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WASHINGTON PUBLIC POWER SUPPLY SYSTEM

WNP-2

OFFSITE DOSE CALCULATION MANUAL

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1.0 INTRODUCTION

The purpose of this manual is to provide the information and methodologies to be used by the Washington Public Power Supply System to ensure compliance with the dose requirements stated in the WNP-2 Effluents Technical Specifications.

2.0 LIQUID EFFLUENT DOSE CALCULATION

2.1 Introduction

Liquid radwaste released from WNP-2 will meet 10 CFR 20 limits at the point of discharge to the Columbia River. This design objective will be kept at all times. Actual discharges of liquid radwaste effluents will only occur on a Batch Basis, and the average concentration at the point of discharge will be only a small percentage of the allowed limits. A simplified block diagram of the liquid waste management system and effluent pathways is contained in Figure 2-1. Solid radioactive wastes are disposed of by way of an approved disposal site. A simplified block diagram of the solid radwaste system is described in Figure 2-2.

The cumulative quarterly dose contributions due to radioactive liquid effluents released to the unrestricted areas will be determined once every 31 days using the LADTAP II computer code. The maximum exposed individual is assumed to be an adult whose exposure pathways include potable water and fish consumption. The choice of an adult as the maximum exposed individual is based on the highest fish and water consumption rates shown by that age group and the fact that most of the dose from the liquid effluent comes from these two pathways.

The dose contributions will be calculated for all radionuclides identified in the released effluent. The calculations are based on guidelines provided by Nureg-0133 and the LADTAP II computer code.

The methods for calculating the doses are discussed in Section 2.4 of this manual.

2.2 Radwaste Liquid Effluent Radiation Monitoring System

This monitoring subsystem measures the radioactivity in the liquid effluent prior to its entering the cooling tower blowdown line.

All radwaste effluent passes through a four-inch line which has an off-line sodium iodide radiation monitor. The radwaste effluent flow, variable from 0 to 190 gpm, combines with the 36-inch cooling water blowdown line, variable from 0 to 7500 gpm, (average of 2690 gpm) and is discharged to the Columbia River with a total flow based on MPC_i total, and cooling water flushing needs.

The radiation monitor has a minimum sensitivity of 10^{-6} μCi/cc of Cs-137, and the radiation indicator has a range of seven decades. The radiation monitor is located on the 437' level of the Radwaste Building.

2.3 10 CFR 20 Release Rate Limits

The requirements pertaining to discharge of radwaste liquid effluents to the unrestricted area are specified in Technical Specification 3.11.1.1:

> "The concentration of radioactive material released from the site to unrestricted areas shall be limited to the concentrations specified in 10 CFR 20, Appendix B, Table II, Column 2 for radionuclides other than noble gases, and 2 x 10^{-4} μCi/m total activity concentratration for all dissolved or entrained noble gases."

In order to comply with the requirements stated above, limits will be set to assure that blowdown line concentrations do not exceed 10 CFR 20, Appendix B, Table II, Column 2 at any time.

2.3.1 Pre-Release Calculation

The activity of the radionuclide mixture will be determined in accordance with Supply System procedure PPM 12.5.3, Liquid Effluent Discharge Determination. Liquid effluent discharge is determined and calculated according to PPM 12.11.1, Radiological Effluent Monitoring Gaseous and Liquid. The effluent concentration is determined by the following equation:

$$Con_{Ci} = \frac{Ci \times fw}{ft} \qquad (1)$$

where:

Con_{Ci} = Concentration of radionuclide i in the effluent at point of discharge - μCi/ml.

Ci = Concentration of radionuclide i in the batch to be released - μCi/ml.

fw = Discharge flow rate from sample tank to the blowdown line - variable from 0 to 190 gpm.

fb = Blowdown flow rate - variable from 0 to 7500 gpm.

ft = Total discharge flow rate - (ft = fb + fw)

The calculated concentration in the blowdown line must be less than the concentrations listed in 10 CFR 20, Appendix B. Before releasing the batch to the environment, the following equation must hold:

$$\sum_{i=1}^{m} (Con_{Ci}/MPC_i) \leq 1 \qquad (2)$$

where:

Con_{Ci} = The concentration of radionuclide i in the effluent at the point of discharge into the river.

MPC_i = Maximum permissible concentration of nuclide i as listed in 10 CFR 20, Appendix B, Table II.

m = Total number of radionuclides in the batch.

2.3.2 Post-Release Calculation

The concentration of each radionuclide in the restricted area, following the batch release, will be calculated as follows:

The average activity of radionuclide i during the time period of the release is divided by the Plant Discharge Flow/Tank Discharge Flow ratio yielding the concentration at the point of discharge:

$$Con_{Cik} = \frac{Cik \times fw}{ft} \qquad (3)$$

where:

Con_{Cik} = The concentration of radionuclide i in the effluent at the point of discharge during the release period k - (μCi/ml).

Cik = The concentration of radionuclide i in the batch during the release period k - (μCi/ml).

fw = Discharge flow rate from sample tank to the blowdown line - variable from 0 to 190 gpm.

fb = Blowdown flow rate - variable from 0 to 7500 gpm.

ft = Total discharge (ft = fb + fw) flow rate - variable from 0 to 7690 gpm.

To assure compliance with 10 CFR 20, the following relationships must hold:

$$\sum_{i=1}^{m} (Con_{Cik}/MPC_i) \leq 1 \qquad (4)$$

where the terms are as defined in Equation (2).

2.3.3 Continuous Release

Continuous release of liquid radwaste effluent is not planned for WNP-2. However, should it occur, the concentrations of various radionuclides in the

unrestricted area would be calculated according to Equation (3) and Equation (4). To show compliance with 10 CFR 20, the two equations must again hold.

2.4 10 CFR 50, Appendix I, Release Rate Limits

Technical Specification 4.11.1.2 requires that the cumulative dose contributions be determined in accordance with the ODCM at least once per 31 days. Technical Specification 3.11.1.2 specifies that the dose to a member of the public from radioactive material in liquid effluents released to the unrestricted area shall be limited to:

$\leq$ 1.5 mrem/Calendar Quarter - Total Body

and

$\leq$ 5.0 mrem/Calendar Quarter - Any Organ.

The cumulative dose for the calendar year shall be limited to:

$\leq$ 3 mrem - Total Body

and

$\leq$ 10 mrem - Any Organ.

The dose contribution will be calculated for all radionuclides identified in the liquid effluent released to the unrestricted area, using the following equation:

$$D_\tau = \sum_i \left(A_{i\tau} \sum_{\ell=1}^{m} \Delta t_\ell C_{i\ell} F_\ell\right) \qquad (5)$$

where:

D_τ = The cumulative dose commitment to the total body or organ, τ, from liquid effluents for the total time period $\sum_{\ell=1}^{m} \Delta t_\ell$, in mrem.

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

m = The number of releases for the time period under consideration.

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

$A_{i\tau}$ = The site-related ingestion dose commitment factor to the total body or any organ τ for each identified principle gamma and beta emitter listed in Table 2-2, in mrem/hr per $\mu Ci/ml$.

F_ℓ = The near field average dilution factor for $C_{i\ell}$ during any liquid waste release. Defined as the ratio of the maximum undiluted liquid waste flow during release to the product of the average flow from the site discharge structure to unrestricted receiving waters times 500.

$$(F_\ell = \frac{\text{Liquid Radioactive Waste Flow}}{\text{Discharge Structure Exit Flow x 500}} = \frac{fw}{ft \times 500} \quad (6)$$

The term A_{ij}, the ingestion dose factors for the total body and critical organs, are tabulated in Table 2-2. It embodies the dose factor, fish bioaccumulation factor, pathway usage factor, and the dilution factor for the plant diffuser pipe to the Richland potable water intake. The following equation was used to calculate the ingestion dose factors:

$$A_{ij} = K_o\left(\frac{U_w}{D_w} + U_F\, B_{Fi}\right)D_{Fi} \qquad (7)$$

where:

A_{ij} = The composite dose parameter for total body or critical organ of an adult for nuclide i (in mrem/hr per μCi/ml).

K_o = A conversion factor:
1.14E+05 = (10^6 pCi/μCi) x (10^3 ml/liter) ÷ 8760 hr/yr.

U_w = 730 liter/yr - which is the annual water consumption by the maximum adult (Table E-4 of Regulatory Guide 1.109, Revision 1).

B_{Fi} = Bioaccumulation factor for radionuclide i in fish - (pCi/Kg per pci/liter) (Table A-1 of Regulatory Guide 1.109, Revision 1 and NUREG/CR-4013).

D_{Fi} = Adult ingestion dose conversion factor for nuclide i - Total body or critical organ - (mrem/pCi) (Table E-11 of Regulatory Guide 1.109, Revision 1 and NUREG/CR-4013).

