ENCLOSURE 3

TENNESSEE VALLEY AUTHORITY
SEMIANNUAL RADIOACTIVE EFFLENT RELEASE REPORT
BROWNS FERRY NUCLEAR PLANT

CHANGES TO THE BFN OFFSITE DOSE CALCULATION MANNUAL

JANUARY THROUGH JUNE 1989

Appendix 1
BFN ODCM Change Description Form

Description of change: (1) Delete Farm W (Map Reference #21) 6.8 miles NE of ~~SQN~~ BFN (vegetation sample). (2) Add Farm T (Map Reference #36) 3.2 miles WNW; vegetation sample only.

Pages affected: (1) 163 & 184 ; (2) 162, 163, & 183

Justification for change: The most recent land use survey identified a milk animal at Farm T but none at Farm W (milk animal previously identified). At Farm T, insufficient milk is available for sampling, therefore only vegetation will be sampled.

Analysis of effect of change on dose calculations, projections, or setpoint calculations: This change will have no effect on dose calculations, projections, or setpoint calculations.

Attach marked-up pages from the current revision of the SQN ODCM which show the change.

RARC Review: [signature]
RARC Chairman

Date: 2/15/89

Appendix 1
BFN ODCM Change Description Form

Description of change: For quarterly gaseous dose calculations, the reference to Table 1.1 is dropped. On Table 1.1, only site boundary and critical receptors used for monthly calculations are retained.

Pages affected: RETS Manual Pages 55, 97

Justification for change: Quarterly dose calculations are based on the most recent land-use survey results. Including all the land use results in the ODCM necessitates an ODCM change once per year, which is cumbersome

Analysis of effect of change on dose calculations, projections, or setpoint calculations:

This change will have no effect on dose calculations, projections or setpoint calculations.

Attach marked-up pages from the current revision of the SQN ODCM which show the change.

RARC Review: [signature] RARC Chairman

Date: 2/15/89

Appendix 1
BFN ODCM Change Description Form

Description of change: Table 1.4 is changed. Dose factors for gamma and beta air dose are taken from Reg. Guide 1.109. Old values were TVA generated values which assumed an infinite cloud model for beta dose and a semi-infinite cloud for gamma dose.

Pages affected: RETS Manual Page 121

Justification for change: Previous methodology (described in "Meteorology and Atomic Energy-1968") was reviewed. Although adequate, it was determined that using R.G. 1.109 dose factors was more consistent with industry practice.

Analysis of effect of change on dose calculations, projections, or setpoint calculations:

This change will have no effect on setpoint calculations. Dose calculations and projections (for air doses) will be affected. Gamma doses will be increased by about 2% per nuclide. Beta doses will be decreased by about a factor of 2 due to the R.G. 1.109 assumption of a semi-infinite cloud.

Attach marked-up pages from the current revision of the SQN ODCM which show the change.

RARC Review: [signature] RARC Chairman

Date: 2/15/84

Appendix 1
BFN ODCM Change Description Form

Description of change: Changed the fraction of riverflow available for dilution from 0.20 to 0.30 (see attached documentation)

Pages affected: RETS Manual pages 85, 86, 88, Section 2.3.3 (INSERT)

Justification for change: Further analyses of the TN River by TVAs Engineering laboratory show that, for actual riverflow and operating conditions, the degree of entrainment is higher than previously estimated.

Analysis of effect of change on dose calculations, projections, or setpoint calculations:

Change will not affect setpoint calculations.
Dose calculations will be lower for identical releases, but should be more realistic.

Attach marked-up pages from the current revision of the SQN ODCM which show the change.

RARC Review: [signature]
RARC Chairman

Date: 2/15/89

TVA 64 (OS-9-65)

UNITED STATES GOVERNMENT

Memorandum

TENNESSEE VALLEY AUTHORITY

TO : F. W. Reimann, Chief, Water and Waste Processing, IBM 1N 52A-C

FROM : E. Ely Driver, Manager, Engineering Laboratory, ENG LAB-N

DATE : October 17, 1988

SUBJECT: VERIFICATION OF DILUTION FACTOR FOR BROWNS FERRY NUCLEAR PLANT (BFN)

This memo is in response to your memo of September 29, 1988, concerning the dilution value provided by the Engineering Laboratory for release of radiological effluents from the subject plant.

A dilution factor of 5 was provided in 1979 as a conservative value to be used in calculations. Field studies and model results (Reference 1) have indicated the dilution factor range at BFN varies from 4 to 11. Note that a dilution factor of 4 does not mean 1/4 (or 25 percent) of the river flow is available for mixing with the diffuser effluent. The dilution factor is the ratio of diffuser flow to the fraction of river flow available for mixing (entrained river flow).

The fraction of river flow available for mixing is a function of river flow, ambient river temperature, diffuser discharge temperature, diffuser flow, and the number of diffusers in operation. The smallest fraction of river flow available for mixing occurs during high river flows and single diffuser operation. Therefore, a conservative value can be obtained using a high monthly average river flow of 70,000 cfs and a single diffuser discharge. Under these conditions, analysis shows that the fraction of river flow available for mixing is 30 percent. This translates to a value of 0.3 for variable d in equation 2.5, Section 2.3.2.1 of the RETS Manual.

Please feel free to call Walter Harper (1882-K) should you have any questions or require additional information.

Reference 1: Almquist, C. W., C. D. Ungate, and W. R. Waldrop, "Field and Model Results for Multiport Diffuser Plume," Presented at the American Society of Civil Engineers Hydraulic Division Specialty Conference on Verification of Mathematical and Physical Models in Hydraulic Engineering, College Park, Maryland, August 9-11, 1978.

Reference 2: Stolzenbach, K. D., "Estimation of Water Temperature Increases in Wheeler Reservoir Caused by the Discharge of Heater Water from Browns Ferry Nuclear Plant During Open Cycle Operation," Memo to TVA Engineering Laboratory, February 1975.

E. Ely Driver

E. Ely Driver

WLH:TSM

cc: Vahid Alavian, ENG LAB-N
Files, ENG LAB, 335 EB-K

Prepared by Walter Harper

Appendix 1
BFN ODCM Change Description Form

Description of change: added a further description for maximum terrain heights to be used for calculating effective release heights. Site boundary locations will use their actual terrain heights, while resident, garden & cow locations will use the maximum terrain height for that sector out to 5 miles, regardless of the receptor's distance

Pages affected: RETS Manual page #77

Justification for change: Eliminates the need to determine the actual terrain heights for receptors that may change yearly. Errors arising from inaccuracy of locating receptor on topographic maps is also eliminated.

Analysis of effect of change on dose calculations, projections, or setpoint calculations:

This change will have no effect on setpoint calculations, or on monthly dose calculations or projections.
Since this is a conservative assumption, some doses may be slightly more conservative (higher), but since BFN is located on relatively flat terrain, the differences will be negligible in most cases (the lowest terrain height is 8 meters, the highest is 40)

Attach marked-up pages from the current revision of the SQN ODCM which show the change.

RARC Review: B. Eiford Lee
RARC Chairman

Date: 2/15/89

Appendix 1
BFN ODCM Change Description Form

Description of change: Tables containing gaseous dose calculation parameters are revised. References are added for all verified parameter values.

Pages affected: RETS Manual pages 121-145, 48

Justification for change: The tables were revised for accuracy, and some nuclides were added and/or deleted to reflect detection capabilities of the plant. Values will be easier to verify against source documents.

Analysis of effect of change on dose calculations, projections, or setpoint calculations:

This change will have some effect on quarterly dose calculations for some nuclides. With the exception of Sb-124, all new calculated dose factors are the same or higher than previously. There will be no effect on monthly dose calculations, projections or setpoint calculations.

Attach marked-up pages from the current revision of the SQN ODCM which show the change.

RARC Review: B. Eiford-Lee
RARC Chairman

Date: 2/15/89

Appendix 1
BFN ODCM Change Description Form

Description of change: Description of monthly and quarterly liquid dose calculation methodologies is revised to reflect changes in the new QWATA code. Nuclides considered, half lives and dose factors are the same as those used for gaseous dose calculations. Doses are calculated only for the 50-mile population (see attached for details).

Pages affected: 84-94, 146-158 (RETS Manual pages)

Justification for change: More consistency between gaseous and liquid methodologies. More closely follows the guidance of R.G.1.109 and NUREG-0133.

Analysis of effect of change on dose calculations, projections, or setpoint calculations:

Liquid dose calculations and projections will be more accurate (less conservative) than with previous methodologies. Setpoint calculations will not be affected.

Attach marked-up pages from the current revision of the SQN ODCM which show the change.

RARC Review: [signature]
RARC Chairman

Date: 2/15/89

Changes to QWATA

General Changes in Methodology and Data

1. Two age groups were added, teen and infant.

2. Two organs were added, kidney and lung. Skin dose is only calculated for recreation pathway.

3. Shoreline recreation dose is the only dose considered in the recreation pathway. In-water and above-water pathways were deleted from the recreation pathway dose based on the determination that they contributed less than one percent each to the total recreation dose.

4. Dose factors are from R.G. 1.109 if possible. For those nuclides which are considered but not listed in R.G. 1.109, Kocher is used as the reference for external dose (recreation) and NUREG 0172 is used for ingestion pathways.

5. If dose factors for specific organs were not listed for a nuclide that is in R.G. 1.109, the dose factors were considered zero. For recreation pathway, dose factors for all organs except skin were set equal to the total body dose factor for each nuclide.

6. Daughter ingrowth is not considered in the new code. However, the isotopes are decayed.

7. Travel times and average flow past the site are no longer calculated but are part of the input data.

8. Sixty-three nuclides were deleted (e.g. natural decay chains and transuranics) while the following four were added: Zn-69m, Br-82, Tc-101, Sb-125.

9. Dilution factors were changed from 0.2 to 0.6 for SQN and 0.3 for BFN. This decreases the concentration in the first reach considered for each plant which in turn lowers the dose calculated for that reach.

10. Acres per reach changed to reflect memo from D.L. stone on April 26,1988.

11. Kocher was used as the reference for all half-lifes which are consistent to 2 decimal places.

12. All files were updated to reflect the most recent data available.

Changes Which Affect Population Dose Calculations Only

1. Total fish harvests in pounds per reach were changed from 52.2 lbs/acre-yr to 3.04 for SQN and WBN and to 8.32 for BFN based on surveys of fish caught in the Chickamauga and Wheeler reservoirs. This decreases the population dose from fish ingestion.

2. Population doses are calculated for a 50 mile radius downstream of each plant instead of to the rivers mouth. This decreases the population doses from every pathway.

3. The most recent data is used for the population numbers in place of the 2% growth rate each year currently assumed. This gives a more realistic assessment of the population potentially receiving dose from plant operation.

Nuclides Deleted from QWATA

1. Na-22
2. As-74
3. As-76
4. Kr-83m
5. Kr-85m
6. Kr-85
7. Nb-95m
8. Nb-97m
9. Tc-99
10. Rh-103m
11. Rh-105
12. Rh-105m
13. Rh-106
14. Ag-111
15. Sb-122
16. Sb-127
17. I-129
18. Xe-133m
19. Xe-133
20. Xe-135m
21. Xe-135
22. Cs-135
23. Ba-137m
24. Pr-144m
25. Pm-147
26. Pm-149
27. Sm-147
28. Sm-151
29. Sm153
30. Eu-155
31. Ta-182
32. Pb-210
33. Pb-212
34. Pb-214
35. Bi-212
36. Bi-214
37. Po-212
38. Po-214
39. Po-216
40. Po-218
41. Ra-224
42. Ra-226
43. Ra-228
44. Ac-228
45. Th-228
46. Th-230
47. Th-232
48. Th-234
49. Pa-234
50. U-234
51. U-238
52. Np-238
53. Pu-238
54. Pu-239
55. Pu-240
56. Pu-241
57. Pu-242
58. Am-241
59. Am-242
60. Am-243
61. Cm-242
62. Cm-243
63. Cm-244

Appendix 1
BFN ODCM Change Description Form

Description of change: Description is added to state that, for quarterly dose calculations, iodines are split into elemental and organic form (50-50 split). This has been done in the past, but was not described in the ODCM.

Pages affected: RETS Manual page 55

Justification for change: Guidance in R.G. 1.109, page 26.

Analysis of effect of change on dose calculations, projections, or setpoint calculations:

—NONE—

Attach marked-up pages from the current revision of the SQN ODCM which show the change.

RARC Review: [signature] RARC Chairman Date: 2/5/89

Appendix 1
BFN ODCM Change Description Form

Description of change: For quarterly gaseous dose calculations, ~~the~~ all stability classes will be considered for stack releases.

Pages affected: RETS Manual page 74

Justification for change: Per discussions at the July 1988 RARC meeting, this will yield a more accurate dose calculation that the conservative assumption that only D stability exists.

Analysis of effect of change on dose calculations, projections, or setpoint calculations:

Quarterly dose calculations will be more accurate. No effect on monthly dose calculations, projections or setpoint calculations.

Attach marked-up pages from the current revision of the SQN ODCM which show the change.

RARC Review: B. E. Dod-Lee (signature)
RARC Chairman

Date: 2/15/89

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LIST OF TABLES

0.9 = fraction of total gamma dose expected to be contributed by the assumed nuclides.

10^6 = μCi/Ci conversion factor.

3.15×10^7 = s/yr conversion factor.

Q_i = monthly release of radionuclide i, Ci.

$DF\gamma_i$ = gamma-to-air dose factor for radionuclide i, mrad/yr per μCi/m³ (Table 1.4).

Monthly Conservative Model - Beta dose to air

$$D_\beta = \frac{(\chi/Q)}{0.9} \frac{10^6}{3.15 \times 10^7} \sum_i Q_i \ DF_{\beta i} \qquad (1.5)$$

where:

D_β = beta dose to air, mrad.

χ/Q = highest land-site boundary annual-average relative concentration, s/m³ (from Table 1.1).
= 1.84×10^{-6} for ground level releases,
= 2.08×10^{-8} for elevated releases (stack).

0.9 = fraction of total beta dose expected to be contributed by the assumed nuclides.

10^6 = μCi/Ci conversion factor.

3.15×10^7 = s/yr conversion factor.

Q_i = monthly release of radionuclide i, Ci.

$DF_{\beta i}$ = beta-to-air dose factor for radionuclide i, mrad/yr per μCi/m³ (Table 1.4).

1.3 Quarterly Dose Calculations

A complete dose analysis utilizing the total estimated gaseous releases for each calendar quarter will be performed and reported as required in Specifications 6.7.5. Methodology for this analysis is that which is described in Section 1.5, using the quarterly release values reported by the plant personnel. For iodine releases, it will be assumed that half the iodines released are organic iodines, which contribute only to the inhalation dose. All real pathways and receptor locations (as identified in the most recent land use survey) are considered. In addition, actual meteorological data representative of each corresponding calendar quarter will be used to calculate dispersion factors as described in section 1.7. Stack releases will be considered elevated releases. Radwaste and reactor building releases will be considered split-level releases. Turbine building releases will be treated as ground level.

The highest gamma-air and beta-air doses calculated will be used to check compliance with the quarterly limits of Specification 3.8.B.3. The highest organ dose for a real receptor is determined by summing the dose contribution from all real pathways including ground contamination, inhalation, vegetable ingestion (for identified garden locations), cow and/or goat milk ingestion (if a cow or goat is identified for the location), beef ingestion (the beef ingestion dose for the location of highest beef dose for all receptors will be considered the beef dose for all receptors). The receptor having the highest organ dose is then used to check compliance with the quarterly limits of Specification 3.8.B.5.

Population Doses

For determining population doses to the 50-mile population around the plant, each compass sector is broken down into elements. These elements are defined in Table 1.5. For each of these sector elements, an average dose is calculated, and then multiplied by the population in that sector element. Dispersion factors are calculated for the midpoint of each sector element (see Table 1.5). For population doses resulting from ingestion, it is conservatively assumed that all food eaten by the average individual is grown locally.

The general equation used for calculating the population dose in a given sector element is:

$$Dose_{pop} = \sum_{P} RATIO_P * POPN * AGE * 0.001 * DOSE_P$$

where

$RATIO_P$ = ratio of average to maximum dose for pathway P. (Average ingestion rates are obtained from Regulatory Guide 1.109, Table E-4.)

= 0.5 for submersion and ground exposure pathways, a shielding/occupancy factor.

1.7 Dispersion Methodology

Dispersion factors are calculated for radioactive effluent releases using hourly average meteorological data collected onsite.

Meteorological data for ground level releases consist of windspeed and direction measurements at 10m and temperature measurements of 10m and 45 m.

Hourly average meteorological data for the ground level portion of a split level release consist of wind speeds and directions measured at the 10m level and temperature measurements at 10m and 45m. The elevated portion of the split level release uses wind speeds and directions measured at the 46m level and temperature measurements at 45m and 90m.

Raw meteorological data for the elevated releases consist of windspeed and directions measured at 93m. Stability class D is assumed to persist during the entire period for elevated releases, except for the quarterly dose calculations described in Section 1.3 when all stability classes will be used to evaluate the elevated releases.

Meteorological data are expressed as a joint-frequency distribution of wind speed, wind direction, and atmospheric stability for each release level (ground, split and elevated). The joint-frequency distributions which represent the historical meteorological data for the period January 1977 to December 1979 are given in Table 1.3.

The wind speed classes that are used are as follows:

Number	Range (m/s)	Midpoint (m/s)
1	<0.3	0.13
2	0.3–0.6	0.45
3	0.7–1.5	1.10
4	1.6–2.4	1.99
5	2.5–3.3	2.88
6	3.4–5.5	4.45
7	5.6–8.2	6.91
8	8.3–10.9	9.59
9	>10.9	10.95

The stability classes that will be used are the standard A through G classifications. The stability classes 1-7 will correspond to A=1, B=2, ..., G=7.

2.3.2.1 Water Ingestion

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

$$D_{jk} = \frac{10^{12}}{0.95} \sum_{i=1}^{20} (DCF)_{ijk}\, I_{ik}, \text{ mrem} \qquad (2.4)$$

where:

D_{jk} = dose for the jth organ and the kth age group from the 20 radionuclides, mrem.

j = the organ of interest (bone, GIT, thyroid, liver or total body).

k = the age group being considered, child or adult.

10^{12} = conversion factor, pCi/Ci.

0.95 = conservative correction factor, considering only 20 radionuclides.

DCF_{ijk} = ingestion dose commitment factor for the ith radionuclide for the jth organ for the kth age group, mrem/pCi (Table 1.7)

I_{ik} = monthly activity ingested of the ith radionuclide by the kth age group, Ci.

The activity ingested due to drinking water, I_{ik}, is described by:

$$I_{ik} = \frac{10^3\, A_i\, U_{wa}\, (1/12)}{F\, d\, (7.34 \times 10^{10})}, \text{ Ci} \qquad (2.5)$$

where:

10^3 = conversion factor, ml/L.

A_i = activity released of ith radionuclide during the month, Ci.

U_{wa} = maximum individual water consumption rate corresponding to the kth age group (Table 1.9), L/yr.

1/12 = conversion factor, yr/month.

F = average river flow rate for the month (cubic feet per second)

d = fraction of river flow available for dilution (0.30)

7.34×10^{10} = conversion from cubic feet per second to milliliters per month

Inserting this for I_{ik} in equation 2.4, the dose equation for water ingestion then becomes:

$$D_{jk} = \frac{3.98 \times 10^3}{F} \sum_{i=1}^{20} U_{wa} \; DCF_{ijk} \; A_i \text{ , mrem} \qquad (2.6)$$

2.3.2.2 Fish Ingestion

The dose to an individual from the consumption of fish is described by Equation 2.4. In this case the activity ingested of the ith radionuclide due to eating fish (I_{ik}) is described by

$$I_{ik} = \frac{10^3 \; A_i \; B_i \; U_{fa} \; (1/12)}{Fd \; (7.34 \times 10^{10})} \text{ , Ci} \qquad (2.7)$$

where:

10^3 = conversion factor, g/kg.

A_i = activity released of the ith radionuclide during the month, Ci

B_i = bioaccumulation factor of ith radionuclide, µCi/g per µCi/ml. (Table 2.2.)

U_{fa} = amount of fish eaten yearly by the kth age group (Table 1.9), kg/yr.

1/12 = conversion factor, yr/month.

F = average river flow rate for the month, cubic feet per second.

d = fraction of river flow available for dilution, 0.30.

7.34×10^{10} = conversion from cubic feet per second to milliliters per month.

Inserting this for I_{ik} in equation 2.4, the dose equation for fish ingestion then becomes:

$$D_{jk} = \frac{3.98 \times 10^3}{F} \sum_{i=1}^{20} A_i \quad B_i \quad U_{fa} \quad DCF_{ijk} \qquad (2.8)$$

2.3.2.3 Recreation

For the recreation dose calculation, the total dose is estimated based on a calculation of the shoreline dose for Co-58, Co-60, Cs-134, and Cs-137. The shoreline dose due to these four nuclides is expected to contribute over 95 percent of the total recreation dose. The total body and maximum organ dose to an individual via the shoreline recreation pathway are assumed to be equal. The recreation dose is described by the following equation:

$$D_r = \frac{10^{12}}{0.95} \sum_{i=1}^{4} [42 \bullet RCDF_i \bullet \xi_i] \text{ , mrem} \qquad (2.9)$$

where:

D_r = recreation dose from plant releases, mrem.

$10^{1.2}$ = conversion factor, pCi/Ci.

0.95 = conservative correction factor for considering only 4 radionuclides.

$RDCF_i$ = dose commitment factor for standing on contaminated ground for the ith radionuclide, mrem/hr per pCi/m² (Table 1.11).

ξ_i = concentration of ith radionuclide in shoreline sediment, Ci/m², as described by the following equation (based on equation A-5 in Regulatory Guide 1.109).

$$\xi_i = 10^3 \bullet 6.94E\text{-}04 \bullet 100 \bullet RHL_i \bullet C_i \bullet W\,[1-\exp(-\lambda_i t_b)] \qquad (2.10)$$

where:

10^3 = conversion factor, ml/L

100 = transfer constant defined in Regulatory Guide 1.109 equation A-4, L per m²-day.

