OFFSITE DOSE CALCULATION MANUAL

FOR

DUKE POWER NUCLEAR STATIONS

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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 the System Radwaste Engineer prior to implementation and shall be audited by the Nuclear Safety Review Board. Changes to this Manual shall be submitted to the Nuclear Regulatory Commission in accordance with plant Technical Specifications.

Normally GASPAR and LADTAP are used for the calculation of offsite doses but this document also describes a method for the calculation of offsite doses when GASPAR and/or LADTAP are not available.

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 and/or apportion the releaserate 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:

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

where:

C_i = The concentration of radionuclide, 'i', in undiluted liquid effluent, in μCi/ml.

MPC_i = the concentration of radionuclide, 'i', from 10CFR20, Appendix B, Table II, Column 2, in μCi/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.

σ = recirculation factor at equilibrium; this factor accounts for the fraction of discharged water reused by the station; this factor is one for stations on rivers or lakes where discharged water cannot be reused, and varies for sites where water is recirculated and is specified in the appropriate Appendix.

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 ≤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

$$\sum_i K_i \times [(\overline{X/Q})\tilde{Q}_i] < 500 \text{ mrem/yr, and}$$

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

where:

K_i = The total body dose factor due to gamma emissions for each identified noble gas radionuclide, in mrem/yr per $\mu Ci/m^3$ 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 $\mu Ci/m^3$ 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 $\mu Ci/m^3$ 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 $\mu Ci/m^3$ 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 μCi/sec.

$\overline{X/Q}$ = 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 μCi/ml.

f = the undiluted effluent flow, in cfm.

k_1 = conversion factor, 2.83E+04 ml/ft^3.

k_2 = conversion factor, 6.0E+01 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 μCi/m³)	Skin Dose Factor L_i (mrem/yr per μCi/m³)	Gamma Air Dose Factor M_i (mrad/yr per μCi/m³)	Beta Air Dose Factor N_i (mrad/yr per μCi/m³)
Kr-83m	7.56E-02**	---	1.93E+01	2.88E+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 = 7.56×10^{-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

	Pathways			Pathways	
Radionuclide	Inhalation (mrem/yr per μCi/m^3)	Milk and Ground (m^2.mrem/yr per μCi/sec)	Radionuclide	Inhalation (mrem/yr per μCi/m^3)	Milk and Ground (m^2.mrem/yr per μCi/sec)
H 3	1.125 E+03	2.4E+03	RU 103	6.625 E+05	1.6E+08
Alpha Act	1.100 E+08	1.8E+10	RU 106	1.432 E+07	2.0E+08
CR 51	1.698 E+04	1.1E+07	AG 110M	5.476 E+06	1.5E+10
MN 54	1.576 E+06	1.1E+09	CD 115M	2.920 E+05	5.2E+07
FE 55	1.110 E+05	1.1E+08	SN 123	3.550 E+06	3.7E+09
FE 59	1.269 E+06	7.2E+08	SN 126	1.120 E+07	1.1E+10
CO 58	1.106 E+06	5.8E+08	SB 124	3.240 E+06	1.4E+09
CO 60	7.067 E+06	4.6E+09	SB 125	2.320 E+06	9.1E+08
NI 63	8.214 E+05	3.0E+10	TE 127M	1.408 E+06	1.0E+09
ZN 65	8.399 E+04	1.8E+10	TE 129M	1.761 E+06	1.3E+09
RB 86	1.983 E+05	2.1E+10	CS 134	1.014 E+06	5.6E+10
SR 89	2.157 E+06	1.1E+10	CS 136	1.709 E+05	5.7E+09
SR 90	1.010 E+08	1.0E+11	CS 137	9.065 E+05	5.0E+10
Y 91	2.627 E+06	5.9E+06	BA 140	1.743 E+06	2.6E+08
ZR 95	2.231 E+06	3.5E+08	CE 141	5.439 E+05	3.2E+07
NB 95	6.142 E+05	3.8E+08	CE 144	1.195 E+07	1.6E+08
MO 99	1.354 E+05	3.2E+08	I 131	1.624 E+07	1.0E+12
			I 133	3.848 E+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.

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 μCi/ml.

C = the radioactivity concentration in μCi/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 $F + f \cong F$.)

2.2 GAS MONITORS

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

$$K_i(\overline{X/Q})\tilde{Q}_i < 500$$

$$\tilde{Q}_i = 4.72E{+}2\ C\ f \text{ (See Section 1.2.1)}$$

where:

C = the gross activity in undiluted effluent, in μCi/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 μCi/m³.

$\overline{X/Q}$ = 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:

$$D_{a\tau} = \sum_i [A_{ai\tau} \sum_{\ell=1}^{m} \Delta t_\ell \, C_{i\ell} \, F_\ell]$$

where:

$D_{a\tau}$ = the cumulative dose commitment to the total body or any organ, τ, 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.

Δt_ℓ = the length of the ℓth time period over which $C_{i\ell}$ and F_ℓ are averaged for all liquid releases, in hours.

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

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

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

where:

σ = recirculation factor at equilibrium; this factor accounts for the fraction of discharged water reused by the station. This factor is one for stations on rivers or lakes where discharged water cannot be reused and varies for sites where water is recirculated. It is specified in the appropriate Appendix.

f = liquid radwaste flow, in gpm.

F = dilution flow, in gpm.

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

$$A_{ai\tau} = 1.14E{+}05 \, (U_{aw}/D_w + U_{af} BF_i) DF_{ai\tau}$$

where:

$1.14E5 = 10^6 pCi/\mu Ci \times 10^3 ml/kg \div 8760$ 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.

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

Using the above information, $A_{ai\tau}$ values for the adult have been calculated for each site. This information is provided in the Table "X" 5.0-4 where "X" is the appendix for the site in question.

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:

$$D_\gamma = 3.17\ E\text{-}8 \sum_{i=1} M_i\ [(\overline{X/Q})\ \tilde{Q}_i]$$

For beta radiation:

$$D_\beta = 3.17\ E\text{-}8 \sum_{i=1} N_i\ [(\overline{X/Q})\ \tilde{Q}_i]$$

where:

3.17E-08 = 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 $\mu Ci/m^3$ 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 $\mu Ci/m^3$ from Table 1.2-1.

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

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

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:

$$D = 3.17\text{ E-8} \sum_i R_i\ [W\tilde{Q}_i]$$

where:

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

$\tilde{Q}_i$ = The release of radioiodines, radioactive materials in particulate form and radionuclides other than noble gases in gaseous effluents, 'i', in µCi. 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.

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

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

R_i = The dose factor for each identified radionuclide, 'i', in m^2 (mrem/yr) per µCi/sec or mrem/yr per $\mu Ci/m^3$, for each pathway. (Tables 3.1-12 → 3.1-30)

where:

<u>Inhalation Pathway Factor, R_i^I [X/Q]</u>

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

where:

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

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

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

Age Group (a)	Breathing Rate (m^3/yr)
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 $(DFA_i)_a$ 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]

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

where:

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

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

λ_i = the decay constant for the ith radionuclide, sec^{-1}.

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

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

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]

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

(m^2 · mrem/yr per μCi/sec)

where:

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

Q_F = the cow's consumption rate, in kg/day (wet weight), (Regulatory Guide 1.109 (Rev. 1)). (Milk cow = 50, Beef Cattle = 50, Goats = 6).

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 kg/m^2, 0.7.

Y_s = the agricultural productivity by unit area of stored feed, in 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 mrem/pCi. See Tables 3.1-2, 3.1-3, 3.1-4, and 3.1-5.

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

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

t_f = the transport time from pasture to cow, to milk, to receptor, in sec, 1.73×10^5 (2 days).

t_h = the transport time from pasture, to harvest, to cow, to milk, to receptor, in sec, 7.78×10^6 (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 [χ/Q]:

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

where:

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

H = absolute humidity of the atmosphere, 8 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:

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

(m^2 · mrem/yr per μCi/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, 1.73 x 10^5 (2 days).

t_h = the transport time from crop field to receptor, in sec, 7.78 x 10^6 (90 days).

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^2 · mrem/yr per μCi/sec)

where:

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

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.

- Child 520
- Teen 630
- Adult 520

f_L = the fraction of the annual intake of fresh leafy vegetation grown locally, (1.0).

f_g = the fraction of the annual intake of stored vegetation grown locally, (0.76).

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

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

Y_v = the vegetation area density, 2.0 kg/m².

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]:

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

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, reactor makeup water storage tanks, and temporary on-site radwaste storage tanks. Dose calculations using this method performed for Duke Nuclear Stations indicate direct radiation doses are much less than 0.01 mrem/yr. and, therefore, makes a negligible contribution to individual dose. Direct radiation doses will not be calculated routinely.

3.2 SIMPLIFIED DOSE PROJECTIONS

To estimate the cumulative dose contributions to the maximum exposed individual for 31 day dose projection 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 projection 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_6 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.

TABLE 3.1-1*
(1 of 1)

BIOACCUMULATION FACTORS TO BE USED IN THE ABSENCE OF SITE-SPECIFIC DATA
(pCi/kg per pCi/liter)

ELEMENT	FRESHWATER FISH	FRESHWATER INVERTEBRATE
H	9.0E-01	9.0E-01
Na	1.0E-02	2.0E 02
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 3.1-2*
(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
NA 24	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06
CR 51	NO DATA	NO DATA	2.66E-09	1.59E-09	5.86E-10	3.53E-09	6.69E-07
MN 54	NO DATA	4.57E-06	8.72E-07	NO DATA	1.36E-06	NO DATA	1.40E-05
MN 56	NO DATA	1.15E-07	2.04E-08	NO DATA	1.46E-07	NO DATA	3.67E-06
FE 55	2.75E-06	1.90E-06	4.43E-07	NO DATA	NO DATA	1.06E-06	1.09E-06
FE 59	4.34E-06	1.02E-05	3.91E-06	NO DATA	NO DATA	2.85E-06	3.40E-05
CO 58	NO DATA	7.45E-07	1.67E-06	NO DATA	NO DATA	NO DATA	1.51E-05
CO 60	NO DATA	2.14E-06	4.72E-06	NO DATA	NO DATA	NO DATA	4.02E-05
NI 63	1.30E-04	9.01E-06	4.36E-06	NO DATA	NO DATA	NO DATA	1.88E-06
NI 65	5.28E-07	6.86E-08	3.13E-08	NO DATA	NO DATA	NO DATA	1.74E-06
CU 64	NO DATA	8.33E-08	3.91E-08	NO DATA	2.10E-07	NO DATA	7.10E-06
ZN 65	4.84E-06	1.54E-05	6.96E-06	NO DATA	1.03E-05	NO DATA	9.70E-06
ZN 69	1.03E-08	1.97E-08	1.37E-09	NO DATA	1.28E-08	NO DATA	2.96E-09
BR 83	NO DATA	NO DATA	4.02E-08	NO DATA	NO DATA	NO DATA	5.79E-08
BR 84	NO DATA	NO DATA	5.21E-08	NO DATA	NO DATA	NO DATA	4.09E-13
BR 85	NO DATA	NO DATA	2.14E-09	NO DATA	NO DATA	NO DATA	LT E-24
RB 86	NO DATA	2.11E-05	9.83E-06	NO DATA	NO DATA	NO DATA	4.16E-06
RB 88	NO DATA	6.05E-08	3.21E-08	NO DATA	NO DATA	NO DATA	8.36E-19
RB 89	NO DATA	4.01E-08	2.82E-08	NO DATA	NO DATA	NO DATA	2.33E-21
SR 89	3.08E-04	NO DATA	8.84E-06	NO DATA	NO DATA	NO DATA	4.94E-05
SR 90	7.58E-03	NO DATA	1.86E-03	NO DATA	NO DATA	NO DATA	2.19E-04
SR 91	5.67E-06	NO DATA	2.29E-07	NO DATA	NO DATA	NO DATA	2.70E-05
SR 92	2.15E-06	NO DATA	9.30E-08	NO DATA	NO DATA	NO DATA	4.26E-05
Y 90	9.62E-09	NO DATA	2.58E-10	NO DATA	NO DATA	NO DATA	1.02E-04
Y 91M	9.09E-11	NO DATA	3.52E-12	NO DATA	NO DATA	NO DATA	2.67E-10
Y 91	1.41E-07	NO DATA	3.77E-09	NO DATA	NO DATA	NO DATA	7.76E-05
Y 92	8.45E-10	NO DATA	2.47E-11	NO DATA	NO DATA	NO DATA	1.48E-05
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 taken from Regulatory Guide 1.109 (Rev. 1)

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
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
TE 129	3.14E-08	1.18E-08	7.65E-09	2.41E-08	1.32E-07	NO DATA	2.37E-08
TE 131M	1.73E-06	8.46E-07	7.05E-07	1.34E-06	8.57E-06	NO DATA	8.40E-05
TE 131	1.97E-08	8.23E-09	6.22E-09	1.62E-08	8.63E-08	NO DATA	2.79E-09
TE 132	2.52E-06	1.63E-06	1.53E-06	1.80E-06	1.57E-05	NO DATA	7.71E-05
I 130	7.56E-07	2.23E-06	8.80E-07	1.89E-04	3.48E-06	NO DATA	1.92E-06
I 131	4.16E-06	5.95E-06	3.41E-06	1.95E-03	1.02E-05	NO DATA	1.57E-06
I 132	2.03E-07	5.43E-07	1.90E-07	1.90E-05	8.65E-07	NO DATA	1.02E-07
I 133	1.42E-06	2.47E-06	7.53E-07	3.63E-04	4.31E-06	NO DATA	2.22E-06
I 134	1.06E-07	2.88E-07	1.03E-07	4.99E-06	4.58E-07	NO DATA	2.51E-10
I 135	4.43E-07	1.16E-06	4.28E-07	7.65E-05	1.86E-06	NO DATA	1.31E-06
CS 134	6.22E-05	1.48E-04	1.21E-04	NO DATA	4.79E-05	1.59E-05	2.59E-06
CS 136	6.51E-06	2.57E-05	1.85E-05	NO DATA	1.43E-05	1.96E-06	2.92E-06
CS 137	7.97E-05	1.09E-04	7.14E-05	NO DATA	3.70E-05	1.23E-05	2.11E-06
CS 138	5.52E-08	1.09E-07	5.40E-08	NO DATA	8.01E-08	7.91E-09	4.65E-13
BA 139	9.70E-08	6.91E-11	2.84E-09	NO DATA	6.46E-11	3.92E-11	1.72E-07
BA 140	2.03E-05	2.55E-08	1.33E-06	NO DATA	8.67E-09	1.46E-08	4.18E-05
BA 141	4.71E-08	3.56E-11	1.59E-09	NO DATA	3.31E-11	2.02E-11	2.22E-17
BA 142	2.13E-08	2.19E-11	1.34E-09	NO DATA	1.85E-11	1.24E-11	3.00E-26
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

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

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
H 3	NO DATA	1.06E-07	1.06E-07	1.06E-07	1.06E-07	1.06E-07	1.06E-07
NA 24	2.30E-06	2.30E-06	2.30E-06	2.30E-06	2.30E-06	2.30E-06	2.30E-06
CR 51	NO DATA	NO DATA	3.60E-09	2.00E-09	7.89E-10	5.14E-09	6.05E-07
MN 54	NO DATA	5.90E-06	1.17E-06	NO DATA	1.76E-06	NO DATA	1.21E-05
MN 56	NO DATA	1.58E-07	2.81E-08	NO DATA	2.00E-07	NO DATA	1.04E-05
FE 55	3.78E-06	2.68E-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
(2 of 3)
INGESTION DOSE FACTORS FOR TEENAGER
(MREM PER PCI INGESTED)

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
Y 93	3.83E-09	NO DATA	1.05E-10	NO DATA	NO DATA	NO DATA	1.17E-04
ZR 95	4.12E-08	1.30E-08	8.94E-09	NO DATA	1.91E-08	NO DATA	3.00E-05
ZR 97	2.37E-09	4.69E-10	2.16E-10	NO DATA	7.11E-10	NO DATA	1.27E-04
NB 95	8.22E-09	4.56E-09	2.51E-09	NO DATA	4.42E-09	NO DATA	1.95E-05
MO 99	NO DATA	6.03E-06	1.15E-06	NO DATA	1.38E-05	NO DATA	1.08E-05
TC 99M	3.32E-10	9.26E-10	1.20E-08	NO DATA	1.38E-08	5.14E-10	6.08E-07
TC 101	3.60E-10	5.12E-10	5.03E-09	NO DATA	9.26E-09	3.12E-10	8.75E-18
[illegible] 103	2.55E-07	NO DATA	1.09E-07	NO DATA	8.99E-07	NO DATA	2.13E-05
RU 105	2.18E-08	NO DATA	8.46E-09	NO DATA	2.75E-07	NO DATA	1.76E-05
RU 106	3.92E-06	NO DATA	4.94E-07	NO DATA	7.56E-06	NO DATA	1.88E-04
AG 110M	2.05E-07	1.94E-07	1.18E-07	NO DATA	3.70E-07	NO DATA	5.45E-05
TE 125M	3.83E-06	1.38E-06	5.12E-07	1.07E-06	NO DATA	NO DATA	1.13E-05
TE 127M	9.67E-06	3.43E-06	[illegible]	2.30E-06	3.92E-05	NO DATA	2.41E-05
TE 127	1.58E-07	5.60E-08	3.40E-08	1.09E-07	6.40E-07	NO DATA	1.22E-05
TE 129M	1.63E-05	6.05E-06	2.58E-06	5.26E-06	6.82E-05	NO DATA	6.12E-05
TE 129	4.48E-08	1.67E-08	1.09E-08	3.20E-08	1.88E-07	NO DATA	2.45E-07
TE 131M	2.44E-06	1.17E-06	9.76E-07	1.76E-06	1.22E-05	NO DATA	9.39E-05
TE 131	2.79E-08	1.15E-08	8.72E-09	2.15E-08	1.22E-07	NO DATA	2.29E-09
TE 132	3.49E-06	2.21E-06	2.08E-06	2.33E-06	2.12E-05	NO DATA	7.00E-05
I 130	1.03E-06	2.98E-06	1.19E-06	2.43E-04	4.59E-06	NO DATA	2.29E-06
I 131	5.85E-06	8.19E-06	4.40E-06	2.39E-03	1.41E-05	NO DATA	1.62E-06
I 132	2.79E-07	7.30E-07	2.62E-07	2.46E-05	1.15E-06	NO DATA	3.18E-07
I 133	2.01E-06	3.41E-06	1.04E-06	4.76E-04	5.98E-06	NO DATA	2.58E-06
I 134	1.46E-07	3.87E-07	1.39E-07	6.45E-06	6.10E-07	NO DATA	5.10E-09
I 135	6.10E-07	1.57E-06	5.82E-07	1.01E-04	2.48E-06	NO DATA	1.74E-06
CS 134	8.37E-05	1.97E-04	9.14E-05	NO DATA	6.26E-05	2.39E-05	2.45E-06
CS 136	8.59E-06	3.38E-05	2.27E-05	NO DATA	1.84E-05	2.90E-06	2.72E-06
CS 137	1.12E-04	1.49E-04	5.19E-05	NO DATA	5.07E-05	1.97E-05	2.12E-06
CS 138	7.76E-08	1.49E-07	7.45E-08	NO DATA	1.10E-07	1.28E-08	6.76E-11
BA 139	1.39E-07	9.78E-11	4.05E-09	NO DATA	9.22E-11	6.74E-11	1.24E-06