D_w = Dilution factor from near field area to the Richland potable water intake - 100.

U_F = Adult fish consumption, 21 kg/yr (Table E-5 of Regulatory Guide 1.109, Revision 1).

The values of BF_i and DF_i are listed in Table 2-1.

The quarterly limits mentioned before represent one-half of the annual design objective of Section II.A of 10 CFR 50, Appendix I. If any of the limits (either that of the calendar quarter or calendar year) are exceeded, a special report pursuant to Section IV.A of 10 CFR 50, Appendix I, shall be filed with the NRC.

2.4.1 Projection of Doses

The projected doses due to releases of WNP-2 radwaste liquid effluents will be calculated for each batch, using equation 5. If the sum of the accumulated dose to date for the month and the projected dose for the remainder of the month exceeds the technical specification 3.11.1.3 limits, then the liquid radwaste treatment system shall be used. This is to ensure compliance with Standard Technical Specification 3.11.1.3. This technical specification states that the liquid radwaste treatment system shall be maintained and the appropriate subsystem shall be used if the radioactive materials in liquid waste, prior to their discharge, when the dose, due to liquid effluent release to unrestricted areas when averaged over the month would exceed 0.06 mrem to total body or 0.2 mrem to any organ.

2.5 Radwaste Liquid Effluent Dilution Ratio and Alarm Setpoints Calculations

2.5.1 Introduction

The dilution alarm ratio and setpoints of the sample liquid effluent monitor are established to ensure that the limits of 10 CFR 20, Appendix B, Table II, Column 2, are not exceeded in the effluent at the discharge point (i.e., compliance with Standard Technical Specification 3.11.1.1, as discussed in section 2.3.1 of this manual).

The trip/alarm setpoint for the liquid radwaste effluent monitor is calculated from the results of the radiochemical analysis of the waste solution. The setpoint will be set into the radwaste monitor just prior to the release of each batch of radioactive liquid.

2.5.2 Methodology for Determining the Maximum Permissible Concentration (MPC) Fraction

Radwaste liquid effluents can only be discharged to the environment through the four-inch radwaste line. The maximum radwaste discharge flow rate is 190 gpm. Prior to discharge, the tank is isolated and recirculated for at least thirty minutes, and a representative sample is taken from the tank. An isotopic analysis of the batch will be made to determine the sum of the MPC fraction (MPC_f) based on 10 CFR 20 limits. From the sample analysis and the MPC values in 10 CFR 20, the MPC_f is determined using the following equation.

$$MPC_f = \sum_{i=1}^{m} \frac{C_i}{MPC_i} \qquad (8)$$

where:

MPC_f = Total fraction of the Maximum Permissible Concentrations (MPCs) in the liquid effluent waste sample.

C_i = The concentration of each measured radionuclide (i) observed by the radiochemical analysis of the liquid waste sample (μCi/ml).

MPC_i = The limiting concentrations of the appropriate radionuclide (i) from 10 CFR 20, Appendix B, Table II, Column 2. For dissolved or entrained noble gases, the concentration shall be limited to 2.0E-04 µCi/ml total activity.

m = The total number of measured radionuclides in the liquid batch to be released.

If the MCP_f is less than or equal to 0.8, the liquid batch may be released at any radwaste discharge or blowdown rate. If the MPC_f exceeds 0.8, then a dilution factor (Fd) must be determined. The liquid effluent radiation monitor responds proportionally to radioactivity concentrations in the undiluted waste stream. Its setpoint must be determined for diluted releases.

2.5.3 Methodology for the Determination of Liquid Effluent Monitor Setpoint

The measured radionuclide concentrations are used to calculate the dilution factor (Fd), which is the ratio of the total discharge flow rates (fw + fb) to the radwaste tank effluent flow rate (fw) that is required to assure that the limiting concentrations of Technical Specification 3.11.1.1 are met at the point of discharge.

The dilution factor (Fd) is determined according to:

$$Fd = \left[\sum_{i=1}^{m} \frac{C_i}{MPC_i} \right] \times Fs \qquad (9)$$

Where:

Fd = The dilution factor required for compliance with 10 CFR 20, Appendix B, Table II, Column 2.

C_i = The concentration of each radionuclide (i) observed by radiochemical analysis of the liquid waste sample (μCi/ml).

MPC_i = The limiting concentration of the appropriate radionuclide (i) from 10 CFR 20, Appendix B, Table II, Column 2. For dissolved or entrained noble gases, the concentration shall be limited to 2.0E-04 μCi/ml total activity.

Fs = The safety factor; a conservative factor used to compensate for statistical fluctuations and errors in measurements. For example, a safety factor (Fs) of 1.5 corresponds to a fifty (50) percent (%) variation.

m = The total number of measured radionuclides (i) in the liquid batch to be released.

The dilution which is required to ensure compliance with Technical Specification 3.11.1.1 concentration limits will be set such that discharge rates are:

$$Fd \leq \frac{fw + fb}{fw} \qquad (10)$$

and follows that:

$$fw \leq \frac{fb}{Fd-1} \qquad (10a)$$

or

$$fb \geq fw(Fd-1) \qquad (10b)$$

Where:

Fd = The dilution factor from equation 9.

fw = The discharge flow rate from the liquid radwaste tank to the blowdown line - variable from 0 to 190 gpm.

fb = The cooling tower blowdown flow rate - variable from 0 to 7500 gpm.

The liquid effluent radiation monitor response is based on the results of the radiochemical analysis of the waste solution. Therefore the calculation for the radiation monitor's alarm/trip setpoint is;

$$SP = C + BKg + K\,[C + Bkg]^{1/2} \qquad (11)$$

Where:

SP = Radiation monitor setpoint (count rate)

C = $\sum_{i=1}^{m} (C_i \times E_{fi})$ represents the count rate from the radionuclides in the liquid radwaste.

C_i = The concentration of each measured radionuclide (i) observed by radiochemical analysis of the liquid waste sample (μCi/ml).

m = Same as for equation 9.

E_{fi} = The radwaste effluent monitor's response to radionuclide (i) (count rate per μCi/ml).

BKg = Background count rate of the radwaste effluent monitor.

K = A constant to compensate for normal expected statistical variations in the liquid effluent radiation monitor count rate to reduce the chance of false alarms/trips; K=3.

2.6 Verification of Compliance with 10 CFR 50, Appendix I, and 10 CFR 20, Appendix B

Verification of compliance with 10 CFR 50, Appendix I, and 10 CFR 20, Appendix B, limits will be achieved by following WNP-2 Plant Procedures for liquid discharge and the periodic application of the LADTAP II computer code.

2.7 Methods for Calculating Doses to Man From Liquid Effluent Pathways

Dose models presented in NRC Regulatory Guide 1.109, Revision 1, as incorporated in the LADTAP II computer code, will be used for offsite dose calculation. The details of the computer code, and user instruction, are included in NUREG/CR-4013, "LADTAP II - Technical Reference and User Guide."

2.7.1 Radiation Doses

Radiation doses from potable water, aquatic food, shoreline deposit, and irrigated food pathways will be calculated by using the following equations:

a. Potable Water

$$R_{apj} = 1100 \frac{U_{ap}M_p}{F} \sum_i Q_i D_{aipj} \exp(-\lambda_i t_p) \tag{13}$$

b. Aquatic Foods

$$R_{apj} = 1100 \frac{U_{ap}M_p}{F} \sum_i Q_i B_{ip} D_{aipj} \exp(-\lambda_i t_p) \tag{14}$$

c. Shoreline Deposits

$$R_{apj} = 110{,}000 \frac{U_{ap}M_p W}{F} \sum_i Q_i T_i D_{aipj} \left[\exp(-\lambda_i t_p)\ (1 - \exp(-\lambda_i t_b)\right] \tag{15}$$

d. Irrigated foods

For all radionuclides except tritium:

$$R_{apj} = U_{ap}^{veg} \sum_i d_i \exp(-\lambda_i t_h) D_{aipj} \left[\frac{r[1 - \exp(-\lambda_{Ei} t_e)]}{Y_v \lambda_{Ei}} + \frac{f_I B_{iv}[1 - \exp(-\lambda_i t_b)]}{P\lambda_i}\right]$$

$$+ U_{ap}^{animal} \sum_i F_{iA} D_{aipj} \left[Q_F d_i \exp(-\lambda_i t_h) \frac{r[1 - \exp(-\lambda_{Ei} t_e)]}{Y_v \lambda_{Ei}}\right.$$

$$\left. + \frac{f_I B_{iv}[1 - \exp(-\lambda_i t_b)]}{P\lambda_i} + C_{iAw} Q_{Aw}\right] \tag{16}$$

For tritium:

$$R_{apj} = U_{ap}^{veg} C_v D_{apj} + U_{ap}^{animal} D_{apj} F_A (C_v Q_F + C_{Aw} Q_{Aw}) \quad (17)$$

where:

B_{ip} The equilibrium bioaccumulation factor for nuclide i in pathway p, expressed as the ratio of the concentration in biota (in pCi/kg) to the radionuclide concentration in water (in pCi/liter), in liters/kg.