RHL_i = radiological half-life of the ith radioisotope, minutes (Table 1.8).

C_i = concentration of ith radionuclide in the Tennessee River, Ci/ml.

$= A_i/(F \bullet d \bullet 7.34 \times 10^{10})$

where:

A_i	= activity released of ith radionuclide during the month, Ci.
F	= average river flow for the month, cubic feet per second.
d	= fraction of river flow available for dilution, 0.30.
7.34×10^{10}	= conversion from cubic feet per second to milliliters per month.
W	= shoreline width factor (Table 1.9).
λ_i	= decay constant of the ith radionuclide, sec^{-1} (Table 1.8).
t_b	= buildup time in sediment, seconds (Table 1.9)
42	= assumed monthly exposure time for maximum individual, = 500 h/year ÷ 12 months/year.

The recreation dose equation then becomes:

$$D_r = \frac{1}{F} (29.8\ A_1 + 1690\ A_2 + 539\ A_3 + 812\ A_4) \cdot \qquad (2.11)$$

where:

A_1, A_2, A_3, A_4, = the activities of Co-58, Co-60, Cs-134, and Cs-137, respectively, Ci.

2.3.2.4 Monthly Summary

To obtain the total monthly dose to the total body, sum the total body dose from water ingestion, the total body dose from fish ingestion, and the recreation dose. This value will be compared to the Technical Specification limit for total body dose. To obtain the total monthly dose to the maximum organ, sum the maximum organ dose from water ingestion, the maximum organ dose from fish ingestion, and the recreation dose. This value will be compared to the Technical Specification limit for maximum organ dose. Calendar quarter doses are first estimated by summing the doses calculated for each month in that quarter. Calendar year doses are first estimated by summing the doses calculated for each month in that year. However, if the annual doses determined in this manner exceed or approach the specification limits, doses calculated for previous quarters with the methodology of Section 2.3.2 will be used instead of those quarterly doses estimated by summing monthly results. An annual check will be made to ensure that the monthly dose estimates account for at least 95 percent of the dose calculated by the method described in Section 2.3.3. If less than 95 percent of the dose has been estimated, either a new list if principal isotopes will be prepared or a new correction factor will be used. The latter option will not be used if less than 90 percent of the total dose is predicted.

2.3.3 Quarterly Dose Calculations

A complete dose analysis utilizing the total estimated liquid releases for each calendar quarter will be performed and reported as required in Section F.2 of the REM. Methodology for this analysis is that which is described in this section using the quarterly release values reported by the plant personnel. The releases are assumed, for this calculation, to be continuous over the 90 day period.

The average dilution factor, D, used for the quarterly calculations is:

$$D = \frac{1}{RF * 0.30} \quad \text{(for receptors upstream of Wheeler Dam)} \qquad (2.13a)$$

and

$$D = \frac{1}{RF} \quad \text{(for receptors downstream of Wheeler Dam)} \qquad (2.13b)$$

where:

RF = the average actual riverflow for the location at which the dose is being determined, cfs.

0.30 = the fraction of the riverflow available for dilution in the near field, dimensionless.

2.3.3.1 Water Ingestion

Water ingestion doses are calculated for each water supply identified within a 50 mile radius downstream of BFN (Table 2.1). Water ingestion doses are calculated for the total body and each internal organ as described below:

$$D_{org} = 10^6 \; 9.8E\text{-}09 \; A_{Wit} \; Q_i \; D \exp(-8.64E{+}04 \; \lambda_i \; t_d) \qquad (2.14)$$

where

10^6 = conversion factor, µCi/Ci.

9.8E-09 = conversion factor, cfs per ml/hour.

A_{Wit} = Dose factor for water ingestion for nuclide i, age group t, mrem/hour per µCi/ml, as calculated in Section 2.5.1.

Q_i = Quantity of nuclide i released during the quarter, Curies.

D = dilution factor, as described above, cfs^{-1}.

λ_i = radiological decay constant of nuclide i, $seconds^{-1}$ (Table 1.8).

t_d = decay time for water ingestion, equal to the travel time from the plant to the water supply plus one-half day (12 hours) to account for the time of processing at the water supply (per Regulatory Guide 1.109), days.

8.64E+04 = conversion factor, seconds per day.

2.3.3.2 Fish Ingestion

Fish ingestion doses are calculated for each identified reach within a 50 mile radius downstream of BFN (Table 2.1). Individual fish ingestion doses are calculated for the total body and each internal organ as described below:

$$D_{org} = 10^6 \; 9.8E{-}09 \; 0.25 \; A_{Fit} \; Q_i \; D \; \exp(-8.64E{+}04 \; \lambda_i \; t_d) \qquad (2.15$$

where

10^6 = conversion factor, μCi/Ci.

9.8E-09 = conversion factor, cfs per ml/hour.

0.25 = fraction of the yearly fish consumption eaten in one quarter, dimensionless.

A_{Fit} = Dose factor for fish ingestion for nuclide i, age group t, mrem/hour per μCi/ml, as calculated in Section 2.5.2.

Q_i = Quantity of nuclide i released during the quarter, Curies.

D = dilution factor, as described above, cfs^{-1}.

λ_i = radiological decay constant of nuclide i, $seconds^{-1}$ (Table 1.8).

t_d = decay time for fish ingestion, equal to the travel time from the plant to the center of the reach plus one day to account for transit through the food chain and food preparation time (per Regulatory Guide 1.109), days.

8.64E+04 = conversion factor, seconds per day.

2.3.3.3 Recreation Shoreline

Recreation doses are calculated for each identified reach within a 50 mile radius downstream of BFN (Table 2.1). It is assumed that the maximum exposed individual spends 500 hours per year on the shoreline at a location immediately downstream from the diffusers. Individual

recreation shoreline doses are calculated for the total body and skin as described below:

$$D_{org} = 10^6\ 9.8E{-}09\ rf\ A_{Rit}\ Q_i\ D\ \exp(-8.64E{+}04\ \lambda_i\ t_d) \quad (2.16)$$

where

10^6 = conversion factor, µCi/Ci.

9.8E-09 = conversion factor, cfs per ml/hour.

rf = recreation factor, used to account for the fact that the same amount of time will not be spent at a recreation site during each quarter. Recreation factors used are:

1st quarter - 0.1
2nd quarter - 0.3
3rd quarter - 0.4
4th quarter - 0.2.

A_{Rit} = Dose factor for shoreline recreation for nuclide i, age group t, mrem/hour per µCi/ml, as calculated in Section 2.5.3.

Q_i = Quantity of nuclide i released during the quarter, Curies.

D = dilution factor, as described above, cfs^{-1}.

λ_i = radiological decay constant of nuclide i, $seconds^{-1}$ (Table 1.8).

t_d = decay time for recreation, equal to the travel time from the plant to the center of the reach, days.

8.64E+04 = conversion factor, seconds per day.

2.3.3.4 Total Maximum Individual Dose

The total maximum individual total body dose is obtained by summing the following for each age group: the highest total body water ingestion dose from among all the public water supplies; the highest total body fish ingestion dose from among all the reaches; and the total body maximum shoreline recreation dose. The total maximum individual organ dose is obtained by summing the following for each organ and each age group: that organ's highest water ingestion dose from among all the public water supplies; that organ's highest fish ingestion dose from among all the reaches; and the total body maximum shoreline recreation dose. The total maximum individual skin dose is that skin dose calculated for the maximum shoreline dose.

2.3.3.5 Population Doses

For determining population doses to the 50-mile population around the plant, an average dose is calculated for each age group and each pathway and then multiplied by the population.

For water ingestion, the general equation used for calculating the population doses, POPWTR, in man-rem for a given PWS is:

$$POPWTR_t = 10^{-3} \sum_{m=1}^{5} POP_m \sum_{a=1}^{4} POP_a * ATMW_a * TWDOS_{amt} \qquad (2.17)$$

where:

$POPWTR_t$ = water ingestion population dose to organ t, man-rem.

POP_a = fraction of population in each age group a (from NUREG CR-1004, table 3.39).

Adult = 0.665
Child = 0.168
Infant = 0.015
Teen = 0.153

POP_m = population at PWS m. The 3 PWSs and their populations are listed in Table 2.1.

$ATMW_a$ = ratio of average to maximum water ingestion rates for each age group a. Maximum water ingestion rates are given in Table 1.9. Average water ingestion rates, in L/year, (from R.G. 1.109 Table E-4) are:

Adult = 370
Child = 260
Infant = 260
Teen = 260

$TWDOS_{amt}$ = total individual water ingestion dose to organ t at PWS m, to the age group a, as described in Section 2.3.3.1, mrem.

10^{-3} = conversion factor for rem/mrem.

For population doses resulting from fish ingestion the calculation assumes that all fish caught within a 50-mile radius downstream of BFN are consumed by local population. An additional 7-day decay term is added due to distribution time of sport fish. The general equation for calculating population doses, POPF, in man-rem from fish ingestion of all fish caught within a 50-mile radius downstream is:

$$POPF_t = \frac{453.6 * HVST\ APR}{10^3 * 10^3} \sum_{r=1}^{4} \sum_{a=1}^{3} \frac{TFDOS_{art} * POP_a}{FISH_a * POP_a} \qquad (2.18)$$

where:

$POPF_t$ = total fish ingestion population dose to organ t, man-rem.

HVST = fish harvest for the Tennessee River, 8.32 lbs/acre/year.

APR = size of reach, acres (Table 2.1).

$TFDOS_{art}$ = total fish ingestion dose to organ t for reach r, for the age group a, as described in Section 2.3.3.2, mrem.

POP_a = fraction of population in each age group a, as given above.

$FISH_a$ = amount of fish ingested by each age group a, kg/year. The average fish ingestion rates (R.G. 1.109 Table E-4) are:

Adult = 6.9
Child = 2.2
Teen = 5.2

453.6 = conversion factor, g/lb.

10^3 = conversion factor, mrem/rem.

10^3 = conversion factor, g/kg.

For recreation shoreline, the general equation used for calculating the population doses, POPR, in man-rem is:

$$POPR_t = \frac{REQFRA}{10^3 * 8760} \sum_{r=1}^{4} TSHDOS_{rt}\, SHVIS_r\, HRSVIS_r \qquad (2.19)$$

where:

$POPR_t$ = total recreation population dose for all reaches to organ t, man-rem.

REQFRA = fraction of yearly recreation which occurs in that quarter,as given in Section 2.3.3.3.

$TSHDOS_{rt}$ = total shoreline dose rate for organ t, in reach r, mrem/h.

$SHVIS_r$ = shoreline visits per year at each reach r, (Table 2.1).

$HRSVIS_r$ = length of shoreline recreation visit at reach r, 5 hours.

10^3 = conversion factor, mrem/rem.

8760 = conversion factor, hours/year.

2.4 Operability of Liquid Radwaste Equipment

The Radiological Effluent Manual (REM) requires that the liquid radwaste system (Figure 2.3) shall be used to reduce the radioactive materials in liquid wastes prior to their discharge when the projected dose due to liquid effluent releases* to unrestricted areas (see Figure 2.1) when averaged over 31 days would exceed 0.06 mrem to the total body or 0.21 mrem to any organ. Doses will be projected monthly.

Dose projections will be done by averaging the calculated dose for the most recent month and the calculated dose for the previous month and assigning that average dose as the projection for the current month.

2.5 Liquid Dose Factor Equations

2.5.1 WATER INGESTION DOSE FACTORS - A_{Wit} (mrem/hr per µCi/ml)

$$A_{Wit} = \frac{DF_{Liat}\ U_{wa}\ 10^6\ 10^3}{8760}$$

where:

DF_{Liat} = ingestion dose conversion factor for nuclide i, age group a, organ t, mrem/pCi, (Table 1.7).

U_{wa} = water consumption rate for age group a, L/year, (Table 1.9).

10^6 = conversion factor, pCi/µCi.

10^3 = conversion factor, ml/L.

8760 = conversion factor, hours per year.

2.5.2 FISH INGESTION DOSE FACTORS - A_{Fit} (mrem/hr per µCi/ml)

$$A_{Fit} = \frac{DF_{Liat}\ U_{fa}\ B_i\ 10^6\ 10^3}{8760}$$

where:

DF_{Liat} = ingestion dose conversion factor for nuclide i, age group a, organ t, mrem/pCi, (Table 1.7).

U_{fa} = fish consumption rate for age group a, kg/year, (Table 1.9).

B_i = bioaccumulation factor for nuclide i, pCi/kg per pCi/L, (Table 2.2).

*Per operating reactor unit.

10^6 = conversion factor, pCi/µCi.

10^3 = conversion factor, ml/L.

8760 = conversion factor, hours per year.

2.5.3 SHORELINE RECREATION DOSE FACTOR - A_{Rit} (mrem/hr per µCi/ml).

$$A_{Rit} = \frac{DF_{Git}\ K_c\ M\ W\ 10^3\ 10^6\ U}{8760 * 3600\ \lambda_i}\ [1-\exp(-\lambda_i\ t_b)]$$

where:

DF_{Git} = dose conversion factor for standing on contaminated ground for nuclide i and organ t (total body and skin), mrem/hr per pCi/m², (Table 1.11).

K_c = transfer coefficient from water to shoreline sediment, L/kg-hr, (Table 1.9).

M = mass density of sediment, kg/m², (Table 1.9).

W = shoreline width factor, dimensionless, (Table 1.9).

10^3 = conversion factor, ml/L.

10^6 = conversion factor, pCi/µCi.

3600 = conversion factor, seconds/hour.

λ_i = decay constant for nuclide i, seconds^{-1}, (Table 1.8).

t_b = time shoreline is exposed to the concentration in the water, seconds, (Table 1.9).

U = usage factor, 500 hours/year.

8760 = conversion factor, hours/year.

3.0 Radiological Environmental Monitoring

3.1 Monitoring Program

An environmental radiological monitoring program as described in Tables 3.1 and 3.2 and in Figures 3.1, 3.2, 3.3, and 3.4 shall be conducted. Results of this program shall be reported in accordance with Section F-1 of the REM.

The atmospheric environmental radiological monitoring program shall consist of 10 monitoring stations from which samples of air particulates and radioiodine shall be collected.

The terrestrial monitoring program shall consist of the collection of vegetation, milk, soil, drinking water, and food crops. In addition, direct gamma radiation levels will be measured at 40 or more locations in the vicinity of the plant.

The reservoir sampling program shall consist of the collection of samples of surface water, sediment, and fish.

Deviations are permitted from the required sampling schedule if specimens are unobtainable due to hazardous conditions, sample unavilability, or malfunction of sampling equipment. If the latter, every effort shall be made to complete corrective action prior to the end of the next sampling period.

3.2 Detection Capabilities

Analytical techniques shall be such that the detection capabilities listed in Table 3.3 are achieved.

3.3 Nonroutine Reports

Nonroutine reports shall be submitted pursuant to Section F-3 of the REM.

4.0 Annual Maximum Individual Doses - Total

To determine compliance with 40 CFR 190, the annual dose contributions to the maximum individual from BFN radioactive effluents and all other nearby uranium fuel cycle sources will be considered. The annual dose to the maximum individual will be conservatively estimated by: first, summing the total body air submersion dose, and the critical organ dose (except thyroid) from gaseous effluents; the total body dose, and critical organ dose (except thyroid) from liquid effluents for each quarter calculated in accordance with sections 1.3 and 2.3.3. Then to this sum for each quarter is added any identifiable increase in direct radiation dose levels attributable to the plant as determined by the environmental monitoring program outlined in section 3.0. These quarterly sums are then conservatively summed for the four calendar quarters to estimate the maximum individual dose for the year. This dose is compared to the limit of Technical Specification 4.8.C, i.e., 25 mrem per year to the total body or any organ (except thyroid), to determine compliance.

The total annual thyroid dose to the maximum individual will be conservatively estimated in the following manner. For each calendar quarter, a total dose will be obtained by summing the total body gaseous submersion dose, the gaseous thyroid dose, the liquid total body dose, and the liquid thyroid dose. To this sum for each quarter is added any identifiable increase in direct radiation dose levels attributable to the

plant as determined by the environmental monitoring program outlined in section 3.0. These quarterly sums are then added together to estimate the maximum individual thyroid dose for the year. This dose is compared to the limit of Technical Specification 4.8.C, i.e., 75 mrem per year to determine compliance.

Table 1.1
BFN - OFFSITE RECEPTOR LOCATION DATA

POINT	DISTANCE from plant (m)		Elev above plant grade (m)	GROUND LEVEL X/Q (s/m^3)	GROUND LEVEL D/Q ($1/m^2$)	ELEVATED X/Q (s/m^3)	ELEVATED D/Q (1/m2)
Site Boundary	1525	N	7	1.60E-06	5.64E-09	9.79E-11	8.57E-10
Site Boundary	1300	NNE	4	7.88E-07	1.97E-09	7.86E-12	5.24E-10
Site Boundary	1250	NE	7	4.52E-07	1.56E-09	5.91E-12	4.66E-10
Site Boundary	1450	ENE	0	7.30E-07	2.92E-09	1.37E-11	4.11E-10
Site Boundary	1375	E	0	8.24E-07	4.04E-09	8.84E-12	4.75E-10
Site Boundary	1575	ESE	0	4.56E-07	3.28E-09	4.98E-11	5.98E-10
Site Boundary	5600	SE	-6	7.61E-08	3.63E-10	7.24E-09	3.00E-10
Site Boundary	2875	SSE	-6	4.86E-07	1.77E-09	1.58E-09	5.59E-10
Site Boundary	2550	S	-6	8.27E-07	2.24E-09	1.12E-09	6.67E-10
Site Boundary	2425	SSW	-6	1.08E-06	2.92E-09	9.27E-10	7.07E-10
Site Boundary	2300	SW	-6	6.87E-07	1.75E-09	5.94E-10	6.06E-10
Site Boundary	2500	WSW	-6	6.38E-07	1.14E-09	5.34E-10	3.45E-10
Site Boundary	2550	W	-6	6.70E-07	1.25E-09	5.06E-10	2.74E-10
Site Boundary	3325	WNW	-6	3.69E-07	9.07E-10	2.69E-09	4.75E-10
Site Boundary	2275	NW	-6	1.69E-06	4.92E-09	1.10E-09	1.24E-09
Site Boundary	1650	NNW	-6	1.84E-06	5.29E-09	1.31E-10	1.05E-09
Garden	1830	NNW	-6	1.57E-06	4.46E-09	3.29E-10	1.13E-09
Milk Cow	8045	N	-6	1.47E-07	3.16E-10	N/A	2.30E-10
Milk Cow	10975	NNW	-6	N/A	N/A	1.69E-08	N/A

NOTE: For quarterly dose calculations, doses will also be calculated for all locations identified in the most recent land use census, and for any additional points deemed necessary.

Table 1.4

DOSE FACTORS FOR SUBMERSION IN NOBLE GASES

	Submersion dose mrem/yr per µCi/m³		Air dose mrad/yr per µCi/m³	
	DFB_i	DFS_i	$DF_{\gamma i}$	$DF_{\beta i}$
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

Reference:
Regulatory Guide 1.109, Table B-1.