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

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
BA 140	2.84E-05	3.48E-08	1.83E-06	NO DATA	1.18E-08	2.34E-08	4.38E-05
BA 141	6.71E-08	5.01E-11	2.24E-08	NO DATA	4.65E-11	3.43E-11	1.43E-13
BA 142	2.99E-08	2.99E-11	1.84E-09	NO DATA	2.53E-11	1.99E-11	9.18E-20
LA 140	3.48E-09	1.71E-09	4.55E-10	NO DATA	NO DATA	NO DATA	9.82E-05
LA 142	1.79E-10	7.95E-11	1.98E-11	NO DATA	NO DATA	NO DATA	2.42E-06
CE 141	1.33E-08	8.88E-09	1.02E-09	NO DATA	4.18E-09	NO DATA	2.54E-05
CE 143	2.35E-09	1.71E-06	1.91E-10	NO DATA	7.67E-10	NO DATA	5.14E-05
CD 144	6.96E-07	2.88E-07	3.74E-08	NO DATA	1.72E-07	NO DATA	1.75E-04
PR 143	1.31E-08	5.23E-09	6.52E-10	NO DATA	3.04E-09	NO DATA	4.31E-05
PR 144	4.30E-11	1.76E-11	2.18E-12	NO DATA	1.01E-11	NO DATA	4.74E-14
ND 147	9.38E-09	1.02E-08	6.11E-10	NO DATA	5.99E-09	NO DATA	3.68E-05
W 187	1.46E-07	1.19E-07	4.17E-08	NO DATA	NO DATA	NO DATA	3.22E-05
NP 239	1.76E-09	1.66E-10	9.22E-11	NO DATA	5.21E-10	NO DATA	2.67E-05

TABLE 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
NA 24	5.80E-06	5.80E-06	5.80E-06	5.80E-06	5.80E-06	5.80E-06	5.80E-06
CR 51	NO DATA	NO DATA	8.90E-09	4.94E-09	1.35E-09	9.02E-09	4.72E-07
MN 54	NO DATA	1.07E-05	2.85E-06	NO DATA	3.00E-06	NO DATA	8.98E-06
MN 56	NO DATA	3.34E-07	7.54E-08	NO DATA	4.04E-07	NO DATA	4.84E-05
FE 55	1.15E-05	6.10E-06	1.89E-06	NO DATA	NO DATA	3.45E-06	1.13E-06
FE 59	1.65E-05	2.67E-05	1.33E-05	NO DATA	NO DATA	7.74E-06	2.78E-05
CO 58	NO DATA	1.80E-06	5.51E-06	NO DATA	NO DATA	NO DATA	1.05E-05
CO 60	NO DATA	5.29E-06	1.56E-05	NO DATA	NO DATA	NO DATA	2.93E-05
NI 63	5.38E-04	2.88E-05	1.83E-05	NO DATA	NO DATA	NO DATA	1.94E-06
NI 65	2.22E-06	2.09E-07	1.22E-07	NO DATA	NO DATA	NO DATA	2.56E-05
CU 64	NO DATA	2.45E-07	1.48E-07	NO DATA	5.92E-07	NO DATA	1.15E-05
ZN 65	1.37E-05	3.65E-05	2.27E-05	NO DATA	2.30E-05	NO DATA	6.41E-06
ZN 69	4.38E-08	6.33E-08	5.85E-09	NO DATA	3.84E-08	NO DATA	3.99E-06
BR 83	NO DATA	NO DATA	1.71E-07	NO DATA	NO DATA	NO DATA	LT E-24
BR 84	NO DATA	NO DATA	1.98E-07	NO DATA	NO DATA	NO DATA	LT E-24
BR 85	NO DATA	NO DATA	9.12E-09	NO DATA	NO DATA	NO DATA	LT E-24
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).

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
TC 101	1.07E-09	1.12E-09	1.42E-08	NO DATA	1.91E-08	5.92E-10	3.56E-09
RU 103	7.31E-07	NO DATA	2.81E-07	NO DATA	1.84E-06	NO DATA	1.89E-05
RU 105	6.45E-08	NO DATA	2.34E-08	NO DATA	5.67E-07	NO DATA	4.21E-05
RU 106	1.17E-05	NO DATA	1.46E-06	NO DATA	1.58E-05	NO DATA	1.82E-04
AG 110M	5.39E-07	3.84E-07	2.91E-07	NO DATA	6.78E-07	NO DATA	4.33E-05
TE 125M	1.14E-05	3.09E-06	1.52E-06	3.20E-06	NO DATA	NO DATA	1.10E-05
TE 127M	2.89E-05	7.78E-06	3.43E-06	6.91E-06	8.24E-05	NO DATA	2.34E-05
TE 127	4.71E-07	1.27E-07	1.01E-07	3.26E-07	1.34E-06	NO DATA	1.84E-05
TE 129M	4.87E-05	1.36E-05	7.56E-06	1.57E-05	1.43E-04	NO DATA	5.94E-05
TE 129	1.34E-07	3.74E-08	3.18E-08	9.56E-08	3.92E-07	NO DATA	8.34E-06
TE 131M	7.20E-06	2.49E-06	2.65E-06	5.12E-06	2.41E-05	NO DATA	1.01E-04
TE 131	8.30E-08	2.53E-08	2.47E-08	6.35E-08	2.51E-07	NO DATA	4.36E-07
TE 132	1.01E-05	4.47E-06	5.40E-06	6.51E-06	4.15E-05	NO DATA	4.50E-05
I 130	2.92E-06	5.90E-06	3.04E-06	6.50E-04	8.82E-06	NO DATA	2.76E-06
I 131	1.72E-05	1.73E-05	9.83E-06	5.72E-03	2.84E-05	NO DATA	1.54E-06
I 132	8.00E-07	1.47E-06	6.76E-07	6.82E-05	2.25E-06	NO DATA	1.73E-06
I 133	5.92E-06	7.32E-06	2.77E-06	1.36E-03	1.22E-05	NO DATA	2.95E-06
I 134	4.19E-07	7.78E-07	3.58E-07	1.79E-05	1.19E-06	NO DATA	5.16E-07
I 135	1.75E-06	3.15E-06	1.49E-06	2.79E-04	4.83E-06	NO DATA	2.40E-06
CS 134	2.34E-04	3.84E-04	8.10E-05	NO DATA	1.19E-04	4.27E-05	2.07E-06
CS 136	2.35E-05	6.46E-05	4.18E-05	NO DATA	3.44E-05	5.13E-06	2.27E-06
CS 137	3.27E-04	3.13E-04	4.62E-05	NO DATA	1.02E-04	3.67E-05	1.96E-06
CS 138	2.28E-07	3.17E-07	2.01E-07	NO DATA	2.23E-07	2.40E-08	1.46E-07
BA 139	4.14E-07	2.21E-10	1.20E-08	NO DATA	1.93E-10	1.30E-10	2.39E-05

INGESTION DOSE FACTORS FOR CHILD
(MREM PER PCI INGESTED)

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
BA 140	8.31E-05	7.28E-08	4.85E-06	NO DATA	2.37E-08	4.34E-08	4.21E-05
BA 141	2.00E-07	1.12E-10	6.51E-09	NO DATA	9.69E-11	6.58E-10	1.14E-07
BA 142	8.74E-08	6.29E-11	4.88E-09	NO DATA	5.09E-11	3.70E-11	1.14E-09
LA 140	1.01E-08	3.53E-09	1.19E-09	NO DATA	NO DATA	NO DATA	9.84E-05
LA 142	5.24E-10	1.67E-10	5.23E-11	NO DATA	NO DATA	NO DATA	3.31E-05
CE 141	3.97E-08	1.98E-08	2.94E-09	NO DATA	8.68E-09	NO DATA	2.47E-05
CE 143	6.99E-09	3.79E-06	5.49E-10	NO DATA	1.59E-09	NO DATA	5.55E-05
CE 144	2.08E-06	6.52E-07	1.11E-07	NO DATA	3.61E-07	NO DATA	1.70E-04
PR 143	3.93E-08	1.18E-08	1.95E-09	NO DATA	6.39E-09	NO DATA	4.24E-05
PR 144	1.29E-10	3.99E-11	6.49E-12	NO DATA	2.11E-11	NO DATA	8.59E-08
ND 147	2.79E-08	2.26E-08	1.75E-09	NO DATA	1.24E-08	NO DATA	3.58E-05
W 187	4.29E-07	2.54E-07	1.14E-07	NO DATA	NO DATA	NO DATA	3.57E-05
NP 239	5.25E-09	3.77E-10	2.65E-10	NO DATA	1.09E-09	NO DATA	2.79E-05

TABLE 3.1-5*
(1 of 3)
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
NA 24	1.01E-05	1.01E-05	1.01E-05	1.01E-05	1.01E-05	1.01E-05	1.01E-05
CR 51	NO DATA	NO DATA	1.41E-08	9.20E-09	2.01E-09	1.79E-08	4.11E-07
MN 54	NO DATA	1.99E-05	4.51E-06	NO DATA	4.41E-06	NO DATA	7.31E-06
MN 56	NO DATA	8.18E-07	1.41E-07	NO DATA	7.03E-07	NO DATA	7.43E-05
FE 55	1.39E-05	8.98E-06	2.40E-06	NO DATA	NO DATA	4.39E-06	1.14E-06
FE 59	3.08E-05	5.38E-05	2.12E-05	NO DATA	NO DATA	1.59E-05	2.57E-05
CO 58	NO DATA	3.60E-06	8.98E-06	NO DATA	NO DATA	NO DATA	8.97E-06
CO 60	NO DATA	1.08E-05	2.55E-05	NO DATA	NO DATA	NO DATA	2.57E-05
NI 63	6.34E-04	3.92E-05	2.20E-05	NO DATA	NO DATA	NO DATA	1.95E-06
NI 65	4.70E-06	5.32E-07	2.42E-07	NO DATA	NO DATA	NO DATA	4.05E-05
CU 64	NO DATA	6.09E-07	2.82E-07	NO DATA	1.03E-06	NO DATA	1.25E-05
ZN 65	1.84E-05	6.31E-05	2.91E-05	NO DATA	3.06E-05	NO DATA	5.33E-05
ZN 69	9.33E-08	1.68E-07	1.25E-08	NO DATA	6.98E-08	NO DATA	1.37E-05
BR 83	NO DATA	NO DATA	3.63E-07	NO DATA	NO DATA	NO DATA	LT E-24
BR 84	NO DATA	NO DATA	3.82E-07	NO DATA	NO DATA	NO DATA	LT E-24
BR 85	NO DATA	NO DATA	1.94E-08	NO DATA	NO DATA	NO DATA	LT E-24
RB 86	NO DATA	1.70E-04	8.40E-05	NO DATA	NO DATA	NO DATA	4.35E-06
RB 88	NO DATA	4.98E-07	2.73E-07	NO DATA	NO DATA	NO DATA	4.85E-07
RB 89	NO DATA	2.86E-07	1.97E-07	NO DATA	NO DATA	NO DATA	9.74E-08
SR 89	2.51E-03	NO DATA	7.20E-05	NO DATA	NO DATA	NO DATA	5.16E-05
SR 90	1.85E-02	NO DATA	4.71E-03	NO DATA	NO DATA	NO DATA	2.31E-04
SR 91	5.00E-05	NO DATA	1.81E-06	NO DATA	NO DATA	NO DATA	5.92E-05
SR 92	1.92E-05	NO DATA	7.13E-07	NO DATA	NO DATA	NO DATA	2.07E-04
Y 90	8.69E-08	NO DATA	2.33E-09	NO DATA	NO DATA	NO DATA	1.20E-04
Y 91M	8.10E-10	NO DATA	2.76E-11	NO DATA	NO DATA	NO DATA	2.70E-06
Y 91	1.13E-06	NO DATA	3.01E-08	NO DATA	NO DATA	NO DATA	8.10E-05
Y 92	7.65E-09	NO DATA	2.15E-10	NO DATA	NO DATA	NO DATA	1.46E-04

*Taken from Regulatory Guide 1.109 (Rev. 1)

TABLE 3.1-5
(2 of 3)
INGESTION DOSE FACTORS FOR INFANT
(MREM PER PCI INGESTED)

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

TABLE 3.1-5
(3 of 3)
INGESTION DOSE FACTORS FOR INFANT
(MREM PER PCI INGESTED)

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
BA 140	1.71E-04	1.71E-07	8.81E-06	NO DATA	4.06E-08	1.05E-07	4.20E-05
BA 141	4.25E-07	2.91E-10	1.34E-08	NO DATA	1.75E-10	1.77E-10	5.19E-06
BA 142	1.84E-07	1.53E-10	9.06E-09	NO DATA	8.81E-11	9.26E-11	7.59E-07
LA 140	2.11E-08	8.32E-09	2.14E-09	NO DATA	NO DATA	NO DATA	9.77E-05
LA 142	1.10E-09	4.04E-10	9.67E-11	NO DATA	NO DATA	NO DATA	6.86E-05
CE 141	7.87E-08	4.80E-08	5.65E-09	NO DATA	1.48E-08	NO DATA	2.48E-05
CE 143	1.48E-08	9.82E-06	1.12E-09	NO DATA	2.86E-09	NO DATA	5.73E-05
CE 144	2.98E-06	1.22E-06	1.67E-07	NO DATA	4.93E-07	NO DATA	1.71E-04
PR 143	8.13E-08	3.04E-08	4.03E-09	NO DATA	1.13E-08	NO DATA	4.29E-05
PR 144	2.74E-10	1.06E-10	1.38E-11	NO DATA	3.84E-11	NO DATA	4.93E-06
ND 147	5.53E-08	5.68E-08	3.48E-09	NO DATA	2.19E-08	NO DATA	3.60E-05
W 187	9.03E-07	6.28E-07	2.17E-07	NO DATA	NO DATA	NO DATA	3.69E-05
NP 239	1.11E-08	9.93E-10	5.61E-10	NO DATA	1.98E-09	NO DATA	2.87E-05

TABLE 3.1-6*
(1 of 1)
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
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
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
ZN 65	4.05E-06	1.29E-05	5.82E-06	NO DATA	8.62E-06	1.08E-04	6.68E-06
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
ZR 95	1.34E-05	4.30E-06	2.91E-06	NO DATA	6.77E-06	2.21E-06	1.88E-05
SB 124	3.90E-06	7.36E-08	1.55E-06	9.44E-09	NO DATA	3.10E-04	5.08E-05
I 131	3.15E-06	4.47E-06	2.56E-06	1.49E-03	7.66E-06	NO DATA	7.85E-07
I 133	1.08E-06	1.85E-06	5.65E-07	2.69E-04	3.23E-06	NO DATA	1.11E-06
CS 134	4.66E-05	1.06E-04	9.10E-05	NO DATA	3.59E-05	1.22E-05	1.30E-06
CS 136	4.88E-06	1.83E-05	1.38E-05	NO DATA	1.07E-05	1.50E-06	1.46E-06
CS 137	5.98E-05	7.76E-05	5.35E-05	NO DATA	2.78E-05	9.40E-06	1.05E-06
BA 140	4.88E-06	6.13E-09	3.21E-07	NO DATA	2.09E-09	1.59E-04	2.73E-05
CE 141	2.49E-06	1.69E-06	1.91E-07	NO DATA	7.83E-07	4.52E-05	1.50E-05
CE 144	4.29E-04	1.79E-04	2.30E-05	NO DATA	1.06E-04	9.72E-04	1.02E-04

*Table taken from NUREG-0597

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
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
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
ZN 65	4.82E-06	1.67E-05	7.80E-06	NO DATA	1.08E-05	1.55E-04	5.83E-06
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
ZR 95	1.82E-05	5.73E-06	3.94E-06	NO DATA	8.42E-06	3.36E-04	1.86E-05
SB 124	5.38E-06	9.92E-08	2.10E-06	1.22E-08	NO DATA	4.81E-04	4.98E-05
I 131	4.43E-06	6.14E-06	3.30E-06	1.83E-03	1.05E-05	NO DATA	8.11E-07
I 133	1.52E-06	2.56E-06	7.78E-07	3.65E-04	4.49E-06	NO DATA	1.29E-06
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
BA 140	6.84E-06	8.38E-09	4.40E-07	NO DATA	2.85E-09	2.54E-09	2.86E-05
CE 141	3.55E-06	2.37E-06	2.71E-07	NO DATA	1.11E-06	7.67E-05	1.58E-05
CE 144	6.11E-04	2.53E-04	3.28E-05	NO DATA	1.51E-04	1.67E-03	1.08E-04

*Table taken from NUREG-0597

TABLE 3.1-8*
(1 of 1)
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
CR 51	NO DATA	NO DATA	4.17E-08	2.31E-08	6.57E-09	4.59E-09	2.93E-07
MN 54	NO DATA	1.16E-05	2.57E-06	NO DATA	2.71E-06	4.26E-04	6.19E-06
FE 55	1.28E-05	6.80E-06	2.10E-06	NO DATA	NO DATA	3.00E-05	7.75E-07
FE 59	5.59E-06	9.04E-06	4.51E-06	NO DATA	NO DATA	3.43E-04	1.91E-05
CO 58	NO DATA	4.79E-07	8.55E-07	NO DATA	NO DATA	2.99E-04	9.29E-06
CO 60	NO DATA	3.55E-06	6.12E-06	NO DATA	NO DATA	1.91E-03	2.60E-05
ZN 65	1.15E-05	3.06E-05	1.90E-05	NO DATA	1.93E-05	2.69E-04	4.41E-06
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
ZR 95	5.13E-05	1.13E-05	1.00E-05	NO DATA	1.16E-05	6.03E-04	1.65E-05
SB 124	1.55E-05	2.00E-07	5.41E-06	3.41E-08	NO DATA	8.76E-04	4.43E-05
I 131	1.30E-05	1.30E-05	7.37E-06	4.39E-03	2.13E-05	NO DATA	7.68E-07
I 133	4.48E-06	5.49E-06	2.08E-06	1.04E-03	9.13E-06	NO DATA	1.48E-06
CS 134	1.76E-04	2.74E-04	6.07E-05	NO DATA	8.93E-05	3.27E-05	1.04E-06
CS 136	1.76E-05	4.62E-05	3.14E-05	NO DATA	2.58E-05	3.93E-06	1.13E-06
CS 137	2.45E-04	2.23E-04	3.47E-05	NO DATA	7.63E-05	2.81E-05	9.78E-07
BA 140	2.00E-05	1.75E-08	1.17E-06	NO DATA	5.71E-09	4.71E-04	2.75E-05
CE 141	1.06E-05	5.28E-06	7.83E-07	NO DATA	2.31E-06	1.47E-04	1.53E-05
CE 144	1.83E-03	5.72E-04	9.77E-05	NO DATA	3.17E-04	3.23E-03	1.05E-04

*Table taken From NUREG-0597.