B_{iv} The concentration factor for uptake of radionuclide i from soil by edible parts of crops, in pCi/kg (wet weight) per pCi/kg dry soil.

C_{iAw} The concentration of radionuclide i in water consumed by animals, in pCi/liter.

C_{iv} The concentration of radionuclide i in vegetation, in pCi/kg.

D_{aipj} The dose factor specific to a given age group a, radionuclide i, pathway p, and organ j, which can be used to calculate the radiation dose from an intake of a radionuclide, in mrem/pCi, or from exposure to a given concentration of a radionuclide in sediment, expressed as a ratio of the dose rate (in mrem/hr) and the areal radionuclide concentration (in pCi/m^2).

d_i The deposition rate of nuclide i, in pCi/m^2 per hour.

F The flow rate of the liquid effluent, in ft^3/sec.

f_I The fraction of the year crops are irrigated, dimensionless.

F_{iA} The stable element transfer coefficient that relates the daily intake rate by an animal to the concentration in an edible portion of animal product, in pCi/liter (milk) per pCi/day or pCi/kg (animal product) per pCi/day.

M_p The mixing ratio (reciprocal of the dilution factor) at the point of exposure (or the point of withdrawal of drinking water or point of harvest of aquatic food), dimensionless.

P The effective "surface density" for soil, in kg (dry soil)/m^2 (Table E-15, Regulatory Guide 1.109, Revision 1).

Q_{Aw} The consumption rate of contaminated water by an animal, in liters/day.

Q_F The consumption rate of contaminated feed or forage by an animal, in kg/day (wet weight).

Q_i The release rate of nuclide i, in Ci/yr.

r The fraction of deposited activity retained on crops, dimensionless (Table E-15, Regulatory Guide 1.109, Revision 1).

R_{apj} The total annual dose to organ j of individuals of age group a from all of the nuclides i in pathway p, in mrem/yr.

t_b The period of time for which sediment or soil is exposed to the contaminated water, in hours (Table E-15, Regulatory Guide 1.109, Revision 1).

t_e The time period that crops are exposed to contamination during the growing season, in hours (Table E-15, Regulatory Guide 1.109, Revision 1).

t_h A holdup time that represents the time interval between harvest and consumption of the food, in hours (Table E-15, Regulatory Guide 1.109, Revision 1).

T_i The radioactive half life of nuclide i, in days.

t_p The average transit time required for nuclides to reach the point of exposure. For internal dose, t_p is the total time elapsed between release of the nuclides and ingestion of food or water, in hours (Table E-15, Regulatory Guide 1.109, Revision 1).

U_{ap} A usage factor that specifies the exposure time or intake rate for an individual of age group a associated with pathway p, in hr/yr, ℓ/yr, or kg/yr (Table E-5, Regulatory Guide 1.109, Revision 1).

W — The shoreline width factor, dimensionless (Table A-2, Regulatory Guide 1.109, Revision 1).

Y_v — The agricultural productivity (yield), in kg (wet weight) /m^2 (Table E-15, Regulatory Guide 1.109, Revision 1).

λ_{Ei} — The effective removal rate constant for radionuclide i from crops, in hr^{-1}, where $\lambda_{Ei} = \lambda_i + \lambda_W$, λ_i is the radioactive decay constant, and λ_W is the removal rate constant for physical loss by weathering (Regulatory Guide 1.109, Revision 1, Table B-15).

λ_i — The radioactive decay constant of nuclide i, in hr^{-1}.

1100 — The factor to convert from (Ci/yr)/(ft^3/sec) to pCi/liter.

110,000 — The factor to convert from (Ci/yr)/(ft^3/sec) to pCi/liter and to account for the proportionality constant used in the sediment radioactivity model.

These equations yield the dose rates to various organs of individuals from the exposure pathways mentioned above.

2.7.2 Plant Parameters

WNP-2 is a river shoreline site with a variable effluent discharge flow rate 0 to 7500 gpm. The population center nearest WNP-2 is the city of Richland, where drinking water withdrawal takes place. The applicable dilution factor is 50,000, using average river flow. The time required for released liquids

leased liquids to reach Richland, approximately 12 miles downstream, is estimated at 4.0 hours. Richland is the "realistic case" location, and doses calculated for the Richland location are typically applicable to the population as a whole. Individual and population doses based on Richland parameters are calculated for all exposure pathways.

Only the population downstream of the WNP-2 site is affected by the liquid effluents released. There is no significant commercial fish harvest in the 50-mile radius region around WNP-2. Sportfish harvest is estimated at 14,000 kg/year.

For irrigated foods exposure pathways, it can be assumed that production within the 50-mile radius region around WNP-2 is sufficient to satisfy consumption requirements.

Other relevant parameters relating to the irrigated foods pathways are defined as follows:

Food Type	Irrigation Rate (liter/m^2/mo)	Annual Yield (kg/m^2)	Growing Period (Days)
Vegetation	150	5.0	70
Leafy Vegetation	200	1.5	70
Feed for Milk Cows	200	1.3	30
Feed for Beef Cattle	160	2.0	130

Source terms are measured based on sampled effluent.

Table 2-3 summarizes the LADTAP II input parameters. Documentation and/or calculations of these parameters are discussed in detail in R.P.I. 2.3, and Rad. Prog. calculation Log 88-3.

2.8 Compliance with Technical Specification 3.11.1.4

2.8.1 Maximum Allowable Liquid Radwaste Activity in Temporary Radwaste Hold-Up Tanks

The use of temporary liquid radwaste hold-up tanks is planned for WNP-2. Technical Specification 3.11.1.4 states the quantity of radioactive material contained in any outside temporary tanks shall be limited to the limits calculated in the ODCM such that a complete release of the tank contents would not result in a concentration at the nearest offsite potable water supply that would exceed the limits specified in 10 CFR Part 20 Appendix B, Table II.

Equation 18 will be used to calculate the curie limit for a temporary radwaste hold-up tank. The total tank concentration will be limited to less than or equal to ten (≤10) curies, excluding tritium and dissolved or entrained gases.

Surveillance requirement 4.11.1.4, states that the quantity of radioactive material in the hold-up tanks shall be determined to be within the limit by analyzing a representative sample of the tank's contents at least once per 7 days when radioactive materials are being added to the tank.

$$A_T = \frac{K_d}{\sum_i \frac{f_i}{MPC_i \, e^{\lambda_i t}}} \qquad (18)$$

where:

A_T = Total allowed activity in tank (curies).

A_i = Activity of radioisotope i (curies).

MPC_i = Maximum permissible concentration of radionuclide i (10 CFR 20, Appendix B, Table II, Column 2).

λ_i = Decay constant ($years^{-1}$) radioisotope i.

t = Transit time of ground water from WNP-2 to WNP-1 well (WNP-2 FSAR Section 2.4) = 67 years.

fi = Fraction of radioisotope fi $= \frac{A_i}{\sum A_i}$.

i = Index for all radioisotopes in tank except tritium and noble gases.

K_d = Dispersion constant based on hydrological parameters,

(2.4E+05 Ci per μCi/cc.)

The total allowed activity (A_T) is based on limiting WNP-1 well water to less than 1 MPC_i of the entire liquid content of the tank spilled to ground and then migrated via ground water to the WNP-1 well. The WNP-1 well is the location of maximum concentration since it is the nearest source of ground water and conditions are such that no spill of liquid should reach surface water. The 70-85 foot depth of the water table and the low ambient moisture of the soil requires a rather large volume of spillage for the liquid to even reach the water table in less than several hundred years. However, allowed tank activity (A_T) is conservatively based on all liquid radwaste in the tank instantaneously reaching the water table.

The hydrological analysis performed for the WNP-2 FSAR (Section 2.4) determined that the transit time through the ground water from WNP-2 to the WNP-1 well is 67 years for Strontium and 660 years for Cesium. These two radionuclides are representative of the radionuclides found in liquid radwaste. Strontium is a moderate sorber and Cesium strongly sorbs to soil particles. This calculation conservatively treats all radionuclides as moderate sorbers with a transit time of 67 years.