Table 1.7 (1 of 8)
INGESTION DOSE FACTORS
(mrem/pCi ingested)

ADULT

	bone	liver	t body	thyroid	kidney	lung	gi-lli
H-3	1.05E-07	1.05E-07	1.05E-07	1.05E-07	1.05E-07	1.05E-07	1.05E-07
C-14	2.84E-06	5.68E-07	5.68E-07	5.68E-07	5.68E-07	5.68E-07	5.68E-07
Na-24	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06
P-32	1.93E-04	1.20E-05	7.46E-06	0.00E+00	0.00E+00	0.00E+00	2.17E-05
Cr-51	0.00E+00	0.00E+00	2.66E-09	1.59E-09	5.86E-10	3.53E-09	6.69E-07
Mn-54	0.00E+00	4.57E-06	8.72E-07	0.00E+00	1.36E-06	0.00E+00	1.40E-05
Mn-56	0.00E+00	1.15E-07	2.04E-08	0.00E+00	1.46E-07	0.00E+00	3.67E-06
Fe-55	2.75E-06	1.90E-06	4.43E-07	0.00E+00	0.00E+00	1.06E-06	1.09E-06
Fe-59	4.34E-06	1.02E-05	3.91E-06	0.00E+00	0.00E+00	2.85E-06	3.40E-05
Co-57	0.00E+00	1.75E-07	2.91E-07	0.00E+00	0.00E+00	0.00E+00	4.44E-06
Co-58	0.00E+00	7.45E-07	1.67E-06	0.00E+00	0.00E+00	0.00E+00	1.51E-05
Co-60	0.00E+00	2.14E-06	4.72E-06	0.00E+00	0.00E+00	0.00E+00	4.02E-05
Ni-63	1.30E-04	9.01E-06	4.36E-06	0.00E+00	0.00E+00	0.00E+00	1.88E-06
Ni-65	5.28E-07	6.86E-08	3.13E-08	0.00E+00	0.00E+00	0.00E+00	1.74E-06
Cu-64	0.00E+00	8.33E-08	3.91E-08	0.00E+00	2.10E-07	0.00E+00	7.10E-06
Zn-65	4.84E-06	1.54E-05	6.96E-06	0.00E+00	1.03E-05	0.00E+00	9.70E-06
Zn-69	1.03E-08	1.97E-08	1.37E-09	0.00E+00	1.28E-08	0.00E+00	2.96E-09
Zn-69m	1.70E-07	4.08E-07	3.73E-08	0.00E+00	2.47E-07	0.00E+00	2.49E-05
Br-82	0.00E+00	0.00E+00	2.26E-06	0.00E+00	0.00E+00	0.00E+00	2.59E-06
Br-83	0.00E+00	0.00E+00	4.02E-08	0.00E+00	0.00E+00	0.00E+00	5.79E-08
Br-84	0.00E+00	0.00E+00	5.21E-08	0.00E+00	0.00E+00	0.00E+00	4.09E-13
Br-85	0.00E+00	0.00E+00	2.14E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	2.11E-05	9.83E-06	0.00E+00	0.00E+00	0.00E+00	4.16E-06
Rb-88	0.00E+00	6.05E-08	3.21E-08	0.00E+00	0.00E+00	0.00E+00	8.36E-19
Rb-89	0.00E+00	4.01E-08	2.82E-08	0.00E+00	0.00E+00	0.00E+00	2.33E-21
Sr-89	3.08E-04	0.00E+00	8.84E-06	0.00E+00	0.00E+00	0.00E+00	4.94E-05
Sr-90	7.58E-03	0.00E+00	1.86E-03	0.00E+00	0.00E+00	0.00E+00	2.19E-04
Sr-91	5.67E-06	0.00E+00	2.29E-07	0.00E+00	0.00E+00	0.00E+00	2.70E-05
Sr-92	2.15E-06	0.00E+00	9.30E-08	0.00E+00	0.00E+00	0.00E+00	4.26E-05
Y-90	9.62E-09	0.00E+00	2.58E-10	0.00E+00	0.00E+00	0.00E+00	1.02E-04
Y-91m	9.09E-11	0.00E+00	3.52E-12	0.00E+00	0.00E+00	0.00E+00	2.67E-10
Y-91	1.41E-07	0.00E+00	3.77E-09	0.00E+00	0.00E+00	0.00E+00	7.76E-05
Y-92	8.45E-10	0.00E+00	2.47E-11	0.00E+00	0.00E+00	0.00E+00	1.48E-05
Y-93	2.68E-09	0.00E+00	7.40E-11	0.00E+00	0.00E+00	0.00E+00	8.50E-05
Zr-95	3.04E-08	9.75E-09	6.60E-09	0.00E+00	1.53E-08	0.00E+00	3.09E-05
Zr-97	1.68E-09	3.39E-10	1.55E-10	0.00E+00	5.12E-10	0.00E+00	1.05E-04
Nb-95	6.22E-09	3.46E-09	1.86E-09	0.00E+00	3.42E-09	0.00E+00	2.10E-05
Nb-97	5.22E-11	1.32E-11	4.82E-12	0.00E+00	1.54E-11	0.00E+00	4.87E-08
Mo-99	0.00E+00	4.31E-06	8.20E-07	0.00E+00	9.76E-06	0.00E+00	9.99E-06
Tc-99m	2.47E-10	6.98E-10	8.89E-09	0.00E+00	1.06E-08	3.42E-10	4.13E-07
Tc-101	2.54E-10	3.66E-10	3.59E-09	0.00E+00	6.59E-09	1.87E-10	1.10E-21
Ru-103	1.85E-07	0.00E+00	7.97E-08	0.00E+00	7.06E-07	0.00E+00	2.16E-05
Ru-105	1.54E-08	0.00E+00	6.08E-09	0.00E+00	1.99E-07	0.00E+00	9.42E-06
Ru-106	2.75E-06	0.00E+00	3.48E-07	0.00E+00	5.31E-06	0.00E+00	1.78E-04
Ag-110m	1.60E-07	1.48E-07	8.79E-08	0.00E+00	2.91E-07	0.00E+00	6.04E-05

Table 1.7 (2 of 8)
INGESTION DOSE FACTORS
(mrem/pCi ingested)

ADULT

	bone	liver	t body	thyroid	kidney	lung	gi-lli
Sb-124	2.80E-06	5.29E-08	1.11E-06	6.79E-09	0.00E-00	2.18E-06	7.95E-05
Sb-125	1.79E-06	2.00E-08	4.26E-07	1.82E-09	0.00E-00	1.38E-06	1.97E-05
Te-125m	2.68E-06	9.71E-07	3.59E-07	8.06E-07	1.09E-05	0.00E+00	1.07E-05
Te-127m	6.77E-06	2.42E-06	8.25E-07	1.73E-06	2.75E-05	0.00E+00	2.27E-05
Te-127	1.10E-07	3.95E-08	2.38E-08	8.15E-08	4.48E-07	0.00E+00	8.68E-06
Te-129m	1.15E-05	4.29E-06	1.82E-06	3.95E-06	4.80E-05	0.00E+00	5.79E-05
Te-129	3.14E-08	1.18E-08	7.65E-09	2.41E-08	1.32E-07	0.00E+00	2.37E-08
Te-131m	1.73E-06	8.46E-07	7.05E-07	1.34E-06	8.57E-06	0.00E+00	8.40E-05
Te-131	1.97E-08	8.23E-09	6.22E-09	1.62E-08	8.63E-08	0.00E+00	2.79E-09
Te-132	2.52E-06	1.63E-06	1.53E-06	1.80E-06	1.57E-05	0.00E+00	7.71E-05
I-130	7.56E-07	2.23E-06	8.80E-07	1.89E-04	3.48E-06	0.00E+00	1.92E-06
I-131	4.16E-06	5.95E-06	3.41E-06	1.95E-03	1.02E-05	0.00E+00	1.57E-06
I-132	2.03E-07	5.43E-07	1.90E-07	1.90E-05	8.65E-07	0.00E+00	1.02E-07
I-133	1.42E-06	2.47E-06	7.53E-07	3.63E-04	4.31E-06	0.00E+00	2.22E-06
I-134	1.06E-07	2.88E-07	1.03E-07	4.99E-06	4.58E-07	0.00E+00	2.51E-10
I-135	4.43E-07	1.16E-06	4.28E-07	7.65E-05	1.86E-06	0.00E+00	1.31E-06
Cs-134	6.22E-05	1.48E-04	1.21E-04	0.00E+00	4.79E-05	1.59E-05	2.59E-06
Cs-136	6.51E-06	2.57E-05	1.85E-05	0.00E+00	1.43E-05	1.96E-06	2.92E-06
Cs-137	7.97E-05	1.09E-04	7.14E-05	0.00E+00	3.70E-05	1.23E-05	2.11E-06
Cs-138	5.52E-08	1.09E-07	5.40E-08	0.00E+00	8.01E-08	7.91E-09	4.65E-13
Ba-139	9.70E-08	6.91E-11	2.84E-09	0.00E+00	6.46E-11	3.92E-11	1.72E-07
Ba-140	2.03E-05	2.55E-08	1.33E-06	0.00E+00	8.67E-09	1.46E-08	4.18E-05
Ba-141	4.71E-08	3.56E-11	1.59E-09	0.00E+00	3.31E-11	2.02E-11	2.22E-17
Ba-142	2.13E-08	2.19E-11	1.34E-09	0.00E+00	1.85E-11	1.24E-11	3.00E-26
La-140	2.50E-09	1.26E-09	3.33E-10	0.00E+00	0.00E+00	0.00E+00	9.25E-05
La-142	1.28E-10	5.82E-11	1.45E-11	0.00E+00	0.00E+00	0.00E+00	4.25E-07
Ce-141	9.36E-09	6.33E-09	7.18E-10	0.00E+00	2.94E-09	0.00E+00	2.42E-05
Ce-143	1.65E-09	1.22E-06	1.35E-10	0.00E+00	5.37E-10	0.00E+00	4.56E-05
Ce-144	4.88E-07	2.04E-07	2.62E-08	0.00E+00	1.21E-07	0.00E+00	1.65E-04
Pr-143	9.20E-09	3.69E-09	4.56E-10	0.00E+00	2.13E-09	0.00E+00	4.03E-05
Pr-144	3.01E-11	1.25E-11	1.53E-12	0.00E+00	7.05E-12	0.00E+00	4.33E-18
Nd-147	6.29E-09	7.27E-09	4.35E-10	0.00E+00	4.25E-09	0.00E+00	3.49E-05
W-187	1.03E-07	8.61E-08	3.01E-08	0.00E+00	0.00E+00	0.00E+00	2.82E-05
Np-239	1.19E-09	1.17E-10	6.45E-11	0.00E+00	3.65E-10	0.00E+00	2.40E-05

References:

Regulatory Guide 1.109, Table E-11.

Dose Factors for Co-57, Zn-69m, Br-82, Nb-97, Sb-124 and Sb-125 are from NUREG-0172 Age Specific Radiation Dose Commitment Factors for a One Year Chronic Intake,, November, 1977, Table 4.

NOTE: The tritium dose factor for bone is assumed to be equal to the total body dose factor.

Table 1.7 (3 of 8)
INGESTION DOSE FACTORS
(mrem/pCi ingested)

TEEN

	bone	liver	t body	thyroid	kidney	lung	gi-lli
H-3	1.06E-07	1.06E-07	1.06E-07	1.06E-07	1.06E-07	1.06E-07	1.06E-07
C-14	4.06E-06	8.12E-07	8.12E-07	8.12E-07	8.12E-07	8.12E-07	8.12E-07
Na-24	2.30E-06	2.30E-06	2.30E-06	2.30E-06	2.30E-06	2.30E-06	2.30E-06
P-32	2.76E-04	1.71E-05	1.07E-05	0.00E+00	0.00E+00	0.00E+00	2.32E-05
Cr-51	0.00E+00	0.00E+00	3.60E-09	2.00E-09	7.89E-10	5.14E-09	6.05E-07
Mn-54	0.00E+00	5.90E-06	1.17E-06	0.00E+00	1.76E-06	0.00E+00	1.21E-05
Mn-56	0.00E+00	1.58E-07	2.81E-08	0.00E+00	2.00E-07	0.00E+00	1.04E-05
Fe-55	3.78E-06	2.68E-06	6.25E-07	0.00E+00	0.00E+00	1.70E-06	1.16E-06
Fe-59	5.87E-06	1.37E-05	5.29E-06	0.00E+00	0.00E+00	4.32E-06	3.24E-05
Co-57	0.00E+00	2.38E-07	3.99E-07	0.00E+00	0.00E+00	0.00E+00	4.44E-06
Co-58	0.00E+00	9.72E-07	2.24E-06	0.00E+00	0.00E+00	0.00E+00	1.34E-05
Co-60	0.00E+00	2.81E-06	6.33E-06	0.00E+00	0.00E+00	0.00E+00	3.66E-05
Ni-63	1.77E-04	1.25E-05	6.00E-06	0.00E+00	0.00E+00	0.00E+00	1.99E-06
Ni-65	7.49E-07	9.57E-08	4.36E-08	0.00E+00	0.00E+00	0.00E+00	5.19E-06
Cu-64	0.00E+00	1.15E-07	5.41E-08	0.00E+00	2.91E-07	0.00E+00	8.92E-06
Zn-65	5.76E-06	2.00E-05	9.33E-06	0.00E+00	1.28E-05	0.00E+00	8.47E-06
Zn-69	1.47E-08	2.80E-08	1.96E-09	0.00E+00	1.83E-08	0.00E+00	5.16E-08
Zn-69m	2.40E-07	5.66E-07	5.19E-08	0.00E+00	3.44E-07	0.00E+00	3.11E-05
Br-82	0.00E+00	0.00E+00	3.04E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-83	0.00E+00	0.00E+00	5.74E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	7.22E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	3.05E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	2.98E-05	1.40E-05	0.00E+00	0.00E+00	0.00E+00	4.41E-06
Rb-88	0.00E+00	8.52E-08	4.54E-08	0.00E+00	0.00E+00	0.00E+00	7.30E-15
Rb-89	0.00E+00	5.50E-08	3.89E-08	0.00E+00	0.00E+00	0.00E+00	8.43E-17
Sr-89	4.40E-04	0.00E+00	1.26E-05	0.00E+00	0.00E+00	0.00E+00	5.24E-05
Sr-90	8.30E-03	0.00E+00	2.05E-03	0.00E+00	0.00E+00	0.00E+00	2.33E-04
Sr-91	8.07E-06	0.00E+00	3.21E-07	0.00E+00	0.00E+00	0.00E+00	3.66E-05
Sr-92	3.05E-06	0.00E+00	1.30E-07	0.00E+00	0.00E+00	0.00E+00	7.77E-05
Y-90	1.37E-08	0.00E+00	3.69E-10	0.00E+00	0.00E+00	0.00E+00	1.13E-04
Y-91m	1.29E-10	0.00E+00	4.93E-12	0.00E+00	0.00E+00	0.00E+00	6.09E-09
Y-91	2.01E-07	0.00E+00	5.39E-09	0.00E+00	0.00E+00	0.00E+00	8.24E-05
Y-92	1.21E-09	0.00E+00	3.50E-11	0.00E+00	0.00E+00	0.00E+00	3.32E-05
Y-93	3.83E-09	0.00E+00	1.05E-10	0.00E+00	0.00E+00	0.00E+00	1.17E-04
Zr-95	4.12E-08	1.30E-08	8.94E-09	0.00E+00	1.91E-08	0.00E+00	3.00E-05
Zr-97	2.37E-09	4.69E-10	2.16E-10	0.00E+00	7.11E-10	0.00E+00	1.27E-04
Nb-95	8.22E-09	4.56E-09	2.51E-09	0.00E+00	4.42E-09	0.00E+00	1.95E-05
Nb-97	7.37E-11	1.83E-11	6.68E-12	0.00E+00	2.14E-11	0.00E+00	4.37E-07
Mo-99	0.00E+00	6.03E-06	1.15E-06	0.00E+00	1.38E-05	0.00E+00	1.08E-05
Tc-99m	3.32E-10	9.26E-10	1.20E-08	0.00E+00	1.38E-08	5.14E-10	6.08E-07
Tc-101	3.60E-10	5.12E-10	5.03E-09	0.00E+00	9.26E-09	3.12E-10	8.75E-17
Ru-103	2.55E-07	0.00E+00	1.09E-07	0.00E+00	8.99E-07	0.00E+00	2.13E-05
Ru-105	2.18E-08	0.00E+00	8.46E-09	0.00E+00	2.75E-07	0.00E+00	1.76E-05
Ru-106	3.92E-06	0.00E+00	4.94E-07	0.00E+00	7.56E-06	0.00E+00	1.88E-04
Ag-110m	2.05E-07	1.94E-07	1.18E-07	0.00E+00	3.70E-07	0.00E+00	5.45E-05

Table 1.7 (4 of 8)
INGESTION DOSE FACTORS
(mrem/pCi ingested)

TEEN

	bone	liver	t body	thyroid	kidney	lung	gi-lli
Sb-124	3.87E-06	7.13E-08	1.51E-06	8.78E-09	0.00E-00	3.38E-06	7.80E-05
Sb-125	2.48E-06	2.71E-08	5.80E-07	2.37E-09	0.00E+00	2.18E-06	1.93E-05
Te-125m	3.83E-06	1.38E-06	5.12E-07	1.07E-06	0.00E+00	0.00E+00	1.13E-05
Te-127m	9.67E-06	3.43E-06	1.15E-06	2.30E-06	3.92E-05	0.00E+00	2.41E-05
Te-127	1.58E-07	5.60E-08	3.40E-08	1.09E-07	6.40E-07	0.00E+00	1.22E-05
Te-129m	1.63E-05	6.05E-06	2.58E-06	5.26E-06	6.82E-05	0.00E+00	6.12E-05
Te-129	4.48E-08	1.67E-08	1.09E-08	3.20E-08	1.88E-07	0.00E+00	2.45E-07
Te-131m	2.44E-06	1.17E-06	9.76E-07	1.76E-06	1.22E-05	0.00E+00	9.39E-05
Te-131	2.79E-08	1.15E-08	8.72E-09	2.15E-08	1.22E-07	0.00E+00	2.29E-09
Te-132	3.49E-06	2.21E-06	2.08E-06	2.33E-06	2.12E-05	0.00E+00	7.00E-05
I-130	1.03E-06	2.98E-06	1.19E-06	2.43E-04	4.59E-06	0.00E+00	2.29E-06
I-131	5.85E-06	8.19E-06	4.40E-06	2.39E-03	1.41E-05	0.00E+00	1.62E-06
I-132	2.79E-07	7.30E-07	2.62E-07	2.46E-05	1.15E-06	0.00E+00	3.18E-07
I-133	2.01E-06	3.41E-06	1.04E-06	4.76E-04	5.98E-06	0.00E+00	2.58E-06
I-134	1.46E-07	3.87E-07	1.39E-07	6.45E-06	6.10E-07	0.00E+00	5.10E-09
I-135	6.10E-07	1.57E-06	5.82E-07	1.01E-04	2.48E-06	0.00E+00	1.74E-06
Cs-134	8.37E-05	1.97E-04	9.14E-05	0.00E+00	6.26E-05	2.39E-05	2.45E-06
Cs-136	8.59E-06	3.38E-05	2.27E-05	0.00E+00	1.84E-05	2.90E-06	2.72E-06
Cs-137	1.12E-04	1.49E-04	5.19E-05	0.00E+00	5.07E-05	1.97E-05	2.12E-06
Cs-138	7.76E-08	1.49E-07	7.45E-08	0.00E+00	1.10E-07	1.28E-08	6.76E-11
Ba-139	1.39E-07	9.78E-11	4.05E-09	0.00E+00	9.22E-11	6.74E-11	1.24E-06
Ba-140	2.84E-05	3.48E-08	1.83E-06	0.00E+00	1.18E-08	2.34E-08	4.38E-05
Ba-141	6.71E-08	5.01E-11	2.24E-09	0.00E+00	4.65E-11	3.43E-11	1.43E-13
Ba-142	2.99E-08	2.99E-11	1.84E-09	0.00E+00	2.53E-11	1.99E-11	9.18E-20
La-140	3.48E-09	1.71E-09	4.55E-10	0.00E+00	0.00E+00	0.00E+00	9.82E-05
La-142	1.79E-10	7.95E-11	1.98E-11	0.00E+00	0.00E+00	0.00E+00	2.42E-06
Ce-141	1.33E-08	8.88E-09	1.02E-09	0.00E+00	4.18E-09	0.00E+00	2.54E-05
Ce-143	2.35E-09	1.71E-06	1.91E-10	0.00E+00	7.67E-10	0.00E+00	5.14E-05
Ce-144	6.96E-07	2.88E-07	3.74E-08	0.00E+00	1.72E-07	0.00E+00	1.75E-04
Pr-143	1.31E-08	5.23E-09	6.52E-10	0.00E+00	3.04E-09	0.00E+00	4.31E-05
Pr-144	4.30E-11	1.76E-11	2.18E-12	0.00E+00	1.01E-11	0.00E+00	4.74E-14
Nd-147	9.38E-09	1.02E-08	6.11E-10	0.00E+00	5.99E-09	0.00E+00	3.68E-05
W-187	1.46E-07	1.19E-07	4.17E-08	0.00E+00	0.00E+00	0.00E+00	3.22E-05
Np-239	1.76E-09	1.66E-10	9.22E-11	0.00E+00	5.21E-10	0.00E+00	2.67E-05

References:

Regulatory Guide 1.109, Table E-12.

Dose Factors for Co-57, Zn-69m, Br-82, Nb-97, Sb-124 and Sb-125 are from NUREG-0172 Age Specific Radiation Dose Commitment Factors for a One Year Chronic Intake,, November, 1977, Table 3.

NOTE: The tritium dose factor for bone is assumed to be equal to the total body dose factor.

Table 1.7 (6 of 8)
INGESTION DOSE FACTORS
(mrem/pCi ingested)

CHILD

	bone	liver	t body	thyroid	kidney	lung	gi-lli
Sb-124	1.11E-05	1.44E-07	3.89E-06	2.45E-08	0.00E+00	6.16E-06	6.94E-05
Sb-125	7.16E-06	5.52E-08	1.50E-06	6.63E-09	0.00E+00	3.99E-06	1.71E-05
Te-125m	1.14E-05	3.09E-06	1.52E-06	3.20E-06	0.00E+00	0.00E+00	1.10E-05
Te-127m	2.89E-05	7.78E-06	3.43E-06	6.91E-06	8.24E-05	0.00E+00	2.34E-05
Te-127	4.71E-07	1.27E-07	1.01E-07	3.26E-07	1.34E-06	0.00E+00	1.84E-05
Te-129m	4.87E-05	1.36E-05	7.56E-06	1.57E-05	1.43E-04	0.00E+00	5.94E-05
Te-129	1.34E-07	3.74E-08	3.18E-08	9.56E-08	3.92E-07	0.00E+00	8.34E-06
Te-131m	7.20E-06	2.49E-06	2.65E-06	5.12E-06	2.41E-05	0.00E+00	1.01E-04
Te-131	8.30E-08	2.53E-08	2.47E-08	6.35E-08	2.51E-07	0.00E+00	4.36E-07
Te-132	1.01E-05	4.47E-06	5.40E-06	6.51E-06	4.15E-05	0.00E+00	4.50E-05
I-130	2.92E-06	5.90E-06	3.04E-06	6.50E-04	8.82E-06	0.00E+00	2.76E-06
I-131	1.72E-05	1.73E-05	9.83E-06	5.72E-03	2.84E-05	0.00E+00	1.54E-06
I-132	8.00E-07	1.47E-06	6.76E-07	6.82E-05	2.25E-06	0.00E+00	1.73E-06
I-133	5.92E-06	7.32E-06	2.77E-06	1.36E-03	1.22E-05	0.00E+00	2.95E-06
I-134	4.19E-07	7.78E-07	3.58E-07	1.79E-05	1.19E-06	0.00E+00	5.16E-07
I-135	1.75E-06	3.15E-06	1.49E-06	2.79E-04	4.83E-06	0.00E+00	2.40E-06
Cs-134	2.34E-04	3.84E-04	8.10E-05	0.00E+00	1.19E-04	4.27E-05	2.07E-06
Cs-136	2.35E-05	6.46E-05	4.18E-05	0.00E+00	3.44E-05	5.13E-06	2.27E-06
Cs-137	3.27E-04	3.13E-04	4.62E-05	0.00E+00	1.02E-04	3.67E-05	1.96E-06
Cs-138	2.28E-07	3.17E-07	2.01E-07	0.00E+00	2.23E-07	2.40E-08	1.46E-07
Ba-139	4.14E-07	2.21E-10	1.20E-08	0.00E+00	1.93E-10	1.30E-10	2.39E-05
Ba-140	8.31E-05	7.28E-08	4.85E-06	0.00E+00	2.37E-08	4.34E-08	4.21E-05
Ba-141	2.00E-07	1.12E-10	6.51E-09	0.00E+00	9.69E-11	6.58E-10	1.14E-07
Ba-142	8.74E-08	6.29E-11	4.88E-09	0.00E+00	5.09E-11	3.70E-11	1.14E-09
La-140	1.01E-08	3.53E-09	1.19E-09	0.00E+00	0.00E+00	0.00E+00	9.84E-05
La-142	5.24E-10	1.67E-10	5.23E-11	0.00E+00	0.00E+00	0.00E+00	3.31E-05
Ce-141	3.97E-08	1.98E-08	2.94E-09	0.00E+00	8.68E-09	0.00E+00	2.47E-05
Ce-143	6.99E-09	3.79E-06	5.49E-10	0.00E+00	1.59E-09	0.00E+00	5.55E-05
Ce-144	2.08E-06	6.52E-07	1.11E-07	0.00E+00	3.61E-07	0.00E+00	1.70E-04
Pr-143	3.93E-08	1.18E-08	1.95E-09	0.00E+00	6.39E-09	0.00E+00	4.24E-05
Pr-144	1.29E-10	3.99E-11	6.49E-12	0.00E+00	2.11E-11	0.00E+00	8.59E-08
Nd-147	2.79E-08	2.26E-08	1.75E-09	0.00E+00	1.24E-08	0.00E+00	3.58E-05
W-187	4.29E-07	2.54E-07	1.14E-07	0.00E+00	0.00E+00	0.00E+00	3.57E-05
Np-239	5.25E-09	3.77E-10	2.65E-10	0.00E+00	1.09E-09	0.00E+00	2.79E-05

References:

Regulatory Guide 1.109, Table E-13.