INHALATION DOSE FACTORS FOR INFANT
(MREM PER PCI INHALED)

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
H 3	NO DATA	4.62E-07	4.62E-07	4.62E-07	4.62E-07	4.62E-07	4.62E-07
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
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
ZN 65	1.38E-05	4.47E-05	2.22E-05	NO DATA	2.32E-05	4.62E-04	3.67E-05
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
ZR 95	8.24E-05	1.99E-05	1.45E-05	NO DATA	2.22E-05	1.25E-03	1.55E-05
SB 124	2.71E-05	3.97E-07	8.56E-06	7.18E-08	NO DATA	1.89E-03	4.22E-05
I 131	2.71E-05	3.17E-05	1.40E-05	1.06E-02	3.70E-05	NO DATA	7.56E-07
I 133	9.46E-06	1.37E-05	4.00E-06	2.54E-03	1.60E-05	NO DATA	1.54E-06
CS 134	2.83E-04	5.02E-04	5.32E-05	NO DATA	1.36E-04	5.69E-05	9.53E-07
CS 136	3.45E-05	9.61E-05	3.78E-05	NO DATA	4.03E-05	8.40E-06	1.02E-06
CS 137	3.92E-04	4.37E-04	3.25E-05	NO DATA	1.23E-04	5.09E-05	9.53E-07
BA 140	4.00E-05	4.00E-08	2.07E-06	NO DATA	9.59E-09	1.14E-03	2.74E-05
CE 141	1.98E-05	1.19E-05	1.42E-06	NO DATA	3.75E-06	3.69E-04	1.54E-05
CE 144	2.28E-03	8.65E-04	1.26E-04	NO DATA	3.84E-04	7.03E-03	1.06E-04

*Table taken from NUREG-0597.

TABLE 3.1-10*
(1 of 2)
EXTERNAL DOSE FACTORS FOR STANDING ON CONTAMINATED GROUND

(mrem/hr per pCi/m^2)

Element	Total Body	Skin
H-3	0.0	0.0
Na-24	2.50E-08	2.90E-08
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 (cont'd)
(2 of 2)

EXTERNAL DOSE FACTORS FOR STANDING ON CONTAMINATED GROUND

(mrem/hr per pCi/m^2)

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

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

Element	F_m(Cow) Milk (d/ℓ)	F_f Meat (d/kg)
H	1.0E-02**	1.2E-02
Na	4.0E-02	3.0E-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**	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)

**Nuclide Transfer parameters for Goat's milk

Element	Fm (d/l)
H	0.17
Fe	1.30E-09
Cu	0.013
Sr	0.014
I	0.06
Cs	0.30

TABLE 3.1-12
(1 of 1)

R_i VALUES - GROUND PATHWAY - ALL AGES

NUCLIDE	T.BODY	SKIN
H 3	NO DATA	NO DATA
CR 51	4.65E+06	5.49E+06
MN 54	1.38E+09	1.62E+09
FE 55	NO DATA	NO DATA
FE 59	2.72E+08	3.20E+08
CO 58	3.79E+08	4.44E+08
CO 60	2.15E+10	2.53E+10
ZN 65	7.44E+08	8.56E+08
SR 89	2.16E+04	2.50E+04
SR 90	NO DATA	NO DATA
ZR 95	2.51E+08	2.91+08
SB 124	5.98E+08	6.91E+08
I 131	8.59E+06	1.04E+07
I 133	1.22E+06	1.49E+06
CS 134	6.82E+09	7.96E+09
CS 136	1.50E+08	1.70E+08
CS 137	1.03E+10	1.20E+10
BA 140	2.05E+07	2.34E+07
CE 141	1.36E+07	1.54E+07
CE 144	6.92E+07	8.01E+07

TABLE 3.1-13
(1 of 1)

R_i VALUES - VEGETABLE PATHWAY - ADULT

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
H 3	0.0	2.28E+03	2.28E+03	2.28E+03	2.28E+03	2.28E+03	2.28E+03
CR 51	0.0	0.0	4.58E+04	2.74E+04	1.01E+04	6.07E+04	1.15E+07
MN 54	0.0	3.07E+08	5.86E+07	0.0	9.14E+07	0.0	9.41E+08
FE 55	1.99E+08	1.38E+08	3.21E+07	0.0	0.0	7.68E+07	7.90E+07
FE 59	1.23E+08	2.90E+08	1.11E+08	0.0	0.0	8.09E+07	9.66E+08
CO 58	0.0	2.99E+07	6.71E+07	0.0	0.0	0.0	6.07E+08
CO 60	0.0	1.66E+08	3.67E+08	0.0	0.0	0.0	3.12E+09
ZN 65	4.00E+08	1.27E+09	5.76E+08	0.0	8.52E+08	0.0	8.02E+08
SR 89	9.75E+09	0.0	2.80E+08	0.0	0.0	0.0	1.56E+09
SR 90	6.70E+11	0.0	1.64E+11	0.0	0.0	0.0	1.94E+10
ZR 95	1.16E+06	3.73E+05	2.52E+05	0.0	5.85E+05	0.0	1.18E+09
SB 124	1.01E+08	1.91E+06	4.01E+07	2.45E+05	0.0	7.88E+07	2.87E+09
I 131	4.03E+07	5.76E+07	3.30E+07	1.89E+10	9.88E+07	0.0	1.52E+07
I 133	1.04E+06	1.80E+06	5.50E+05	2.65E+08	3.15E+06	0.0	1.62E+06
CS 134	4.54E+09	1.08E+10	8.83E+09	0.0	3.49E+09	1.16E+09	1.89E+08
CS 136	4.23E+07	1.67E+08	1.20E+08	0.0	9.30E+07	1.27E+07	1.90E+07
CS 137	6.63E+09	9.07E+09	5.94E+09	0.0	3.08E+09	1.02E+09	1.76E+08
BA 140	1.28E+08	1.61E+05	8.40E+06	0.0	5.47E+04	9.22E+04	2.64E+08
CE 141	1.94E+05	1.31E+05	1.49E+04	0.0	6.09E+04	0.0	5.02E+08
CE 144	3.15E+07	1.31E+07	1.69E+06	0.0	7.80E+06	0.0	1.06E+10

TABLE 3.1-14
(1 of 1)

R_i VALUES - VEGETABLE PATHWAY - TEENAGER

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
H 3	0.0	2.61E+03	2.61E+03	2.61E+03	2.61E+03	2.61E+03	2.61E+03
CR 51	0.0	0.0	6.08E+04	3.38E+04	1.33E+04	8.68E+04	1.02E+07
MN 54	0.0	4.46E+08	8.85E+07	0.0	1.33E+08	0.0	9.15E+08
FE 55	3.10E+08	2.20E+08	5.13E+07	0.0	0.0	1.39E+08	9.51E+07
FE 59	1.75E+08	4.09E+08	1.58E+08	0.0	0.0	1.29E+08	9.68E+08
CO 58	0.0	4.25E+07	9.79E+07	0.0	0.0	0.0	5.86E+08
CO 60	0.0	2.47E+08	5.57E+08	0.0	0.0	0.0	3.22E+09
ZN 65	5.35E+08	1.86E+09	8.66E+08	0.0	1.19E+09	0.0	7.86E+08
SR 89	1.48E+10	0.0	4.24E+08	0.0	0.0	0.0	1.76E+09
SR 90	8.32E+11	0.0	2.05E+11	0.0	0.0	0.0	2.34E+10
ZR 95	1.70E+06	5.38E+05	3.70E+05	0.0	7.90E+05	0.0	1.24E+09
SB 124	1.51E+08	2.78E+06	5.88E+07	3.42E+05	0.0	1.32E+08	3.04E+09
I 131	3.83E+07	5.37E+07	2.88E+07	1.57E+10	9.24E+07	0.0	1.06E+07
I 133	9.63E+05	1.63E+06	4.98E+05	2.28E+08	2.87E+06	0.0	1.24E+06
CS 134	6.90E+09	1.62E+10	7.54E+09	0.0	5.16E+09	1.97E+09	2.02E+08
CS 136	4.33E+07	1.71E+08	1.15E+08	0.0	9.28E+07	1.46E+07	1.37E+07
CS 137	1.06E+10	1.41E+10	4.90E+09	0.0	4.78E+09	1.86E+09	2.00E+08
BA 140	1.38E+08	1.69E+05	8.88E+06	0.0	5.72E+04	1.14E+05	2.12E+08
CE 141	2.78E+05	1.86E+05	2.13E+04	0.0	8.75E+04	0.0	5.32E+08
CE 144	5.04E+07	2.09E+07	2.71E+06	0.0	1.25E+07	0.0	1.27E+10

TABLE 3.1-15
(1 of 1)
R_i VALUES - VEGETABLE PATHWAY - CHILD

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
H 3	0.0	4.04E+03	4.04E+03	4.04E+03	4.04E+03	4.04E+03	4.04E+03
CR 51	0.0	0.0	1.15E+05	6.40E+04	1.75E+04	1.17E+05	6.12E+06
MN 54	0.0	6.53E+08	1.74E+08	0.0	1.83E+08	0.0	5.48E+08
FE 55	7.62E+08	4.04E+08	1.25E+08	0.0	0.0	2.29E+08	7.49E+07
FE 59	3.88E+08	6.29E+08	3.13E+08	0.0	0.0	1.82E+08	6.54E+08
CO 58	0.0	6.27E+07	1.92E+08	0.0	0.0	0.0	3.66E+08
CO 60	0.0	3.76E+08	1.11E+09	0.0	0.0	0.0	2.08E+09
ZN 65	1.02E+09	2.73E+09	1.70E+09	0.0	1.72E+09	0.0	4.80E+08
SR 89	3.52E+10	0.0	1.00E+09	0.0	0.0	0.0	1.36E+09
SR 90	1.38E+12	0.0	3.49E+11	0.0	0.0	0.0	1.86E+10
ZR 95	3.82E+06	8.40E+05	7.48E+05	0.0	1.20E+06	0.0	8.77E+08
SB 124	3.44E+08	4.46E+06	1.20E+08	7.59E+05	0.0	1.91E+08	2.15E+09
I 131	7.13E+07	7.17E+07	4.08E+07	2.37E+10	1.18E+08	0.0	6.39E+06
I 133	1.76E+06	2.17E+06	8.22E+05	4.03E+08	3.62E+06	0.0	8.75E+05
CS 134	1.56E+10	2.56E+10	5.40E+09	0.0	7.93E+09	2.85E+09	1.38E+08
CS 136	8.16E+07	2.24E+08	1.45E+08	0.0	1.19E+08	1.78E+07	7.88E+06
CS 137	2.49E+10	2.39E+10	3.52E+09	0.0	7.78E+09	2.80E+09	1.50E+08
BA 140	2.76E+08	2.42E+05	1.61E+07	0.0	7.87E+04	1.44E+05	1.40E+08
CE 141	6.45E+05	3.22E+05	4.78E+04	0.0	1.41E+05	0.0	4.02E+08
CE 144	1.22E+08	3.81E+07	6.48E+06	0.0	2.11E+07	0.0	9.93E+09

TABLE 3.1-16
(1 of 1)
R_i VALUES - MEAT PATHWAY - ADULT

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
H 3	0.0	3.27E+02	3.27E+02	3.27E+02	3.27E+02	3.27E+02	3.27E+02
CR 51	0.0	0.0	5.86E+03	3.50E+03	1.29E+03	7.77E+03	1.47E+06
MN 54	0.0	6.83E+06	1.30E+06	0.0	2.03E+06	0.0	2.09E+07
FE 55	2.13E+08	1.47E+08	3.43E+07	0.0	0.0	8.20E+07	8.44E+07
FE 59	2.12E+08	4.99E+08	1.91E+08	0.0	0.0	1.39E+08	1.66E+09
CO 58	0.0	1.41E+07	3.17E+07	0.0	0.0	0.0	2.87E+08
CO 60	0.0	5.56E+07	1.23E+08	0.0	0.0	0.0	1.04E+09
ZN 65	3.01E+08	9.57E+08	4.32E+08	0.0	6.40E+08	0.0	6.03E+08
SR 89	2.39E+08	0.0	6.86E+06	0.0	0.0	0.0	3.83E+07
SR 90	9.67E+09	0.0	2.37E+09	0.0	0.0	0.0	2.79E+08
ZR 95	1.47E+06	4.72E+05	3.20E+05	0.0	7.41E+05	0.0	1.50E+09
SB 124	1.55E+07	2.93E+05	6.15E+06	3.76E+04	0.0	1.21E+07	4.40E+08
I 131	4.92E+06	7.03E+06	4.03E+06	2.30E+09	1.21E+07	0.0	1.86E+06
I 133	1.69E-01	2.94E-01	8.97E-02	4.32E+01	5.14E-01	0.0	2.65E-01
CS 134	4.83E+08	1.15E+09	9.39E+08	0.0	3.72E+08	1.23E+08	2.01E+07
CS 136	1.06E+07	4.20E+07	3.03E+07	0.0	2.34E+07	3.21E+06	4.78E+06
CS 137	6.58E+08	9.00E+08	5.89E+08	0.0	3.05E+08	1.02E+08	1.74E+07
BA 140	2.56E+07	3.22E+04	1.68E+06	0.0	1.09E+04	1.84E+04	5.27E+07
CE 141	1.15E+04	7.79E+03	8.84E+02	0.0	3.62E+03	0.0	2.98E+07
CE 144	1.07E+06	4.49E+05	5.76E+04	0.0	2.66E+05	0.0	3.63E+08

TABLE 3.1-17
(1 of 1)
R_i VALUES - MEAT PATHWAY - TEENAGER

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
H 3	0.0	1.95E+02	1.95E+02	1.95E+02	1.95E+02	1.95E+02	1.95E+02
CR 51	0.0	0.0	4.68E+03	2.60E+03	1.03E+03	6.69E+03	7.87E+05
MN 54	0.0	5.21E+06	1.03E+06	0.0	1.55E+06	0.0	1.07E+07
FE 55	1.73E+08	1.23E+08	2.86E+07	0.0	0.0	7.78E+07	5.31E+07
FE 59	1.70E+08	3.96E+08	1.53E+08	0.0	0.0	1.25E+08	9.36E+08
CO 58	0.0	1.09E+07	2.51E+07	0.0	0.0	0.0	1.50E+08
CO 60	0.0	4.31E+07	9.72E+07	0.0	0.0	0.0	5.62E+08
ZN 65	2.11E+08	7.34E+08	3.43E+08	0.0	4.70E+08	0.0	3.11E+08
SR 89	2.02E+08	0.0	5.78E+06	0.0	0.0	0.0	2.40E+07
SR 90	6.26E+09	0.0	1.55E+09	0.0	0.0	0.0	1.76E+08
ZR 95	1.18E+06	3.72E+05	2.56E+05	0.0	5.47E+05	0.0	8.58E+08
SB 124	1.27E+07	2.33E+05	4.94E+06	2.87E+04	0.0	1.11E+07	2.55E+08
I 131	4.09E+06	5.72E+06	3.07E+06	1.67E+09	9.85E+06	0.0	1.13E+06
I 133	1.42E-01	2.40E-01	7.32E-02	3.35E+01	4.21E-01	0.0	1.82E-01
CS 134	3.84E+08	9.04E+08	4.19E+08	0.0	2.87E+08	1.10E+08	1.12E+07
CS 136	8.30E+06	3.27E+07	2.19E+07	0.0	1.78E+07	2.80E+06	2.63E+06
CS 137	5.46E+08	7.27E+08	2.53E+08	0.0	2.47E+08	9.61E+07	1.03E+07
BA 140	2.12E+07	2.59E+04	1.36E+06	0.0	8.79E+03	1.74E+04	3.26E+07
CE 141	9.67E+03	6.46E+03	7.42E+02	0.0	3.04E+03	0.0	1.85E+07
CE 144	9.04E+05	3.74E+05	4.86E+04	0.0	2.24E+05	0.0	2.27E+08

TABLE 3.1-18
(1 of 1)
R_i VALUES - MEAT PATHWAY - CHILD

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
H 3	0.0	2.36E+02	2.36E+02	2.36E+02	2.36E+02	2.36E+02	2.36E+02
CR 51	0.0	0.0	7.31E+03	4.06E+03	1.11E+03	7.40E+03	3.87E+05
MN 54	0.0	5.96E+06	1.59E+06	0.0	1.67E+06	0.0	5.00E+06
FE 55	3.32E+08	1.76E+08	5.45E+07	0.0	0.0	9.95E+07	3.26E+07
FE 59	3.01E+08	4.86E+08	2.42E+08	0.0	0.0	1.41E+08	5.06E+08
CO 58	0.0	1.27E+07	3.90E+07	0.0	0.0	0.0	7.43E+07
CO 60	0.0	5.12E+07	1.51E+08	0.0	0.0	0.0	2.84E+08
ZN 65	3.17E+08	8.45E+08	5.26E+08	0.0	5.33E+08	0.0	1.48E+08
SR 89	3.82E+08	0.0	1.09E+07	0.0	0.0	0.0	1.48E+07
SR 90	8.08E+09	0.0	2.05E+09	0.0	0.0	0.0	1.09E+08
ZR 95	2.09E+06	4.60E+05	4.10E+05	0.0	6.59E+05	0.0	4.80E+08
SB 124	2.29E+07	2.97E+05	8.03E+06	5.06E+04	0.0	1.27E+07	1.43E+08
I 131	7.58E+06	7.62E+06	4.33E+06	2.52E+09	1.25E+07	0.0	6.78E+05
I 133	2.63E-01	3.25E-01	1.23E-01	6.04E+01	5.42E-01	0.0	1.31E-01
CS 134	6.77E+08	1.11E+09	2.34E+08	0.0	3.44E+08	1.24E+08	5.99E+06
CS 136	1.43E+07	3.94E+07	2.55E+07	0.0	2.10E+07	3.13E+06	1.38E+06
CS 137	1.01E+09	9.63E+08	1.42E+08	0.0	3.14E+08	1.13E+08	6.03E+06
BA 140	3.91E+07	3.42E+04	2.28E+06	0.0	1.11E+04	2.04E+04	1.98E+07
CE 141	1.82E+04	9.08E+03	1.35E+03	0.0	3.98E+03	0.0	1.13E+07
CE 144	1.70E+06	5.34E+05	9.10E+04	0.0	2.96E+05	0.0	1.39E+08