The concentration of each radionuclide in the well (CW_i) is simply the concentration in the tank (CT_i) adjusted for radioactive decay during transit ($e^{-\lambda t}$) and divided by the minimum concentration reduction factor (CRF min). Limiting well concentration to 1 MPC yields:

$$\sum \frac{CW_i}{MPC_i} = 1 = \sum \frac{CT_i \, e^{-\lambda t}}{CRF_{min} MPC_i} \quad \text{(From section 2.4 of WNP-2 FSAR.)} \qquad (19)$$

$$CRF_{min} = \frac{(4 \pi L)^{3/2} \, (\alpha_x \;\; \alpha_Y \;\; \alpha_Z)^{1/2}}{2V} \qquad (20)$$

where:

L = Migration distance = 1 mile.

V = Volume of tank.

$\alpha_X, \alpha_Y, \alpha_Z$ = Dispersion constants.

Combining Equations 19 and 20 yields:

$$1 = \sum \frac{CT_i \; 2V \; e^{-\lambda_i t}}{(4\pi L)^{3/2}(\alpha_X \; \alpha_Y \; \alpha_Z)^{1/2} MPC_i} \qquad (21)$$

Substituting A_i for CT_i V and reorganizing terms yields:

$$\frac{(4\pi L)^{3/2}(\alpha_X \; \alpha_Y \; \alpha_Z)^{1/2}}{2} = \sum \frac{A_i}{MPC_i \; e^{+\lambda_i t}} \qquad (22)$$

Making the following substitutions

$$A_i = f_i \; AT$$

$$K_d = \frac{(4\pi L)^{3/2}(\alpha_X \; \alpha_Y \; \alpha_Z)^{1/2}}{2} \times 10^{-6} Ci/\mu Ci = 2.4 \times 10^{5} \; Ci \text{ per } \frac{\mu Ci}{cc} \qquad (23)$$

yields:

$$K_d = A_T \sum \frac{f_i}{MPC_i e^{+\lambda t}}$$

or

$$A_T = \frac{K_d}{\sum \frac{f_i}{MPC_i e^{+\lambda t}}} \qquad (24)$$

2.8.2 Maximum Allowable Liquid Radwaste in Tanks That Are Not Surrounded by Liners, Dikes, or Walls

Although permanent outside liquid radwaste tanks which are not surrounded by liners, dikes, or walls are not planned for WNP-2, Equation 18 will be used should such tanks become necessary in the future.

2.9 Liquid Process Monitors and Alarm Setpoints Calculations

As mentioned in Section 2.2 of this manual, all liquid radwaste effluent is discharged through a four-inch line that is monitored by an off-line sodium iodide radiation monitor. This monitor is located on the 437' level of the Radwaste Building. All WNP-2 radwaste liquid effluent is discharged to the Columbia River through the 36-inch Cooling Water Blowdown line. In addition to the liquid effluent discharge monitor there are three liquid streams that are normally non-radioactive but have a finite possibility of having radioactive material injected into them. These liquid streams are:

- o Standby Service Water (SW)
- o Turbine Building Service Water (TSW)
- o Turbine Building Sump Water (FD)

To prevent any discharges of radioactive liquid from these streams, radiation monitoring systems have been installed to detect any increase above the normal background concentration of radioactive material.

Alarm/setpoints are established to prevent any release of radioactive material in concentrations greater than 10CFR20 limits. The maximum radiation detector setpoint calculation for the three systems is based on the MPC_i concentration of Cs-137 which is 2.0E-05 μCi/ml. The following equation is used to calculate the maximum setpoint:

$$\text{Setpoint max. (in cpm or cps)} = \left[(2.0\text{E-05 } \mu\text{Ci/ml})\ (\text{CF})\right] \quad (25)$$

where:

2.0E-05 μCi/ml = MPC limit for Cs-137

CF = Monitor calibration factor - in cpm/ μCi/ml or cps/ μCi/ml

2.9.1 <u>Standby Service Water (SW) Monitor</u> - The Standby Service Water Monitors (SW) are located on the 522' level of the Reactor Building.

The meter is located in the main control room on panel P-604.

The flow rate through the monitor is variable, from zero (0) to two (2) gpm with a normal flow of 1.0-1.5 gpm.

To ensure 10CFR20 limits are never exceeded, the alarm setpoint shall be established at 80% or less of the maximum setpoint plus background.

If the setpoint is exceeded, an alarm will activate in the main control room. The control room operator can then terminate the discharge and mitigate any uncontrolled release of radioactive material.

2.9.2 Turbine Building Service Water (TSW) Monitor - This monitor is located on the 441' level of the Turbine Building. The readout meter and recorder is located in the main control panel BD-RAD-24.

The flow rate through that monitor is variable, from zero (0) to six (6) gpm with a normal flow of 3-4 gpm.

To ensure 10CFR20 limits are never exceeded, the alarm setpoint shall be established at 80% or less of the maximum setpoint plus background.

If the setpoint is exceeded, an alarm will activate in the main control room. The control room operator can then terminate the discharge and mitigate any uncontrolled release of radioactive material.

2.9.3 Turbine Building Sumps Water (FD) Monitor - There are three detectors to measure the activity of each of the three non-radioactive sumps. The monitors are located on the 441' level of the Turbine Building. The readout meters and recorder are located in the Radwaste Control Room Panel BD-RAD-41.

The Turbine Building Sump Water Effluents are not released to the Columbia River. This effluent is discharged to the Storm Drain System which is an open pond by the WNP-2 Warehouse.

The hydrological analysis performed for the WNP-2 FSAR (Section 2.4) determined that the transmit time through the ground water from WNP-2 to the WNP-1 well is 67 years for strontium and 660 years for cesium.

In the event the setpoint is exceeded, the sump water will be automatically routed to the radioactive waste system.

To prevent the sum of the sump water discharged from the three pumps from exceeding 10CFR20 limits, the alarm/setpoint will be established at 80% or less of the maximum setpoint plus background.

Table 2-1

FISH BIOACCUMULATION FACTORS (BF_i)(1)
AND ADULT INGESTION DOSE CONVERSION FACTORS (DF_i)(2)

Nuclide	Fish Bioaccumulation Factor (BF_i) (pCi/kg per pCi/liter)	Dose Conversion Factor (DF_i) Total Body	Bone	Thyroid	Liver	GI Tract
		(mRem per pCi Ingested)				
H-3	9.0E-01	6.0E-08	____(3)	6.0E-08	6.0E-08	6.0E-08
Na-24	1.0E+02	1.7E-06	1.7E-06	1.7E-06	1.7E-06	1.7E-06
P-32	1.0E+05	7.5E-06	1.9E-04	____(3)	1.2E-05	2.2E-05
Cr-51	2.0E+02	2.7E-09	____(3)	1.6E-09	____(3)	6.7E-07
Mn-54	4.0E+02	8.7E-07	____(3)	____(3)	4.6E-06	1.4E-05
Mn-56	4.0E+02	2.0E-08	____(3)	____(3)	1.2E-07	3.7E-06
Fe-55	1.0E+02	4.4E-07	2.8E-06	____(3)	1.9E-06	1.1E-06
Fe-59	1.0E+02	3.9E-06	4.3E-06	____(3)	1.0E-05	3.4E-05
Co-58	5.0E+01	1.7E-06	____(3)	____(3)	7.5E-07	1.5E-05
Co-60	5.0E+01	4.7E-06	____(3)	____(3)	2.1E-06	4.0E-05
Ni-65	1.0E+02	3.1E-08	5.3E-07	____(3)	6.9E-08	1.7E-06
Cu-64	5.0E+01	3.9E-08	____(3)	____(3)	8.3E-08	7.1E-06
Zn-65	2.0E+03	7.0E-06	4.8E-06	____(3)	1.5E-05	9.7E-06
Zn-69m	2.0E+03	3.7E-08	1.7E-07	____(3)	4.1E-07	2.5E-05
As-76	1.0E+02	4.8E-06	____(3)	____(3)	____(3)	4.4E-05
Br-82	4.2E+02	2.3E-06	____(3)	____(3)	____(3)	2.6E-06
Br-83	4.2E+02	4.0E-08	____(3)	____(3)	____(3)	5.8E-08
Br-84	4.2E+02	5.2E-08	____(3)	____(3)	____(3)	4.1E-13
Rb-89	2.0E+03	2.8E-08	____(3)	____(3)	4.0E-08	2.3E-21
Sr-89	3.0E+01	8.8E-06	3.1E-04	____(3)	____(3)	4.9E-05
Sr-90	3.0E+01	1.8E-04	8.7E-03	____(3)	____(3)	2.2E-04

Table 2-1 (contd.)

