm

C=MPC = 1E-7  $\mu\text{Ci}/\text{ml}$ , the MPC for an unidentified mixture

$\sigma$  = 1

F = the flow may vary from 80 to 50,000 cfs, but is conservatively estimated at 80 cfs ( $3.6E+4$  gpm), the minimum flow available

### B3.2 GAS MONITORS

As stated in Section B2.2, the unit vent is the release point for waste gas decay tanks, containment building purges, the condenser air ejector, and auxiliary building ventilation. Since all of these releases are through the unit vent, the radiation monitor on the unit vent may be used to assure that station release limits are not exceeded. Depending on the stack flow, the radiation monitor setpoint may be:

$$C < 1.29E+3/f < 1.6E-2 \mu\text{Ci}/\text{ml}$$

where:

f = 54,000 cfm (auxiliary building) + 28,000 cfm (containment purge) = 82,000 cfm

or may be:

$$C < 1.29E+3/f < 2.4E-1 \mu\text{Ci}/\text{ml}$$

where:

F = 54,000 cfm (auxiliary building ventilation)

B4.0        DOSE CALCULATIONS

B4.1        FREQUENCY OF CALCULATIONS

Dose contributions to the maximum exposed individual shall be calculated quarterly, semiannually, and annually (as required by Technical Specifications) using the methodology in the generic information sections. This methodology shall also be used for any special reports. Dose projections and dose calculations for time periods less than a quarter shall be performed using simplified estimates. Fuel cycle and population doses calculations shall be performed annually or as required by special reports. Dose contributions shall be calculated using the methodology in the appropriate generic information sections.

B4.2        DOSE MODELS FOR MAXIMUM EXPOSED INDIVIDUAL

B4.2.1      Liquid Effluents

For liquid radioactive effluent release, it is assumed that the maximum exposed individual is an adult who consumes fish caught in the discharge area and drinks water from the nearest "downstream" water supply.

B4.2.2      Gaseous Effluents

B4.2.2.1     Noble Gases

For dose contributions from exposure to beta and gamma radiation from noble gases, it is assumed that the maximum exposed individual is an adult on the site boundary in each meteorological sectors.

B4.2.2.2     Radioiodines, Particulates, and Other Nuclides

For dose contributions from radioiodines, particulates and other radionuclides; it is assumed that the maximum exposed individual is an infant who breathes the air and consumes milk from the nearest goat or cow in each meteorological sector.

B4.3        SIMPLIFIED DOSE ESTIMATE

B4.3.1      Liquid Effluents

For dose calculations for time periods less than a quarter, simplified dose estimates using the assumptions presented in Section B4.2.2 and source terms presented in the FSAR are presented below. Dose calculations used to evaluate Appendix I to 10 CFR50 compliance indicate that the maximum exposed individual is an adult who consumes fish caught in the discharge area and that 90% of the dose is from cesium-134 and cesium-137.

$$D_{WB} = 6.64E5 \sum_{l=1}^m (C_{Cs-134} + 0.59 C_{Cs-137})$$

where:

$$6.64E5 = (1.10)(1.14E5) \left[ \frac{U_{aw}}{D_w} + 21 BF_i \right] DF_i$$
 and all terms are as previously defined except the following:

$C_{Cs-134}$  = the average concentration of Cs-134 in undiluted effluent, in  $\mu\text{Ci}/\text{ml}$ , during the time period considered.

$C_{Cs-137}$  = the average concentration of Cs-137 in undiluted effluent, in  $\mu\text{Ci}/\text{ml}$ , during the time period considered.

$D_w$  = dilution factor from the near field area to the potable water intake, 0.42.

#### B4.3.2 Gaseous Effluents

Meteorological data is provided in Tables B4.0-1 and B4.0-2.