Dose Factors for Co-57, Zn-69m, Br-82, Nb-97, Sb-124 and Sb-125 are from NUREG-0172 Age Specific Radiation Dose Commitment Factors for a One Year Chronic Intake,, November, 1977, Table 2.

NOTE: The tritium dose factor for bone is assumed to be equal to the total body dose factor.

Table 1.7 (5 of 8)
INGESTION DOSE FACTORS
(mrem/pCi ingested)

CHILD

	bone	liver	t body	thyroid	kidney	lung	gi-lli
H-3	2.03E-07	2.03E-07	2.03E-07	2.03E-07	2.03E-07	2.03E-07	2.03E-07
C-14	1.21E-05	2.42E-06	2.42E-06	2.42E-06	2.42E-06	2.42E-06	2.42E-06
Na-24	5.80E-06	5.80E-06	5.80E-06	5.80E-06	5.80E-06	5.80E-06	5.80E-06
P-32	8.25E-04	3.86E-05	3.18E-05	0.00E+00	0.00E+00	0.00E+00	2.28E-05
Cr-51	0.00E+00	0.00E+00	8.90E-09	4.94E-09	1.35E-09	9.02E-09	4.72E-07
Mn-54	0.00E+00	1.07E-05	2.85E-06	0.00E+00	3.00E-06	0.00E+00	8.98E-06
Mn-56	0.00E+00	3.34E-07	7.54E-08	0.00E+00	4.04E-07	0.00E+00	4.84E-05
Fe-55	1.15E-05	6.10E-06	1.89E-06	0.00E+00	0.00E+00	3.45E-06	1.13E-06
Fe-59	1.65E-05	2.67E-05	1.33E-05	0.00E+00	0.00E+00	7.74E-06	2.78E-05
Co-57	0.00E+00	4.93E-07	9.98E-07	0.00E+00	0.00E+00	0.00E+00	4.04E-06
Co-58	0.00E+00	1.80E-06	5.51E-06	0.00E+00	0.00E+00	0.00E+00	1.05E-05
Co-60	0.00E+00	5.29E-06	1.56E-05	0.00E+00	0.00E+00	0.00E+00	2.93E-05
Ni-63	5.38E-04	2.88E-05	1.83E-05	0.00E+00	0.00E+00	0.00E+00	1.94E-06
Ni-65	2.22E-06	2.09E-07	1.22E-07	0.00E+00	0.00E+00	0.00E+00	2.56E-05
Cu-64	0.00E+00	2.45E-07	1.48E-07	0.00E+00	5.92E-07	0.00E+00	1.15E-05
Zn-65	1.37E-05	3.65E-05	2.27E-05	0.00E+00	2.30E-05	0.00E+00	6.41E-06
Zn-69	4.38E-08	6.33E-08	5.85E-09	0.00E+00	3.84E-08	0.00E+00	3.99E-06
Zn-69m	7.10E-07	1.21E-06	1.43E-07	0.00E+00	7.03E-07	0.00E+00	3.94E-05
Br-82	0.00E+00	0.00E+00	7.55E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-83	0.00E+00	0.00E+00	1.71E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	1.98E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	9.12E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	6.70E-05	4.12E-05	0.00E+00	0.00E+00	0.00E+00	4.31E-06
Rb-88	0.00E+00	1.90E-07	1.32E-07	0.00E+00	0.00E+00	0.00E+00	9.32E-09
Rb-89	0.00E+00	1.17E-07	1.04E-07	0.00E+00	0.00E+00	0.00E+00	1.02E-09
Sr-89	1.32E-03	0.00E+00	3.77E-05	0.00E+00	0.00E+00	0.00E+00	5.11E-05
Sr-90	1.70E-02	0.00E+00	4.31E-03	0.00E+00	0.00E+00	0.00E+00	2.29E-04
Sr-91	2.40E-05	0.00E+00	9.06E-07	0.00E+00	0.00E+00	0.00E+00	5.30E-05
Sr-92	9.03E-06	0.00E+00	3.62E-07	0.00E+00	0.00E+00	0.00E+00	1.71E-04
Y-90	4.11E-08	0.00E+00	1.10E-09	0.00E+00	0.00E+00	0.00E+00	1.17E-04
Y-91m	3.82E-10	0.00E+00	1.39E-11	0.00E+00	0.00E+00	0.00E+00	7.48E-07
Y-91	6.02E-07	0.00E+00	1.61E-08	0.00E+00	0.00E+00	0.00E+00	8.02E-05
Y-92	3.60E-09	0.00E+00	1.03E-10	0.00E+00	0.00E+00	0.00E+00	1.04E-04
Y-93	1.14E-08	0.00E+00	3.13E-10	0.00E+00	0.00E+00	0.00E+00	1.70E-04
Zr-95	1.16E-07	2.55E-08	2.27E-08	0.00E+00	3.65E-08	0.00E+00	2.66E-05
Zr-97	6.99E-09	1.01E-09	5.96E-10	0.00E+00	1.45E-09	0.00E+00	1.53E-04
Nb-95	2.25E-08	8.76E-09	6.26E-09	0.00E+00	8.23E-09	0.00E+00	1.62E-05
Nb-97	2.17E-10	3.92E-11	1.83E-11	0.00E+00	4.35E-11	0.00E+00	1.21E-05
Mo-99	0.00E+00	1.33E-05	3.29E-06	0.00E+00	2.84E-05	0.00E+00	1.10E-05
Tc-99m	9.23E-10	1.81E-09	3.00E-08	0.00E+00	2.63E-08	9.19E-10	1.03E-06
Tc-101	1.07E-09	1.12E-09	1.42E-08	0.00E+00	1.91E-08	5.92E-10	3.56E-09
Ru-103	7.31E-07	0.00E+00	2.81E-07	0.00E+00	1.84E-06	0.00E+00	1.89E-05
Ru-105	6.45E-08	0.00E+00	2.34E-08	0.00E+00	5.67E-07	0.00E+00	4.21E-05
Ru-106	1.17E-05	0.00E+00	1.46E-06	0.00E+00	1.58E-05	0.00E+00	1.82E-04
Ag-110m	5.39E-07	3.64E-07	2.91E-07	0.00E+00	6.78E-07	0.00E+00	4.33E-05

Table 1.7 (7 of 8)
INGESTION DOSE FACTORS
(mrem/pCi ingested)

INFANT

	bone	liver	t body	thyroid	kidney	lung	gi-lli
H-3	3.08E-07	3.08E-07	3.08E-07	3.08E-07	3.08E-07	3.08E-07	3.08E-07
C-14	2.37E-05	5.06E-06	5.06E-06	5.06E-06	5.06E-06	5.06E-06	5.06E-06
Na-24	1.01E-05	1.01E-05	1.01E-05	1.01E-05	1.01E-05	1.01E-05	1.01E-05
P-32	1.70E-03	1.00E-04	6.59E-05	0.00E+00	0.00E+00	0.00E+00	2.30E-05
Cr-51	0.00E+00	0.00E+00	1.41E-08	9.20E-09	2.01E-09	1.79E-08	4.11E-07
Mn-54	0.00E+00	1.99E-05	4.51E-06	0.00E+00	4.41E-06	0.00E+00	7.31E-06
Mn-56	0.00E+00	8.18E-07	1.41E-07	0.00E+00	7.03E-07	0.00E+00	7.43E-05
Fe-55	1.39E-05	8.98E-06	2.40E-06	0.00E+00	0.00E+00	4.39E-06	1.14E-06
Fe-59	3.08E-05	5.38E-05	2.12E-05	0.00E+00	0.00E+00	1.59E-05	2.57E-05
Co-57	0.00E+00	1.15E-06	1.87E-06	0.00E+00	0.00E+00	0.00E+00	3.92E-06
Co-58	0.00E+00	3.60E-06	8.98E-06	0.00E+00	0.00E+00	0.00E+00	8.97E-06
Co-60	0.00E+00	1.08E-05	2.55E-05	0.00E+00	0.00E+00	0.00E+00	2.57E-05
Ni-63	6.34E-04	3.92E-05	2.20E-05	0.00E+00	0.00E+00	0.00E+00	1.95E-06
Ni-65	4.70E-06	5.32E-07	2.42E-07	0.00E+00	0.00E+00	0.00E+00	4.05E-05
Cu-64	0.00E+00	6.09E-07	2.82E-07	0.00E+00	1.03E-06	0.00E+00	1.25E-05
Zn-65	1.84E-05	6.31E-05	2.91E-05	0.00E+00	3.06E-05	0.00E+00	5.33E-05
Zn-69	9.33E-08	1.68E-07	1.25E-08	0.00E+00	6.98E-08	0.00E+00	1.37E-05
Zn-69m	1.50E-06	3.06E-06	2.79E-07	0.00E+00	1.24E-06	0.00E+00	4.24E-05
Br-82	0.00E+00	0.00E+00	1.27E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-83	0.00E+00	0.00E+00	3.63E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	3.82E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	1.94E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	1.70E-04	8.40E-05	0.00E+00	0.00E+00	0.00E+00	4.35E-06
Rb-88	0.00E+00	4.98E-07	2.73E-07	0.00E+00	0.00E+00	0.00E+00	4.85E-07
Rb-89	0.00E+00	2.86E-07	1.97E-07	0.00E+00	0.00E+00	0.00E+00	9.74E-08
Sr-89	2.51E-03	0.00E+00	7.20E-05	0.00E+00	0.00E+00	0.00E+00	5.16E-05
Sr-90	1.85E-02	0.00E+00	4.71E-03	0.00E+00	0.00E+00	0.00E+00	2.31E-04
Sr-91	5.00E-05	0.00E+00	1.81E-06	0.00E+00	0.00E+00	0.00E+00	5.92E-05
Sr-92	1.92E-05	0.00E+00	7.13E-07	0.00E+00	0.00E+00	0.00E+00	2.07E-04
Y-90	8.69E-08	0.00E+00	2.33E-09	0.00E+00	0.00E+00	0.00E+00	1.20E-04
Y-91m	8.10E-10	0.00E+00	2.76E-11	0.00E+00	0.00E+00	0.00E+00	2.70E-06
Y-91	1.13E-06	0.00E+00	3.01E-08	0.00E+00	0.00E+00	0.00E+00	8.10E-05
Y-92	7.65E-09	0.00E+00	2.15E-10	0.00E+00	0.00E+00	0.00E+00	1.46E-04
Y-93	2.43E-08	0.00E+00	6.62E-10	0.00E+00	0.00E+00	0.00E+00	1.92E-04
Zr-95	2.06E-07	5.02E-08	3.56E-08	0.00E+00	5.41E-08	0.00E+00	2.50E-05
Zr-97	1.48E-08	2.54E-09	1.16E-09	0.00E+00	2.56E-09	0.00E+00	1.62E-04
Nb-95	4.20E-08	1.73E-08	1.00E-08	0.00E+00	1.24E-08	0.00E+00	1.46E-05
Nb-97	4.59E-10	9.79E-11	3.53E-11	0.00E+00	7.65E-11	0.00E+00	3.09E-05
Mo-99	0.00E+00	3.40E-05	6.63E-06	0.00E+00	5.08E-05	0.00E+00	1.12E-05
Tc-99m	1.92E-09	3.96E-09	5.10E-08	0.00E+00	4.26E-08	2.07E-09	1.15E-06
Tc-101	2.27E-09	2.86E-09	2.83E-08	0.00E+00	3.40E-08	1.56E-09	4.86E-07
Ru-103	1.48E-06	0.00E+00	4.95E-07	0.00E+00	3.08E-06	0.00E+00	1.80E-05
Ru-105	1.36E-07	0.00E+00	4.58E-08	0.00E+00	1.00E-06	0.00E+00	5.41E-05
Ru-106	2.41E-05	0.00E+00	3.01E-06	0.00E+00	2.85E-05	0.00E+00	1.83E-04
Ag-110m	9.96E-07	7.27E-07	4.81E-07	0.00E+00	1.04E-06	0.00E+00	3.77E-05

Table 1.7 (8 of 8)
INGESTION DOSE FACTORS
(mrem/pCi ingested)

INFANT

	bone	liver	t body	thyroid	kidney	lung	gi-lli
Sb-124	2.14E-05	3.15E-07	6.63E-06	5.68E-08	0.00E+00	1.34E-05	6.60E-05
Sb-125	1.23E-05	1.19E-07	2.53E-06	1.54E-08	0.00E+00	7.72E-06	1.64E-05
Te-125m	2.33E-05	7.79E-06	3.15E-06	7.84E-06	0.00E+00	0.00E+00	1.11E-05
Te-127m	5.85E-05	1.94E-05	7.08E-06	1.69E-05	1.44E-04	0.00E+00	2.36E-05
Te-127	1.00E-06	3.35E-07	2.15E-07	8.14E-07	2.44E-06	0.00E+00	2.10E-05
Te-129m	1.00E-04	3.43E-05	1.54E-05	3.84E-05	2.50E-04	0.00E+00	5.97E-05
Te-129	2.84E-07	9.79E-08	6.63E-08	2.38E-07	7.07E-07	0.00E+00	2.27E-05
Te-131m	1.52E-05	6.12E-06	5.05E-06	1.24E-05	4.21E-05	0.00E+00	1.03E-04
Te-131	1.76E-07	6.50E-08	4.94E-08	1.57E-07	4.50E-07	0.00E+00	7.11E-06
Te-132	2.08E-05	1.03E-05	9.61E-06	1.52E-05	6.44E-05	0.00E+00	3.81E-05
I-130	6.00E-06	1.32E-05	5.30E-06	1.48E-03	1.45E-05	0.00E+00	2.83E-06
I-131	3.59E-05	4.23E-05	1.86E-05	1.39E-02	4.94E-05	0.00E+00	1.51E-06
I-132	1.66E-06	3.37E-06	1.20E-06	1.58E-04	3.76E-06	0.00E+00	2.73E-06
I-133	1.25E-05	1.82E-05	5.33E-06	3.31E-03	2.14E-05	0.00E+00	3.08E-06
I-134	8.69E-07	1.78E-06	6.33E-07	4.15E-05	1.99E-06	0.00E+00	1.84E-06
I-135	3.64E-06	7.24E-06	2.64E-06	6.49E-04	8.07E-06	0.00E+00	2.62E-06
Cs-134	3.77E-04	7.03E-04	7.10E-05	0.00E+00	1.81E-04	7.42E-05	1.91E-06
Cs-136	4.59E-05	1.35E-04	5.04E-05	0.00E+00	5.38E-05	1.10E-05	2.05E-06
Cs-137	5.22E-04	6.11E-04	4.33E-05	0.00E+00	1.64E-04	6.64E-05	1.91E-06
Cs-138	4.81E-07	7.82E-07	3.79E-07	0.00E+00	3.90E-07	6.09E-08	1.25E-06
Ba-139	8.81E-07	5.84E-10	2.55E-08	0.00E+00	3.51E-10	3.54E-10	5.58E-05
Ba-140	1.71E-04	1.71E-07	8.81E-06	0.00E+00	4.06E-08	1.05E-07	4.20E-05
Ba-141	4.25E-07	2.91E-10	1.34E-08	0.00E+00	1.75E-10	1.77E-10	5.19E-06
Ba-142	1.84E-07	1.53E-10	9.06E-09	0.00E+00	8.81E-11	9.26E-11	7.59E-07
La-140	2.11E-08	8.32E-09	2.14E-09	0.00E+00	0.00E+00	0.00E+00	9.77E-05
La-142	1.10E-09	4.04E-10	9.67E-11	0.00E+00	0.00E+00	0.00E+00	6.86E-05
Ce-141	7.87E-08	4.80E-08	5.65E-09	0.00E+00	1.48E-08	0.00E+00	2.48E-05
Ce-143	1.48E-08	9.82E-06	1.12E-09	0.00E+00	2.86E-09	0.00E+00	5.73E-05
Ce-144	2.98E-06	1.22E-06	1.67E-07	0.00E+00	4.93E-07	0.00E+00	1.71E-04
Pr-143	8.13E-08	3.04E-08	4.03E-09	0.00E+00	1.13E-08	0.00E+00	4.29E-05
Pr-144	2.74E-10	1.06E-10	1.38E-11	0.00E+00	3.84E-11	0.00E+00	4.93E-06
Nd-147	5.53E-08	5.68E-08	3.48E-09	0.00E+00	2.19E-08	0.00E+00	3.60E-05
W-187	9.03E-07	6.28E-07	2.17E-07	0.00E+00	0.00E+00	0.00E+00	3.69E-05
Np-239	1.11E-08	9.93E-10	5.61E-10	0.00E+00	1.98E-09	0.00E+00	2.87E-05

References:

Regulatory Guide 1.109, Table E-14.

Dose Factors for Co-57, Zn-69m, Br-82, Nb-97, Sb-124 and Sb-125 are from NUREG-0172 Age Specific Radiation Dose Commitment Factors for a One Year Chronic Intake,, November, 1977, Table 1.

NOTE: The tritium dose factor for bone is assumed to be equal to the total body dose factor.

Table 1.8 (1 of 3)
RADIONUCLIDE DECAY AND STABLE ELEMENT TRANSFER DATA

	Half-Life (minutes)	λ (1/s)	B_{iv}	F_{mi} (cow)	F_{mi} (goat)	F_{fi} (beef)
H-3	6.46E+06	1.79E-09	4.80E+00	1.00E-02	1.70E-01	1.20E-02
C-14	3.01E+09	3.84E-12	5.50E+00	1.20E-02	1.00E-01	3.10E-02
Na-24	9.00E+02	1.28E-05	5.20E-02	4.00E-02	4.00E-02	3.00E-02
P-32	2.06E+04	5.61E-07	1.10E+00	2.50E-02	2.50E-01	4.60E-02
Cr-51	3.99E+04	2.90E-07	2.50E-04	2.20E-03	2.20E-03	2.40E-03
Mn-54	4.50E+05	2.57E-08	2.90E-02	2.50E-04	2.50E-04	8.00E-04
Mn-56	1.55E+02	7.45E-05	2.90E-02	2.50E-04	2.50E-04	8.00E-04
Fe-55	1.42E+06	8.13E-09	6.60E-04	1.20E-03	1.30E-04	1.20E-02
Fe-59	6.43E+04	1.80E-07	6.60E-04	1.20E-03	1.30E-04	1.20E-02
Co-57	3.90E+05	2.96E-08	9.40E-03	1.00E-03	1.00E-03	1.30E-02
Co-58	1.02E+05	1.13E-07	9.40E-03	1.00E-03	1.00E-03	1.30E-02
Co-60	2.77E+06	4.17E-09	9.40E-03	1.00E-03	1.00E-03	1.30E-02
Ni-63	5.27E+07	2.19E-10	1.90E-02	6.70E-03	6.70E-03	5.30E-02
Ni-65	1.51E+02	7.65E-05	1.90E-02	6.70E-03	6.70E-03	5.30E-02
Cu-64	7.62E+02	1.52E-05	1.20E-01	1.40E-02	1.30E-02	9.70E-04
Zn-65	3.52E+05	3.28E-08	4.00E-01	3.90E-02	3.90E-02	3.00E-02
Zn-69m	8.26E+02	1.40E-05	4.00E-01	3.90E-02	3.90E-02	3.00E-02
Zn-69	5.56E+01	2.08E-04	4.00E-01	3.90E-02	3.90E-02	3.00E-02
Br-82	2.12E+03	5.45E-06	7.60E-01	5.00E-02	5.00E-02	2.60E-02
Br-83	1.43E+02	8.08E-05	7.60E-01	5.00E-02	5.00E-02	2.60E-02
Br-84	3.18E+01	3.63E-04	7.60E-01	5.00E-02	5.00E-02	2.60E-02
Br-85	2.87E+00	4.02E-03	7.60E-01	5.00E-02	5.00E-02	2.60E-02
Rb-86	2.69E+04	4.29E-07	1.30E-01	3.00E-02	3.00E-02	3.10E-02
Rb-88	1.78E+01	6.49E-04	1.30E-01	3.00E-02	3.00E-02	3.10E-02
Rb-89	1.54E+01	7.50E-04	1.30E-01	3.00E-02	3.00E-02	3.10E-02
Sr-89	7.28E+04	1.59E-07	1.70E-02	1.40E-03	1.40E-02	6.00E-04
Sr-90	1.50E+07	7.70E-10	1.70E-02	1.40E-03	1.40E-02	6.00E-04
Sr-91	5.70E+02	2.03E-05	1.70E-02	1.40E-03	1.40E-02	6.00E-04
Sr-92	1.63E+02	7.09E-05	1.70E-02	1.40E-03	1.40E-02	6.00E-04
Y-90	3.85E+03	3.00E-06	2.60E-03	1.00E-05	1.00E-05	4.60E-03
Y-91m	4.97E+01	2.32E-04	2.60E-03	1.00E-05	1.00E-05	4.60E-03
Y-91	8.43E+04	1.37E-07	2.60E-03	1.00E-05	1.00E-05	4.60E-03
Y-92	2.12E+02	5.45E-05	2.60E-03	1.00E-05	1.00E-05	4.60E-03
Y-93	6.06E+02	1.91E-05	2.60E-03	1.00E-05	1.00E-05	4.60E-03
Zr-95	9.22E+04	1.25E-07	1.70E-04	5.00E-06	5.00E-06	3.40E-02
Zr-97	1.01E+03	1.14E-05	1.70E-04	5.00E-06	5.00E-06	3.40E-02
Nb-95	5.05E+04	2.29E-07	9.40E-03	2.50E-03	2.50E-03	2.80E-01
Nb-97	7.21E+01	1.60E-04	9.40E-03	2.50E-03	2.50E-03	2.80E-01
Mo-99	3.96E+03	2.92E-06	1.20E-01	7.50E-03	7.50E-03	1.10E-03
Tc-99m	3.61E+02	3.20E-05	2.50E-01	2.50E-02	2.50E-02	4.00E-01
Tc-101	1.42E+01	8.13E-04	2.50E-01	2.50E-02	2.50E-02	4.00E-01
Ru-103	5.67E+04	2.04E-07	5.00E-02	1.00E-06	1.00E-06	4.00E-01
Ru-105	2.66E+02	4.34E-05	5.00E-02	1.00E-06	1.00E-06	4.00E-01
Ru-106	5.30E+05	2.18E-08	5.00E-02	1.00E-06	1.00E-06	4.00E-01
Ag-110m	3.60E+05	3.21E-08	1.50E-01	5.00E-02	5.00E-02	1.70E-02