Nuclide	Fish Bioaccumulation Factor (BF_i) (pCi/kg per pCi/liter)	Dose Conversion Factor (DF_i) (mRem per pCi Ingested)				
		Total Body	Bone	Thyroid	Liver	GI Tract
Sr-91	3.0E+01	2.3E-07	5.7E-06	____(3)	____(3)	2.7E-05
Sr-92	3.0E+01	9.3E-08	2.2E-06	____(3)	____(3)	4.3E-05
Y-90	2.5E+01	2.6E-10	9.7E-09	____(3)	____(3)	1.0E-04
Y-91m	2.5E+01	3.5E-12	9.1E-11	____(3)	____(3)	2.7E-10
Y-91	2.5E+01	3.8E-09	1.4E-07	____(3)	____(3)	7.8E-05
Y-92	2.5E+01	2.5E-11	8.5E-10	____(3)	____(3)	1.5E-05
Y-93	2.5E+01	7.4E-11	2.7E-09	____(3)	____(3)	8.5E-05
Zr-95	3.3E+00	6.6E-09	3.1E-08	____(3)	9.8E-09	3.1E-05
Nb-95	3.0E+04	1.9E-09	6.2E-09	____(3)	3.5E-09	2.1E-05
Zr-97	3.3E+00	1.6E-10	1.7E-09	____(3)	3.4E-10	1.1E-04
Nb-97	3.0E+04	4.8E-12	5.2E-11	____(3)	1.3E-11	4.9E-08
Mo-99	1.0E+01	8.2E-07	____(3)	____(3)	4.3E-06	1.0E-05
Tc-99m	1.5E+01	8.9E-09	2.5E-10	____(3)	7.0E-10	4.1E-07
Tc-101	1.5E+01	3.6E-09	2.5E-10	____(3)	3.7E-10	1.1E-21
Ru-103	1.0E+01	8.0E-08	1.9E-07	____(3)	____(3)	2.2E-05
Ru-105	1.0E+01	6.1E-09	1.5E-08	____(3)	____(3)	9.4E-06
Rh-105	1.0E+01	5.8E-08	1.2E-07	____(3)	8.9E-08	1.4E-05
Ru-106	1.0E+01	3.5E-07	2.8E-06	____(3)	____(3)	1.8E-04
Ag-110m	2.3E+00	8.8E-08	1.6E-07	____(3)	1.5E-07	6.0E-05
Sb-124	1.0E+00	1.1E-06	2.8E-06	6.8E-09	5.3E-08	8.0E-05
Sb-125	1.0E+00	4.3E-07	1.8E-06	1.8E-09	2.0E-08	2.0E-05
Sb-126	1.0E+00	4.2E-07	1.2E-06	7.0E.09	2.3E-08	9.4E-05
Sb-127	1.0E+00	9.9E-08	2.6E-07	3.1E-09	5.7E-09	5.9E-05
Te-127	4.0E+02	2.4E-08	1.1E-07	8.2E-08	4.0E-08	8.7E-06
Te-129m	4.0E+02	1.8E-06	1.2E-05	4.0E-06	4.3E-06	5.8E-05
Te-129	4.0E+02	7.7E-09	3.1E-08	2.4E-08	1.2E-08	2.4E-08

Table 2-1 (contd.)

Nuclide	Fish Bioaccumulation Factor (BF_i) (pCi/kg per pCi/liter)	Dose Conversion Factor (DF_i) Total Body	Bone	Thyroid	Liver	GI Tract
		(mRem per pCi Ingested)				
Te-131m	4.0E+02	7.1E-07	1.7E-06	1.3E-06	8.5E-07	8.4E-05
Te-131	4.0E+02	6.2E-09	2.0E-08	1.6E-08	8.2E-09	2.8E-09
Te-132	4.0E+02	1.5E-06	2.5E-06	1.8E-06	1.6E-06	7.7E-05
I-131	1.5E+01	3.4E-06	4.2E-06	2.0E-03	6.0E-06	1.6E-06
I-132	1.5E+01	1.9E-07	2.0E-07	1.9E-05	5.4E-07	1.0E-07
I-133	1.5E+01	7.5E-07	1.4E-06	3.6E-04	2.5E-06	2.2E-06
I-134	1.5E+01	1.0E-07	1.1E-07	5.0E-06	2.9E-07	2.5E-10
I-135	1.5E+01	4.3E-07	4.4E-07	7.7E-05	1.2E-06	1.3E-06
Cs-134	2.0E+03	1.2E-04	6.2E-05	____(3)	1.5E-04	2.6E-06
Cs-136	2.0E+03	1.9E-05	6.5E-06	____(3)	2.6E-05	2.9E-06
Cs-137	2.0E+03	7.1E-05	8.0E-05	____(3)	1.1E-04	2.1E-06
Cs-138	2.0E+03	5.4E-08	5.5E-08	____(3)	1.1E-07	4.7E-13
Ba-139	4.0E+00	2.8E-09	9.7E-08	____(3)	6.9E-11	1.7E-07
Ba-140	4.0E+00	1.3E-06	2.0E-05	____(3)	2.6E-08	4.2E-05
La-140	2.5E+01	3.3E-10	2.5E-09	____(3)	1.3E-09	9.3E-05
La-141	2.5E+01	1.6E-11	3.2E-10	____(3)	9.9E-11	1.2E-05
La-142	2.5E+01	1.5E-11	1.3E-10	____(3)	5.8E-11	4.3E-07
Ce-141	1.0E+00	7.2E-10	9.4E-09	____(3)	6.3E-09	2.4E-05
Ce-143	1.0E+00	1.4E-10	1.7E-09	____(3)	1.2E-06	4.6E-05
Ce-144	1.0E+00	2.6E-08	4.9E-07	____(3)	2.0E-07	1.7E-04
Pr-143	2.5E+01	4.6E-10	9.2E-09	____(3)	3.7E-09	4.0E-05
Nd-147	2.5E+01	4.4E-10	6.2E-09	____(3)	7.3E-09	3.5E-05
Hf-179m	3.3E+00	4.8E-06	____(3)	____(3)	____(3)	4.1E-05
Hf-181	3.3E+00	4.3E-06	____(3)	____(3)	____(3)	4.1E-05
W-185	1.2E+03	1.4E-08	4.1E-07	____(3)	1.4E-07	1.6E-05

Table 2-1 (contd.)

Nuclide	Fish Bioaccumulation Factor (BF_i) (pCi/kg per pCi/liter)	Dose Conversion Factor (DF_i) Total Body	Bone	Thyroid	Liver	GI Tract
		(mRem per pCi Ingested)				
W-187	1.2E+03	3.0E-08	1.0E-07	____(3)	8.6E-08	2.8E-05
Np-239	1.0E+01	6.5E-11	1.2E-09	____(3)	1.2E-10	2.4E-05

(1) NRC NUREG/CR-4013.

(2) NRC NUREG/CR-4013.

(3) No data listed in NUREG/CR-4013.
(Use total body dose conversion factor as an approximation.)

Table 2-2

INGESTION DOSE FACTORS (A_{ij}) FOR TOTAL BODY AND CRITICAL ORGAN

(in mrem/hr per Ci/ml)

Liquid Effluent

Nuclide	Total Body	Bone	Thyroid	Liver	Gi Tract
H-3	1.8E-01	**	1.8E-01	1.8E-01	1.8E-01
Na-24	4.1E+02	4.1E+02	4.1E+02	4.1E+02	4.1E+02
P-32	1.8E+06	4.6E+07	**	2.9E+06	5.3E+06
Cr-51	1.3E+00	**	7.7E-01	**	3.2E+02
Mn-54	8.3E+02	**	**	4.4E+03	1.3E+04
Mn-56	1.9E+01	**	**	1.6E+02	3.6E+03
Fe-55	1.1E+02	6.7E+02	**	4.6E+02	2.6E+02
Fe-59	9.4E+02	1.0E+03	**	2.4E+03	8.2E+03
Co-58	2.1E+02	**	**	9.0E+01	1.8E+03
Co-60	5.7E+02	**	**	2.5E+02	4.8E+03
Ni-65	7.5E+00	1.3E+02	**	1.7E+01	4.1E+02
Cu-64	4.7E+00	**	**	1.0E+01	8.6E+02
Zn-65	3.4E+04	2.3E+04	**	7.2E+04	4.7E+04
Zn-69m	1.8E+02	8.1E+02	**	2.0E+03	1.2E+05
As-76	1.2E+03	**	**	**	1.1E+04
Br-82	2.3E+03	**	**	**	2.6E+03
Br-83	4.0E+01	**	**	**	5.8E+01
Br-84	5.2E+01	**	**	**	4.1E-04
Rb-89	1.3E+02	**	**	1.9E+02	1.1E-11
Sr-89	6.4E+02	2.3E+04	**	**	3.6E+03
Sr-90	1.3E+04	6.3E+05	**	**	1.6E+04
Sr-91	1.7E+01	4.1E+02	**	**	2.0E+03
Sr-92	6.8E+00	1.6E+02	**	**	3.1E+03

Table 2-2 (contd.)