##### B4.3.2.1 Noble Gases

For dose calculations for time periods less than a quarter, simplified dose estimates using the assumptions in B4.2.2.1 and source terms in the FSAR are presented below. These calculations further assume that the annual average dispersion parameter is used and that xenon-133 contributes 45% of the dose.

$$\overset{\sim}{D}_\gamma = 6.96E-11 [Q]_{Xe-133}$$

$$\overset{\sim}{D}_\beta = 2.07E-10 [Q]_{Xe-133}$$

where:

$$\overline{X/Q} = 2.8E-6 \text{ sec}/\text{m}^3$$

$6.96E-11$  = constant determined from factors previously presented

$2.07E-10$  = constant determined from factors previously presented

$[Q]_{Xe-133}$  = the total xenon-133 activity released in  $\mu\text{Ci}$

##### B4.3.2.2 Radioiodines, Particulates, and Other Nuclides

For dose calculations for time periods less than a quarter, simplified dose estimates using the assumptions in B4.2.2.2 and source terms in the FSAR are presented below. These calculations further assume that the annual average dispersion/deposition parameter is used and that 95% of the dose is from iodine-131 concentrated in goat's milk. The simplified dose estimate to the thyroid of an infant is:

$$\overset{\sim}{D} = 1.75E5 w (Q)_{I-131}$$

where:

$w$  =  $\overline{D/Q}$  for food and ground plane pathway, i.e.  $\text{m}^{-2}$  from Table B4.0-2 for location of nearest real cow or goat.

$(Q)_{I-131}$  = the release of iodine-131 in gaseous effluents, in  $\mu\text{Ci}$ .

$1.75E+5 = (1.05(3.17E-8) R_i^C [D/Q])$  with the appropriate substitutions in  
 $R_i^C [D/Q]$  for iodine-131. See Section B3.1.2.

B4.3 FUEL CYCLE CALCULATIONS

These calculations shall be performed using models presented in Section 3.3.

B4.4 POPULATION DOSES

TO BE SUPPLIED LATER.

TABLE B4.0-1

(1 of 1)

MCGUIRE NUCLEAR STATIONDISPERSION PARAMETER (X/Q) FOR LONG TERM RELEASES > 500 HR/YR OR > 125 HR/QTR

Sector 0	Distance to the control location, in miles									
	0-0.5*	0.5-1.0	1.0-1.5	1.5-2.0	2.0-2.5	2.5-3.0	3.0-3.5	3.5-4.0	4.0-4.5	4.5-5.0
N	1.2E-6	5.2E-7	2.7E-7	1.7E-7	1.2E-7	9.0E-8	7.0E-8	6.1E-8	4.8E-8	
NNE	2.3E-6	1.0E-6	5.7E-7	3.6E-7	2.4E-7	2.0E-7	1.4E-7	1.2E-7	9.6E-8	
NE	2.3E-6	1.0E-6	5.5E-7	2.9E-7	2.3E-7	1.7E-7	1.2E-7	1.1E-7	9.2E-8	
ENE	1.6E-6	6.7E-7	3.6E-7	2.2E-7	1.5E-7	1.0E-7	8.9E-8	8.0E-8	6.6E-8	
E	1.1E-6	3.8E-7	2.1E-7	1.4E-7	9.0E-8	7.8E-8	6.1E-8	5.3E-8	4.0E-8	
ESE	9.6E-7	3.8E-7	1.8E-7	1.2E-7	8.4E-8	5.5E-8	4.3E-8	4.1E-8	3.4E-8	
SE	1.0E-6	4.1E-7	1.7E-7	1.1E-7	8.1E-8	5.7E-8	4.6E-8	4.1E-8	3.3E-8	
SSE	1.1E-6	4.4E-7	1.9E-7	1.2E-7	8.3E-8	6.0E-8	5.4E-8	4.8E-8	3.7E-8	
S	1.2E-6	5.2E-7	2.7E-7	1.7E-7	1.3E-7	9.0E-8	6.5E-8	6.5E-8	5.2E-8	
SSW	2.3E-6	9.0E-7	4.2E-7	2.6E-7	1.8E-7	1.2E-7	9.4E-8	8.3E-8	6.6E-8	
SW	2.6E-6	9.3E-7	4.2E-7	2.4E-7	1.7E-7	1.1E-7	9.5E-8	8.6E-8	7.0E-8	
WSW	1.6E-6	5.8E-7	2.7E-7	1.5E-7	9.8E-8	6.6E-8	5.5E-8	4.8E-8	3.7E-8	
W	1.0E-6	3.8E-7	2.0E-7	1.2E-7	8.6E-8	6.2E-8	5.0E-8	4.3E-8	3.3E-8	
WNW	6.8E-7	2.6E-7	1.6E-7	1.0E-7	6.9E-8	5.1E-8	4.2E-8	3.7E-8	3.0E-8	
NW	6.4E-7	2.9E-7	1.6E-7	1.1E-7	7.4E-8	5.3E-8	4.7E-8	4.2E-8	3.4E-8	
NNW	8.0E-7	3.8E-7	2.1E-7	1.3E-7	8.4E-8	7.2E-8	5.9E-8	5.4E-8	4.4E-8	