Table 1.8 (2 of 3)
RADIONUCLIDE DECAY AND STABLE ELEMENT TRANSFER DATA

	Half-Life (minutes)	λ (1/s)	B_{iv}	F_{mi} (cow)	F_{mi} (goat)	F_{fi} (beef)
Sb-124	8.67E+04	1.33E-07	N/A	1.50E-03	1.50E-03	N/A
Sb-125	1.46E+06	7.91E-09	N/A	1.50E-03	1.50E-03	N/A
Te-125m	8.35E+04	1.38E-07	1.30E+00	1.00E-03	1.00E-03	7.70E-02
Te-127m	1.57E+05	7.36E-08	1.30E+00	1.00E-03	1.00E-03	7.70E-02
Te-127	5.61E+02	2.06E-05	1.30E+00	1.00E-03	1.00E-03	7.70E-02
Te-129m	4.84E+04	2.39E-07	1.30E+00	1.00E-03	1.00E-03	7.70E-02
Te-129	6.96E+01	1.66E-04	1.30E+00	1.00E-03	1.00E-03	7.70E-02
Te-131m	1.80E+03	6.42E-06	1.30E+00	1.00E-03	1.00E-03	7.70E-02
Te-131	2.50E+01	4.62E-04	1.30E+00	1.00E-03	1.00E-03	7.70E-02
Te-132	4.69E+03	2.46E-06	1.30E+00	1.00E-03	1.00E-03	7.70E-02
I-130	7.42E+02	1.56E-05	2.00E-02	1.20E-02	4.30E-01	2.90E-03
I-131	1.16E+04	9.96E-07	2.00E-02	1.20E-02	4.30E-01	2.90E-03
I-132	1.38E+02	8.37E-05	2.00E-02	1.20E-02	4.30E-01	2.90E-03
I-133	1.25E+03	9.24E-06	2.00E-02	1.20E-02	4.30E-01	2.90E-03
I-134	5.26E+01	2.20E-04	2.00E-02	1.20E-02	4.30E-01	2.90E-03
I-135	3.97E+02	2.91E-05	2.00E-02	1.20E-02	4.30E-01	2.90E-03
Cs-134	1.08E+06	1.06E-08	1.00E-02	8.00E-03	3.00E-01	1.50E-02
Cs-136	1.90E+04	6.08E-07	1.00E-02	8.00E-03	3.00E-01	1.50E-02
Cs-137	1.59E+07	7.26E-10	1.00E-02	8.00E-03	3.00E-01	1.50E-02
Cs-138	3.22E+01	3.59E-04	1.00E-02	8.00E-03	3.00E-01	1.50E-02
Ba-139	8.31E+01	1.39E-04	5.00E-03	4.00E-04	4.00E-04	3.20E-03
Ba-140	1.84E+04	6.28E-07	5.00E-03	4.00E-04	4.00E-04	3.20E-03
Ba-141	1.83E+01	6.31E-04	5.00E-03	4.00E-04	4.00E-04	3.20E-03
Ba-142	1.07E+01	1.08E-03	5.00E-03	4.00E-04	4.00E-04	3.20E-03
La-140	2.41E+03	4.79E-06	2.50E-03	5.00E-06	5.00E-06	2.00E-04
La-142	9.54E+01	1.21E-04	2.50E-03	5.00E-06	5.00E-06	2.00E-04
Ce-141	4.68E+04	2.47E-07	2.50E-03	1.00E-04	1.00E-04	1.20E-03
Ce-143	1.98E+03	5.83E-06	2.50E-03	1.00E-04	1.00E-04	1.20E-03
Ce-144	4.09E+05	2.82E-08	2.50E-03	1.00E-04	1.00E-04	1.20E-03
Pr-143	1.95E+04	5.92E-07	2.50E-03	5.00E-06	5.00E-06	4.70E-03
Pr-144	1.73E+01	6.68E-04	2.50E-03	5.00E-06	5.00E-06	4.70E-03
Nd-147	1.58E+04	7.31E-07	2.40E-03	5.00E-06	5.00E-06	3.30E-03
W-187	1.43E+03	8.08E-06	1.80E-02	5.00E-04	5.00E-04	1.30E-03
Np-239	3.39E+03	3.41E-06	2.50E-03	5.00E-06	5.00E-06	2.00E-04
Ar-41	1.10E+02	1.05E-04	N/A	N/A	N/A	N/A
Kr-83m	1.10E+02	1.05E-04	N/A	N/A	N/A	N/A
Kr-85m	2.69E+02	4.29E-05	N/A	N/A	N/A	N/A
Kr-85	5.64E+06	2.05E-09	N/A	N/A	N/A	N/A
Kr-87	7.63E+01	1.51E-04	N/A	N/A	N/A	N/A
Kr-88	1.70E+02	6.79E-05	N/A	N/A	N/A	N/A
Kr-89	3.16E+00	3.66E-03	N/A	N/A	N/A	N/A
Kr-90	5.39E-01	2.14E-02	N/A	N/A	N/A	N/A
Xe-131m	1.70E+04	6.79E-07	N/A	N/A	N/A	N/A
Xe-133m	3.15E+03	3.67E-06	N/A	N/A	N/A	N/A

Table 1.8 (3 of 3)
RADIONUCLIDE DECAY AND STABLE ELEMENT TRANSFER DATA

	Half-Life (minutes)	λ (1/s)	B_{iv}	F_{mi} (cow)	F_{mi} (goat)	F_{fi} (beef)
Xe-133	7.55E+03	1.53E-06	N/A	N/A	N/A	N/A
Xe-135m	1.54E+01	7.50E-04	N/A	N/A	N/A	N/A
Xe-135	5.47E+02	2.11E-05	N/A	N/A	N/A	N/A
Xe-137	3.83E+00	3.02E-03	N/A	N/A	N/A	N/A
Xe-138	1.41E+01	8.19E-04	N/A	N/A	N/A	N/A

References:

Half lives for all nuclides: DOE-TIC-11026, "Radioactive Decay Data Tables - A handbook of Decay Data for Application to Radiation Dosimetry and Radiological Assessment," D. C. Kocher, 1981.

Transfer factors for Sb- isotopes are from ORNL 4992, "Methodology for Calculating Radiation Doses from Radioactivity Released to the Environment," March 1976, Table 2-7.

Cow-milk transfer factors for Iodine, Strontium, and Cesium nuclides are from NUREG/CR-1004, Table 3.17.

Goat-milk transfer factors for Iodine nuclides are from NUREG/CR-1004, Table 3.17.

Beef transfer factors for Iron, Copper, Molybdenum, and Cesium nuclides are from NUREG/CR-1004, Table 3.18.

All other nuclides' transfer factors are from Regulatory Guide 1.109, Tables E-1 and E-2.

Table 1.9 (1 of 2)
DOSE CALCULATION FACTORS

Factor	Value	Units	Reference
BR_a (infant)	1400	m^3/year	ICRP 23
BR_a (child)	5500	m^3/year	ICRP 23
BR_a (teen)	8000	m^3/year	ICRP 23
BR_a (adult)	8100	m^3/year	ICRP 23
f_g	1		TVA Assumption
f_L	1		R. G. 1.109 (Table E-15)
f_p	1		TVA Assumption
f_s	0		TVA Assumption
H	9	g/m^3	TVA Value
K_c	0.072	L/kg-hr	R. G. 1.109 (Section 2.C.)
M	40	kg/m^2	R. G. 1.109 (Section 2.C.)
P	240	kg/m^2	R. G. 1.109 (Table E-15)
Q_f (cow)	64	kg/day	NUREG/CR-1004 (Sect. 3.4)
Q_f (goat)	08	kg/day	NUREG/CR-1004 (Sect. 3.4)
r	0.47		NUREG/CR-1004 (Sect. 3.2)
t_b	4.73E+08 (15 years)	seconds	R. G. 1.109 (Table E-15)
t_{cb}	7.78E+06 (90 days)	seconds	SQN FSAR Section 11.3.9.1
t_{csf}	1.56E+07 (180 days)	seconds	SQN FSAR Section 11.3.9.1
t_e	5.18E+06 (60 days)	seconds	R. G. 1.109 (Table E-15)
t_{ep}	2.59E+06 (30 days)	seconds	R. G. 1.109 (Table E-15)
t_{esf}	7.78E+06 (90 days)	seconds	R. G. 1.109 (Table E-15)
t_{fm}	8.64E+04 (1 day)	seconds	SQN FSAR Section 11.3.9.1
t_{hc}	8.64E+04 (1 day)	seconds	NUREG/CR-1004, Table 3.40
t_s	1.12E+06 (13 days)	seconds	NUREG/CR-1004, Table 3.40
t_{sv}	2.38E+07 (275 days)	seconds	SQN FSAR Section 11.3.9.1
U_{am} (infant)	0	kg/year	R. G. 1.109 (Table E-5)
U_{am} (child)	41	kg/year	R. G. 1.109 (Table E-5)
U_{am} (teen)	65	kg/year	R. G. 1.109 (Table E-5)
U_{am} (adult)	110	kg/year	R. G. 1.109 (Table E-5)
U_{ap} (infant)	330	L/year	R. G. 1.109 (Table E-5)
U_{ap} (child)	330	L/year	R. G. 1.109 (Table E-5)
U_{ap} (teen)	400	L/year	R. G. 1.109 (Table E-5)
U_{ap} (adult)	310	L/year	R. G. 1.109 (Table E-5)

Table 1.9 (2 of 2)
DOSE CALCULATION FACTORS

Factor	Value	Units	Reference
U_{fa}(infant)	0	kg/year	R. G. 1.109 (Table E-5)
U_{fa}(child)	6.9	kg/year	R. G. 1.109 (Table E-5)
U_{fa}(teen)	16	kg/year	R. G. 1.109 (Table E-5)
U_{fa}(adult)	21	kg/year	R. G. 1.109 (Table E-5)
U_{FLa} (infant)	0	kg/year	R. G. 1.109 (Table E-5)
U_{FLa} (child)	26	kg/year	R. G. 1.109 (Table E-5)
U_{FLa} (teen)	42	kg/year	R. G. 1.109 (Table E-5)
U_{FLa} (adult)	64	kg/year	R. G. 1.109 (Table E-5)
U_{Sa} (infant)	0	kg/year	R. G. 1.109 (Table E-5)
U_{Sa} (child)	520	kg/year	R. G. 1.109 (Table E-5)
U_{Sa} (teen)	630	kg/year	R. G. 1.109 (Table E-5)
U_{Sa} (adult)	520	kg/year	R. G. 1.109 (Table E-5)
U_{wa}(infant)	330	L/year	R. G. 1.109 (Table E-5)
U_{wa}(child)	510	L/year	R. G. 1.109 (Table E-5)
U_{wa}(teen)	510	L/year	R. G. 1.109 (Table E-5)
U_{wa}(adult)	730	L/year	R. G. 1.109 (Table E-5)
W	0.3	none	R. G. 1.109 (Table A-2)
Y_f	1.85	kg/m²	NUREG/CR-1004 (Table 3.4)
Y_p	1.18	kg/m²	NUREG/CR-1004 (Table 3.3)
Y_{sf}	0.64	kg/m²	NUREG/CR-1004 (Table 3.3)
Y_{sv}	0.57	kg/m²	NUREG/CR-1004 (Table 3.4) (value selected is for non-leafy vegetables)
λ_w (iodines)	7.71E-07 (15.4 d half-life)	sec^{-1}	NUREG/CR-1004 (Table 3.10)
λ_w (particulates)	5.21E-07 (10.4 d half-life)	sec^{-1}	NUREG/CR-1004 (Table 3.10)

Table 1.10 (1 of 8)
INHALATION DOSE FACTORS
(mrem/pCi inhaled)

ADULT

	bone	liver	t body	thyroid	kidney	lung	gi-lli
H-3	1.58E-07	1.58E-07	1.58E-07	1.58E-07	1.58E-07	1.58E-07	1.58E-07
C-14	2.27E-06	4.26E-07	4.26E-07	4.26E-07	4.26E-07	4.26E-07	4.26E-07
Na-24	1.28E-06	1.28E-06	1.28E-06	1.28E-06	1.28E-06	1.28E-06	1.28E-06
P-32	1.65E-04	9.64E-06	6.26E-06	0.00E+00	0.00E+00	0.00E+00	1.08E-05
Cr-51	0.00E+00	0.00E+00	1.25E-08	7.44E-09	2.85E-09	1.80E-06	4.15E-07
Mn-54	0.00E+00	4.95E-06	7.87E-07	0.00E+00	1.23E-06	1.75E-04	9.67E-06
Mn-56	0.00E+00	1.55E-10	2.29E-11	0.00E+00	1.63E-10	1.18E-06	2.53E-06
Fe-55	3.07E-06	2.12E-06	4.93E-07	0.00E+00	0.00E+00	9.01E-06	7.54E-07
Fe-59	1.47E-06	3.47E-06	1.32E-06	0.00E+00	0.00E+00	1.27E-04	2.35E-05
Co-57	0.00E+00	8.65E-08	8.39E-08	0.00E+00	0.00E+00	4.62E-05	3.93E-06
Co-58	0.00E+00	1.98E-07	2.59E-07	0.00E+00	0.00E+00	1.16E-04	1.33E-05
Co-60	0.00E+00	1.44E-06	1.85E-06	0.00E+00	0.00E+00	7.46E-04	3.56E-05
Ni-63	5.40E-05	3.93E-06	1.81E-06	0.00E+00	0.00E+00	2.23E-05	1.67E-06
Ni-65	1.92E-10	2.62E-11	1.14E-11	0.00E+00	0.00E+00	7.00E-07	1.54E-06
Cu-64	0.00E+00	1.83E-10	7.69E-11	0.00E+00	5.78E-10	8.48E-07	6.12E-06
Zn-65	4.05E-06	1.29E-05	5.82E-06	0.00E+00	8.62E-06	1.08E-04	6.68E-06
Zn-69	4.23E-12	8.14E-12	5.65E-13	0.00E+00	5.27E-12	1.15E-07	2.04E-09
Zn-69m	1.02E-09	2.45E-09	2.24E-10	0.00E+00	1.48E-09	2.38E-06	1.71E-05
Br-82	0.00E+00	0.00E+00	1.69E-06	0.00E+00	0.00E+00	0.00E+00	1.30E-06
Br-83	0.00E+00	0.00E+00	3.01E-08	0.00E+00	0.00E+00	0.00E+00	2.90E-08
Br-84	0.00E+00	0.00E+00	3.91E-08	0.00E+00	0.00E+00	0.00E+00	2.05E-13
Br-85	0.00E+00	0.00E+00	1.60E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	1.69E-05	7.37E-06	0.00E+00	0.00E+00	0.00E+00	2.08E-06
Rb-88	0.00E+00	4.84E-08	2.41E-08	0.00E+00	0.00E+00	0.00E+00	4.18E-19
Rb-89	0.00E+00	3.20E-08	2.12E-08	0.00E+00	0.00E+00	0.00E+00	1.16E-21
Sr-89	3.80E-05	0.00E+00	1.09E-06	0.00E+00	0.00E+00	1.75E-04	4.37E-05
Sr-90	1.24E-02	0.00E+00	7.62E-04	0.00E+00	0.00E+00	1.20E-03	9.02E-05
Sr-91	7.74E-09	0.00E+00	3.13E-10	0.00E+00	0.00E+00	4.56E-06	2.39E-05
Sr-92	8.43E-10	0.00E+00	3.64E-11	0.00E+00	0.00E+00	2.06E-06	5.38E-06
Y-90	2.61E-07	0.00E+00	7.01E-09	0.00E+00	0.00E+00	2.12E-05	6.32E-05
Y-91m	3.26E-11	0.00E+00	1.27E-12	0.00E+00	0.00E+00	2.40E-07	1.66E-10
Y-91	5.78E-05	0.00E+00	1.55E-06	0.00E+00	0.00E+00	2.13E-04	4.81E-05
Y-92	1.29E-09	0.00E+00	3.77E-11	0.00E+00	0.00E+00	1.96E-06	9.19E-06
Y-93	1.18E-08	0.00E+00	3.26E-10	0.00E+00	0.00E+00	6.06E-06	5.27E-05
Zr-95	1.34E-05	4.30E-06	2.91E-06	0.00E+00	6.77E-06	2.21E-04	1.88E-05
Zr-97	1.21E-08	2.45E-09	1.13E-09	0.00E+00	3.71E-09	9.84E-06	6.54E-05
Nb-95	1.76E-06	9.77E-07	5.26E-07	0.00E+00	9.67E-07	6.31E-05	1.30E-05
Nb-97	2.78E-11	7.03E-12	2.56E-12	0.00E+00	8.18E-12	3.00E-07	3.02E-08
Mo-99	0.00E+00	1.51E-08	2.87E-09	0.00E+00	3.64E-08	1.14E-05	3.10E-05
Tc-99m	1.29E-13	3.64E-13	4.63E-12	0.00E+00	5.52E-12	9.55E-08	5.20E-07
Tc-101	5.22E-15	7.52E-15	7.38E-14	0.00E+00	1.35E-13	4.99E-08	1.36E-21
Ru-103	1.91E-07	0.00E+00	8.23E-08	0.00E+00	7.29E-07	6.31E-05	1.38E-05
Ru-105	9.88E-11	0.00E+00	3.89E-11	0.00E+00	1.27E-10	1.37E-06	6.02E-06
Ru-106	8.64E-06	0.00E+00	1.09E-06	0.00E+00	1.67E-05	1.17E-03	1.14E-04
Ag-110m	1.35E-06	1.25E-06	7.43E-07	0.00E+00	2.46E-06	5.79E-04	3.78E-05

Table 1.10 (2 of 8)
INHALATION DOSE FACTORS
(mrem/pCi inhaled)

ADULT

	bone	liver	t body	thyroid	kidney	lung	gi-lli
Sb-124	3.90E-06	7.36E-08	1.55E-06	9.44E-09	0.00E+00	3.10E-04	5.08E-05
Sb-125	6.67E-06	7.44E-08	1.58E-06	6.75E-09	0.00E+00	2.18E-04	1.26E-05
Te-125m	4.27E-07	1.98E-07	5.84E-08	1.31E-07	1.55E-06	3.92E-05	8.83E-06
Te-127m	1.58E-06	7.21E-07	1.96E-07	4.11E-07	5.72E-06	1.20E-04	1.87E-05
Te-127	1.75E-10	8.03E-11	3.87E-11	1.32E-10	6.37E-10	8.14E-07	7.17E-06
Te-129m	1.22E-06	5.84E-07	1.98E-07	4.30E-07	4.57E-06	1.45E-04	4.79E-05
Te-129	6.22E-12	2.99E-12	1.55E-12	4.87E-12	2.34E-11	2.42E-07	1.96E-08
Te-131m	8.74E-09	5.45E-09	3.63E-09	6.88E-09	3.86E-08	1.82E-05	6.95E-05
Te-131	1.39E-12	7.44E-13	4.49E-13	1.17E-12	5.46E-12	1.74E-07	2.30E-09
Te-132	3.25E-08	2.69E-08	2.02E-08	2.37E-08	1.82E-07	3.60E-05	6.37E-05
I-130	5.72E-07	1.68E-06	6.60E-07	1.42E-04	2.61E-06	0.00E+00	9.61E-07
I-131	3.15E-06	4.47E-06	2.56E-06	1.49E-03	7.66E-06	0.00E+00	7.85E-07
I-132	1.45E-07	4.07E-07	1.45E-07	1.43E-05	6.48E-07	0.00E+00	5.08E-08
I-133	1.08E-06	1.85E-06	5.65E-07	2.69E-04	3.23E-06	0.00E+00	1.11E-06
I-134	8.05E-08	2.16E-07	7.69E-08	3.73E-06	3.44E-07	0.00E+00	1.26E-10
I-135	3.35E-07	8.73E-07	3.21E-07	5.60E-05	1.39E-06	0.00E+00	6.56E-07
Cs-134	4.66E-05	1.06E-04	9.10E-05	0.00E+00	3.59E-05	1.22E-05	1.30E-06
Cs-136	4.88E-06	1.83E-05	1.38E-05	0.00E+00	1.07E-05	1.50E-06	1.46E-06
Cs-137	5.98E-05	7.76E-05	5.35E-05	0.00E+00	2.78E-05	9.40E-06	1.05E-06
Cs-138	4.14E-08	7.76E-08	4.05E-08	0.00E+00	6.00E-08	6.07E-09	2.33E-13
Ba-139	1.17E-10	8.32E-14	3.42E-12	0.00E+00	7.78E-14	4.70E-07	1.12E-07
Ba-140	4.88E-06	6.13E-09	3.21E-07	0.00E+00	2.09E-09	1.59E-04	2.73E-05
Ba-141	1.25E-11	9.41E-15	4.20E-13	0.00E+00	8.75E-15	2.42E-07	1.45E-17
Ba-142	3.29E-12	3.38E-15	2.07E-13	0.00E+00	2.86E-15	1.49E-07	1.96E-26
La-140	4.30E-08	2.17E-08	5.73E-09	0.00E+00	0.00E+00	1.70E-05	5.73E-05
La-142	8.54E-11	3.88E-11	9.65E-12	0.00E+00	0.00E+00	7.91E-07	2.64E-07
Ce-141	2.49E-06	1.69E-06	1.91E-07	0.00E+00	7.83E-07	4.52E-05	1.50E-05
Ce-143	2.33E-08	1.72E-08	1.91E-09	0.00E+00	7.60E-09	9.97E-06	2.83E-05
Ce-144	4.29E-04	1.79E-04	2.30E-05	0.00E+00	1.06E-04	9.72E-04	1.02E-04
Pr-143	1.17E-06	4.69E-07	5.80E-08	0.00E+00	2.70E-07	3.51E-05	2.50E-05
Pr-144	3.76E-12	1.56E-12	1.91E-13	0.00E+00	8.81E-13	1.27E-07	2.69E-18
Nd-147	6.59E-07	7.62E-07	4.56E-08	0.00E+00	4.45E-07	2.76E-05	2.16E-05
W-187	1.06E-09	8.85E-10	3.10E-10	0.00E+00	0.00E+00	3.63E-06	1.94E-05
Np-239	2.87E-08	2.82E-09	1.55E-09	0.00E+00	8.75E-09	4.70E-06	1.49E-05

Reference:

Regulatory Guide 1.109, Table E-7.