Nuclide	Total Body	Bone	Thyroid	Liver	Gi Tract
Y-90	1.6E-02	5.9E-01	**	**	6.1E+03
Y-91m	2.1E-04	5.5E-03	**	**	1.6E-02
Y-91	2.3E-01	8.5E+00	**	**	4.7E+03
Y-92	1.5E-03	5.2E-02	**	**	9.1E+02
Y-93	4.5E-03	1.6E-01	**	**	5.2E+03
Zr-95	5.3E-02	2.5E-01	**	7.9E-02	2.5E+02
Nb-95	1.4E+02	4.5E+02	**	2.5E+02	1.5E+06
Zr-97	1.3E-03	1.4E-02	**	2.7E-03	8.8E+02
Nb-97	3.5E-01	3.7E+00	**	9.3E-01	3.5E+03
Mo-99	2.0E+01	**	**	1.1E+02	2.5E+02
Tc-99m	3.3E-01	9.2E-03	**	2.6E-02	1.5E+01
Tc-101	1.3E-01	9.2E-03	**	1.4E-02	4.0E-14
Ru-103	2.0E+00	4.7E+00	**	**	5.5E+02
Ru-105	1.5E-01	3.7E-01	**	**	2.3E+02
Rh-105	1.4E+00	3.0E+00	**	2.2E+00	3.5E+02
Ru-106	8.7E+00	6.9E+01	**	**	4.5E+03
Ag-110m	5.6E-01	1.0E-00	**	9.5E-01	3.8E+02
Sb-124	3.6E+00	9.0E+00	2.2E-02	1.7E-01	2.6E+02
Sb-125	1.4E+00	5.8E+00	5.8E-03	6.5E-02	6.5E+01
Sb-126	1.4E+00	3.9E+00	2.3E-02	7.4E-02	3.0E+02
Sb-127	3.2E-01	8.4E-01	1.0E-02	1.8E-02	1.9E+02
Te-127	2.3E+01	1.1E+02	7.9E+01	3.8E+01	8.3E+03
Te-129m	1.7E+03	1.2E+04	3.8E+03	4.1E+03	5.6E+04
Te-129	7.4E+00	3.0E+01	2.3E+01	1.2E+01	2.3E+01
Te-131m	6.8E+02	1.6E+03	1.3E+03	8.2E+02	8.1E+04
Te-131	5.9E+00	1.9E+01	1.5E+01	7.9E+00	2.7E+00
Te-132	1.4E+03	2.4E+03	1.7E+03	1.5E+03	7.4E-04
I-131	1.3E+02	1.5E+02	7.4E+04	2.2E+02	5.9E+01
I-132	7.0E+00	7.4E+00	7.0E+02	2.0E+01	3.7E+00
I-133	2.8E+01	5.1E+01	1.3E+04	9.2E+01	8.1E+01
I-134	3.7E+00	4.0E+00	1.8E+02	1.1E+01	9.2E-03
I-135	1.6E+01	1.6E+01	2.8E+03	4.4E+01	4.8E+01

Table 2-2 (contd.)

Nuclide	Total Body	Bone	Thyroid	Liver	Gi Tract
Cs-134	5.8E+05	3.0E+05	**	7.2E+05	1.3E+04
Cs-136	9.1E+04	3.1E+04	**	1.3E+05	1.4E+04
Cs-137	3.4E+05	3.8E+05	**	5.3E+05	1.0E+04
Cs-138	2.6E+02	2.6E+02	**	5.3E+02	2.3E-03
Ba-139	2.9E-02	1.0E-00	**	7.2E-04	1.8E+00
Ba-140	1.4E+01	2.1E+02	**	2.7E-01	4.4E+02
La-140	2.0E-02	1.5E-01	**	7.9E-02	5.6E+03
La-141	9.7E-04	1.9E-02	**	6.0E-03	7.3E+02
La-142	9.1E-04	7.9E-03	**	3.5E-03	2.6E+01
Ce-141	2.3E-03	3.0E-02	**	2.0E-02	7.7E+01
Ce-143	4.5E-04	5.5E-03	**	3.9E+00	1.5E+02
Ce-144	8.4E-02	1.6E+00	**	6.5E-01	5.5E+02
Pr-143	2.8E-02	5.6E-01	**	2.3E-01	2.4E+03
Nd-147	2.7E-02	3.8E-01	**	4.4E-01	2.1E+03
Hf-179m	4.2E+01	**	**	**	3.6E+02
Hf-181	3.8E+01	**	**	**	3.6E+02
W-185	4.0E+01	1.2E+03	**	4.0E+02	4.6E+04
W-187	8.6E+01	2.9E+02	**	2.5E+02	8.1E+04
Np-239	1.6E-03	3.0E-02	**	3.0E-03	6.0E+02

**No Ingestion Dose Factor (DF_i) is listed in NUREG/CR-4013. (Total body dose factor value will be used as an approximation.)

TABLE 2-3
INPUT PARAMETERS USED TO CALCULATE MAXIMUM INDIVIDUAL DOSE FROM LIQUID EFFLUENTS

Drinking Water

River Dilution:	50,000	
River Transit Time:	4 hours	
Usage Factors:	Adult = 730 l/yr	Teenager = 510 l/yr
	Child = 510 l/yr	Infant = 330 l/yr

Boating and Aquatic Food

River Dilution:	2,000	
Transit Time:	2 hours	
Usage Factors: (Aquatic Food)	Adult = 21 kg/yr	Teenager = 16 kg/yr
	Child = 6.9 kg/yr	Infant = 0
(Boating)	Adult = 100 hr/yr	Teenager = 100 hr/yr
	Child = 85 hr/yr	Infant = 0