R_i VALUES - COW MILK PATHWAY - ADULT

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
H 3	0.0	7.69E+02	7.69E+02	7.69E+02	7.69E+02	7.69E+02	7.69E+02
CR 51	0.0	0.0	2.38E+04	1.42E+04	5.24E+03	3.15E+04	5.98E+06
MN 54	0.0	6.26E+06	1.19E+06	0.0	1.86E+06	0.0	1.92E+07
FE 55	1.82E+07	1.26E+07	2.94E+06	0.0	0.0	7.03E+06	7.22E+06
FE 59	2.37E+07	5.58E+07	2.14E+07	0.0	0.0	1.56E+07	1.86E+08
CO 58	0.0	3.66E+06	8.19E+06	0.0	0.0	0.0	7.41E+07
CO 60	0.0	1.21E+07	2.68E+07	0.0	0.0	0.0	2.28E+08
ZN 65	1.16E+09	3.69E+09	1.67E+09	0.0	2.47E+09	0.0	2.32E+09
SR 89	1.15E+09	0.0	3.30E+07	0.0	0.0	0.0	1.84E+08
SR 90	3.64E+10	0.0	8.93E+09	0.0	0.0	0.0	1.05E+09
ZR 95	7.38E+02	2.37E+02	1.60E+02	0.0	3.71E+02	0.0	7.50E+05
SB 124	2.02E+07	3.81E+05	7.99E+06	4.89E+04	0.0	1.57E+07	5.72E+08
I 131	1.36E+08	1.94E+08	1.11E+08	6.36E+10	3.32E+08	0.0	5.12E+07
I 133	1.80E+06	3.13E+06	9.55E+05	4.61E+08	5.47E+06	0.0	2.82E+06
CS 134	4.15E+09	9.88E+09	8.08E+09	0.0	3.20E+09	1.06E+09	1.73E+08
CS 136	2.33E+08	9.22E+08	6.63E+08	0.0	5.13E+08	7.03E+07	1.05E+08
CS 137	5.57E+09	7.62E+09	4.99E+09	0.0	2.59E+09	8.59E+08	1.47E+08
BA 140	2.39E+07	3.01E+04	1.57E+06	0.0	1.02E+04	1.72E+04	4.93E+07
CE 141	2.38E+04	1.61E+04	1.83E+03	0.0	7.49E+03	0.0	6.17E+07
CE 144	1.58E+06	6.61E+05	8.48E+04	0.0	3.92E+05	0.0	5.34E+08

TABLE 3.1-20
(1 of 1)
R_i VALUES - COW MILK PATHWAY - TEENAGER

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
H 3	0.0	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03
CR 51	0.0	0.0	4.15E+04	2.31E+04	9.10E+03	5.93E+04	6.98E+06
MN 54	0.0	1.04E+07	2.07E+06	0.0	3.11E+06	0.0	2.14E+07
FE 55	3.23E+07	2.29E+07	5.34E+06	0.0	0.0	1.45E+07	9.92E+06
FE 59	4.14E+07	9.67E+07	3.73E+07	0.0	0.0	3.05E+07	2.29E+08
CO 58	0.0	6.15E+06	1.42E+07	0.0	0.0	0.0	8.48E+07
CO 60	0.0	2.06E+07	4.63E+07	0.0	0.0	0.0	2.68E+08
ZN 65	1.78E+09	6.18E+09	2.88E+09	0.0	3.96E+09	0.0	2.62E+09
SR 89	2.12E+09	0.0	6.07E+07	0.0	0.0	0.0	2.53E+08
SR 90	5.14E+10	0.0	1.27E+10	0.0	0.0	0.0	1.44E+09
ZR 95	1.29E+03	4.07E+02	2.80E+02	0.0	5.98E+02	0.0	9.39E+05
SB 124	3.60E+07	6.62E+05	1.40E+07	8.16E+04	0.0	3.14E+07	7.25E+08
I 131	2.46E+08	3.44E+08	1.85E+08	1.01E+11	5.93E+08	0.0	6.81E+07
I 133	3.29E+06	5.58E+06	1.70E+06	7.79E+08	9.79E+06	0.0	4.22E+06
CS 134	7.21E+09	1.70E+10	7.87E+09	0.0	5.39E+09	2.06E+09	2.11E+08
CS 136	3.97E+08	1.56E+09	1.05E+09	0.0	8.51E+08	1.34E+08	1.26E+08
CS 137	1.01E+10	1.34E+10	4.68E+09	0.0	4.57E+09	1.78E+09	1.91E+08
BA 140	4.32E+07	5.30E+04	2.78E+06	0.0	1.80E+04	3.56E+04	6.67E+07
CE 141	4.37E+04	2.92E+04	3.35E+03	0.0	1.37E+04	0.0	8.35E+07
CE 144	2.91E+06	1.20E+06	1.56E+05	0.0	7.19E+05	0.0	7.31E+08

TABLE 3.1-21
(1 of 1)
R_i VALUES - COW MILK PATHWAY - CHILD

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
H 3	0.0	1.58E+03	1.58E+03	1.58E+03	1.58E+03	1.58E+03	1.58E+03
CR 51	0.0	0.0	8.47E+04	4.70E+04	1.28E+04	8.58E+04	4.49E+06
MN 54	0.0	1.56E+07	4.16E+06	0.0	4.38E+06	0.0	1.31E+07
FE 55	8.11E+07	4.30E+07	1.33E+07	0.0	0.0	2.43E+07	7.97E+06
FE 59	9.61E+07	1.55E+08	7.74E+07	0.0	0.0	4.51E+07	1.62E+08
CO 58	0.0	9.40E+06	2.88E+07	0.0	0.0	0.0	5.48E+07
CO 60	0.0	3.19E+07	9.41E+07	0.0	0.0	0.0	1.77E+08
ZN 65	3.49E+09	9.31E+09	5.79E+09	0.0	5.87E+09	0.0	1.63E+09
SR 89	5.25E+09	0.0	1.50E+08	0.0	0.0	0.0	2.03E+08
SR 90	8.69E+10	0.0	2.20E+10	0.0	0.0	0.0	1.17E+09
ZR 95	3.00E+03	6.59E+02	5.86E+02	0.0	9.43E+02	0.0	6.87E+05
SB 124	8.51E+07	1.10E+06	2.98E+07	1.88E+05	0.0	4.72E+07	5.32E+08
I 131	5.97E+08	6.00E+08	3.41E+08	1.98E+11	9.85E+08	0.0	5.34E+07
I 133	8.00E+06	9.89E+06	3.74E+06	1.84E+09	1.65E+07	0.0	3.98E+06
CS 134	1.66E+10	2.73E+10	5.75E+09	0.0	8.45E+09	3.03E+09	1.47E+08
CS 136	8.97E+08	2.47E+09	1.60E+09	0.0	1.31E+09	1.96E+08	8.67E+07
CS 137	2.43E+10	2.33E+10	3.44E+09	0.0	7.59E+09	2.73E+09	1.46E+08
BA 140	1.04E+08	9.14E+04	6.09E+06	0.0	2.98E+04	5.45E+04	5.29E+07
CE 141	1.08E+05	5.37E+04	7.97E+03	0.0	2.35E+04	0.0	6.70E+07
CE 144	7.17E+06	2.25E+06	3.83E+05	0.0	1.24E+06	0.0	5.86E+08

TABLE 3.1-22
(1 of 1)
R_i VALUES - COW MILK PATHWAY - INFANT

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
H 3	0.0	2.40E+03	2.40E+03	2.40E+03	2.40E+03	2.40E+03	2.40E+03
CR 51	0.0	0.0	1.34E+05	8.75E+04	1.91E+04	1.70E+05	3.91E+06
MN 54	0.0	2.90E+07	6.58E+06	0.0	6.43E+06	0.0	1.07E+07
FE 55	9.81E+07	6.34E+07	1.69E+07	0.0	0.0	3.[illegible]0E+07	8.04E+06
FE 59	1.79E+08	3.13E+08	1.23E+08	0.0	0.0	9.26E+07	1.50E+08
CO 58	0.0	1.88E+07	4.69E+07	0.0	0.0	0.0	4.69E+07
CO 60	0.0	6.52E+07	1.54E+08	0.0	0.0	0.0	1.55E+08
ZN 65	4.69E+09	1.61E+10	7.42E+09	0.0	7.80E+09	0.0	1.36E+10
SR 89	9.98E+09	0.0	2.86E+08	0.0	0.0	0.0	2.05E+08
SR 90	9.45E+10	0.0	2.41E+10	0.0	0.0	0.0	1.18E+09
ZR 95	5.32E+03	1.30E+03	9.20E+02	0.0	1.40E+03	0.0	6.46E+05
SB 124	1.64E+08	2.41E+06	5.08E+07	4.35E+05	0.0	1.03E+08	5.06E+08
I 131	1.25E+09	1.47E+09	6.45E+08	4.82E+11	1.71E+09	0.0	5.24E+07
I 133	1.69E+07	2.46E+07	7.20E+06	4.47E+09	2.89E+07	0.0	4.16E+06
CS 134	2.68E+10	4.99E+10	5.04E+09	0.0	1.29E+10	5.27E+09	1.36E+08
CS 136	1.75E+09	5.15E+09	1.92E+09	0.0	2.05E+09	4.20E+08	7.83E+07
CS 137	3.88E+10	4.54E+10	3.22E+09	0.0	1.22E+10	4.94E+09	1.42E+08
BA 140	2.15E+08	2.15E+05	1.11E+07	0.0	5.10E+04	1.32E+05	5.27E+07
CE 141	2.13E+05	1.30E+05	1.53E+04	0.0	4.01E+04	0.0	6.73E+07
CE 144	1.03E+07	4.21E+06	5.76E+05	0.0	1.70E+06	0.0	5.89E+08

TABLE 3.1-23
(1 of 1)
R_i VALUES - GOAT MILK PATHWAY - ADULT

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
H 3	0.0	1.57E+03	1.57E+03	1.57E+03	1.57E+03	1.57E+03	1.57E+03
CR 51	0.0	0.0	2.85E+03	1.71E+03	6.28E+02	3.79E+03	7.17E+05
MN 54	0.0	7.51E+05	1.43E+05	0.0	2.24E+05	0.0	2.30E+06
FE 55	2.37E+06	1.64E+06	3.82E+05	0.0	0.0	9.13E+05	9.39E+05
FE 59	3.09E+06	7.25E+06	2.78E+06	0.0	0.0	2.03E+06	2.42E+07
CO 58	0.0	4.39E+05	9.83E+05	0.0	0.0	0.0	8.89E+06
CO 60	0.0	1.46E+06	3.21E+06	0.0	0.0	0.0	2.73E+07
ZN 65	1.39E+08	4.43E+08	2.00E+08	0.0	2.96E+08	0.0	2.79E+08
SR 89	2.42E+09	0.0	6.93E+07	0.0	0.0	0.0	3.87E+08
SR 90	7.64E+10	0.0	1.87E+10	0.0	0.0	0.0	2.21E+09
ZR 95	8.85E+01	2.84E+01	1.92E+01	0.0	4.46E+01	0.0	9.00E+04
SB 124	2.42E+06	4.57E+04	9.59E+05	5.87E+03	0.0	1.88E+06	6.87E+07
I 131	1.63E+08	2.33E+08	1.33E+08	7.63E+10	3.99E+08	0.0	6.14E+07
I 133	2.16E+06	3.76E+06	1.15E+06	5.53E+08	6.56E+06	0.0	3.38E+06
CS 134	1.25E+10	2.96E+10	2.42E+10	0.0	9.59E+09	3.18E+09	5.19E+08
CS 136	7.00E+08	2.76E+09	1.99E+09	0.0	1.54E+09	2.11E+08	3.14E+08
CS 137	1.67E+10	2.28E+10	1.50E+10	0.0	7.76E+09	2.58E+09	4.42E+08
BA 140	2.87E+06	3.61E+03	1.88E+05	0.0	1.23E+03	2.07E+03	5.92E+06
CE 141	2.86E+03	1.94E+03	2.20E+02	0.0	8.99E+02	0.0	7.40E+06
CE 144	1.90E+05	7.93E+04	1.02E+04	0.0	4.70E+04	0.0	6.41E+07

TABLE 3.1-24
(1 of 1)
R_i VALUES - GOAT MILK PATHWAY - TEENAGER

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
H 3	0.0	204E+03	2.04E+03	2.04E+03	2.04E+03	2.04E+03	2.04E+03
CR 51	0.0	0.0	4.98E+03	2.77E+03	1.09E+03	7.11E+03	8.37E+05
MN 54	0.0	1.25E+06	2.48E+05	0.0	3.73E+05	0.0	2.57E+06
FE 55	4.20E+06	2.98E+06	6.95E+05	0.0	0.0	1.89E+06	1.29E+06
FE 59	5.39E+06	1.26E+07	4.85E+06	0.0	0.0	3.96E+06	2.97E+07
CO 58	0.0	7.39E+05	1.70E+06	0.0	0.0	0.0	1.02E+07
CO 60	0.0	2.47E+06	5.56E+06	0.0	0.0	0.0	3.21E+07
ZN 65	2.14E+08	7.42E+08	3.46E+08	0.0	4.75E+08	0.0	3.14E+08
SR 89	4.45E+09	0.0	1.28E+08	0.0	0.0	0.0	5.30E+08
SR 90	1.08E+11	0.0	2.67E+10	0.0	0.0	0.0	3.03E+09
ZR 95	1.55E+02	4.88E+01	3.36E+01	0.0	7.18E+01	0.0	1.13E+05
SB 124	4.31E+06	7.95E+04	1.68E+06	9.79E+03	0.0	3.77E+06	8.70E+07
I 131	2.95E+08	4.13E+08	2.22E+08	1.21E+11	7.12E+08	0.0	8.18E+07
I 133	3.95E+06	6.70E+06	2.04E+06	9.35E+08	1.17E+07	0.0	5.07E+06
CS 134	2.16E+10	5.09E+10	2.36E+10	0.0	1.62E+10	6.17E+09	6.33E+08
CS 136	1.19E+09	4.69E+09	3.15E+09	0.0	2.55E+09	4.03E+08	3.78E+08
CS 137	3.03E+10	4.03E+10	1.40E+10	0.0	1.37E+10	5.33E+09	5.73E+08
BA 140	5.19E+06	6.35E+03	3.34E+05	0.0	2.15E+03	4.27E+03	8.00E+06
CE 141	5.25E+03	3.50E+03	4.02E+02	0.0	1.65E+03	0.0	1.00E+07
CE 144	3.49E+05	1.44E+05	1.88E+04	0.0	8.62E+04	0.0	8.77E+07

TABLE 3.1-25
(1 of 1)

R_i VALUES - GOAT MILK PATHWAY - CHILD

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
H 3	0.0	3.23E+03	3.23E+03	3.23E+03	3.23E+03	3.23E+03	3.23E+03
CR 51	0.0	0.0	1.02E+04	5.64E+03	1.54E+03	1.03E+04	5.39E+05
MN 54	0.0	1.87E+06	4.99E+05	0.0	5.25E+05	0.0	1.57E+06
FE 55	1.05E+07	5.59E+06	1.73E+06	0.0	0.0	3.16E+06	1.04E+06
FE 59	1.25E+07	2.02E+07	1.01E+07	0.0	0.0	5.86E+06	2.10E+07
CO 58	0.0	1.13E+06	3.45E+06	0.0	0.0	0.0	6.58E+06
CO 60	0.0	3.83E+06	1.13E+07	0.0	0.0	0.0	2.12E+07
ZN 65	4.19E+08	1.12E+09	6.95E+08	0.0	7.04E+08	0.0	1.96E+08
SR 89	1.10E+10	0.0	3.15E+08	0.0	0.0	0.0	4.27E+08
SR 90	1.82E+11	0.0	4.62E+10	0.0	0.0	0.0	2.46E+09
ZR 95	3.60E+02	7.91E+01	7.04E+01	0.0	1.13E+02	0.0	8.25E+04
SB 124	1.02E+07	1.32E+05	3.58E+06	2.25E+04	0.0	5.67E+06	6.38E+07
I 131	7.16E+08	7.20E+08	4.09E+08	2.38E+11	1.18E+09	0.0	6.41E+07
I 133	9.59E+06	1.19E+07	4.49E+06	2.20E+09	1.98E+07	0.0	4.78E+06
CS 134	4.99E+10	8.18E+10	1.73E+10	0.0	2.54E+10	9.10E+09	4.41E+08
CS 136	2.69E+09	7.40E+09	4.79E+09	0.0	3.94E+09	5.88E+08	2.60E+08
CS 137	7.30E+10	6.98E+10	1.03E+10	0.0	2.28E+10	8.19E+09	4.37E+08
BA 140	1.25E+07	1.10E+04	7.31E+05	0.0	3.57E+03	6.54E+03	6.34E+06
CE 141	1.29E+04	6.44E+03	9.57E+02	0.0	2.83E+03	0.0	8.04E+06
CE 144	8.60E+05	2.70E+05	4.59E+04	0.0	1.49E+05	0.0	7.03E+07

TABLE 3.1-26
(1 of 1)
R_i VALUES - GOAT MILK PATHWAY - INFANT

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
H 3	0.0	4.90E+03	4.90E+03	4.90E+03	4.90E+03	4.90E+03	4.90E+03
CR 51	0.0	0.0	1.61E+04	1.05E+04	2.29E+03	2.04E+04	4.69E+05
MN 54	0.0	3.48E+06	7.89E+05	0.0	7.72E+05	0.0	1.28E+06
FE 55	1.27E+07	8.24E+06	2.20E+06	0.0	0.0	4.03E+06	1.05E+06
FE 59	2.33E+07	4.07E+07	1.60E+07	0.0	0.0	1.20E+07	1.95E+07
CO 58	0.0	2.26E+06	5.63E+06	0.0	0.0	0.0	5.62E+06
CO 60	0.0	7.82E+06	1.85E+07	0.0	0.0	0.0	1.86E+07
ZN 65	5.63E+08	1.93E+09	8.91E+08	0.0	9.36E+08	0.0	1.63E+09
SR 89	2.10E+10	0.0	6.01E+08	0.0	0.0	0.0	4.31E+08
SR 90	1.98E+11	0.0	5.05E+10	0.0	0.0	0.0	2.48E+09
ZR 95	6.39E+02	1.56E+02	1.10E+02	0.0	1.68E+02	0.0	7.75E+04
SB 124	1.97E+07	2.90E+05	6.10E+06	5.22E+04	0.0	1.23E+07	6.07E+07
I 131	1.49E+09	1.76E+09	7.74E+08	5.79E+11	2.06E+09	0.0	6.29E+07
I 133	2.03E+07	2.95E+07	8.64E+06	5.36E+09	3.47E+07	0.0	4.99E+06
CS 134	8.03E+10	1.50E+11	1.51E+10	0.0	3.86E+10	1.58E+10	4.07E+08
CS 136	5.26E+09	1.55E+10	5.77E+09	0.0	6.16E+09	1.26E+09	2.35E+08
CS 137	1.16E+11	1.36E+11	9.66E+09	0.0	3.66E+10	1.48E+10	4.26E+08
BA 140	2.58E+07	2.58E+04	1.33E+06	0.0	6.12E+03	1.58E+04	6.33E+06
CE 141	2.56E+04	1.56E+04	1.84E+03	0.0	4.82E+03	0.0	8.07E+06
CE 144	1.23E+06	5.05E+05	6.91E+04	0.0	2.04E+05	0.0	7.07E+07