Dose Factors for Co-57, Zn-69m, Br-82, Nb-97, Sb-124 and Sb-125 are from NUREG-0172 Age Specific Radiation Dose Commitment Factors for a One Year Chronic Intake, November 1977, Table 8.

NOTE: The tritium dose factor for bone is assumed to be equal to the total body dose factor.

Table 1.10 (3 of 8)
INHALATION DOSE FACTORS
(mrem/pCi inhaled)

TEEN

	bone	liver	t body	thyroid	kidney	lung	gi-lli
H-3	1.59E-07	1.59E-07	1.59E-07	1.59E-07	1.59E-07	1.59E-07	1.59E-07
C-14	3.25E-06	6.09E-07	6.09E-07	6.09E-07	6.09E-07	6.09E-07	6.09E-07
Na-24	1.72E-06	1.72E-06	1.72E-06	1.72E-06	1.72E-06	1.72E-06	1.72E-06
P-32	2.36E-04	1.37E-05	8.95E-06	0.00E+00	0.00E+00	0.00E+00	1.16E-05
Cr-51	0.00E+00	0.00E+00	1.69E-08	9.37E-09	3.84E-09	2.62E-06	3.75E-07
Mn-54	0.00E+00	6.39E-06	1.05E-06	0.00E+00	1.59E-06	2.48E-04	8.35E-06
Mn-56	0.00E+00	2.12E-10	3.15E-11	0.00E+00	2.24E-10	1.90E-06	7.18E-06
Fe-55	4.18E-06	2.98E-06	6.93E-07	0.00E+00	0.00E+00	1.55E-05	7.99E-07
Fe-59	1.99E-06	4.62E-06	1.79E-06	0.00E+00	0.00E+00	1.91E-04	2.23E-05
Co-57	0.00E+00	1.18E-07	1.15E-07	0.00E+00	0.00E+00	7.33E-05	3.93E-06
Co-58	0.00E+00	2.59E-07	3.47E-07	0.00E+00	0.00E+00	1.68E-04	1.19E-05
Co-60	0.00E+00	1.89E-06	2.48E-06	0.00E+00	0.00E+00	1.09E-03	3.24E-05
Ni-63	7.25E-05	5.43E-06	2.47E-06	0.00E+00	0.00E+00	3.84E-05	1.77E-06
Ni-65	2.73E-10	3.66E-11	1.59E-11	0.00E+00	0.00E+00	1.17E-06	4.59E-06
Cu-64	0.00E+00	2.54E-10	1.06E-10	0.00E+00	8.01E-10	1.39E-06	7.68E-06
Zn-65	4.82E-06	1.67E-05	7.80E-06	0.00E+00	1.08E-05	1.55E-04	5.83E-06
Zn-69	6.04E-12	1.15E-11	8.07E-13	0.00E+00	7.53E-12	1.98E-07	3.56E-08
Zn-69m	1.44E-09	3.39E-09	3.11E-10	0.00E+00	2.06E-09	3.92E-06	2.14E-05
Br-82	0.00E+00	0.00E+00	2.28E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-83	0.00E+00	0.00E+00	4.30E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	5.41E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	2.29E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	2.38E-05	1.05E-05	0.00E+00	0.00E+00	0.00E+00	2.21E-06
Rb-88	0.00E+00	6.82E-08	3.40E-08	0.00E+00	0.00E+00	0.00E+00	3.65E-15
Rb-89	0.00E+00	4.40E-08	2.91E-08	0.00E+00	0.00E+00	0.00E+00	4.22E-17
Sr-89	5.43E-05	0.00E+00	1.56E-06	0.00E+00	0.00E+00	3.02E-04	4.64E-05
Sr-90	1.35E-02	0.00E+00	8.35E-04	0.00E+00	0.00E+00	2.06E-03	9.56E-05
Sr-91	1.10E-08	0.00E+00	4.39E-10	0.00E+00	0.00E+00	7.59E-06	3.24E-05
Sr-92	1.19E-09	0.00E+00	5.08E-11	0.00E+00	0.00E+00	3.43E-06	1.49E-05
Y-90	3.73E-07	0.00E+00	1.00E-08	0.00E+00	0.00E+00	3.66E-05	6.99E-05
Y-91m	4.63E-11	0.00E+00	1.77E-12	0.00E+00	0.00E+00	4.00E-07	3.77E-09
Y-91	8.26E-05	0.00E+00	2.21E-06	0.00E+00	0.00E+00	3.67E-04	5.11E-05
Y-92	1.84E-09	0.00E+00	5.36E-11	0.00E+00	0.00E+00	3.35E-06	2.06E-05
Y-93	1.69E-08	0.00E+00	4.65E-10	0.00E+00	0.00E+00	1.04E-05	7.24E-05
Zr-95	1.82E-05	5.73E-06	3.94E-06	0.00E+00	8.42E-06	3.36E-04	1.86E-05
Zr-97	1.72E-08	3.40E-09	1.57E-09	0.00E+00	5.15E-09	1.62E-05	7.88E-05
Nb-95	2.32E-06	1.29E-06	7.08E-07	0.00E+00	1.25E-06	9.39E-05	1.21E-05
Nb-97	3.92E-11	9.72E-12	3.55E-12	0.00E+00	1.14E-11	4.91E-07	2.71E-07
Mo-99	0.00E+00	2.11E-08	4.03E-09	0.00E+00	5.14E-08	1.92E-05	3.36E-05
Tc-99m	1.73E-13	4.83E-13	6.24E-12	0.00E+00	7.20E-12	1.44E-07	7.66E-07
Tc-101	7.40E-15	1.05E-14	1.03E-13	0.00E+00	1.90E-13	8.34E-08	1.09E-16
Ru-103	2.63E-07	0.00E+00	1.12E-07	0.00E+00	9.29E-07	9.79E-05	1.36E-05
Ru-105	1.40E-10	0.00E+00	5.42E-11	0.00E+00	1.76E-10	2.27E-06	1.13E-05
Ru-106	1.23E-05	0.00E+00	1.55E-06	0.00E+00	2.38E-05	2.01E-03	1.20E-04
Ag-110m	1.73E-06	1.64E-06	9.99E-07	0.00E+00	3.13E-06	8.44E-04	3.41E-05

Table 1.10 (4 of 8)
INHALATION DOSE FACTORS
(mrem/pCi inhaled)

TEEN

	bone	liver	t body	thyroid	kidney	lung	gi-lli
Sb-124	5.38E-06	9.92E-08	2.10E-06	1.22E-08	0.00E+00	4.81E-04	4.98E-05
Sb-125	9.23E-06	1.01E-07	2.15E-06	8.80E-09	0.00E+00	3.42E-04	1.24E-05
Te-125m	6.10E-07	2.80E-07	8.34E-08	1.75E-07	0.00E+00	6.70E-05	9.38E-06
Te-127m	2.25E-06	1.02E-06	2.73E-07	5.48E-07	8.17E-06	2.07E-04	1.99E-05
Te-127	2.51E-10	1.14E-10	5.52E-11	1.77E-10	9.10E-10	1.40E-06	1.01E-05
Te-129m	1.74E-06	8.23E-07	2.81E-07	5.72E-07	6.49E-06	2.47E-04	5.06E-05
Te-129	8.87E-12	4.22E-12	2.20E-12	6.48E-12	3.32E-11	4.12E-07	2.02E-07
Te-131m	1.23E-08	7.51E-09	5.03E-09	9.06E-09	5.49E-08	2.97E-05	7.76E-05
Te-131	1.97E-12	1.04E-12	6.30E-13	1.55E-12	7.72E-12	2.92E-07	1.89E-09
Te-132	4.50E-08	3.63E-08	2.74E-08	3.07E-08	2.44E-07	5.61E-05	5.79E-05
I-130	7.80E-07	2.24E-06	8.96E-07	1.86E-04	3.44E-06	0.00E+00	1.14E-06
I-131	4.43E-06	6.14E-06	3.30E-06	1.83E-03	1.05E-05	0.00E+00	8.11E-07
I-132	1.99E-07	5.47E-07	1.97E-07	1.89E-05	8.65E-07	0.00E+00	1.59E-07
I-133	1.52E-06	2.56E-06	7.78E-07	3.65E-04	4.49E-06	0.00E+00	1.29E-06
I-134	1.11E-07	2.90E-07	1.05E-07	4.94E-06	4.58E-07	0.00E+00	2.55E-09
I-135	4.62E-07	1.18E-06	4.36E-07	7.76E-05	1.86E-06	0.00E+00	8.69E-07
Cs-134	6.28E-05	1.41E-04	6.86E-05	0.00E+00	4.69E-05	1.83E-05	1.22E-06
Cs-136	6.44E-06	2.42E-05	1.71E-05	0.00E+00	1.38E-05	2.22E-06	1.36E-06
Cs-137	8.38E-05	1.06E-04	3.89E-05	0.00E+00	3.80E-05	1.51E-05	1.06E-06
Cs-138	5.82E-08	1.07E-07	5.58E-08	0.00E+00	8.28E-08	9.84E-09	3.38E-11
Ba-139	1.67E-10	1.18E-13	4.87E-12	0.00E+00	1.11E-13	8.08E-07	8.06E-07
Ba-140	6.84E-06	8.38E-09	4.40E-07	0.00E+00	2.85E-09	2.54E-04	2.86E-05
Ba-141	1.78E-11	1.32E-14	5.93E-13	0.00E+00	1.23E-14	4.11E-07	9.33E-14
Ba-142	4.62E-12	4.63E-15	2.84E-13	0.00E+00	3.92E-15	2.39E-07	5.99E-20
La-140	5.99E-08	2.95E-08	7.82E-09	0.00E+00	0.00E+00	2.68E-05	6.09E-05
La-142	1.20E-10	5.31E-11	1.32E-11	0.00E+00	0.00E+00	1.27E-06	1.50E-06
Ce-141	3.55E-06	2.37E-06	2.71E-07	0.00E+00	1.11E-06	7.67E-05	1.58E-05
Ce-143	3.32E-08	2.42E-08	2.70E-09	0.00E+00	1.08E-08	1.63E-05	3.19E-05
Ce-144	6.11E-04	2.53E-04	3.28E-05	0.00E+00	1.51E-04	1.67E-03	1.08E-04
Pr-143	1.67E-06	6.64E-07	8.28E-08	0.00E+00	3.86E-07	6.04E-05	2.67E-05
Pr-144	5.37E-12	2.20E-12	2.72E-13	0.00E+00	1.26E-12	2.19E-07	2.94E-14
Nd-147	9.83E-07	1.07E-06	6.41E-08	0.00E+00	6.28E-07	4.65E-05	2.28E-05
W-187	1.50E-09	1.22E-09	4.29E-10	0.00E+00	0.00E+00	5.92E-06	2.21E-05
Np-239	4.23E-08	3.99E-09	2.21E-09	0.00E+00	1.25E-08	8.11E-06	1.65E-05

Reference:

Regulatory Guide 1.109, Table E-8.

Dose Factors for Co-57, Zn-69m, Br-82, Nb-97, Sb-124 and Sb-125 are from NUREG-0172 Age Specific Radiation Dose Commitment Factors for a One Year Chronic Intake, November 1977, Table 7.

NOTE: The tritium dose factor for bone is assumed to be equal to the total body dose factor.

Table 1.10 (5 of 8)
INHALATION DOSE FACTORS
(mrem/pCi inhaled)

CHILD

	bone	liver	t body	thyroid	kidney	lung	gi-lli
H-3	3.04E-07	3.04E-07	3.04E-07	3.04E-07	3.04E-07	3.04E-07	3.04E-07
C-14	9.70E-06	1.82E-06	1.82E-06	1.82E-06	1.82E-06	1.82E-06	1.82E-06
Na-24	4.35E-06	4.35E-06	4.35E-06	4.35E-06	4.35E-06	4.35E-06	4.35E-06
P-32	7.04E-04	3.09E-05	2.67E-05	0.00E+00	0.00E+00	0.00E+00	1.14E-05
Cr-51	0.00E+00	0.00E+00	4.17E-08	2.31E-08	6.57E-09	4.59E-06	2.93E-07
Mn-54	0.00E+00	1.16E-05	2.57E-06	0.00E+00	2.71E-06	4.26E-04	6.19E-06
Mn-56	0.00E+00	4.48E-10	8.43E-11	0.00E+00	4.52E-10	3.55E-06	3.33E-05
Fe-55	1.28E-05	6.80E-06	2.10E-06	0.00E+00	0.00E+00	3.00E-05	7.75E-07
Fe-59	5.59E-06	9.04E-06	4.51E-06	0.00E+00	0.00E+00	3.43E-04	1.91E-05
Co-57	0.00E+00	2.44E-07	2.88E-07	0.00E+00	0.00E+00	1.37E-04	3.58E-06
Co-58	0.00E+00	4.79E-07	8.55E-07	0.00E+00	0.00E+00	2.99E-04	9.29E-06
Co-60	0.00E+00	3.55E-06	6.12E-06	0.00E+00	0.00E+00	1.91E-03	2.60E-05
Ni-63	2.22E-04	1.25E-05	7.56E-06	0.00E+00	0.00E+00	7.43E-05	1.71E-06
Ni-65	8.08E-10	7.99E-11	4.44E-11	0.00E+00	0.00E+00	2.21E-06	2.27E-05
Cu-64	0.00E+00	5.39E-10	2.90E-10	0.00E+00	1.63E-09	2.59E-06	9.92E-06
Zn-65	1.15E-05	3.06E-05	1.90E-05	0.00E+00	1.93E-05	2.69E-04	4.41E-06
Zn-69	1.81E-11	2.61E-11	2.41E-12	0.00E+00	1.58E-11	3.84E-07	2.75E-06
Zn-69m	4.26E-09	7.28E-09	8.59E-10	0.00E+00	4.22E-09	7.36E-06	2.71E-05
Br-82	0.00E+00	0.00E+00	5.66E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-83	0.00E+00	0.00E+00	1.28E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	1.48E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	6.84E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	5.36E-05	3.09E-05	0.00E+00	0.00E+00	0.00E+00	2.16E-06
Rb-88	0.00E+00	1.52E-07	9.90E-08	0.00E+00	0.00E+00	0.00E+00	4.66E-09
Rb-89	0.00E+00	9.33E-08	7.83E-08	0.00E+00	0.00E+00	0.00E+00	5.11E-10
Sr-89	1.62E-04	0.00E+00	4.66E-06	0.00E+00	0.00E+00	5.83E-04	4.52E-05
Sr-90	2.73E-02	0.00E+00	1.74E-03	0.00E+00	0.00E+00	3.99E-03	9.28E-05
Sr-91	3.28E-08	0.00E+00	1.24E-09	0.00E+00	0.00E+00	1.44E-05	4.70E-05
Sr-92	3.54E-09	0.00E+00	1.42E-10	0.00E+00	0.00E+00	6.49E-06	6.55E-05
Y-90	1.11E-06	0.00E+00	2.99E-08	0.00E+00	0.00E+00	7.07E-05	7.24E-05
Y-91m	1.37E-10	0.00E+00	4.98E-12	0.00E+00	0.00E+00	7.60E-07	4.64E-07
Y-91	2.47E-04	0.00E+00	6.59E-06	0.00E+00	0.00E+00	7.10E-04	4.97E-05
Y-92	5.50E-09	0.00E+00	1.57E-10	0.00E+00	0.00E+00	6.46E-06	6.46E-05
Y-93	5.04E-08	0.00E+00	1.38E-09	0.00E+00	0.00E+00	2.01E-05	1.05E-04
Zr-95	5.13E-05	1.13E-05	1.00E-05	0.00E+00	1.61E-05	6.03E-04	1.65E-05
Zr-97	5.07E-08	7.34E-09	4.32E-09	0.00E+00	1.05E-08	3.06E-05	9.49E-05
Nb-95	6.35E-06	2.48E-06	1.77E-06	0.00E+00	2.33E-06	1.66E-04	1.00E-05
Nb-97	1.16E-10	2.08E-11	9.74E-12	0.00E+00	2.31E-11	9.23E-07	7.52E-06
Mo-99	0.00E+00	4.66E-08	1.15E-08	0.00E+00	1.06E-07	3.66E-05	3.42E-05
Tc-99m	4.81E-13	9.41E-13	1.56E-11	0.00E+00	1.37E-11	2.57E-07	1.30E-06
Tc-101	2.19E-14	2.30E-14	2.91E-13	0.00E+00	3.92E-13	1.58E-07	4.41E-09
Ru-103	7.55E-07	0.00E+00	2.90E-07	0.00E+00	1.90E-06	1.79E-04	1.21E-05
Ru-105	4.13E-10	0.00E+00	1.50E-10	0.00E+00	3.63E-10	4.30E-06	2.69E-05
Ru-106	3.68E-05	0.00E+00	4.57E-06	0.00E+00	4.97E-05	3.87E-03	1.16E-04
Ag-110m	4.56E-06	3.08E-06	2.47E-06	0.00E+00	5.74E-06	1.48E-03	2.71E-05

Table 1.10 (6 of 8)
INHALATION DOSE FACTORS
(mrem/pCi inhaled)

CHILD

	bone	liver	t body	thyroid	kidney	lung	gi-lli
Sb-124	1.55E-05	2.00E-07	5.41E-06	3.41E-08	0.00E+00	8.76E-04	4.43E-05
Sb-125	2.66E-05	2.05E-07	5.59E-06	2.46E-08	0.00E+00	6.27E-04	1.09E-05
Te-125m	1.82E-06	6.29E-07	2.47E-07	5.20E-07	0.00E+00	1.29E-04	9.13E-06
Te-127m	6.72E-06	2.31E-06	8.16E-07	1.64E-06	1.72E-05	4.00E-04	1.93E-05
Te-127	7.49E-10	2.57E-10	1.65E-10	5.30E-10	1.91E-09	2.71E-06	1.52E-05
Te-129m	5.19E-06	1.85E-06	8.22E-07	1.71E-06	1.36E-05	4.76E-04	4.91E-05
Te-129	2.64E-11	9.45E-12	6.44E-12	1.93E-11	6.94E-11	7.93E-07	6.89E-06
Te-131m	3.63E-08	1.60E-08	1.37E-08	2.64E-08	1.08E-07	5.56E-05	8.32E-05
Te-131	5.87E-12	2.28E-12	1.78E-12	4.59E-12	1.59E-11	5.55E-07	3.60E-07
Te-132	1.30E-07	7.36E-08	7.12E-08	8.58E-08	4.79E-07	1.02E-04	3.72E-05
I-130	2.21E-06	4.43E-06	2.28E-06	4.99E-04	6.61E-06	0.00E+00	1.38E-06
I-131	1.30E-05	1.30E-05	7.37E-06	4.39E-03	2.13E-05	0.00E+00	7.68E-07
I-132	5.72E-07	1.10E-06	5.07E-07	5.23E-05	1.69E-06	0.00E+00	8.65E-07
I-133	4.48E-06	5.49E-06	2.08E-06	1.04E-03	9.13E-06	0.00E+00	1.48E-06
I-134	3.17E-07	5.84E-07	2.69E-07	1.37E-05	8.92E-07	0.00E+00	2.58E-07
I-135	1.33E-06	2.36E-06	1.12E-06	2.14E-04	3.62E-06	0.00E+00	1.20E-06
Cs-134	1.76E-04	2.74E-04	6.07E-05	0.00E+00	8.93E-05	3.27E-05	1.04E-06
Cs-136	1.76E-05	4.62E-05	3.14E-05	0.00E+00	2.58E-05	3.93E-06	1.13E-06
Cs-137	2.45E-04	2.23E-04	3.47E-05	0.00E+00	7.63E-05	2.81E-05	9.78E-07
Cs-138	1.71E-07	2.27E-07	1.50E-07	0.00E+00	1.68E-07	1.84E-08	7.29E-08
Ba-139	4.98E-10	2.66E-13	1.45E-11	0.00E+00	2.33E-13	1.56E-06	1.56E-05
Ba-140	2.00E-05	1.75E-08	1.17E-06	0.00E+00	5.71E-09	4.71E-04	2.75E-05
Ba-141	5.29E-11	2.95E-14	1.72E-12	0.00E+00	2.56E-14	7.89E-07	7.44E-08
Ba-142	1.35E-11	9.73E-15	7.54E-13	0.00E+00	7.87E-15	4.44E-07	7.41E-10
La-140	1.74E-07	6.08E-08	2.04E-08	0.00E+00	0.00E+00	4.94E-05	6.10E-05
La-142	3.50E-10	1.11E-10	3.49E-11	0.00E+00	0.00E+00	2.35E-06	2.05E-05
Ce-141	1.06E-05	5.28E-06	7.83E-07	0.00E+00	2.31E-06	1.47E-04	1.53E-05
Ce-143	9.89E-08	5.37E-08	7.77E-09	0.00E+00	2.26E-08	3.12E-05	3.44E-05
Ce-144	1.83E-03	5.72E-04	9.77E-05	0.00E+00	3.17E-04	3.23E-03	1.05E-04
Pr-143	4.99E-06	1.50E-06	2.47E-07	0.00E+00	8.11E-07	1.17E-04	2.63E-05
Pr-144	1.61E-11	4.99E-12	8.10E-13	0.00E+00	2.64E-12	4.23E-07	5.32E-08
Nd-147	2.92E-06	2.36E-06	1.84E-07	0.00E+00	1.30E-06	8.87E-05	2.22E-05
W-187	4.41E-09	2.61E-09	1.17E-09	0.00E+00	0.00E+00	1.11E-05	2.46E-05
Np-239	1.26E-07	9.04E-09	6.35E-09	0.00E+00	2.63E-08	1.57E-05	1.73E-05

Reference:

Regulatory Guide 1.109, Table E-9.