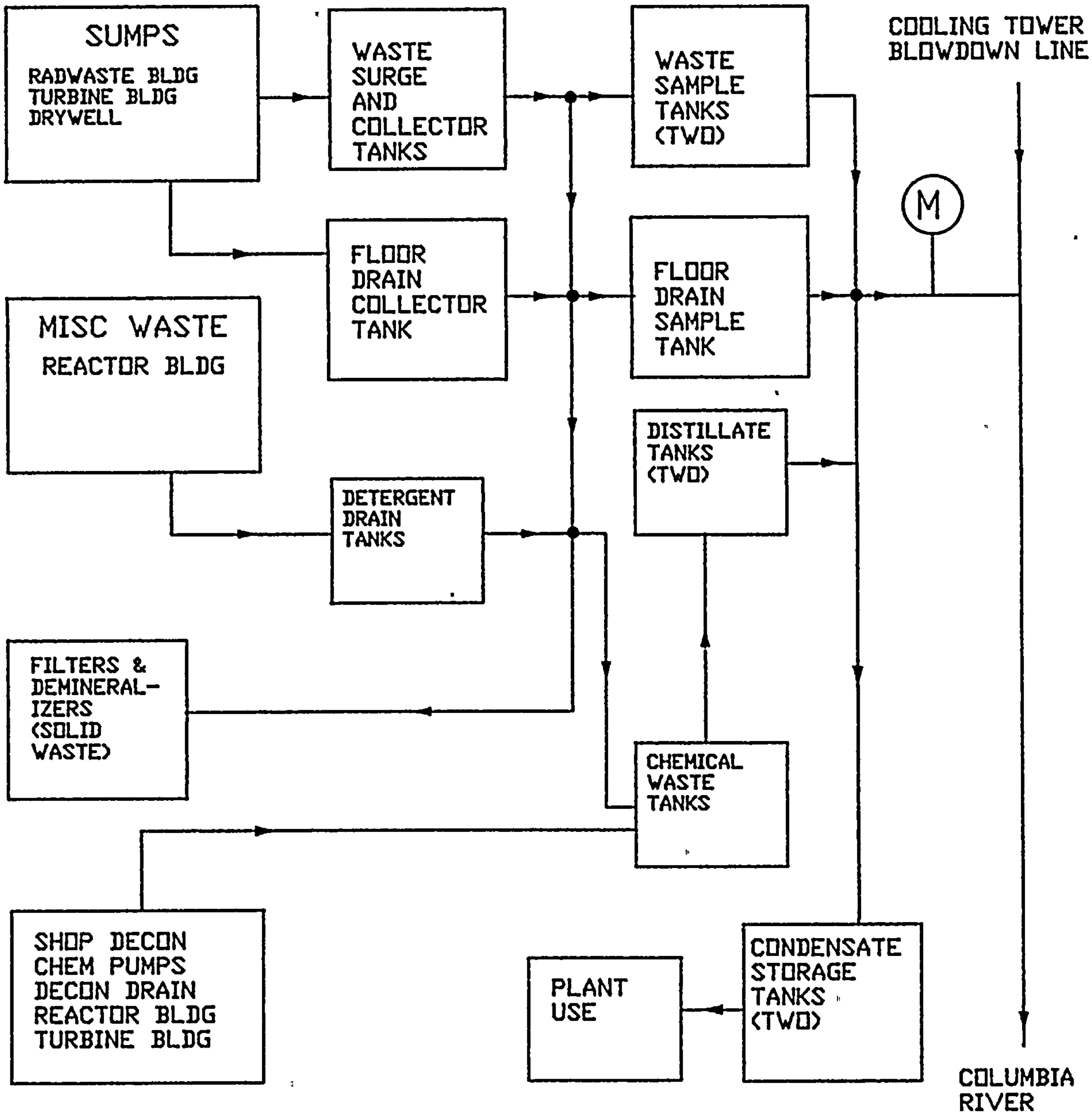
Recreation

River Dilution:	20,000	
Shoreline Width Factor:	0.2	
Usage Factors:	Shoreline Activities:	Adult = 90 hr/yr
		Teenager = 500 hr/yr
		Child = 105 hr/yr
		Infant = 0
	Swimming:	Adult = 18 hr/yr
		Teenager = 100 hr/yr
		Child = 21 hr/yr

Irrigated Foodstuffs

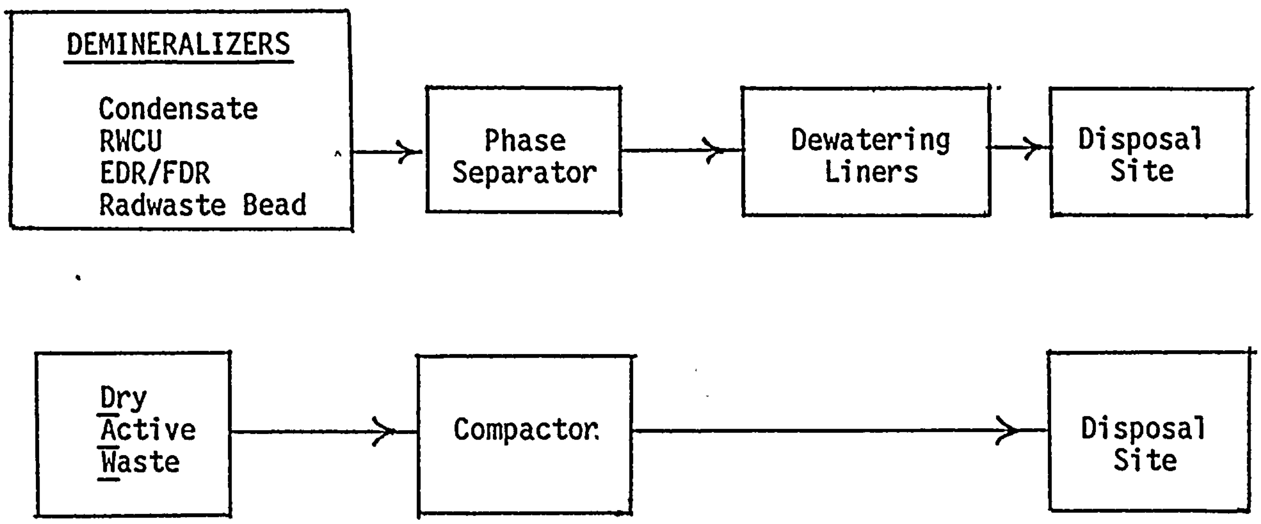
River Dilution: 50,000
River Transit Time: 4 hours

	Vegetables	Milk	Meat	Leafy Vegetables
Food Delivery Time:	14 days	48 hours	20 days	24 hours
Usage Factors:				
Adult	520 kg/yr	310 l/yr	110 kg/yr	64 kg/yr
Teenager	630 kg/yr	400 l/yr	65 kg/yr	42 kg/yr
Child	520 kg/yr	330 l/yr	41 kg/yr	26 kg/yr
Monthly Irrigation Rate:	180 l/m^2	200 l/m^2	160 l/m^2	200 l/m^2
Annual Yield:	5.0 kg/m^2	1.3 l/m^2	2.0 kg/m^2	1.5 kg/m^2
Annual Growing Period:	70 days	30 days	130 days	70 days
Annual 50-Mile Production:	3.5E+09 kg	2.8E+08 L	2.3E+07 kg	1.9E+06 kg



SIMPLIFIED BLOCK DIAGRAM OF LIQUID WASTE SYSTEM

FIGURE 2-1



SIMPLIFIED BLOCK DIAGRAM
OF
SOLID RADWASTE SYSTEM

Figure 2-2

3.0 GASEOUS EFFLUENTS DOSE CALCULATIONS

3.1 Introduction

WNP-2 gaseous effluents are released on a continuous basis; in addition, batch releases also occur when containment and mechanical vacuum pump purges are performed and when the OFF-GAS treatment system operates in the charcoal bypass mode. The gaseous effluents released from WNP-2 will meet instantaneous technical specification requirement at the site boundary.

Figure 3-1 delineates the WNP-2 Site boundary. There are several low occupancy unrestricted locations within the site boundary. These locations, with the exception of the WNP-2 visitor center, are not continuously controlled by the Supply System. The special locations are:

1. Wye burial site - normally controlled by DOE.

2. DOE train - two railroad lines pass through the site (approximately 3 miles of line). According to DOE, the train makes one round trip a day, through the site at an average speed of 20 mph, 5 days a week, 52 weeks/year.

3. BPA Ashe Substation - occupied 2080 hours/year. These people are not normally controlled by the Supply System but are involved in activities directly in support of WNP-2.

4. WNP-2 - Supply System Visitor Center - assumed occupied 8 hrs/yr by non-Supply System individuals.

5. WNP-1 - occupied 2080 hrs/yr. This location is controlled by the Supply System. However, activities are not in direct support of WNP-2.

6. WNP-4 - occupied 2080 hrs/yr. This location is controlled by the Supply System. However, activities are not in direct support of WNP-2.

All other locations listed in Figure 3-1 support WNP-2 activities and are controlled by the Supply System. Figure 3-2 provides a simplified block diagram of the gaseous radwaste system for the reactor, turbine and radwaste buildings. Figure 3-3 provides a simplified block diagram for the Off-Gas Treatment System.

Air doses and doses to individuals at these locations were calculated based on the NRC GALE code design base mixture, location specific estimated occupancy, and X/Qs from XOQDOQ. (Note: Desert Sigmas were used in calculating X/Q and D/Q values, and are listed in Table 3-10 to 3-12). These doses are listed in Tables 3-16 and 3-17 along with the doses to the maximum exposed individual. The most likely exposed member of the public is considered to be residing in Taylor Flats (4.2 miles ESE of WNP-2). This is the closest residential area with the high- est X/Q and D/Q values.

3.2 Gaseous Effluent Radiation Monitoring System

3.2.1 Main Plant Release Point

The Main Plant Release is instrument monitored for gaseous radioactivity prior to discharge to the environment via the main plant vent release point. Particulates and iodine activity are accumulated in filters which will be changed and analyzed as per Technical Specification 4.11.2.1.2 and Table 4.11.2. The effluent is supplied from: the gland seal exhauster, mechanical vacuum pumps, treated off gas, standby gas treatment, and exhaust air from the entire reactor building's ventilation.

Two 100-percent capacity vanaxial fans supply 98,000 CFM ventilation air. One is normally operating, the other is in standby. The radiation monitors are located on the ventilation exhaust plenum.

Effluent monitoring consists of a low range beta scintillator, an intermediate range beta scintillator and two ion chamber LOCA monitors. The beta scintillators are mounted in thick lead shielded chambers. The low range beta scintillator has an approximate response of 80 cpm/pCi/cc to Kr-85, and 50 cpm/pCi/cc to Xe-133 and a meter range of $10-10^6$ cpm. The intermediate

range has a response from 10^{-2} -10^{3} µCi/cc Xe -133 equivalent, and reads in panel meter units (PMU) with a meter range of 10^{0} -10^{5} PMU.

The readouts and recorder are located in the main control room panel BD-RAD-24. Power is provided from 125 VDC divisional buses. This monitor has no control function but annunciates in the main control room. The alarm will initiate proper action as defined in the WNP-2 Plant Procedures.

3.2.2 Radwaste Building Ventilation Exhaust Monitor

The radwaste building ventilation exhaust monitoring system monitors the radioactivity in the exhaust air prior to discharge. Radioactivity can originate from: radwaste tank vents, laboratory hoods, and various cubicles housing liquid process treatment equipment and systems.