TABLE 3.1-27
(1 of 1)
R_i VALUES - INHALATION PATHWAY - ADULT

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
H 3	0.0	1.26E+03	1.26E+03	1.26E+03	1.26E+03	1.26E+03	1.26E+03
CR 51	0.0	0.0	9.99E+01	5.94E+01	2.28E+01	5.94E+04	3.32E+03
MN 54	0.0	3.95E+04	6.29E+03	0.0	9.83E+03	1.40E+06	7.72E+04
FE 55	2.45E+04	1.69E+04	3.94E+03	0.0	0.0	7.20E+04	6.02E+03
FE 59	1.17E+04	2.77E+04	1.05E+04	0.0	0.0	1.01E+06	1.88E+05
CO 58	0.0	1.58E+03	2.07E+03	0.0	0.0	9.27E+05	1.06E+05
CO 60	0.0	1.15E+04	1.48E+04	0.0	0.0	5.96E+06	2.84E+05
ZN 65	3.24E+04	1.03E+05	4.65E+04	0.0	6.89E+04	8.63E+05	5.34E+04
SR 89	3.04E+05	0.0	8.71E+03	0.0	0.0	1.40E+06	3.49E+05
SR 90	9.91E+07	0.0	6.09E+06	0.0	0.0	9.59E+06	7.21E+05
ZR 95	1.07E+05	3.44E+04	2.32E+04	0.0	5.41E+04	1.77E+06	1.50E+05
SB 124	3.12E+04	5.88E+02	1.24E+04	7.54E+01	0.0	2.48E+06	4.06E+05
I 131	2.52E+04	3.57E+04	2.05E+04	1.19E+07	6.12E+04	0.0	6.27E+03
I 133	8.63E+03	1.48E+04	4.51E+03	2.15E+06	2.58E+04	0.0	8.87E+03
CS 134	3.72E+05	8.47E+05	7.27E+05	0.0	2.87E+05	9.75E+04	1.04E+04
CS 136	3.90E+04	1.46E+05	1.10E+05	0.0	8.55E+04	1.20E+04	1.17E+04
CS 137	4.78E+05	6.20E+05	4.27E+05	0.0	2.22E+05	7.51E+04	8.39E+03
BA 140	3.90E+04	4.90E+01	2.56E+03	0.0	1.67E+01	1.27E+06	2.18E+05
CE 141	1.99E+04	1.35E+04	1.53E+03	0.0	6.25E+03	3.61E+05	1.20E+05
CE 144	3.43E+06	1.43E+06	1.84E+05	0.0	8.47E+05	7.76E+06	8.15E+05

TABLE 3.1-28
(1 of 1)
R_i VALUES - INHALATION PATHWAY - TEENAGER

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
H 3	0.0	1.27E+03	1.27E+03	1.27E+03	1.27E+03	1.27E+03	1.27E+03
CR 51	0.0	0.0	1.35E+02	7.49E+01	3.07E+01	2.09E+04	3.00E+03
MN 54	0.0	5.10E+04	8.39E+03	0.0	1.27E+04	1.98E+06	6.67E+04
FE 55	3.34E+04	2.38E+04	5.54E+03	0.0	0.0	1.24E+05	6.38E+03
FE 59	1.59E+04	3.69E+04	1.43E+04	0.0	0.0	1.53E+06	1.78E+05
CO 58	0.0	2.07E+03	2.77E+03	0.0	0.0	1.34E+06	9.51E+04
CO 60	0.0	1.51E+04	1.98E+04	0.0	0.0	8.71E+06	2.59E+05
ZN 65	3.85E+04	1.33E+05	6.23E+04	0.0	8.63E+04	1.24E+06	4.66E+04
SR 89	4.34E+05	0.0	1.25E+04	0.0	0.0	2.41E+06	3.71E+05
SR 90	1.08E+08	0.0	6.67E+06	0.0	0.0	1.65E+07	7.64E+05
ZR 95	1.45E+05	4.58E+04	3.15E+04	0.0	6.73E+04	2.68E+06	1.49E+05
SB 124	4.30E+04	7.92E+02	1.68E+04	9.75E+01	0.0	3.84E+06	3.98E+05
I 131	3.54E+04	4.90E+04	2.64E+04	1.46E+07	8.39E+04	0.0	6.48E+03
I 133	1.21E+04	2.05E+04	6.21E+03	2.92E+06	3.59E+04	0.0	1.03F+04
CS 134	5.02E+05	1.13E+06	5.48E+05	0.0	3.75E+05	1.46E+05	9.75E+03
CS 136	5.14E+04	1.93E+05	1.37E+05	0.0	1.10E+05	1.77E+04	1.09E+04
CS 137	6.69E+05	8.47E+05	3.11E+05	0.0	3.04E+05	1.21E+05	8.47E+03
BA 140	5.46E+04	6.69E+01	3.51E+03	0.0	2.28E+01	2.03E+06	2.28E+05
CE 141	2.84E+04	1.89E+04	2.16E+03	0.0	8.87E+03	6.13E+05	1.26E+05
CE 144	4.88E+06	2.02E+06	2.62E+05	0.0	1.21E+06	1.33E+07	8.63E+05

TABLE 3.1-29
(1 of 1)
R_i VALUES - INHALATION PATHWAY - CHILD

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
H 3	0.0	1.12E+03	1.12E+03	1.12E+03	1.12E+03	1.12E+03	1.12E+03
CR 51	0.0	0.0	1.54E+02	8.53E+01	2.43E+01	1.70E+04	1.08E+03
MN 54	0.0	4.29E+04	9.50E+03	0.0	1.00E+04	1.57E+06	2.29E+04
FE 55	4.73E+04	2.51E+04	7.76E+03	0.0	0.0	1.11E+05	2.86E+03
FE 59	2.07E+04	3.34E+04	1.67E+04	0.0	0.0	1.27E+06	7.06E+04
CO 58	0.0	1.77E+03	3.16E+03	0.0	0.0	1.10E+06	3.43E+04
CO 60	0.0	1.31E+04	2.26E+04	0.0	0.0	7.06E+06	9.61E+04
ZN 65	4.25E+04	1.13E+05	7.02E+04	0.0	7.13E+04	9.94E+05	1.63E+04
SR 89	5.99E+05	0.0	1.72E+04	0.0	0.0	2.15E+06	1.67E+05
SR 90	1.01E+08	0.0	6.43E+06	0.0	0.0	1.47E+07	3.43E+05
ZR 95	1.90E+05	4.17E+04	3.69E+04	0.0	5.95E+04	2.23E+06	6.10E+04
SB 124	5.73E+04	7.39E+02	2.00E+04	1.26E+02	0.0	3.24E+06	1.64E+05
I 131	4.80E+04	4.80E+04	2.72E+04	1.62E+07	7.87E+04	0.0	2.84E+03
I 133	1.66E+04	2.03E+04	7.68E+03	3.84E+06	3.37E+04	0.0	5.47E+03
CS 134	6.50E+05	1.01E+06	2.24E+05	0.0	3.30E+05	1.21E+05	3.84E+03
CS 136	6.50E+04	1.71E+05	1.16E+05	0.0	9.53E+04	1.45E+04	4.17E+03
CS 137	9.05E+05	8.24E+05	1.28E+05	0.0	2.82E+05	1.04E+05	3.61E+03
BA 140	7.39E+04	6.47E+01	4.32E+03	0.0	2.11E+01	1.74E+06	1.02E+05
CE 141	3.92E+04	1.95E+04	2.89E+03	0.0	8.53E+03	5.43E+05	5.65E+04
CE 144	6.76E+06	2.11E+06	3.61E+05	0.0	1.17E+06	1.19E+07	3.88E+05

TABLE 3.1-30
(1 of 1)
R_i VALUES - INHALATION PATHWAY - INFANT

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
H 3	0.0	6.46E+02	6.46E+02	6.46E+02	6.46E+02	6.46E+02	6.46E+02
CR 51	0.0	0.0	8.93E+01	5.75E+01	1.32E+01	1.28E+04	3.56E+02
MN 54	0.0	2.53E+04	4.98E+03	0.0	4.98E+03	9.98E+05	7.05E+03
FE 55	1.97E+04	1.17E+04	3.33E+03	0.0	0.0	8.68E+04	1.09E+03
FE 59	1.35E+04	2.35E+04	9.46E+03	0.0	0.0	1.01E+06	2.47E+04
CO 58	0.0	1.22E+03	1.82E+03	0.0	0.0	7.76E+05	1.11E+04
CO 60	0.0	8.01E+03	1.18E+04	0.0	0.0	4.50E+06	3.19E+04
ZN 65	1.93E+04	6.25E+04	3.10E+04	0.0	3.24E+04	6.46E+05	5.13E+04
SR 89	3.97E+05	0.0	1.14E+04	0.0	0.0	2.03E+06	6.39E+04
SR 90	4.08E+07	0.0	2.59E+06	0.0	0.0	1.12E+07	1.31E+05
ZR 95	1.15E+05	2.78E+04	2.03E+04	0.0	3.10E+04	1.75E+06	2.17E+04
SB 124	3.79E+04	5.55E+02	1.20E+04	1.00E+02	0.0	2.64E+06	5.90E+04
I 131	3.79E+04	4.43E+04	1.96E+04	1.48E+07	5.17E+04	0.0	1.06E+03
I 133	1.32E+04	1.92E+04	5.59E+03	3.55E+06	2.24E+04	0.0	2.15E+03
CS 134	3.96E+05	7.02E+05	7.44E+04	0.0	1.90E+05	7.95E+04	1.33E+03
CS 136	4.82E+04	1.34E+05	5.28E+04	0.0	5.63E+04	1.17E+04	1.43E+03
CS 137	5.48E+05	6.11E+05	4.54E+04	0.0	1.72E+05	7.12E+04	1.33E+03
BA 140	5.59E+04	5.59E+01	2.89E+03	0.0	1.34E+01	1.59E+06	3.83E+04
CE 141	2.77E+04	1.66E+04	1.99E+03	0.0	5.24E+03	5.16E+05	2.15E+04
CE 144	3.19E+06	1.21E+06	1.76E+05	0.0	5.37E+05	9.83E+06	1.48E+05

APPENDIX C

CATAWBA NUCLEAR STATION

SITE SPECIFIC INFORMATION

APPENDIX C - TABLE OF CONTENTS

C1.0 CATAWBA NUCLEAR STATION RADWASTE SYSTEMS

C1.1 LIQUID RADWASTE PROCESSING

The liquid radwaste system at Catawba Nuclear Station (CNS) is used to collect and treat fluid chemical and radiochemical by-products of unit operation. The system produces effluents which can be reused in the plant or discharged in small, dilute quantities to the environment. The means of treatment vary with waste type and desired product in the various systems:

A) Filtration - All waste sources are filtered during processing. In some cases, such as the Floor Drain Tank (FDT) Subsystem of the Liquid Waste (WL) System, filtration may be the only treatment required.

B) Adsorption - Adsorption of halides and organic chemicals by activated charcoal (Carbon Filter) is used primarily in treating waste in the Laundry and Hot Shower Tank (LHST) Subsystem of the WL System. FDT waste may also be treated by this method.

C) Ion Exchange - Ion exchange is used to remove radioactive cations from solution, as in the case of either LHST or FDT waste in the WL System after removal of organics by carbon filtration (adsorption). Ion exchange is also used in removing both cations (cobalt, manganese) and anions (chloride, fluoride) from evaporator distillates in order to purify the distillates for reuse as makeup water. Distillate from the Waste Evaporator in the WL System and the Boron Recycle Evaporator in the Boron Recycle System (NB) can be treated by this method, as well as FDT, LHST waste, and letdown.

D) Gas Stripping - Removal of gaseous radioactive fission products is accomplished in both the WL Evaporator and the NB Evaporator.

E) Distillation - Production of pure water from the waste by boiling it away from the contaminated solution which originally contained it is accomplished by both evaporators. Proper control of the process will yield water which can be reused for makeup. Polishing of this product can be achieved by ion exchange as pointed out above.

F) Concentration - In both the WL and NB Evaporators, dissolved chemicals are concentrated in the lower shell as water is boiled away. In the case of the WL Evaporator, the volume of water containing waste chemicals and radioactive cations is reduced so that the waste may be more easily and cheaply solidified and shipped for burial. In the NB Evaporator, the dilute boron is concentrated to 4% so that it may be reused for makeup to the reactor coolant system.

Figure C1.0-1 is a schematic representation of the liquid radwaste system at Catawba.

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Table C1.0-1

ABBREVIATIONS

Systems:

CM - Condensate System

KC - Component Cooling

NB - Boron Recycle

RL - Low Pressure Service Water

RN - Nuclear Service Water System

WC - Conventional Waste Water Treatment

WL - Liquid Waste Recycle

WP - Turbine Building Sump

WS - Nuclear Solid Waste Disposal

Tanks:

BA - Boric Acid Tank

FDT - Floor Drain Tank

LHST - Laundry and Hot Shower Tank

MST - Mixing and Settling Tank

NCDT - Reactor Coolant Drain Tank

RHT - Recycle Holdup Tank

RMT - Recycle Monitor Tank

RMWST - Reactor Makeup Water Storage Tank

SGDT - Steam Generator Drain Tank

VUCDT - Ventilation Unit Condensate Drain Tank

WDT - Waste Drain Tank

WEFT - Waste Evaporator Feed Tank

WMT - Waste Monitor Tank

C1.2 GASEOUS RADWASTE SYSTEMS

The gaseous waste disposal system for Catawba 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. C1.0-2 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 limit 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.

C1.2.1 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.

C1.2.2 Containment and Auxiliary Building Ventilation

Nonrecyclable reactor coolant leakage occurring either inside the containment or inside the auxiliary building will generate gaseous activity. Gases resulting from leakage inside the containment will be contained until the containment air is released through the VQ or VP system. The containment atmosphere will be discharged through a charcoal adsorber and a particulate filter prior to release to the atmosphere.

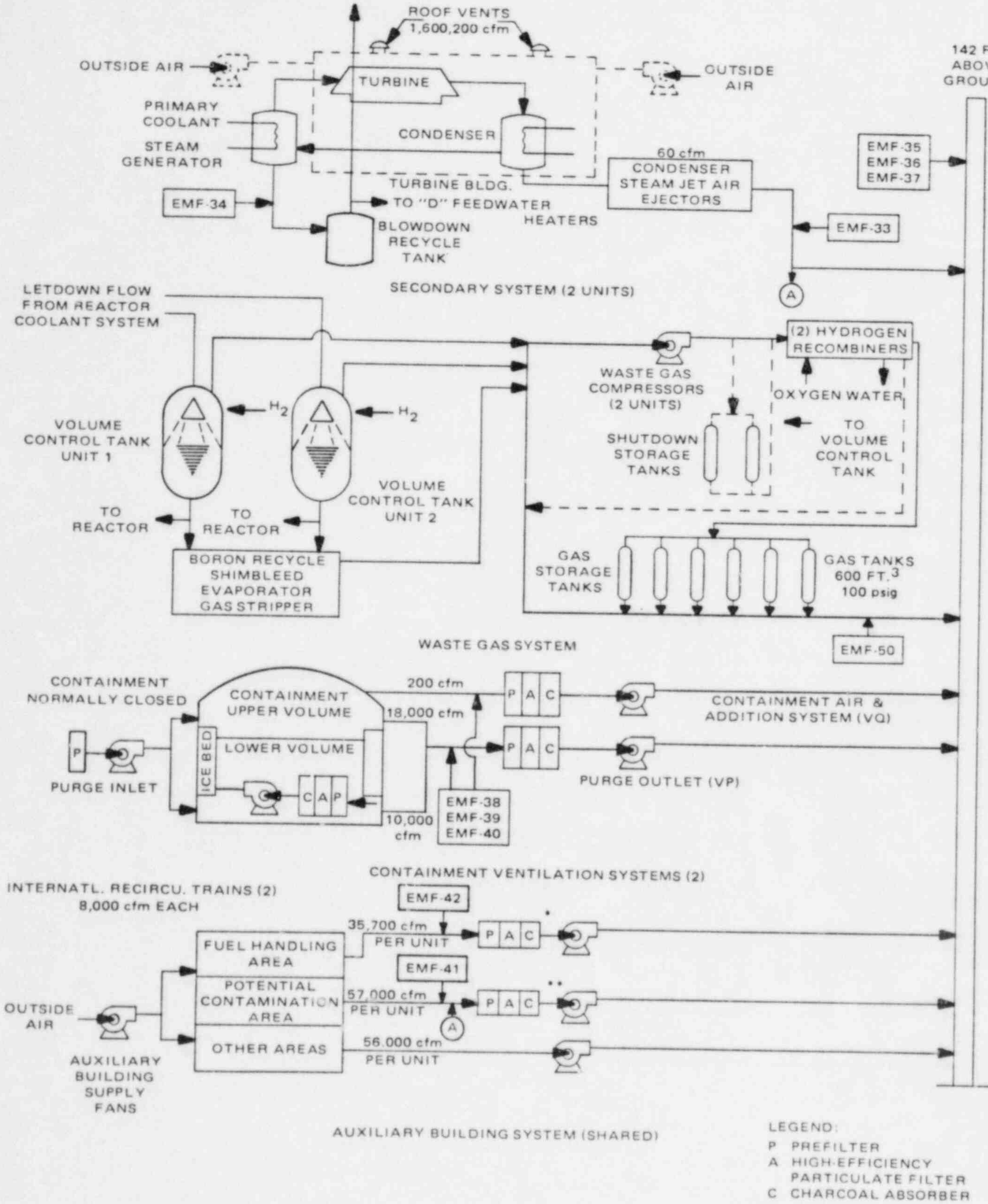
Gases resulting from leakage inside the auxiliary building are released, without further decay, to the atmosphere via the auxiliary building ventilation system. The ventilation exhaust from potentially contaminated areas in the auxiliary building is normally unfiltered. However, on a radiation monitor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

C1.2.3 Secondary Systems

Normally, condensate flow and steam generator blowdown will go parallel through 4 of the 5 condensate polishing demineralizers to remove activity and harmful ions from the water. Noncondensable gases will be taken from the

secondary system by the condenser steam air ejector and are passed through a radiation monitor to the unit vent.

Figure C1.0-2 is a schematic representation of the gaseous radwaste system at Catawba.