\* Inside EAB

TABLE B4.0-2

(1 of 1)

## MCGUIRE NUCLEAR STATION

DEPOSITION PARAMETER (D/Q) FOR LONG TERM RELEASES &gt; 500 HR/YR OR &gt; 125 HR/QTR

TABLE B4.0-2  
(1 of 1)

		Distance to the control location, in miles									
Sector	0-0.5*	0.5-1.0	1.0-1.5	1.5-2.0	2.0-2.5	2.5-3.0	3.0-3.5	3.5-4.0	4.0-4.5	4.5-5.0	
N		2.2E-8	5.8E-9	2.3E-9	1.1E-9	6.5E-10	4.0E-10	2.9E-10	2.4E-10	1.8E-10	
NNE		4.8E-8	1.3E-8	5.0E-9	2.4E-9	1.5E-9	9.0E-10	6.4E-10	5.4E-10	4.0E-10	
NE		5.2E-8	1.6E-8	5.7E-9	2.6E-9	1.7E-9	1.0E-9	7.0E-10	5.9E-10	4.4E-10	
ENE		2.2E-8	6.1E-9	2.3E-9	1.1E-9	6.8E-10	4.2E-10	3.0E-10	2.5E-10	1.9E-10	
E		1.6E-8	4.9E-9	2.0E-9	9.0E-10	5.6E-10	3.4E-10	2.4E-10	2.0E-10	1.5E-10	
ESE		1.9E-8	4.6E-9	1.8E-9	8.5E-10	5.1E-10	3.1E-10	2.3E-10	1.9E-10	1.4E-10	
SE		3.2E-8	8.1E-9	3.2E-9	1.4E-9	8.9E-10	5.5E-10	3.8E-10	3.2E-10	2.4E-10	
SSE		2.8E-8	7.0E-9	2.7E-9	1.2E-9	7.5E-10	4.6E-10	3.2E-10	2.8E-10	2.1E-10	
S		3.9E-8	9.9E-9	3.8E-9	1.7E-9	1.1E-9	6.6E-10	4.7E-10	4.0E-10	3.0E-10	
SSW		5.6E-8	1.4E-8	5.5E-9	2.4E-9	1.5E-9	9.4E-10	6.6E-10	5.6E-10	4.3E-10	
SW		7.6E-8	1.8E-8	6.9E-9	3.1E-9	2.0E-9	1.2E-9	8.3E-10	7.1E-10	5.3E-10	
WSW		3.1E-8	1.3E-9	2.9E-9	1.3E-9	8.0E-10	4.8E-10	3.5E-10	3.0E-10	2.2E-10	
W		2.4E-8	5.8E-9	2.3E-9	1.0E-9	6.3E-10	3.9E-10	2.8E-10	2.4E-10	1.8E-10	
WNW		1.3E-8	3.2E-9	1.2E-9	5.6E-10	3.5E-10	2.1E-10	1.6E-10	1.3E-10	9.6E-11	
NW		1.6E-8	4.1E-9	1.6E-9	7.3E-10	4.5E-10	2.7E-10	2.0E-10	1.7E-10	1.2E-10	
NNW		1.8E-8	4.6E-9	1.8E-9	8.3E-10	5.1E-10	3.1E-10	2.3E-10	1.9E-10	1.4E-10	

\* Inside EAB

B5.0      RADIOLOGICAL ENVIRONMENTAL MONITORING

The radiological environmental monitoring program shall be conducted in accordance with Technical Specification 3/4.12. The monitoring program locations and analyses are given in Tables B5.0-1 through B5.0-3 and Figure B5.0-1. Site specific characteristics make groundwater sampling, special low level I-131 analyses on drinking water, and food product sampling unnecessary. Groundwater recharge is from precipitation and the groundwater gradient is toward the effluent discharge area; therefore, contamination of groundwater from liquid effluents is highly improbable. Special low level I-131 analyses in drinking water will not be performed routinely since the expected I-131 dose from this pathway is less than 1 mrem/year. Food products will not be sampled since lake water irrigation of crops is not practiced in the vicinity. Additionally, two site boundary TLD locations in the NW and NNW sectors do not exist since the required locations are over water.