Dose Factors for Co-57, Zn-69m, Br-82, Nb-97, Sb-124 and Sb-125 are from NUREG-0172 Age Specific Radiation Dose Commitment Factors for a One Year Chronic Intake, November 1977, Table 6.

NOTE: The tritium dose factor for bone is assumed to be equal to the total body dose factor.

Table 1.10 (7 of 8)
INHALATION DOSE FACTORS
(mrem/pCi inhaled)

INFANT

	bone	liver	t body	thyroid	kidney	lung	gi-lli
H-3	4.62E-07	4.62E-07	4.62E-07	4.62E-07	4.62E-07	4.62E-07	4.62E-07
C-14	1.89E-05	3.79E-06	3.79E-06	3.79E-06	3.79E-06	3.79E-06	3.79E-06
Na-24	7.54E-06	7.54E-06	7.54E-06	7.54E-06	7.54E-06	7.54E-06	7.54E-06
P-32	1.45E-03	8.03E+05	5.53E-05	0.00E+00	0.00E+00	0.00E+00	1.15E-05
Cr-51	0.00E+00	0.00E+00	6.39E-08	4.11E-08	9.45E-09	9.17E-06	2.55E-07
Mn-54	0.00E+00	1.81E-05	3.56E-06	0.00E+00	3.56E-06	7.14E-04	5.04E-06
Mn-56	0.00E+00	1.10E-09	1.58E-10	0.00E+00	7.86E-10	8.95E-06	5.12E-05
Fe-55	1.41E-05	8.39E-06	2.38E-06	0.00E+00	0.00E+00	6.21E-05	7.82E-07
Fe-59	9.69E-06	1.68E-05	6.77E-06	0.00E+00	0.00E+00	7.25E-04	1.77E-05
Co-57	0.00E+00	4.65E-07	4.58E-07	0.00E+00	0.00E+00	2.71E-04	3.47E-06
Co-58	0.00E+00	8.71E-07	1.30E-06	0.00E+00	0.00E+00	5.55E-04	7.95E-06
Co-60	0.00E+00	5.73E-06	8.41E-06	0.00E+00	0.00E+00	3.22E-03	2.28E-05
Ni-63	2.42E-04	1.46E-05	8.29E-06	0.00E+00	0.00E+00	1.49E-04	1.73E-06
Ni-65	1.71E-09	2.03E-10	8.79E-11	0.00E+00	0.00E+00	5.80E-06	3.58E-05
Cu-64	0.00E+00	1.34E-09	5.53E-10	0.00E+00	2.84E-09	6.64E-06	1.07E-05
Zn-65	1.38E-05	4.47E-05	2.22E-05	0.00E+00	2.32E-05	4.62E-04	3.67E-05
Zn-69	3.85E-11	6.91E-11	5.13E-12	0.00E+00	2.87E-11	1.05E-06	9.44E-06
Zn-69m	8.98E-09	1.84E-08	1.67E-09	0.00E+00	7.45E-09	1.91E-05	2.92E-05
Br-82	0.00E+00	0.00E+00	9.49E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-83	0.00E+00	0.00E+00	2.72E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-84	0.00E+00	0.00E+00	2.86E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Br-85	0.00E+00	0.00E+00	1.46E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb-86	0.00E+00	1.36E-04	6.30E-05	0.00E+00	0.00E+00	0.00E+00	2.17E-06
Rb-88	0.00E+00	3.98E-07	2.05E-07	0.00E+00	0.00E+00	0.00E+00	2.42E-07
Rb-89	0.00E+00	2.29E-07	1.47E-07	0.00E+00	0.00E+00	0.00E+00	4.87E-08
Sr-89	2.84E-04	0.00E+00	8.15E-06	0.00E+00	0.00E+00	1.45E-03	4.57E-05
Sr-90	2.92E-02	0.00E+00	1.85E-03	0.00E+00	0.00E+00	8.03E-03	9.36E-05
Sr-91	6.83E-08	0.00E+00	2.47E-09	0.00E+00	0.00E+00	3.76E-05	5.24E-05
Sr-92	7.50E-09	0.00E+00	2.79E-10	0.00E+00	0.00E+00	1.70E-05	1.00E-04
Y-90	2.35E-06	0.00E+00	6.30E-08	0.00E+00	0.00E+00	1.92E-04	7.43E-05
Y-91m	2.91E-10	0.00E+00	9.90E-12	0.00E+00	0.00E+00	1.99E-06	1.68E-06
Y-91	4.20E-04	0.00E+00	1.12E-05	0.00E+00	0.00E+00	1.75E-03	5.02E-05
Y-92	1.17E-08	0.00E+00	3.29E-10	0.00E+00	0.00E+00	1.75E-05	9.04E-05
Y-93	1.07E-07	0.00E+00	2.91E-09	0.00E+00	0.00E+00	5.46E-05	1.19E-04
Zr-95	8.24E-05	1.99E-05	1.45E-05	0.00E+00	2.22E-05	1.25E-03	1.55E-05
Zr-97	1.07E-07	1.83E-08	8.36E-09	0.00E+00	1.85E-08	7.88E-05	1.00E-04
Nb-95	1.12E-05	4.59E-06	2.70E-06	0.00E+00	3.37E-06	3.42E-04	9.05E-06
Nb-97	2.44E-10	5.21E-11	1.88E-11	0.00E+00	4.07E-11	2.37E-06	1.92E-05
Mo-99	0.00E+00	1.18E-07	2.31E-08	0.00E+00	1.89E-07	9.63E-05	3.48E-05
Tc-99m	9.98E-13	2.06E-12	2.66E-11	0.00E+00	2.22E-11	5.79E-07	1.45E-06
Tc-101	4.65E-14	5.88E-04	5.80E-13	0.00E+00	6.99E-13	4.17E-07	6.03E-07
Ru-103	1.44E-06	0.00E+00	4.85E-07	0.00E+00	3.03E-06	3.94E-04	1.15E-05
Ru-105	8.74E-10	0.00E+00	2.93E-10	0.00E+00	6.42E-10	1.12E-05	3.46E-05
Ru-106	6.20E-05	0.00E+00	7.77E-06	0.00E+00	7.61E-05	8.26E-03	1.17E-04
Ag-110m	7.13E-06	5.16E-06	3.57E-06	0.00E+00	7.80E-06	2.62E-03	2.36E-05

Table 1.10 (8 of 8)
INHALATION DOSE FACTORS
(mrem/pCi inhaled)

INFANT

	bone	liver	t body	thyroid	kidney	lung	gi-lli
Sb-124	2.71E-05	3.97E-07	8.56E-06	7.18E-08	0.00E+00	1.89E-03	4.22E-05
Sb-125	3.69E-05	3.41E-07	7.78E-06	4.45E-08	0.00E+00	1.17E-03	1.05E-05
Te-125m	3.40E-06	1.42E-06	4.70E-07	1.16E-06	0.00E+00	3.19E-04	9.22E-06
Te-127m	1.19E-05	4.93E-06	1.48E-06	3.48E-06	2.68E-05	9.37E-04	1.95E-05
Te-127	1.59E-09	6.81E-10	3.49E-10	1.32E-09	3.47E-09	7.39E-06	1.74E-05
Te-129m	1.01E-05	4.35E-06	1.59E-06	3.91E-06	2.27E-05	1.20E-03	4.93E-05
Te-129	5.63E-11	2.48E-11	1.34E-11	4.82E-11	1.25E-10	2.14E-06	1.88E-05
Te-131m	7.62E-08	3.93E-08	2.59E-08	6.38E-08	1.89E-07	1.42E-04	8.51E-05
Te-131	1.24E-11	5.87E-12	3.57E-12	1.13E-11	2.85E-11	1.47E-06	5.87E-06
Te-132	2.66E-07	1.69E-07	1.26E-07	1.99E-07	7.39E-07	2.43E-04	3.15E-05
I-130	4.54E-06	9.91E-06	3.98E-06	1.14E-03	1.09E-05	0.00E+00	1.42E-06
I-131	2.71E-05	3.17E-05	1.40E-05	1.06E-02	3.70E-05	0.00E+00	7.56E-07
I-132	1.21E-06	2.53E-06	8.99E-07	1.21E-04	2.82E-06	0.00E+00	1.36E-06
I-133	9.46E-06	1.37E-05	4.00E-06	2.54E-03	1.60E-05	0.00E+00	1.54E-06
I-134	6.58E-07	1.34E-06	4.75E-07	3.18E-05	1.49E-06	0.00E+00	9.21E-07
I-135	2.76E-06	5.43E-06	1.98E-06	4.97E-04	6.05E-06	0.00E+00	1.31E-06
Cs-134	2.83E-04	5.02E-04	5.32E-05	0.00E+00	1.36E-04	5.69E-05	9.53E-07
Cs-136	3.45E-05	9.61E-05	3.78E-05	0.00E+00	4.03E-05	8.40E-06	1.02E-06
Cs-137	3.92E-04	4.37E-04	3.25E-05	0.00E+00	1.23E-04	5.09E-05	9.53E-07
Cs-138	3.61E-07	5.58E-07	2.84E-07	0.00E+00	2.93E-07	4.67E-08	6.26E-07
Ba-139	1.06E-09	7.03E-13	3.07E-11	0.00E+00	4.23E-13	4.25E-06	3.64E-05
Ba-140	4.00E-05	4.00E-08	2.07E-06	0.00E+00	9.59E-09	1.14E-03	2.74E-05
Ba-141	1.12E-10	7.70E-14	3.55E-12	0.00E+00	4.64E-14	2.12E-06	3.39E-06
Ba-142	2.84E-11	2.36E-14	1.40E-12	0.00E+00	1.36E-14	1.11E-06	4.95E-07
La-140	3.61E-07	1.43E-07	3.68E-08	0.00E+00	0.00E+00	1.20E-04	6.06E-05
La-142	7.36E-10	2.69E-10	6.46E-11	0.00E+00	0.00E+00	5.87E-06	4.25E-05
Ce-141	1.98E-05	1.19E-05	1.42E-06	0.00E+00	3.75E-06	3.69E-04	1.54E-05
Ce-143	2.09E-07	1.38E-07	1.58E-08	0.00E+00	4.03E-08	8.30E-05	3.55E-05
Ce-144	2.28E-03	8.65E-04	1.26E-04	0.00E+00	3.84E-04	7.03E-03	1.06E-04
Pr-143	1.00E-05	3.74E-06	4.99E-07	0.00E+00	1.41E-06	3.09E-04	2.66E-05
Pr-144	3.42E-11	1.32E-11	1.72E-12	0.00E+00	4.80E-12	1.15E-06	3.06E-06
Nd-147	5.67E-06	5.81E-06	3.57E-07	0.00E+00	2.25E-06	2.30E-04	2.23E-05
W-187	9.26E-09	6.44E-09	2.23E-09	0.00E+00	0.00E+00	2.83E-05	2.54E-05
Np-239	2.65E-07	2.37E-08	1.34E-08	0.00E+00	4.73E-08	4.25E-05	1.78E-05

Reference:

Regulatory Guide 1.109, Table E-10.

Dose Factors for Co-57, Zn-69m, Br-82, Nb-97, Sb-124 and Sb-125 are from NUREG-0172 Age Specific Radiation Dose Commitment Factors for a One Year Chronic Intake, November 1977, Table 5.

NOTE: The tritium dose factor for bone is assumed to be equal to the total body dose factor.

Table 1.11 (1 of 2)
EXTERNAL DOSE FACTORS FOR STANDING ON CONTAMINATED GROUND
(mrem/h per pCi/m^2)

Nuclide	Total Body	Skin
H-3	0.0	0.0
C-14	0.0	0.0
Na-24	2.50E-08	2.90E-08
P-32	0.0	0.0
Cr-51	2.20E-10	2.60E-10
Mn-54	5.80E-09	6.80E-09
Mn-56	1.10E-08	1.30E-08
Fe-55	0.0	0.0
Fe-59	8.00E-09	9.40E-09
Co-57	1.77E-09	2.21E-09
Co-58	7.00E-09	8.20E-09
Co-60	1.70E-08	2.00E-08
Ni-63	0.0	0.0
Ni-65	3.70E-09	4.30E-09
Cu-64	1.50E-09	1.70E-09
Zn-65	4.00E-09	4.60E-09
Zn-69	0.0	0.0
Zn-69m	5.50E-09	6.59E-09
Br-82	3.18E-08	3.90E-08
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
Nb-97	8.11E-09	1.00E-08
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
Sb-124	2.17E-08	2.57E-08

Table 1.11 (2 of 2)
EXTERNAL DOSE FACTORS FOR STANDING ON CONTAMINATED GROUND
(mrem/h per pCi/m^2)

Nuclide	Total Body	Skin
Sb-125	5.48E-09	6.80E-09
Te-125m	3.50E-11	4.80E-11
Te-127m	1.10E-12	1.30E-12
Te-127	1.00E-11	1.10E-11
Te-129m	7.70E-10	9.00E-10
Te-129	7.10E-10	8.40E-10
Te-131m	8.40E-09	9.90E-09
Te-131	2.20E-09	2.60E-06
Te-132	1.70E-09	2.00E-09
I-130	1.40E-08	1.70E-08
I-131	2.80E-09	3.40E-09
I-132	1.70E-08	2.00E-08
I-133	3.70E-09	4.50E-09
I-134	1.60E-08	1.90E-08
I-135	1.20E-08	1.40E-08
Cs-134	1.20E-08	1.40E-08
Cs-136	1.50E-08	1.70E-08
Cs-137	4.20E-09	4.90E-09
Cs-138	2.10E-08	2.40E-08
Ba-139	2.40E-09	2.70E-09
Ba-140	2.10E-09	2.40E-09
Ba-141	4.30E-09	4.90E-09
Ba-142	7.90E-09	9.00E-09
La-140	1.50E-08	1.70E-08
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

References:

Regulatory Guide 1.109, Table E-6.

Dose Factors for Co-57, Zn-69m, Br-82, Nb-97, Sb-124 and Sb-125 are from Dose-Rate Conversion Factors for External Exposure to Photon and Electron Radiation from Radionuclides Occurring in Routine Releases from Nuclear Fuel Cycle Facilities, D. C. Kocher, Health Physics Volume 38, April 1980.

Table 2.1
RECEPTORS FOR LIQUID DOSE CALCULATIONS

Tennessee River Reaches Within 50 Mile Radius Downstream of BFN

Name	Beginning TRM	Ending TRM	Size (acres)	Recreation visits/year
Wheeler Lake below BFN	294.0	275.0	26076	1,408,600
Wilson Lake	275.0	260.0	15930	3,816,800
Pickwick Lake	260.0	230.0	15048	705,500

Public Water Supplies Within 50 Mile Radius Downstream of BFN

Name	TRM	Population
Muscle Shoals, AL	259.6	10,740
Sheffield, AL	254.3	13,065
Cherokee, AL	239.2	3,400

Table 2.2
BIOACCUMULATION FACTORS FOR FRESHWATER FISH
(Page 1 of 1)

Nuclide		Nuclide	
H-3	9.0E-01	Tc-101	1.5E+101
C-14	4.6E+03	Ru-103	1.0E+01
Na-24	1.0E+02	Ru-105	1.0E+01
P-32	1.0E+05	Ru-106	1.0E+01
Cr-51	2.0E+02	Ag-110m	0.0E+00
Mn-54	4.0E+02	Sb-124	1.0E+00
Mn-56	4.0E+02	Sb-125	1.0E+00
Fe-55	1.0E+02	Te-125m	4.0E+02
Fe-59	1.0E+02	Te-127m	4.0E+02
Co-57	5.0E+01	Te-127	4.0E+02
Co-58	5.0E+01	Te-129m	4.0E+02
Co-60	5.0E+01	Te-129	4.0E+02
Ni-63	1.0E+02	Te-131m	4.0E+02
Ni-65	1.0E+02	Te-131	4.0E+02
Cu-64	5.0E+01	Te-132	4.0E+02
Zn-65	2.0E+03	I-130	4.0E+01
Zn-69	2.0E+03	I-131	4.0E+01
Zn-69m	2.0E+03	I-132	4.0E+01
Br-82	4.2E+02	I-133	4.0E+01
Br-83	4.2E+02	I-134	4.0E+01
Br-84	4.2E+02	I-135	4.0E+01
Br-85	4.2E+02	Cs-134	1.9E+03
Rb-86	2.0E+03	Cs-136	1.9E+03
Rb-88	2.0E+03	Cs-137	1.9E+03
Rb-89	2.0E+03	Cs-138	1.9E+03
Sr-89	5.6E+01	Ba-139	4.0E+00
Sr-90	5.6E+01	Ba-140	4.0E+00
Sr-91	5.6E+01	Ba-141	4.0E+00
Sr-92	5.6E+01	Ba-142	4.0E+00
Y-90	2.5E+01	La-140	2.5E+01
Y-91m	2.5E+01	La-142	2.5E+01
Y-91	2.5E+01	Ce-141	1.0E+00
Y-92	2.5E+01	Ce-143	1.0E+00
Y-93	2.5E+01	Ce-144	1.0E+00
Zr-95	3.3E+00	Pr-143	2.5E+01
Zr-97	3.3E+00	Pr-144	2.5E+01
Nb-95	3.0E+04	Nd-147	2.5E+01
Nb-97	3.0E+04	W-187	1.2E+03
Mo-99	1.0E+01	Np-239	1.0E+01

References:
Bioaccumulation factors for Sb- nuclides are from ORNL-4992, "A Methodology for Calculating Radiation Doses from Radioactivity Released to the Environment, March 1976, Table 4.12A.
Bioaccumulation factors for Iodine, Cesium, and Strontium nuclides are from NUREG/CR-1004, Table 3.2.4.
All other nuclides' bioaccumulation factors are from Regulatory Guide 1.109, Table A-1.

TABLE 3.1
(Sheet 4 of 4)
ENVIRONMENTAL RADIOLOGICAL MONITORING

Exposure Pathway and/or Sample	Number of Samples and Locations	Sampling and Collection Frequency	Type and Frequency of Analysis
Fish	3 samples representing commercial and game species in Guntersville Reservoir above the plant 3 samples representing commercial and game species in Wheeler Reservoir near the plant 3 samples representing commercial and game species in Wilson Reservoir near the plant	At least once per 184 days	Gamma scan at least once per 184 days on edible portions.
Clams	Sample from same locations as sediment (if available)	Same as sediment	Gamma scan on flesh only
Fruits & Vegetables	Samples of food crops such as corn, green beans, tomatoes, and potatoes grown at private gardens and/or farms in the immediate vicinity of the plant 1 sample of each of the same foods grown at greater than 10 miles distance from the plant	At least once per year at time of harvest	Gamma scan on edible portion
Vegetation (pasturage and grass)	Samples from the nearby dairy farms (Farms B, Bn, L and T) and from the local atmospheric monitoring stations (LM-1, LM-2, LM-3, LM-4, LM-6 and LM-7) Control samples from 1 remote air monitor (RM-1) and 1 control dairy farm (Farm O)	Once per 31 days	I-131, gamma scan once per 31 days. Sr-89 and Sr-90 analysis on the last monthly sample of each quarter.