* FUEL HANDLING AREA IS NORMALLY UNFILTERED. UPON A RADIATION ALARM BY EMF-42, THE EXHAUST WILL BE DIVERTED TO THE FILTERED MODE.

** POTENTIALLY CONTAIMINATED AREAS OF THE AUXILIARY BUILDING ARE NORMALLY UNFILTERED. UPON A RADIATION ALARM BY EMF-41, THE EXHAUST WILL BE DIVERTED TO THE FILTERED MODE.

FIGURE C1.0-2
CATAWBA NUCLEAR STATION
GASEOUS RADWASTE SYSTEM

C2.0 RELEASE RATE CALCULATION

Generic release rate calculations are presented in Section 1.0; these calculations will be used to calculate release rates for Catawba Nuclear Station. Catawba Nuclear Station will operate as a single unit until the second unit is completed and licensed. As a single unit, releases shall be administratively controlled to assure that release rate calculations limit releases as stated in the Technical Specifications.

C2.1 LIQUID RELEASE RATE CALCULATIONS

There are two potential release points at Catawba. They are as follows:

1. Liquid Waste Effluent Discharge Line
2. Conventional Waste Water Treatment System Effluent Line

C2.1.1 Liquid Waste Effluent Discharge Line

There are three low-pressure service water pumps with a minimum flow rate of 16,500 gpm each and four nuclear service water pumps with a minimum flow rate of 9,000 gpm each which provide the required dilution water needed for a release. The LPSW system flow rate monitor has a variable setpoint which terminates the release by closing the isolation valve, 1 WL124 should the dilution flow fall below the setpoint. The following equation shall be used to calculate a discharge flow, in gpm.

$$f \leq F_{RL} \div \sigma \left[\sum_{i=1}^{n} \frac{C_i}{MPC_i} \right]$$

where:

f = the undiluted effluent flow, in gpm.

F_{RL} = actual low pressure service water flowrate, in gpm, from the sum of the flowrate monitors located in the Control Room.

σ = the recirculation factor at equilibrim (dimensionless), 1.027.

$$\sigma = 1 + \frac{Q_R}{Q_H} = 1 + \frac{120 \text{ cfs}}{4400 \text{ cfs}} = 1.027$$

where:

Q_R = average dilution flow (120 cfs)

Q_H = average flow past Wylie Dam (4400 cfs)

C_i = the concentration of radionuclide, i, in undiluted effluent as determined by laboratory analyses, in µCi/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 = 2.0E-04 µCi/ml.

C2.1.2 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. The water sources listed below that are normally discharged via the conventional waste water treatment system and/or the Turbine Building Sump will be diverted if they become radioactive.

a. Containment Ventilation Unit Condensate Effluent Line

Normally the containment ventilation unit condensate effluent line would discharge into the Turbine Building sump, but if radiation is detected above background, the discharge will be terminated and an alarm actuated. The containment ventilation unit condensate tank will then be recirculated, sampled and then discharged through the liquid waste effluent line and monitored or processed thru the WL system.

b. Auxiliary Feedwater Sump Pumps and Floor Drain Sump Pump Line

Normally the discharge line coming from these sumps will discharge into the Turbine Building sump, but if radiation is detected above background, the discharge flow will automatically be routed to the floor drain tank for processing and later be discharged through the liquid waste effluent line.

c. Turbine Building Sump Discharge Line

Normally the discharge from the Turbine Building sump will go into the conventional waste water treatment system, but if radiation is detected above background, the sump pumps A, B, and C will stop and an alarm actuated. The Turbine Building sump discharge line can either be routed to the floor drain tank for processing or routed directly to the liquid waste effluent discharge line.

d. Steam Generator Blowdown Line

Normally the discharge from the Steam Generator Blowdown will be pumped to the Turbine Building Sump, but if radiation is detected above background, each blowdown flow control valve, the atmospheric vent, and the valve to the Turbine Building Sump will close, thus terminating the discharge. Blowdown can only be continued by venting the steam to "D" heater and pumping the liquid to the condensate system.

C2.2 GASEOUS RELEASE RATE CALCULATIONS

The unit vent is the release point for waste gas decay tanks, containment air releases, 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/or 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 C.3.0 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 C2.2.1 and C2.2.2 shall control the release rate for a single release point.

C2.2.1 Noble Gases

$$\sum_i K_i \; [(\overline{X/Q})\tilde{Q}_i] < 500 \text{ mrem/yr, and}$$

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

where the terms are defined below.

C2.2.2 Radioiodines, Particulates, and Other Radionuclides With T 1/2 $>$ 8 Days

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

where:

K_i = The total body dose factor due to gamma emissions for each identified noble gas radionuclide, in mrem/yr per $\mu Ci/m^3$ 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 $\mu Ci/m^3$ 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 $\mu Ci/m^3$ 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 $\mu Ci/m^3$ and for the food and ground plane pathways in $m^2 \cdot$(mrem/yr) per μCi/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 μCi/sec.

$(\overline{X/Q})$ = 3.10E-05 sec/m^3. The highest calculated annual average relative concentration for any area at or beyond the unrestricted area boundary. The location is the NNE sector @ 0.5 miles.

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

W = 3.1E-05 sec/m^3, for the inhalation pathway. The location is the unrestricted area in the NNE sector @ 0.5 miles.

W = 1.1E-07 meter^{-2}, for the food and ground plane pathways. The location is the unrestricted area boundary in the NE/NNE sector @ 0.5 miles (nearest residence, and vegetable garden).

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

where:

C_i = the concentration of radionuclide, i, in undiluted gaseous effluent, in μCi/ml.

f = the undiluted effluent flow, in cfm

k_1 = conversion factor, 2.83E4 ml/ft^3

k_2 = conversion factor, 6E1 sec/min

C3.0 RADIATION MONITOR SETPOINTS

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

All radiation monitors for Catawba are off-line except EMF-50 (Waste Gas System) which is in-line. These monitors alarm on low flow; the minimum flow alarm level for both the liquid monitors and the gas monitors is based on the manufacturer's recommendations. These monitors measure the activity in the liquid or gas volume exposed to the detector and are independent of flow rate if a minimum flow rate is assured.

Radiation monitoring setpoints calculated in the following sections are expressed in activity concentrations; in reality the monitor readout is in counts per minute. The relationship between concentration and counts per minute is established by a station procedure using the following relationship:

$$c = \frac{r}{2.22 \times 10^6 e\ V}$$

where:

c = the gross activity, in μCi/ml
r = the count rate, in cpm
2.22×10^6 = the disintegration per minute per μCi
e = the counting efficiency, cpm/dpm
V = the volume of fluid exposed to the detector, in ml.

For those occurrences when simultaneous releases of radioactive material must be made, monitor setpoints will be adjusted downward in accordance with Station Procedures to insure that instantaneous concentrations will not be exceeded.

C3.1 LIQUID RADIATION MONITORS

C3.1.1 Waste Liquid Effluent Line

As described in Section C2.1.1 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 used to calculate the release rate. A typical radiation monitor setpoint may be calculated as follows:

$$c \leq \frac{MPC \times F}{\sigma f} \leq 2.48E\text{-}05\ \mu Ci/ml$$

where:

c = the gross activity in undiluted effluent, in μCi/ml

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

MPC = 1.0E-07 μCi/ml, the MPC for an unidentified mixture

σ = 1.027 (See Section C2.1.1)

F = the dilution flow may vary as described in section C2.1.1, but is conservatively estimated at 25,500 gpm, the minimum flow available.

C3.1.2 Containment Ventilation Unit Condensate Effluent Line - EMF 44

As described in Section C2.1.2 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. Since the tank contents are discharged automatically, the radiation monitor setpoint will be set at 1.0E-06 μCi/ml (the monitor's lowest level of detection) plus background to assure that release limits are not exceeded.

C3.1.3 Auxiliary Feedwater Sump Pumps and Floor Drain Sump Pump - EMF 52

As described in Section C2.1.2 on release rate calculations for the auxiliary feedwater sump pumps and floor drain sump pump effluents, 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. Since the sumps are discharged automatically, the radiation monitor setpoint will be set at 1.0E-06 μCi/ml (the monitor's lowest level of detection) plus background to assure that release limits are not exceeded.

C3.1.4 Turbine Building Sump Discharge Line - EMF 31

As described in Section C2.1.2 on release rate calculations for the turbine building sumps, 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. Since the sump contents are discharged automatically, the radiation monitor setpoint will be set at 1.0E-06 μCi/ml (the monitor's lowest level of detection) plus background to assure that release limits are not exceeded.

C3.1.5 Steam Generator Blowdown Line - EMF 34

As described in Section C2.1.2 on Release Rate Calculations for the Steam Generator Blowdown, 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. Since the Steam Generator Blowdown line is discharged automatically, the radiation monitor setpoint will be set at 1.0E-06 μCi/ml (the monitor's lowest level of detection) plus background to assure that release limits are not exceeded.

C3.2 GAS MONITORS

The following equation shall be used to calculate noble gas radiation monitor setpoints based on Xe-133 (Historical data shows that Xe-133 is most predominant isotope):

$$K(\overline{X/Q})\tilde{Q}_i < 500 \qquad \text{(see Section C2.2.1)}$$

$$\tilde{Q}_i = 4.72E{+}02\ C_i f \quad \text{(see Section C2.2.2)}$$

$$C_i < 1.16/f$$

where:

C_i = the gross activity in undiluted effluent, in μCi/ml

f = the flow from the tank or building sources, in cfm

K = from Table 1.2-1 for Xe-133, 2.94E+2 mrem/yr per $\mu Ci/m^3$

$\overline{X/Q}$ = 3.1E-05, as defined in Section C.2.2.2

As stated in Section C2.2, the unit vent is the release point for the containment purge ventilation system, the containment air release and addition system, the condenser air ejector, and auxiliary building ventilation.

For releases from the containment purge ventilation system, a typical radiation monitor setpoint may be calculated as follows:

$$C_i < 1.16/f = 6.5E{-}06$$

where:

f = 151,000 cfm (auxiliary building ventilation) + 28,000 cfm (containment purge) = 179,000 cfm

For release from the containment air release and addition system, the waste gas decay tanks, the condenser air ejectors, and the auxiliary building ventilation, a typical radiation monitor setpoint may be calculated as follows:

$$C_i < 1.16/f = 7.7E{-}06$$

where:

f = 151,000 cfm (auxiliary building ventilation)

C4.0 DOSE CALCULATIONS

C4.1 FREQUENCY OF CALCULATIONS

Dose contributions to the maximum exposed individual shall be calculated every 31 days, 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 shall be performed using simplified estimates. Fuel cycle dose calculations shall be performed annually or as required by special reports. Dose contributions may be calculated using the methodology in the appropriate generic information sections.

C4.2 DOSE MODELS FOR MAXIMUM EXPOSED INDIVIDUAL

C4.2.1 Liquid Effluents

For dose contributions from liquid radioactive releases, one of the two following cases will apply:

1. If the radionuclides Co-58 and/or Co-60 have been detected and Cs-134 and/or Cs-137 have not been detected (i.e., plants without any fuel failure) dose calculations will be based upon an adult who consumed fish caught in the discharge canal and who drank water from the nearest "downstream" potable water intake. The dose from these two radionuclides has been calculated to be 13% of that individual's total body dose.

2. If the radionuclides Cs-134 and/or Cs-137 have been detected, dose calculations indicate that the maximum exposed individual would be an adult who consumed fish caught in the discharge canal and who drank water from the nearest "downstream" potable water intake. The dose from these two radionuclides has been calculated to be 90% of that individual's total body dose.

C4.2.2 Gaseous Effluents

C4.2.2.1 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.

C4.2.2.2 Radioiodines, Particulates, and Other Radionuclides T 1/2 > 8 days

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.

C4.3 SIMPLIFIED DOSE ESTIMATE

C4.3.1 Liquid Effluents

For dose estimates, two simplified calculations using the assumptions presented in Section C4.2.1 and source terms presented in the FSAR are presented. Once operational source term data is available, this information shall be used to revise these calculations, if necessary.

Case 1 - No Cs-134 or Cs-137 present in effluent.

$$D_{WB} = 1.57E{+}03 \sum_{\ell=1}^{m} (F_{\ell})(T_{\ell}) \; (C_{Co-60} + 0.35\, C_{Co-58})$$

where:

$$1.57E{+}03 = 1.14E{+}05 \; (U_{aw}/D_{w} + U_{af}\, BF_{i})\; DF_{ai\tau}\; (7.69)$$

where:

$1.14E{+}05 = 10^{6}$pCi/μCi x 10^{3}ml/kg ÷ 8760 hr/yr

U_{aw} = 730 kg/yr, adult water consumption

D_{w} = 37.7, dilution factor from the near field area to the nearest potable water intake.

where:

$$D_{W} = \frac{\sigma}{Q_R \div Q_H} \quad \text{(See Section C2.1.1)}$$

U_{af} = 21 kg/yr, adult fish consumption

BF_{i} = 5.0E+01, bioaccumulation factor for Cobalt (Table 3.1-1)

$DF_{ai\tau}$ = 1.67E-06, adult, total body, ingestion dose factor for Co-60 (Table 3.1-2)

7.69 = factor derived from assumption that 13% of dose is from Co-58 and Co-60 or 100% ÷ 13% = 7.69

And where:

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

where:

f = liquid radwaste flow, in gpm

σ = recirculation factor at equilibrium, 1.027 (see Section C2.1.1)

F = dilution flow, in gpm

And where:

T_ℓ = The length of time, in hours, over which C_{Co-58}, C_{Co-60}, and F_ℓ are averaged.

C_{Co-58} = the average concentration of Co-58 in undiluted effluent, in μCi/ml, during the time period considered.

C_{Co-60} = the average concentration of Co-60 in undiluted effluent, in μCi/ml, during the time period considered.

0.35 = The ratio of the adult total body ingestion dose factors for Co-58 and Co-60 or 1.67E-06 ÷ 4.72E-06 - Table 3.1-2.

Case 2 - Cs-134 and/or Cs-137 present in effluent.

$$D_{WB} = 6.38E{+}05 \sum_{\ell=1}^{m} (F_\ell)(T_\ell)\ (C_{Cs-134} + 0.59\ C_{Cs-137})$$

where:

$6.38E{+}05 = 1.14E{+}05\ (U_{aw}/D_w + U_{af}\ BF_i)\ DF_{ai\tau}\ (1.10)$

where:

$1.14E{+}05 = 10^6 pCi/\mu Ci \times 10^3 ml/kg \div 8760\ hr/yr$

U_{aw} = 730 kg/yr, adult water consumption

D_w = 37.7, dilution factor from the near field area to the nearest potable water intake.

where:

$D_w = \frac{\sigma}{Q_R \div Q_H}$ (see Section C2.1.1)

U_{af} = 21 kg/yr, adult fish consumption

BF_i = 2.00E+03, bioaccumulation factor for Cesium (Table 3.1-1)

$DF_{ai\tau}$ = 1.21E-04, adult, total body, ingestion dose factor for Cs-134 (Table 3.1-2)

1.10 = factor derived from the assumption that 90% of dose is from Cs-134 and Cs-137 or 100% ÷ 90% = 1.10

And where:

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

where:

f = liquid radwaste flow, in gpm

σ = recirculation factor at equilibrium, 1.027 (see Section C2.1.1)

F = dilution flow, in gpm

And where:

T_ℓ = The length of time, in hours, over which C_{Cs-134}, C_{Cs-137}, and F_ℓ are averaged.

C_{Cs-134} = the average concentration of Cs-134 in undiluted effluent, in µCi/ml, during the time period considered.

C_{Cs-137} = the average concentration of Cs-137 in undiluted effluent, in µCi/ml, during the time period considered.

0.59 = The ratio of the adult total body ingestion dose factors for Cs-134 and Cs-137 or 7.14E-05 ÷ 1.21E-04 = 0.59

C4.3.2 Gaseous Effluents

Meteorological data is provided in Tables C4.0-1 and C4.0-2.

C4.3.2.1 Noble Gases

For dose estimates, simplified dose estimates using the assumptions in C4.2.2.1 and source terms in the FSAR are presented below. Once operational source term data is available, this information shall be used to revise these calculations, if necessary. These calculations further assume that the annual average dispersion parameter is used and that Xenon-133 contributes 45% of the dose.

$$D_\gamma = 3.47E\text{-}10\ [\tilde{Q}]_{Xe-133}\ (2.22)$$

$$D_\beta = 1.03E\text{-}09\ [\tilde{Q}]_{Xe-133}\ (2.22)$$

where:

3.47E-10 = (3.17E-8)(353) ($\overline{X/Q}$), derived from equation presented in Section 3.1.2.1.

1.03E-09 = (3.17E-08) (1050) ($\overline{X/Q}$), derived from equation presented in Section 3.1.2.1.

$\overline{X/Q}$ = 3.1E-05 sec/m^3, as defined in Section C2.2.2

$[\tilde{Q}]_{Xe-133}$ = the total Xenon-133 activity released in µCi

2.22 = factor derived from the conservative assumption (based on historical data) that 45% of the dose is contributed by Xe-133.

C4.3.2.2 Radioiodines, Particulates, and Other Radionuclides with $T_{1/2} > 8$ days

For dose estimates, simplified dose estimates using the assumptions in C4.2.2.2 and source terms in the FSAR are presented below. Once operational source term data is available, this information shall be used to revise these calculations, if necessary. 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:

$$D = 1.84E{+}04 \; w \; (\tilde{Q})_{I-131} \; (1.05)$$

where:

$w = 7.3E{-}10 = \overline{D/Q}$ for food and ground plane pathway, in m^{-2} from Table C4.0-2 for location of nearest real goat (NW sector at 2.5 miles).

$(\tilde{Q})_{I-131}$ = the total Iodine-131 activity released in µCi.

1.84E+04 = $(3.17E{-}08)(R_i^C\,[\overline{D/Q}])$ with the appropriate substitutions for goat's milk in the grass-cow-milk-pathway factor, $R_i^C\,[\overline{D/Q}]$ for Iodine-131. See Section 3.1.2.2.

1.05 = factor derived from the conservative assumption (based on historical data) that 95% of the dose is contributed by I-131.

C4.3 FUEL CYCLE CALCULATIONS

As discussed in Section 3.3.5, 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. The fuel cycle dose assessments for Catawba Nuclear Station must include dose contributions from McGuire Nuclear Station, which is located upstream approximately thirty miles NNE of Catawba. For this dose assessment, the maximum exposed individual is conservatively assumed to live 5 miles NNE of Catawba and 5 miles SSW of McGuire; this individual eats fish caught in the discharge area at Catawba.

The dose contributions resulting from gaseous effluents are calculated using the methodology in Section 3.1.2:

$$D_f(g) < 0.47\, D_M(g) + 0.55\, D_C(g)$$

Where:

$D_M(g)$ = dose contribution from McGuire calculated using $\overline{X/Q} = 1.5E{-}07$ sec/m³ and $\overline{D/Q} = 3.8E{-}10$ sec/m³. The location is 5 miles SSW of McGuire.