The laboratory performing the radiological environmental analyses shall participate in an interlaboratory comparison program which has been approved by the NRC.

TABLE B5.0-1  
 (1 of 1)  
 MC GUIRE RADIOPHYSICAL MONITORING PROGRAM SAMPLING LOCATIONS  
 (TLD LOCATIONS)

SAMPLING LOCATION DESCRIPTION *			SAMPLING LOCATION DESCRIPTION *		
120	SITE BOUNDARY	(0.5 MILES N)	140	4-5 MILE RADIUS	(5.0 MILES SE)
121	SITE BOUNDARY	(0.7 MILES NNE)	141	4-5 MILE RADIUS	(4.5 MILES SSE)
122	SITE BOUNDARY	(0.5 MILES NE)	142	4-5 MILE RADIUS	(5.0 MILES S)
123	SITE BOUNDARY	(0.5 MILES ENE)	143	4-5 MILE RADIUS	(5.2 MILES SSW)
124	SITE BOUNDARY	(0.5 MILE E)	144	4-5 MILE RADIUS	(4.9 MILES SW)
125	SITE BOUNDARY	(0.5 MILES ESE)	145	4-5 MILE RADIUS	(4.7 MILES WSW)
126	SITE BOUNDARY	(0.6 MILES SE)	146	4-5 MILE RADIUS	4.4 MILES W)
127	SITE BOUNDARY	(0.5 MILES SSE)	147	4-5 MILE RADIUS	(4.4 MILES WNW)
128	SITE BOUNDARY	(0.5 MILES S)	148	4-5 MILE RADIUS	(4.5 MILES NW)
129	SITE BOUNDARY	(0.5 MILES SSW)	149	4-5 MILE RADIUS	(5.2 MILES NNW)
130	SITE BOUNDARY	(0.5 MILES SW)	150	SPECIAL INTEREST	(8.5 MILES N)
131	SITE BOUNDARY	(0.7 MILES WSW)	151	SPECIAL INTEREST	(12.5 MILES NE)
132	SITE BOUNDARY	(0.7 MILES W)	152	SPECIAL INTEREST	(7.5 MILES NE)
133	SITE BOUNDARY	(0.5 MILES WNW)	153	SPECIAL INTEREST	(6.2 MILES ENE)
134	4-5 MILE RADIUS	(4.8 MILES N)	154	SPECIAL INTEREST	(10.8 MILES ESE)
135	4-5 MILE RADIUS	(4.4 MILES NNE)	155	SPECIAL INTEREST	(5.9 MILES S)
136	4-5 MILE RADIUS	(5.0 MILES NE)	156	SPECIAL INTEREST	(10.8 MILES SW)
137	4-5 MILE RADIUS	(4.9 MILES ENE)	157	CONTROL	(12.2 MILES SSE)
138	4-5 MILE RADIUS	(4.7 MILES E)	158	CONTROL	(8.9 MILES S)
139	4-5 MILE RADIUS	(4.6 MILES ESE)	159	CONTROL	(8.7 MILES WSW)

\* All TLD samples are collected quarterly

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TABLE B5.0-2  
(1 of 1)  
MC GUIRE RADIOLOGICAL MONITORING PROGRAM SAMPLING LOCATIONS  
(OTHER SAMPLING LOCATIONS)

CODE:

W - Weekly      Q - Quarterly

SM - Semimonthly      SA - Semiannual

M - Monthly

	SAMPLING LOCATION DESCRIPTION	AIR RADIODIOTIDES AND PARTICULATES	SURFACE WATER	DRINKING WATER	SHORELINE SEDIMENT	MILK	FISH	BROADLEAF VEGETATION
160	Site Boundary (0.7 miles NNE)	W						
161	Site Boundary (0.5 miles NE)	W						
162	Site Boundary (0.5 miles SW)	W					M	
163	Discharge Canal Bridge (0.4 miles ENE)			M				
164	Discharge Canal Entrance to Lake Norman (0.6 miles ENE)				SA	SA		
165	Hwy. 73 Bridge Downstream (0.6 miles SW)		M		SA			
166	Huntersville Municipal Water Supply (3.0 miles ENE)			M				
167	Charlotte Municipal Water Supply (11.2 miles SSE)			M				
168	Cornelius (6.2 miles NE)	W						
169	East Lincoln Junior High School (8.7 miles WNW)	Control	W					M
170	Plant Marshall Intake Canal (12.0 miles N)	Control		M				
171	Mooresville Municipal Water Supply (12.5 miles NNE)	Control			M			
172	Pinnacle Access Area (12.0 miles N)	Control				SA	SA	
173	Aubbard Dairy (1.8 miles ESE) - Cows						M	
174	RC Howell Residence (1.8 miles SSE) - Goats						M	
175	Kidd Dairy (2.8 miles SSE) - Cows						M	
176	Eecker Dairy (7.3 miles NW) - Cows	Control					M	
177	Davidson Municipal Water Supply (7.5 miles NE)			M				