TABLE 3.2 A
BROWNS FERRY NUCLEAR PLANT
Environmental Radiological Monitoring Program
Sampling Locations

Map Location Number [a]	Station	Sector	Approximate Distance (Miles)	Indicator (I) or Control (C)	Samples Collected[b]
1	PM-1	NW	13.8	I	AP, CF, S
2	PM-2	NE	10.9	I	AP, CF, S
3	PM-3	SSE	8.2	I	AP, CF, S
4	LM-7	W	2.1	I	AP, CF, S, V
5	RM-1	W	31.3	C	AP, CF, S, V
6	RM-6	E	24.2	C	AP, CF, S
7	LM-1	N	0.97	I	AP, CF, S, V
8	LM-2	NNE	0.88	I	AP, CF, S, V
9	LM-3	ENE	0.92	I	AP, CF, S, V
10	LM-4	NNW	1.7	I	AP, CF, S, V
11	LM-6	SSW	3.0	I	AP, CF, S, V
12	Farm B	NNW	6.8	I	M, V
13	Farm Bn	N	5.0	I	M, V
14	Farm L	ENE	5.9	I	M, V, W
22	Well #6	NW	0.02	I	W
23	TRM[c] 282.6	-	11.4[d]	I	PW
24	TRM 303.0	-	12.0	C	PW
25	Muscle Shoals, AL	W	31.3	I	PW
26	TRM 274.9	-	19.1[d]	I	PW
27	TRM 285.2	-	8.8[d]	I	SW
28	TRM 293.5	-	0.5[d]	I	SW
29	TRM 305.0	-	11.0[d]	C[e]	SW
30	TRM 307.52	-	13.52	C	CL, SD
31	TRM 293.7	-	0.3[d]	I	CL, SD
32	TRM 288.78	-	5.22[d]	I	CL, SD
33	TRM 277.98	-	16.02[d]	I	CL, SD
34	Farm Be	NW	28.8	C	M
35	Farm O	E	26.2	C	M, V
36	Farm T	WNW	3.2	I	V
37	TRM 297.0	-	-	I	F
	Wilson Reservoir (TRM 259-275)			I	F
	Wheeler Reservoir (TRM 275-349)			I	F
	Guntersville Reservoir (TRM 349-424)			I	F

a See figures 3.1, 3.2, and 3.3
b Sample codes:
AP = Air particulate filter; S = Soil; SD = Sediment
CF = Charcoal Filter; SW = Surface Water; CL = Clams
F = Fish; V = Vegetation; PW = Public Water
W = Well Water
c TRM = Tennessee River Mile
d Miles from plant discharge (TRM 294)
e Also used as a control for public water

Figure 3.2

Environmental Radiological Sampling Locations From 1 to 5 Miles From The Plant

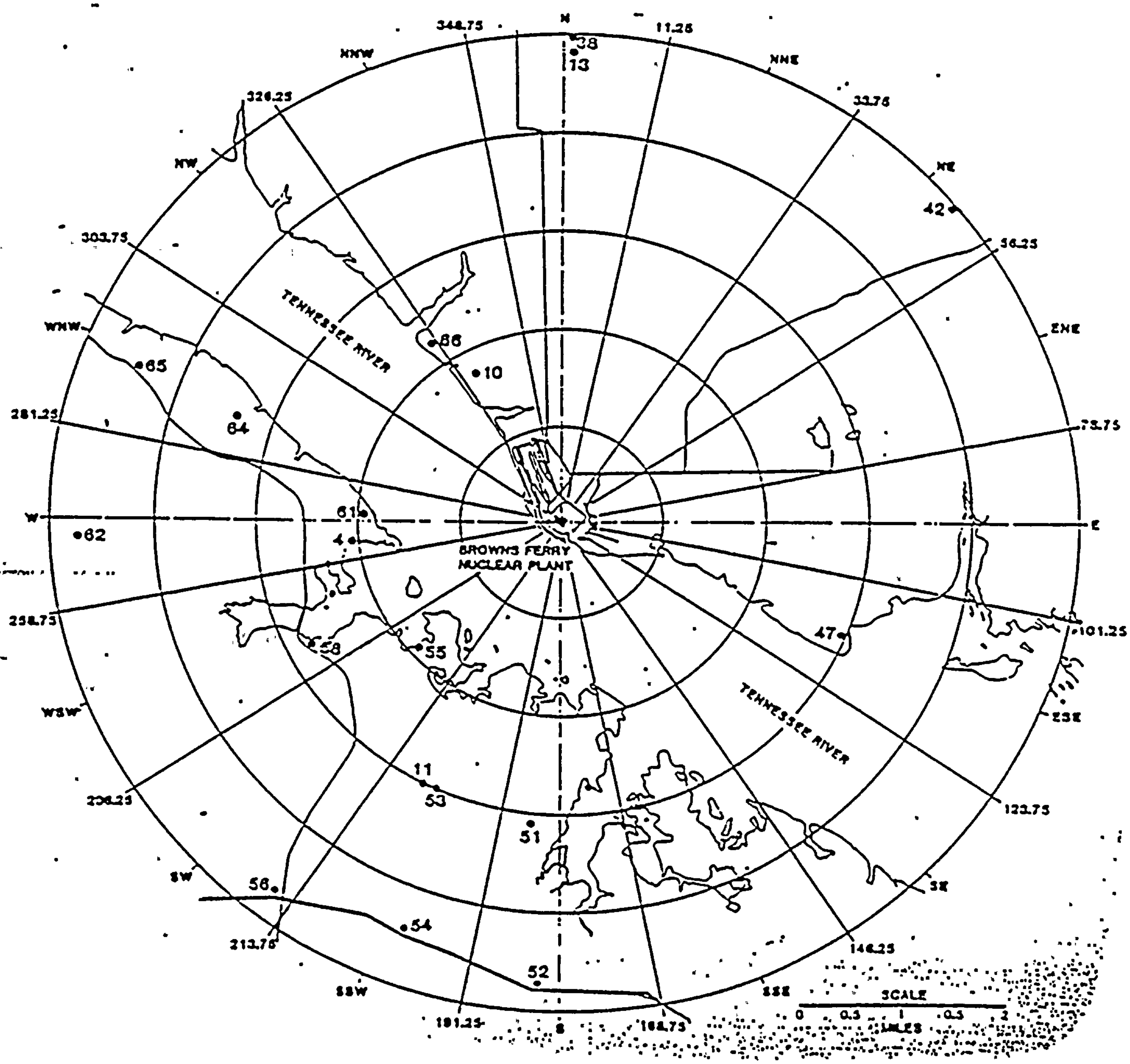
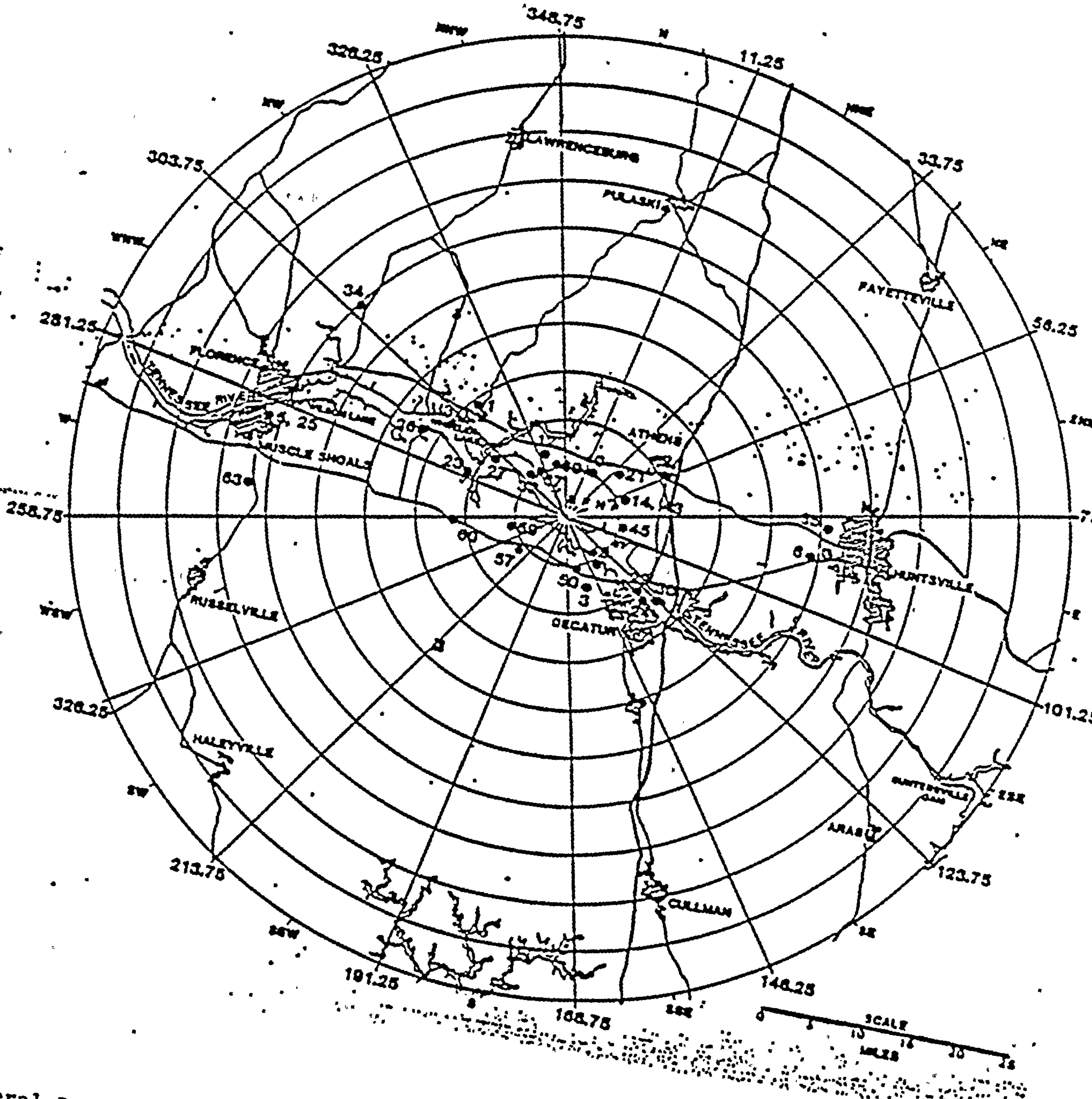


Figure 3.3

Environmental Radiological Sampling Locations Greater Than 5 Miles From The Plant



TO : Those listed

FROM : D. R. Gallien, Supervisor, Chemical Technical Support Section, Browns Ferry Nuclear Plant

DATES :

SUBJECT: BROWNS FERRY NUCLEAR PLANT (BFN) - INOPERABLE RADIOACTIVE EFFLUENT INSTRUMENT REPORT COMMITMENT DATES

Attached is the draft of the semi-annual Inoperable Radioactive Effluent Instrument Report prepared by the Chemical Technical Support Section. A breakdown of the completion dates for work involving several groups follows:

Responsible Group	Item	Comp Date
	Liquid Process Radiation Monitors:	
Mods	Complete field work	4-22-88
PMT	Complete Post Mod Test	5-20-88
CTS	Source check SI written and approved	5-20-88
I&C Tech	Calibration and Functional SIs written and approved	5-20-88
IMs	Run New SIs	6-17-88
	Liquid Radwaste Effluent Instrumentation:	
PMT	Complete Post Mod Test	4-29-88
I&C Tech	New SIs written and approved	4-29-88
IMs	Run new SIs	5-27-88

Other dates involving only instrument maintenance (IM) are listed in the report. It is important that the dates committed to in the semi-annual report be met. Please review those commitments related to your section and contact John Wilson at extension 2652 by January 28, 1988 if you cannot meet the commitment date.

D. R. Gallien

G. A. Hartsfield, BFN
A. W. McCaleb, BFN
P. McGraw, BFN
S. H. McRight, BFN
J. A. Savage, BFN
T. E. Scott, BFN
R. L. Smith, BFN

JAW:LSM
Attachment
cc (Attachment):
RIMS, MR 4N 72A-C

This was prepared principally by P. S. Kirby.

TO : Patrick P. Carier, Manager of Site Licensing, PAB C, Browns Ferry Nuclear Plant

FROM : Guy G. Campbell, Plant Manager, POB C, Browns Ferry Nuclear Plant

DATE :

SUBJECT: BROWNS FERRY NUCLEAR PLANT - TRANSMITTAL OF INOPERABLE RADIOACTIVE EFFLUENT INSTRUMENT REPORT

Attached is the Inoperable Radioactive Effluent Instrument Report for the period from January 1 through June 30, 1989. The report was prepared by the Chemistry Technical Support Section for incorporation into the Semi-annual Radioactive Release Report, in accordance with Limiting Conditions of Operations 3.2.K.2 and 3.2.D.2.

Guy G. Campbell

DCS:NMM:PSK:TRS
Attachment
cc (Attachment):
RIMS, MR 4N 72A-C
J. L. Bates, CST 11A 8A-C
W. Christopher, PMB A, BFN
C. M. Crane, PMC F, BFN
J. W. Hutton, POB E, BFN
T. E. Scott, PMC F, BFN
W. L. Sutor, PEB A4, BFN

This was prepared principally by P. S. Kirby.

0151m/2

{ Enclosure 2 }

TENNESSEE VALLEY AUTHORITY

BROWNS FERRY NUCLEAR PLANT

INOPERABLE RADIOACTIVE EFFLUENT INSTRUMENTATION REPORT

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spacing

Inoperable Radioactive Effluent Instrumentation Report

This report is to comply with Radiological Effluent-Technical Specifications (RETS) section 3.2.D.2 and 3.2.K.2 reporting requirements for instruments that are inoperable for more than 30 days. The RETS became effective at BFN on May 6, 1987. This report covers the period from January 1 - June 30, 1989. Because of significant technical specification changes, a large number of radioactive effluent monitoring instruments became technically inoperable on May 6, 1987. RETS were incorporated during a BFN administrative outage. Site resources were, and still are endeavoring to resolve previously identified problem areas. Modifications required to bring BFN effluent monitoring equipment into technical compliance with RETS compete for resources with other regulatory driven modifications.

The instruments that were inoperable for more than 30 days are:

RHR service water monitor (1-RM-90-133)

RHR service water monitor (1-RM-90-134)

RHR service water monitor (2-RM-90-133)

RHR service water monitor (3-RM-90-133)

RHR service water monitor (3-RM-90-134)

Raw cooling water monitor (2-RM-90-132)

Stack effluent flow meter (0-FE-90-271)

Off Gas Post Treatment noble gas activity monitor (2-RM-90-265)

Off Gas Post Treatment noble gas activity monitor (2-RM-90-266)

Off Gas Post Treatment noble gas activity monitor (3-RM-90-265)

Off Gas Post Treatment noble gas activity monitor (3-RM-90-266)

Off Gas Sample Flow Abnormal (2-PA-90-262)

During the entire reporting period, fuel was off loaded from units one and three and all compensatory sampling requirements were met.

Liquid Process Radiation Monitors

BFN Tech Spec Table 3.2.D requires Residual Heat Removal (RHR) service water monitors (1-RM-90-133, 1-RM-90-134, 2-RM-90-133, 3-RM-90-133, and 3-RM-90-134) and raw cooling water monitor (2-RM-90-132) to be operable when these systems are in service. Contrary to this requirement, these six monitors were not available for operability for greater than 30 days during this reporting period.

1-RM-90-133, 3-RM-90-133, and 3-RM-90-134 monitors were not available for operability because they were not designed to meet the requirements in Tech Spec Table 4.2.D, Footnote 2. This footnote requires that control room annunciation occur if instrument controls are not set in operate mode. Design Change Request (DCR) 1687, revision 1, was written to correct this problem and was approved on September 29, 1986. 1-RM-90-133, 3-RM-90-133, and 3-RM-90-134 are still not in service due to the associated residual heat removal piping being capped and out of service. 1-RM-90-134 was removed from service due to seismic concerns which are being resolved with Design Change Notice (DCN) H3949 and 2-RM-90-133 was declared inoperable on April 4, 1989 because a downscale alarm came in. After investigation, it was determined there was not sufficient flow from the RHR headers causing problems with the monitor's flow switch. The monitor was functioning properly and the operability SI was successfully completed on the monitor on May 12, 1989.

2-RM-90-132 was removed from service because the system was not designed to operate at very low RCW discharge flow rates. DCN H4377 was written to redesign the suction tap for 2-RM-90-132 to allow obtaining a sample from RCW regardless of RCW flow rate. DCN H4377 is complete except for paperwork closure and plant acceptance. Compensatory sampling is being utilized to verify discharge release rates are met.

Stack Radioactive Effluent Instrumentation

The stack effluent flow meter (0-FE-90-271) was inoperable for more than 30 days during this reporting period.

The stack effluent flow meter (0-FE-90-271) was declared inoperable on May 27, 1989 due to a loss of flow indication in the control room. The meter has not been returned to service because the spare parts had to be ordered and have not been received.

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Off Gas Post Treatment

BFN Technical Specification Table 3.2.K requires the Off Gas Post Treatment noble gas activity monitors (1-RM-90-265, 1-RM-90-266, 2-RM-90-265, 2-RM-90-266, 3-RM-90-265, and 3-RM-90-266) to be operable at all times. Contrary to this requirement, four of these monitors (2-RM-90-265, 2-RM-90-266, 3-RM-90-265 and 3-RM-90-266) along with Sample Flow Abnormal (2-PA-90-262), were inoperable for more than 30 days during this reporting period.

The Unit 2 monitors, 2-RM-90-265 and 266, and Sample Flow Abnormal, 2-PA-90-262, were declared inoperable on February 7, 1989 due to the failure of a daily alarm check on 2-PA-90-262. The problem was corrected and the monitors were returned to service on March 10, 1989.

The Unit 3 monitors, 3-RM-90-265 and 266, were taken out of service on January 19, 1989 due to the lack of performance of the Quarterly Functional Test Surveillance Instructions (SIs). The SIs could not be performed due to a hold order on the Unit 3 offgas isolation valve. The SIs were added to the hold order to ensure no releases were made through this pathway. This is in compliance with Technical Specification Table 3.2.K, action (F). These monitors were returned to service on July 12, 1989 to support Unit 3 off gas layup.

The off gas systems were not in service during this period.

TVA 64 (OS-9-65) (OP-WP-5-85)

R4 890714 967

UNITED STATES GOVERNMENT

Memorandum

TENNESSEE VALLEY AUTHORITY

TO : Patrick P. Carier, Manager of Site Licensing, PAB C, Browns Ferry Nuclear Plant

FROM : Guy G. Campbell, Plant Manager, POB C, Browns Ferry Nuclear Plant

DATE : JUL 18 1989

SUBJECT: BROWNS FERRY NUCLEAR PLANT - TRANSMITTAL OF INOPERABLE RADIOACTIVE EFFLUENT INSTRUMENT REPORT

Attached is the Inoperable Radioactive Effluent Instrument Report for the period from January 1 through June 30, 1989. The report was prepared by the Chemistry Technical Support Section for incorporation into the Semi-annual Radioactive Release Report, in accordance with Limiting Conditions of Operations 3.2.K.2 and 3.2.D.2.

Guy G. Campbell

DCS:NMM:PSK:TRS
Attachment
cc (Attachment):
RIMS, MR 4N 72A-C
J. L. Bates, CST 11A 8A-C
W. Christopher, PMB A, BFN
C. M. Crane, PMC F, BFN
J. W. Hutton, POB E, BFN
T. E. Scott, PMC F, BFN
W. L. Sutor, PEB A4, BFN

This was prepared principally by P. S. Kirby.

Licensing and Safety
Browns Ferry Nuclear Plant
JUL 13 '89
RLB

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TENNESSEE VALLEY AUTHORITY

BROWNS FERRY NUCLEAR PLANT

INOPERABLE RADIOACTIVE EFFLUENT INSTRUMENTATION REPORT

Inoperable Radioactive Effluent Instrumentation Report

This report is to comply with Radiological Effluent Technical Specifications (RETS) section 3.2.D.2 and 3.2.K.2 reporting requirements for instruments that are inoperable for more than 30 days. The RETS became effective at BFN on May 6, 1987. This report covers the period from January 1 - June 30, 1989. Because of significant technical specification changes, a large number of radioactive effluent monitoring instruments became technically inoperable on May 6, 1987. RETS were incorporated during a BFN administrative outage. Site resources were, and still are endeavoring to resolve previously identified problem areas. Modifications required to bring BFN effluent monitoring equipment into technical compliance with RETS compete for resources with other regulatory driven modifications.

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2-RM-90-132 was removed from service because the system was not designed to operate at very low RCW discharge flow rates. DCN H4377 was written to redesign the suction tap for 2-RM-90-132 to allow obtaining a sample from RCW regardless of RCW flow rate. DCN H4377 is complete except for paperwork closure and plant acceptance. Compensatory sampling is being utilized to verify discharge release rates are met.

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BFN Technical Specification Table 3.2.K requires the Off Gas Post Treatment noble gas activity monitors (1-RM-90-265, 1-RM-90-266, 2-RM-90-265, 2-RM-90-266, 3-RM-90-265, and 3-RM-90-266) to be operable at all times. Contrary to this requirement, four of these monitors (2-RM-90-265, 2-RM-90-266, 3-RM-90-265 and 3-RM-90-266) along with Sample Flow Abnormal (2-PA-90-262), were inoperable for more than 30 days during this reporting period.

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The off gas systems were not in service during this period.

LICENSING SUBMITTAL CHECKLIST

Submittal Subject: BFN - Semiannual Radioactive Effluent Release Report

Preparer: Raymond L. Boyd

RLB Submittal has been proofed/spell checked

_____ Independent reading by licensing engineer

_____ Licensing strategy approved by senior management

_____ Backup documentation list is complete

_____ Engineering/Technical Report is ___ preliminary, ___ final

_____ New commitments identified. If yes,
  _____ CCTS load sheets complete
  _____ concurrences obtained from responsible organization

_____ Notarization required (Yes/No)

_____ Proper docket number(s) included on submittal

_____ Tac number included on submittal

_____ Contains Safeguards Information per 10 CFR 73.21 (Yes/No)

_____ Contains proprietary information per 10 CFR 2.790 (Yes/No)

_____ Fee required per 10 CFR 170.12 (Yes/No)

_____ Submittal affects Final Safety Analysis Report (Yes/No)
  _____ If yes copy provided to FSAR coordinator

_____ Status of corrective actions:

0100y/6

LICENSING SUBMITTAL CHECKLIST (Cont'd)

(a) CAQR/SCR/NCR # ______________

condition identified	___
corrective action approved	___
corrective action complete*	___
root cause determined	___
recurrence control*	___
CAQ closed	___

(b) ECN/WP - ECN #	___________	issued	_______
WP #	___________	status	_______
(c) WR/MR #	___________	status	_______
(d) CCTS #	___________	status	_______

Other status notes: ____

____

* If not 100% complete indicate by 'R/C' that action is restart complete.

0100y/7