0.47 = fraction of time the wind direction is out of NNE.

$D_c(g)$ = dose contribution from Catawba calculated using $\overline{X/Q}$ = 3.3E-07 sec/m^3 and $\overline{D/Q}$ = 3.5E-10 sec/m^3. The location is 5 miles NNE of Catawba.

0.55 = Fraction of time the wind direction is out of SSW.

Using the methodology above and the assumption that each station releases their maximum Technical Specification dose limit, the gaseous effluent contribution to the fuel cycle calculation is but a small fraction (< 1/100) of the allowable dose. Therefore, fuel cycle calculations will not normally be performed unless either station exceeds their gaseous effluent Technical Specifications by a factor of 10.

The dose contribution resulting from liquid effluents is calculated using the methodology in Section 3.1.1:

$$D_f(\ell) < 0.607 \cdot D_M(\ell) + D_C(\ell)$$

Where:

$$.607 = \frac{\text{2670 cfs (average flow past Cowans Ford Dam)}}{\text{4400 cfs (average flow past Lake Wylie Dam)}} \text{ dilution}$$

$D_m(\ell)$ = Dose contribution from McGuire via liquid effluents

$D_c(\ell)$ = Dose contribution from Catawba via liquid effluents

Using the methodology above and the assumption that each station releases its maximum Technical Specification dose limit, the liquid effluent contribution to the fuel cycle calculation would be 48% of the allowable dose. Therefore, fuel cycle calculations will not normally be preformed unless either station exceeds its liquid effluent Technical Specifications by a factor of 2.

In summary, Technical Specification 3.11.4 will be the deciding criteria for Catawba fuel cycle calculations since it is either equal to (liquid) or is more restrictive than (gaseous) the cases outlined above.

TABLE C4.0-1

(1 of 2)

CATAWBA NUCLEAR STATION

DISPERSION PARAMETER ($\overline{X/Q}$) FOR LONG TERM RELEASES $>$ 500 HR/YR OR $>$ 125 HR/QTR

(sec/m^3)

Sector	Distance to the control location, (miles)									
	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
N	2.6E-5	6.5E-6	2.7E-6	1.5E-6	9.7E-7	6.9E-7	5.2E-7	4.1E-7	3.3E-7	2.8E-7
NNE	3.1E-5	8.1E-6	3.3E-6	1.8E-6	1.2E-6	8.2E-7	6.2E-7	4.9E-7	4.0E-7	3.3E-7
NE	3.0E-5	7.8E-6	3.2E-6	1.8E-6	1.1E-6	8.0E-7	6.0E-7	4.7E-7	3.9E-7	3.2E-7
ENE	1.5E-5	3.9E-6	1.6E-6	8.9E-7	5.7E-7	4.1E-7	3.1E-7	2.4E-7	2.0E-7	1.6E-7
E	1.4E-5	3.7E-6	1.5E-6	8.4E-7	5.4E-7	3.8E-7	2.9E-7	2.3E-7	1.9E-7	1.6E-7
ESE	9.0E-6	2.3E-6	9.5E-7	5.3E-7	3.4E-7	2.4E-7	1.8E-7	1.4E-7	1.2E-7	9.7E-8
SE	9.2E-6	2.4E-6	9.8E-7	5.4E-7	3.5E-7	2.4E-7	1.8E-7	1.4E-7	1.2E-7	9.8E-8
SSE	1.1E-5	2.9E-6	1.2E-6	6.4E-7	4.1E-7	2.9E-7	2.2E-7	1.7E-7	1.4E-7	1.1E-7
S	2.5E-5	6.4E-6	2.6E-6	1.5E-6	9.3E-7	6.6E-7	5.0E-7	3.9E-7	3.2E-7	2.7E-7
SSW	1.7E-5	4.4E-6	1.8E-6	1.0E-6	6.4E-7	4.5E-7	3.4E-7	2.7E-7	2.2E-7	1.8E-7
SW	1.3E-5	3.4E-6	1.4E-6	7.4E-7	4.7E-7	3.3E-7	2.4E-7	1.9E-7	1.5E-7	1.3E-7
WSW	7.0E-6	1.8E-6	7.2E-7	3.9E-7	2.5E-7	1.7E-7	1.3E-7	1.0E-7	8.2E-8	6.8E-8
W	8.9E-6	2.3E-6	9.3E-7	5.0E-7	3.2E-7	2.2E-7	1.7E-7	1.3E-7	1.1E-7	8.7E-8
WNW	6.6E-6	1.7E-6	6.8E-7	3.7E-7	2.4E-7	1.7E-7	1.3E-7	9.8E-8	8.0E-8	6.6E-8
NW	1.0E-5	2.6E-6	1.1E-6	5.9E-7	3.8E-7	2.7E-7	2.0E-7	1.6E-7	1.3E-7	1.1E-7
NNW	1.3E-5	3.3E-6	1.4E-6	7.5E-7	4.8E-7	3.4E-7	2.6E-7	2.0E-7	1.6E-7	1.4E-7

TABLE C4.0-1

CATAWBA NUCLEAR STATION

The values presented in this table were generated by using the computer program XOQDOQ (NUREQ/CR-2919) which implements NRC Regulatory Guide 1.111 (1977) and the following assumptions:

1. Data Collection Period, 12/17/75 to 12/16/77.

2. Ground Level Releases.

3. Height of The Vent's Building = 47 meters.

4. Open Terrain Recirculation Connection Factors.

TABLE C4.0-2

(1 of 2)

CATAWBA NUCLEAR STATION

DIPERSION PARAMETER ($\overline{D/Q}$) FOR LONG TERM RELEASES > 500 HR/YR OR > 125 HR/QTR

(meter $^{-2}$)

	Distance to the control location, (miles)									
Sector	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
N	6.4E-8	1.6E-8	5.6E-9	2.8E-9	1.6E-9	1.1E-9	7.5E-10	5.6E-10	4.3E-10	3.4E-10
NNE	1.1E-7	2.7E-8	9.6E-9	4.7E-9	2.8E-9	1.8E-9	1.3E-9	9.5E-10	7.4E-10	5.8E-10
NE	1.1E-7	2.6E-8	9.3E-9	4.6E-9	2.7E-9	1.8E-9	1.3E-9	9.3E-10	7.2E-10	5.7E-10
ENE	4.1E-8	1.0E-8	3.6E-9	1.8E-9	1.1E-9	6.9E-10	4.9E-10	3.6E-10	2.8E-10	2.2E-10
E	3.6E-8	8.3E-9	3.2E-9	1.6E-9	9.3E-10	6.1E-10	4.3E-10	3.2E-10	2.4E-10	1.9E-10
ESE	2.5E-8	6.0E-9	2.2E-9	1.1E-9	6.3E-10	4.2E-10	2.9E-10	2.2E-10	1.7E-10	1.3E-10
SE	3.0E-8	7.3E-9	2.6E-9	1.3E-9	7.7E-10	5.0E-10	3.5E-10	2.6E-10	2.0E-10	1.6E-10
SSE	3.8E-8	9.3E-9	3.3E-9	1.7E-9	9.7E-10	6.4E-10	4.5E-10	3.3E-10	2.6E-10	2.0E-10
S	7.2E-8	1.8E-8	6.3E-9	3.1E-9	1.8E-9	1.2E-9	8.5E-10	6.3E-10	4.8E-10	3.8E-10
SSW	6.6E-8	1.6E-8	5.8E-9	2.9E-9	1.7E-9	1.1E-9	7.8E-10	5.8E-10	4.4E-10	3.5E-10
SW	5.7E-8	1.4E-8	5.0E-9	2.5E-9	1.5E-9	9.6E-10	6.7E-10	5.0E-10	3.9E-10	3.1E-10
WSW	2.4E-8	5.7E-9	2.1E-9	1.0E-9	6.0E-10	4.0E-10	2.8E-10	2.1E-10	1.6E-10	1.3E-10
W	2.8E-8	6.7E-9	2.4E-9	1.2E-9	7.0E-10	4.6E-10	3.2E-10	2.4E-10	1.9E-10	1.5E-10
WNW	1.9E-8	4.6E-9	1.7E-9	8.2E-10	4.8E-10	3.2E-10	2.2E-10	1.6E-10	1.3E-10	1.0E-10
NW	2.9E-8	7.0E-9	2.5E-9	1.3E-9	7.3E-10	4.8E-10	3.4E-10	2.5E-10	1.9E-10	1.5E-10
NNW	4.1E-8	9.9E-9	3.6E-9	1.8E-9	1.0E-9	6.8E-10	4.8E-10	3.6E-10	2.7E-10	2.2E-10

TABLE C4.0-2
(2 of 2)
CATAWBA NUCLEAR STATION

The valves presented in this table were generated by using the computer program XOQDOQ (NUREQ/CR-2919) which implements NRC Regulatory Guide 1.111 (1977) and the following assumptions:

1. Data Collection Period, 12/17/75 to 12/16/77.

2. Ground Level Releases.

3. Height of The Vent's Building = 47 meters.

4. Open Terrain Recirculation Connection Factors.

TABLE C4.0-3 *

(1 of 3)

CATAWBA NUCLEAR STATION
ADULT $A_{ai\tau}$ DOSE PARAMETERS

(mrem/hr per μCi/ml)

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
H 3	0.0	4.58E-01	4.58E-01	4.58E-01	4.58E-01	4.58E-01	4.58E-01
NA 24	4.11E+02	4.11E+02	4.11E+02	4.11E+02	4.11E+02	4.11E+02	4.11E+02
CR 51	0.0	0.0	1.28E+00	7.65E-01	2.82E-01	1.70E+00	3.22E+02
MN 54	0.0	4.39E+03	8.37E+02	0.0	1.31E+03	0.0	1.34E+04
MN 56	0.0	1.10E+02	1.96E+01	0.0	1.40E+02	0.0	3.52E+03
FE 55	6.64E+02	4.59E+02	1.07E+02	0.0	0.0	2.56E+02	2.63E+02
FE 59	1.05E+03	2.46E+03	9.45E+02	0.0	0.0	6.89E+02	8.21E+03
CO 58	0.0	9.08E+01	2.04E+02	0.0	0.0	0.0	1.84E+03
CO 60	0.0	2.61E+02	5.75E+02	0.0	0.0	0.0	4.90E+03
NI 63	3.14E+04	2.18E+03	1.05E+03	0.0	0.0	0.0	4.54E+02
NI 65	1.28E+02	1.66E+01	7.56E+00	0.0	0.0	0.0	4.20E+02
CU 64	0.0	1.02E+01	4.77E+00	0.0	2.56E+01	0.0	8.66E+02
ZN 65	2.32E+04	7.38E+04	3.33E+04	0.0	4.93E+04	0.0	4.65E+04
ZN 69	4.93E+01	9.44E+01	6.56E+00	0.0	6.13E+01	0.0	1.42E+01
BR 83	0.0	0.0	4.05E+01	0.0	0.0	0.0	5.83E+01
BR 84	0.0	0.0	5.25E+01	0.0	0.0	0.0	4.12E-04
BR 85	0.0	0.0	2.16E+00	0.0	0.0	0.0	0.0
RB 86	0.0	1.01E+05	4.71E+04	0.0	0.0	0.0	1.99E+04
RB 88	0.0	2.90E+02	1.54E+02	0.0	0.0	0.0	4.00E-09
RB 89	0.0	1.92E+02	1.35E+02	0.0	0.0	0.0	1.12E-11
SR 89	2.28E+04	0.0	6.54E+02	0.0	0.0	0.0	3.66E+03
SR 90	2.84E+05	0.0	7.62E+04	0.0	0.0	0.0	1.62E+04
SR 91	4.20E+02	0.0	1.70E+01	0.0	0.0	0.0	2.00E+03
SR 92	1.59E+02	0.0	6.88E+00	0.0	0.0	0.0	3.15E+03
Y 90	5.97E-01	0.0	1.60E-02	0.0	0.0	0.0	6.33E+03
Y 91M	5.64E-03	0.0	2.18E-04	0.0	0.0	0.0	1.66E-02
Y 91	8.75E+00	0.0	2.34E-01	0.0	0.0	0.0	4.82E+03
Y 92	5.24E-02	0.0	1.53E-03	0.0	0.0	0.0	9.18E+02

* Methodology for table provided by: M. E. Wrangler, RAB:NRR:NRC on 3/17/83

CATAWBA NUCLEAR STATION
ADULT $A_{ai\tau}$ DOSE PARAMETERS

(mrem/hr per µCi/ml)

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
Y 93	1.66E-01	0.0	4.59E-03	0.0	0.0	0.0	5.27E+03
ZR 95	3.07E-01	9.85E-02	6.67E-02	0.0	1.55E-01	0.0	3.12E+02
ZR 97	1.70E-02	3.43E-03	1.57E-03	0.0	5.18E-03	0.0	1.06E+03
NB 95	4.47E+02	2.49E+02	1.34E+02	0.0	2.46E+02	0.0	1.51E+06
MO 99	0.0	1.13E+02	2.14E+01	0.0	2.55E+02	0.0	2.61E+02
TC 99M	9.41E-03	2.66E-02	3.39E-01	0.0	4.04E-01	1.30E-02	1.57E+01
TC 101	9.68E-03	1.40E-02	1.37E-01	0.0	2.51E-01	7.13E-03	4.19E-14
RU 103	4.84E+00	0.0	2.08E+00	0.0	1.85E+01	0.0	5.65E+02
RU 105	4.03E-01	0.0	1.59E-01	0.0	5.20E+00	0.0	2.46E+02
RU 106	7.19E+01	0.0	9.10E+00	0.0	1.39E+02	0.0	4.65E+03
AG 110M	1.23E+00	1.14E+00	6.78E-01	0.0	2.24E+00	0.0	4.66E+02
TE 125M	2.57E+03	9.32E+02	3.45E+02	7.74E+02	1.05E+04	0.0	1.03E+04
TE 127M	6.50E+03	2.32E+03	7.92E+02	1.66E+03	2.64E+04	0.0	2.18E+04
TE 127	1.06E+02	3.79E+01	2.28E+01	7.82E+01	4.30E+02	0.0	8.33E+03
TE 129M	1.10E+04	4.12E+03	1.75E+03	3.79E+03	4.61E+04	0.0	5.56E+04
TE 129	3.01E+01	1.13E+01	7.34E+00	2.31E+01	1.27E+02	0.0	2.27E+01
TE 131M	1.66E+03	8.12E+02	6.77E+02	1.29E+03	8.23E+03	0.0	8.06E+04
TE 131	1.89E+01	7.90E+00	5.97E+00	1.55E+01	8.28E+01	0.0	2.68E+00
TE 132	2.42E+03	1.56E+03	1.47E+03	1.73E+03	1.51E+04	0.0	7.40E+04
I 130	2.88E+01	8.50E+01	3.35E+01	7.20E+03	1.33E+02	0.0	7.32E+01
I 131	1.59E+02	2.27E+02	1.30E+02	7.43E+04	3.89E+02	0.0	5.98E+01
I 132	7.74E+00	2.07E+01	7.24E+00	7.24E+02	3.30E+01	0.0	3.89E+00
I 133	5.41E+01	9.41E+01	2.87E+01	1.38E+04	1.64E+02	0.0	8.46E+01
I 134	4.04E+00	1.10E+01	3.93E+00	1.90E+02	1.75E+01	0.0	9.57E-03
I 135	1.69E+01	4.42E+01	1.63E+01	2.92E+03	7.09E+01	0.0	4.99E+01
CS 134	2.98E+05	7.09E+05	5.80E+05	0.0	2.29E+05	7.62E+04	1.24E+04
CS 136	3.12E+04	1.23E+05	8.86E+04	0.0	6.85E+04	9.39E+03	1.40E+04
CS 137	3.82E+05	5.22E+05	3.42E+05	0.0	1.77E+05	5.89E+04	1.01E+04
CS 138	2.64E+02	5.22E+02	2.59E+02	0.0	3.84E+02	3.79E+01	2.23E-03
BA 139	1.14E+00	8.14E-04	3.35E-02	0.0	7.61E-04	4.62E-04	2.03E+00

TABLE C4.0-3

(3 of 3)

CATAWBA NUCLEAR STATION
ADULT $A_{ai\tau}$ DOSE PARAMETERS

(mrem/hr per μCi/ml)

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
BA 140	2.39E+02	3.00E-01	1.57E+01	0.0	1.02E-01	1.72E-01	4.93E+02
BA 141	5.55E-01	4.19E-04	1.87E-02	0.0	3.90E-04	2.38E-04	2.62E-10
BA 142	2.51E-01	2.58E-04	1.58E-02	0.0	2.18E-04	1.46E-04	3.54E-19
LA 140	1.55E-01	7.82E-02	2.07E-02	0.0	0.0	0.0	5.74E+03
LA 142	7.94E-03	3.61E-03	9.00E-04	0.0	0.0	0.0	2.64E+01
CE 141	4.31E-02	2.91E-02	3.30E-03	0.0	1.35E-02	0.0	1.11E+02
CE 143	7.59E-03	5.61E+00	6.21E-04	0.0	2.47E-03	0.0	2.10E+02
CE 144	2.25E+00	9.39E-01	1.21E-01	0.0	5.57E-01	0.0	7.59E+02
PR 143	5.71E-01	2.29E-01	2.83E-02	0.0	1.32E-01	0.0	2.50E+03
PR 144	1.87E-03	7.76E-04	9.49E-05	0.0	4.38E-04	0.0	2.69E-10
ND 147	3.90E-01	4.51E-01	2.70E-02	0.0	2.64E-01	0.0	2.17E+03
W 187	2.96E+02	2.48E+02	8.65E+01	0.0	0.0	0.0	8.11E+04
NP 239	3.11E-02	3.06E-03	1.69E-03	0.0	9.54E-03	0.0	6.28E+02

C5.0 Radiological Environmental Monitoring

The Radiological Environmental Monitoring Program shall be conducted in accordance with Technical Specification, Section 3/4.12.

The monitoring program locations and analyses are given in Tables C5.0-1 through C5.0-3 and Figure C5.0-1.

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 lakewater irrigation is not practiced in the vicinity.

The laboratory performing the radiological environmental analyses shall participate in an interlaboratory comparison program which has been approved by the NRC. This program is the Environmental Protection Agency's (EPA's) Environmental Radioactivity Laboratory Intercomparsion Studies (crosscheck) Program, our participation code is CP.

The dates of the land-use census that was used to identify the controlling receptor locations was 10/26/82 - 10/28/82. These dates will not be changed unless a subsequent census changes a controlling receptor's location.