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(1301)  
7-15837191

TABLE B5.0-3  
 (1 of 1)  
 REQUIRE RADILOGICAL MONITORING PROGRAM ANALYSES

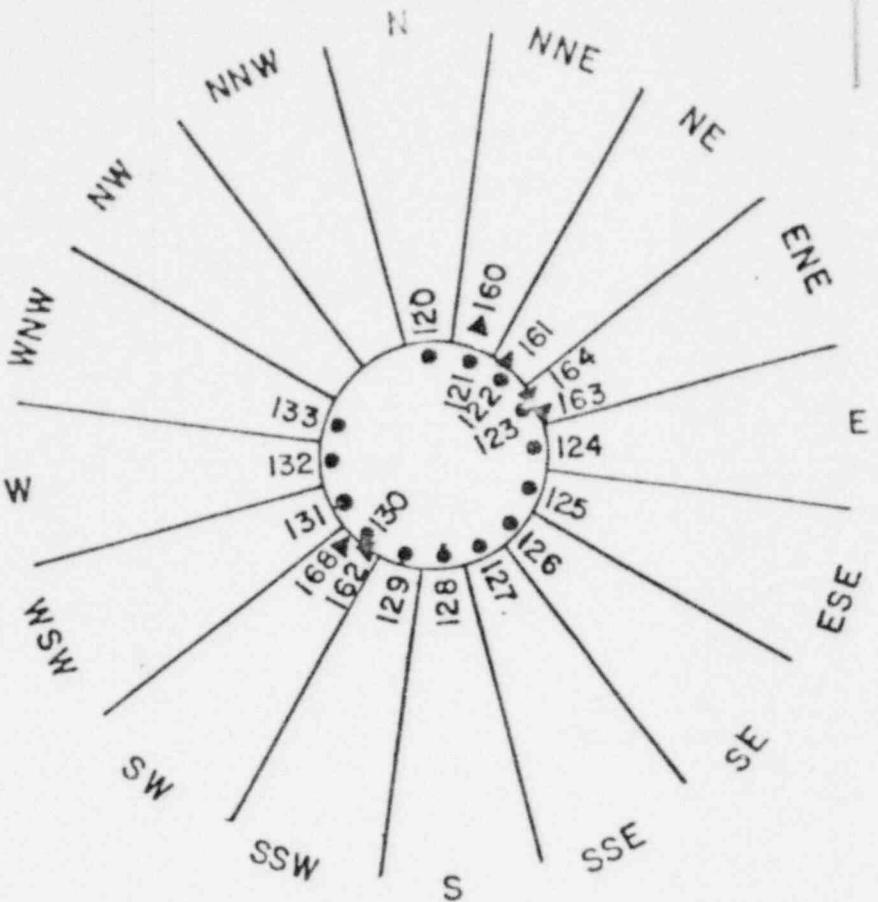
SAMPLE MEDIUM	ANALYSIS SCHEDULE	ANALYSES				
		GAMMA ISOTOPIC	TRITIUM	LOW LEVEL I-131	GROSS BETA	TLD
1. Air Radioiodine and Particulates	Weekly	X				
2. Direct Radiation	Quarterly					X
3. Surface Water	Monthly Quarterly Composite	X		X		
4. Drinking Water	Monthly Quarterly Composite	X		X		X
5. Shoreline Sediment	Semiannually	X				
6. Milk	Semimonthly	X			X	
7. Fish	Semiannually	X				
8. Broadleaf Vegetation	Monthly	X				

TABLE B5.0-3  
 (1 of 1)

POOR ORIGINAL

# POOR ORIGINAL





#### • TLD LOCATIONS

**▲ ALL OTHER LOCATIONS**

## POOR ORIGINAL

#### MONITORING PROGRAM LOCATIONS

FIGURE B5.0-1

(1 of 1)