TABLE C5.0-1
(1 of 1)
CATAWBA RADIOLOGICAL MONITORING PROGRAM SAMPLING LOCATIONS

(TLD LOCATIONS)

	SAMPLING LOCATION DESCRIPTION			SAMPLING LOCATION DESCRIPTION	
200	SITE BOUNDARY	(0.7M NNE)	232	4-5 MILE RADIUS	(4.1M NE)
201	SITE BOUNDARY	(0.5M NE)	233	4-5 MILE RADIUS	(4.0M ENE)
202	SITE BOUNDARY	(0.6M ENE)	234	4.5 MILE RADIUS	(4.5M E)
203	SITE BOUNDARY	(0.5M SE)	235	4.5 MILE RADIUS	(4.0M ESE)
204	SITE BOUNDARY	(0.5M SSW)	236	4-5 MILE RADIUS	(4.2M SE)
205	SITE BOUNDARY	(0.6M SW)	237	4-5 MILE RADIUS	(4.8M SSE)
206	SITE BOUNDARY	(0.7M WNW)	238	4-5 MILE RADIUS	(4.2M S)
207	SITE BOUNDARY	(0.8M NNW)	239	4-5 MILE RADIUS	(4.6M SSW)
212	SPECIAL INTEREST	(2.7M ESE)	240	4-5 MILE RADIUS	(4.1M SW)
217	CONTROL	(10.0M SSE)	241	4-5 MILE RADIUS	(4.7M WSW)
222	SITE BOUNDARY	(0.7M N)	242	4-5 MILE RADIUS	(4.6M W)
223	SITE BOUNDARY	(0.5M E)	243	4-5 MILE RADIUS	(4.6M WNW)
224	SITE BOUNDARY	(0.7M ESE)	244	4-5 MILE RADIUS	(4.1M NW)
225	SITE BOUNDARY	(0.5M SSE)	245	4-5 MILE RADIUS	(4.2M NNW)
226	SITE BOUNDARY	(0.5M S)	246	SPECIAL INTEREST	(8.1M ENE)
227	SITE BOUNDARY	(0.5M WSW)	247	CONTROL	(7.5M ESE)
228	SITE BOUNDARY	(0.6M W)	248	SPECIAL INTEREST	(8.2M SSE)
229	SITE BOUNDARY	(0.9M NW)	249	SPECIAL INTEREST	(8.1M S)
230	4-5 MILE RADIUS	(4.4M N)	250	SPECIAL INTEREST	(10.3M WSW)
231	4-5 MILE RADIUS	(4.2M NNE)	251	CONTROL	(9.8M WNW)

TABLE C5.0-2
(1 of 1)
CATAWBA RADIOLOGICAL MONITORING PROGRAM SAMPLING LOCATIONS
(OTHER SAMPLING LOCATIONS)

CODE:

W - Weekly
SM - Semimonthly
M - Monthly
Q - Quarterly
SA - Semiannual

	SAMPLING LOCATION DESCRIPTION	Air Radioiodines & Particulates	Surface Water	Drinking Water	Shoreline Sediment	Milk	Fish	Broadleaf Vegetation
200	Site Boundary (0.7m NNE)	W						
201	Site Boundary (0.5m NE)	W						M
205	Site Boundary (0.6m SW)	W						
208	Discharge Canal (0.5m S)		M		SA		SA	
209	Dairy (7.0m SSW)					SM		
210	Ebenezer Access (2.4m SE)				SA			
211	Wylie Dam (4.0m ESE)		M					
212	Tega Cay (2.7m ESE)	W						
213	Fort Mill Water Supply (7.5m ESE)			M				
214	Rock Hill Water Supply (7.3m SSE)			M				
215	Camp Steere-Hwy 49 (4.1m NNE) Control				SA			
216	Hwy 49 Bridge (4.0m NNE) Control		M				SA	
217	Rock Hill Substation (10.0m SSE) Control	W						M
218	Belmont Water Supply (13.5m N) Control			M				
219	Dairy (6.0m SW)					SM		
220	Dairy (8.0m WSW)					SM		
221	Dairy (13.0m NW) Control					SM		

TABLE C5.0-3
(1 of 1)
CATAWBA RADIOLOGICAL 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	X				
	Quarterly Composite		X			
4. Drinking Water	Monthly	X			X	
	Quarterly Composite		X			
5. Shoreline Sediment	Semiannually	X				
6. Milk	Semimonthly	X		X		
7. Fish	Semiannually	X				
8. Broadleaf Vegetation	Monthly	X				

▲218(IN BE
▲221
10 MILE
5 MILE
NNW
N
WNW
W
WSW
SW
SSW
S
230
231
▲215
▲216
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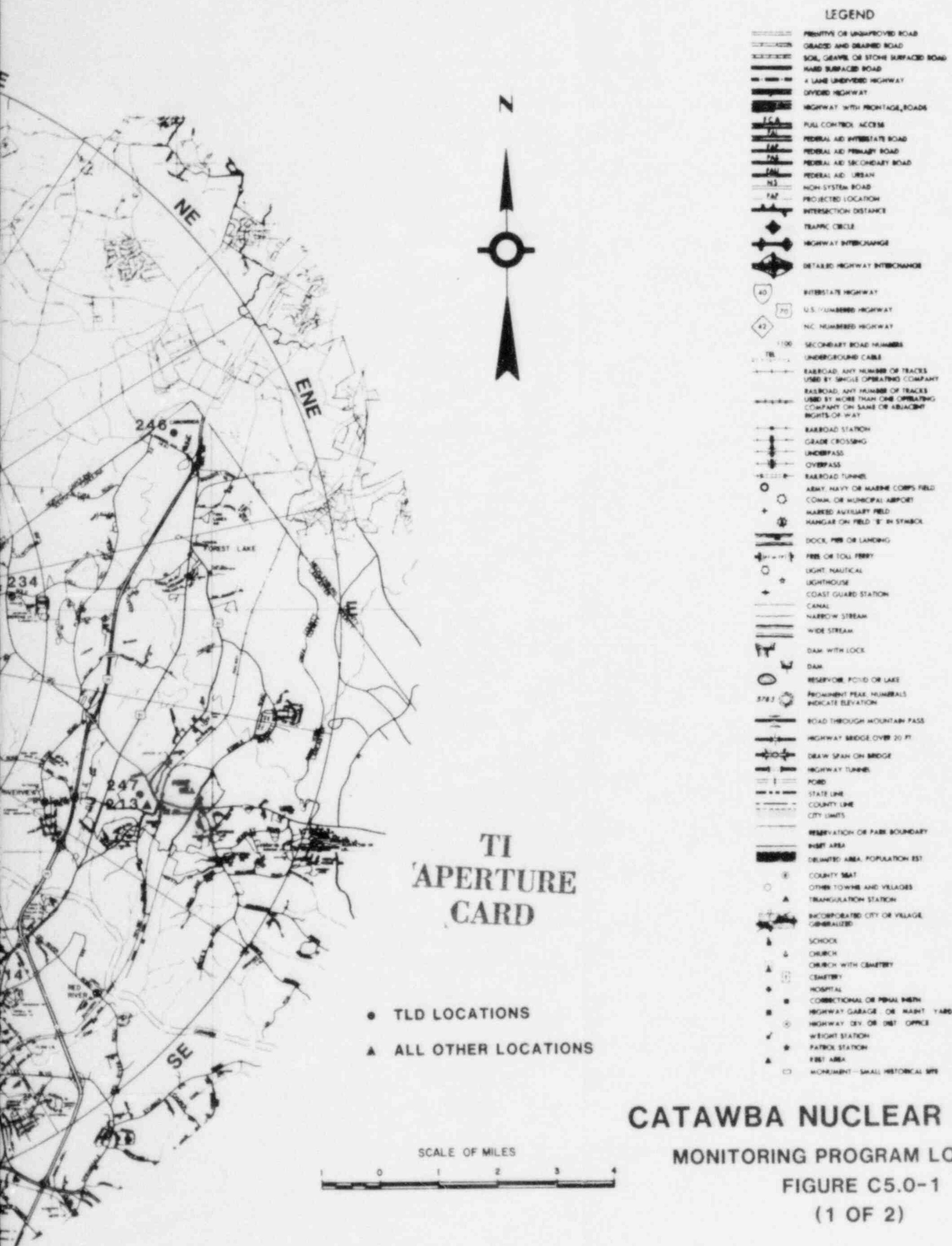
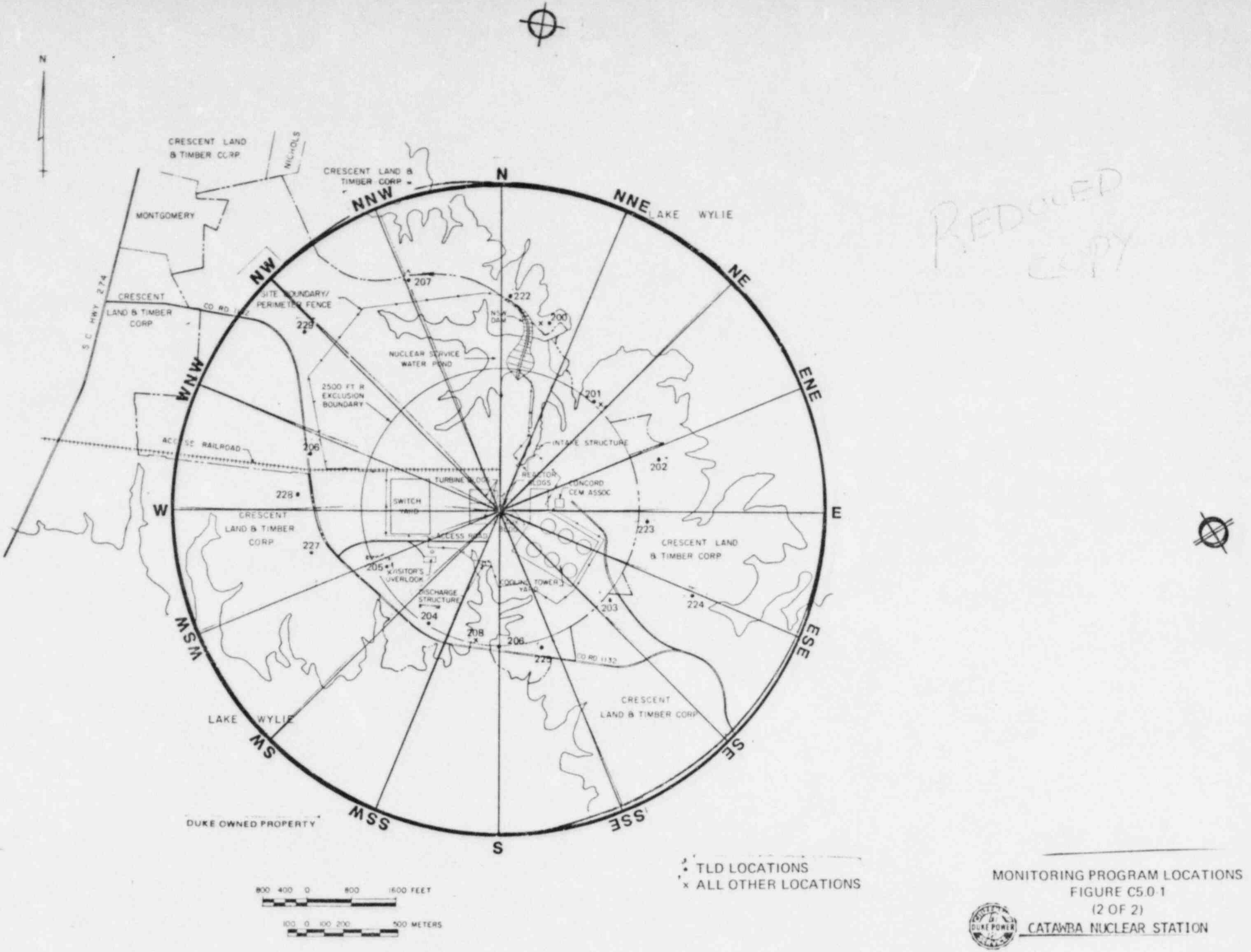
249
TEGA CAY
ROCK HILL



CATAWBA NUCLEAR STATION

MONITORING PROGRAM LOCATIONS

FIGURE C5.0-1
(1 OF 2)



MONITORING PROGRAM LOCATIONS
FIGURE C5.0-1
(2 OF 2)
CATAWBA NUCLEAR STATION

DUKE POWER COMPANY
P.O. BOX 33189
CHARLOTTE, N.C. 28242

HAL B. TUCKER
VICE PRESIDENT
NUCLEAR PRODUCTION

TELEPHONE
(704) 373-4531

July 9, 1984

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

Attention: Ms. E. G. Adensam, Chief
Licensing Branch No. 4

Re: Catawba Nuclear Station
Docket Nos. 50-413 and 50-414

Dear Mr. Denton:

Please find attached for your review and approval five (5) copies of the Offsite Dose Calculation Manual for the Catawba Nuclear Station. This manual incorporates changes resulting from your staff's review.

Very truly yours,

Hal B. Tucker

Hal B. Tucker

RWO/rhs

Attachment

cc: (w/attachment)
Mr. James P. O'Reilly, Regional Administrator
U. S. Nuclear Regulatory Commission
Region II
101 Marietta Street, NW, Suite 2900
Atlanta, Georgia 30303

NRC Resident Inspector
Catawba Nuclear Station

(w/o attachment)
Mr. Robert Guild, Esq.
Attorney-at-Law
P. O. Box 12097
Charleston, South Carolina 29412

Aperture Card Dist

A009 1/5

Palmetto Alliance
2135½ Devine Street
Columbia, South Carolina 29205

Mr. Jesse L. Riley
Carolina Environmental Study Group
854 Henley Place
Charlotte, North Carolina 28207

December 22, 1983

Offsite Dose Calculation Manual Distribution

SUBJECT: Offsite Dose Calculation Manual
Special Instructions for Issue - ONS
File: GS-778.00

The General Office Radwaste Engineering staff is transmitting to you this date 7 copy/copies, number(s) 34-40 of the subject manual for issue by December 28, 1983.

This manual is limited in distribution to facilitate future revisions. Copies of this manual should be controlled in accordance with the requirements of Section 2.1 of the Administrative Policy Manual for Nuclear Stations.

All copies of this manual issued for use at nuclear stations will be issued to the station manager for reissue to the following individuals or locations:

Copy Number	Individual/Location
34	C. T. Yongue
35	J. A. Long
36	C. L. Harlin
37	D. P. Rochester
38	#1 Control Room
39	#2 Control Room
40	Master File

If you have any questions regarding this distribution, please call Jim Stewart at Ext. 5444.

M. L. Birch
System Radwaste Engineer

James M. Stewart Jr.

By: James M. Stewart, Jr.
Associate Health Physicist
WC - 2389

JMS/dkt

December 22, 1983

SUBJECT: Offsite Dose Calculation Manual - Revision 3

The General Office Radwaste Engineering staff is transmitting to you this date, Revision 3 of the Offsite Dose Calculation Manual. As this revision only affects Oconee Nuclear Station, the approval of the manager of McGuire Nuclear Station is not necessary. Please update your copy No. __________, and discard affected pages.

REMOVE THESE PAGES	INSERT THESE PAGES
Remove all pages currently located behind the tab labeled "Oconee", and in front of the tab labeled "McGuire".	Insert this package behind the tab labeled "Oconee", and in front of the tab labeled "McGuire".

NOTE: As this letter contains "LOEP" information, please insert this letter in front of the September 30, 1983 letter.

Approval Date: 12/12/83	Approval Date: 12/14/83
Effective Date: 01/01/84	Effective Date: 01/01/84
Mary L. Birch	J. Ed Smith
Mary L. Birch System Radwaste Engineer	J. Ed Smith, Manager Oconee Nuclear Station

If you have any questions concerning Revision 3, please call Jim Stewart at (704) 373-5444.

James M. Stewart, Jr.

James M. Stewart, Jr.
Associate Health Physicist

MLB/JES/JMS/dkt

Enclosures

September 30, 1983

SUBJECT: Offsite Dose Calculation Manual - Revision 2

The General Office Radwaste Engineering staff is transmitting to you this date, Revision 2 of the Offsite Dose Calculation Manual. Please update your copy No. ___________, and discard affected pages.

REMOVE THESE PAGES	INSERT THESE PAGES	
Page B-6	Page B-6	Revision 2
Page B-11	Page B-11	Revision 2
Page B-15	Page B-15	Revision 2
Table B4.0-1	Table B4.0-1	Revision 2
Table B4.0-2	Table B4.0-2	Revision 2

NOTE: As this letter contains "LOEP" information, please insert this letter in front of the April 15, 1983 letter.

Approval Date: 9/21/83

Effective Date: 10/07/83

Mary L. Birch

M. L. Birch
System Radwaste Engineer

Approval Date: 9/29/83

Effective Date: 10/07/83

M. D. McIntosh, Manager
McGuire Nuclear Station

If you have any questions concerning Revision 2, please call Jim Stewart at (704) 373-5444.

James M. Stewart, Jr.

James M. Stewart, Jr.
Associate Health Physicist
WC-2389

JMS/dkt

April 15, 1983

Subject: McGuire Nuclear Station
Offsite Dose Calculation Manual

The General Office Radwaste Engineering staff is transmitting to you this date, Revision 1, of the Offsite Dose Calculation Manual. Please update your copy No. ______ and discard affected pages.

Remove These Pages	Insert These Pages	
Table 1.2-2	Table 1.2-2	Rev. 1
Page 3-6	Page 3-6	Rev. 1
Page 3-7	Page 3-7	Rev. 1
Table B4.0-2	Table B4.0-2	Rev. 1
Table B5.0-4 (1 of 3)	Table B4.0-3 (1 of 3)	Rev. 1
Table B5.0-4 (2 of 3)	Table B4.0-3 (2 of 3)	Rev. 1
Table B5.0-4 (3 of 3)	Table B4.0-3 (3 of 3)	Rev. 1

Note: As this letter contains "LOEP" information, please insert this letter in front of the February 28, 1983 letter.

Approval Date: 4/11/83

Effective Date: 4/15/83

Mary L. Birch

M.L. Birch
System Radwaste Engineer

Approval Date: 4/8/83

Effective Date: 4/15/83

M.D. McIntosh, Manager
McGuire Nuclear Station

If you have any questions concerning Revision 1, please call Jim Stewart at 704/373-5444.

James M. Stewart, Jr.

James M. Stewart, Jr.
Associate Health Physicist
WC-2389

JMS/fkc

February 28, 1983

Subject: McGuire Nuclear Station
Offsite Dose Calculation Manual

Please find attached copy/copies No.__________________ of the subject manual. As this revision constitutes a complete reprint of the manual, please discard all present manuals. Subsequent revisions will be issued as required and only affected pages will be changed.

Approval Date: 2/28/83

Mary L. Birch

M. L. Birch
System Radwaste Engineer

Approval Date: 2/28/83

M. D. McIntosh

M. D. McIntosh, Manager
McGuire Nuclear Station