The radwaste building exhaust system has three 50 percent capacity exhaust filter units of 42,000 cfm capacity. Each exhaust unit has a medium-efficiency prefilter, a high efficiency particulate air filter (HEPA) and two centrifugal fans. Total exhaust flow will vary as the combined exhaust unit maintains a radwaste building differential pressure of -0.25 inches H_2O to the environment.

Particulate and iodine air sample filters are changed weekly for laboratory analysis. After the particulate and iodine filters, the air sample streams are combined in a manifold prior to being monitored by a beta scintillator.

The beta scintillators, on the 487' level are mounted in lead shielded chambers. The low range beta scintillator has an approximate response of 80 cpm/pCi/cc to Kr-85, and 50 cpm/pCi/cc to Xe-133 and a meter range of 10-10^{6} cpm. The intermediate range has a response from 10^{-2} -10^{3} µCi/cc Xe -133 equivalent, and reads in panel meter units (PMU) with a meter range of 10^{0} -10^{5} PMU. The readouts and recorder are located in the main control room panel BD-RAD-24. Power is provided from 125 VDC divisional buses. This monitor has no control functions but annunciates in the main control room. The alarm will initiate proper action as defined in the WNP-2 plant procedures.

3.2.3 Turbine Building Ventilation Exhaust Monitor

This monitoring system detects fission and the activation products from the turbine building air which may be present due to leaks from the turbine and other primary components in the building.

The turbine building main exhaust system consists of four roof-mounted centrifugal fans which draw air from a central exhaust plenum. Three fans operate continuously, with one in standby to provide a flow of 260,000 cfm.

A representative sample is extracted from the exhaust vent and passed through a particulate and charcoal filter. The air sample then passes to a beta scintillator.

The beta scintillators are mounted in lead shielded chambers. The low range beta scintillator has an approximate response of 80 cpm/pCi/cc to Kr-85, and 50 cpm/pCi/cc to Xe-133 and a meter range of $10-10^6$ cpm. The intermediate range has a response from $10^{-2} - 10^3$ μCi/cc Xe -133 equivalent, and reads in panel meter units (PMU) with a meter range of $10^0 - 10^5$ PMU. The monitors are on the 525' level of the radwaste building and the readouts and the recorder are located in the main control room panel BD-RAD-24. Power is provided from the 125 VDC divisional buses. This monitor has no control functions but annunciates in the main control room. The alarm will initiate proper action as defined in the WNP-2 plant procedures.

3.3 10 CFR 20 Release Rate Limits

Limits for release of airborne effluents to the unrestricted area are stated in Technical Specification 3.11.2.1. The dose rate in unrestricted areas due to radioactive materials released in gaseous effluents from the site shall be limited to the following values:

(a) "The dose rate limit for noble gases shall be $\leq$500 mrem/yr to the total body and $\leq$3000 mrem/yr to the skin.

(b) "The dose rate limit for all radioiodines and for all radioactive materials in particulate form and radionuclides other than noble gases with half-lives greater than eight days shall be $\leq$1500 mrem/yr to any organ."

3.3.1 Noble Gases

In order to comply with Technical Specification 3.11.2.1, the following equations must hold:

Whole body:

$$\sum_i K_i \left[(\overline{X/Q})_m \dot{Q}_{im} + (\overline{X/Q})_g \dot{Q}_{ig} \right] \leq 500 \text{ mrem/yr} \quad (1)$$

Skin

$$\sum_i \left[(L_i + 1.1M_i)((\overline{X/Q})_m \dot{Q}_{im} + (\overline{X/Q})_g \dot{Q}_{ig}) \right] \leq 3000 \text{mrem/yr} \quad (2)$$

3.3.2 Radioiodines and Particulates

Part "b" of Technical Specification 3.11.2.1 requires that the release rate limit for all radioiodines and radioactive materials in particulate form and radionuclides other than noble gases must meet the following relationship:

Any organ:

$$\sum_i P_i \left[W_M \dot{Q}_{im} + W_g \dot{Q}_{ig} \right] \leq 1500 \text{ mrem/yr} \quad (3)$$

The terms used in equations 1 through 3 are defined as follows:

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

L_i = The skin dose factor due to beta emissions for each identified noble gas radionuclide i (mrem/yr per $\mu Ci/m^3$).

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

P_i = The dose parameter for all radionuclides other than noble gases for the inhalation pathway, (mrem/yr per $\mu Ci/m^3$) and for food and ground plane pathways, m^2(mrem/yr per μCi/sec). The dose factors are based on the critical individual organ and the most restrictive age group.

$\dot{Q}_{im}$ = The release rate of radionuclide i in gaseous effluent from mixed mode release. The main plant release point is a partially elevated mixed·mode release (μCi/sec).

$\dot{Q}_{ig}$ = The release rate of radionuclide i in gaseous effluent from all ground level releases (μCi/sec).

$(\overline{X/Q})_m$ = (sec/m^3). For partially elevated mixed mode releases from the main plant vent release point. The highest calculated partially elevated annual average relative concentration for any area at or beyond the site boundary.

$(\overline{X/Q})_g$ = (sec/m^3). For all Turbine Building and Radwaste releases. The highest calculated ground level annual average relative concentration for any area at or beyond the site boundary.

W_g = The highest calculated annual average dispersion parameter for estimating the dose to an individual at the controlling location due to all ground level releases.

W_g = (sec/m^3). For the inhalation pathway. The location is the site boundary in the sector of maximum concentration.

W_g = m^{-2}. For ground plane pathways. The location is the site boundary in the sector of maximum concentration.

W_M = The highest calculated annual average dispersion parameter for estimating the dose to an individual at the controlling location due to partially elevated releases:

W_M = sec/m^3. For inhalation pathway. The location is the site boundary in the sector of maximum concentration.

W_M = m^{-2}. For ground plane pathways. The location is the site boundary in the sector of maximum concentration.

The factors, L_i and M_i, relate the radionuclide airborne concentrations to various dose rates assuming a semi-infinite cloud. These factors are listed in Table B-1 of Regulatory Guide 1.109, Revision 1, and in Table 3-1 of this manual.

The $\overline{X/Q}$ values used in the equations for the implementation of Technical Specification 3.11.2.1 are based upon the maximum long-term annual average at the site boundary. The distances between the nearest unrestricted area and the WNP-2 site are listed in Table 3-2. The distances between WNP-2 and the nearest vegetable garden, milk cow, and beef animal are tabulated in Table 3-3, along with representative X/Q and D/Q values.

The X/Q and D/Q values listed in Tables 3-10 through 3-12 reflect correct acquired meteorological data up to 1983 and were utilized in the initial GASPAR Computer runs. Subsequent reports will use updated X/Q and D/Q averages Characteristics of WNP-2 gaseous effluent release points are listed in Table 3-13.

3.3.2.1 Dose Parameter for Radionuclide i (P_i)

The dose parameters used in Equation 3 are based on:

1. Inhalation and ground plane. (Note: Food pathway is not applicable to WNP-2 since no food is grown at or near the restricted area boundary.)

2. The annual average continuous release meteorology at the site boundary.

3. The critical organ for each radionuclide (thyroid for radioiodine).

4. The most restrictive age group.

Calculation of P_i^I (Inhalation): The following equation will be used to calculate P_i^I (Inhalation).

$$P_i^I \text{ (Inhalation)} = K^A(BR)\ DFA_i \ \text{(mrem/yr per} \mu\text{Ci/m}^3) \qquad (5)$$

where:

K^A = A constant of conversion, 10^6 pCi/μCi.

BR = The breathing rate of the child age group, 3700 m^3/yr.

DFA_i = The critical organ inhalation dose factor for the child age group for the ith radionuclide in mrem/pCi. The total body is considered as an organ in the selection of DFA_i.

The inhalation dose factor for DFA_i for the child age group is listed in Table E-9 of Regulatory Guide 1.109, Revision 1, and Table 3-4 of this manual. Resolving the units yields:

$$P_i^I = \text{(Inhalation)} = (3.7 \times 10^9)(DFA_i) \text{ (mrem/yr per } \mu Ci/m^3) \qquad (6)$$

The P_i^I (Inhalation) values for the child age group are tabulated in Table 3-4 of this manual.

3.4 10 CFR 50 Release Rate Limits

The requirements pertaining to 10 CFR 50 release rate limits are specified in Technical Specifications 3.11.2.2 and 3.11.2.3.

Technical Specification 3.11.2.2 deals with the air dose from noble gases and requires that the air dose at or beyond the site boundary due to noble gases released in gaseous effluents shall be limited to the following:

(a) "During any calendar quarter, to ≤5 mrad for gamma radiation and to ≤10 mrad for beta radiation."

(b) "During any calendar year, to ≤10 mrad for gamma radiation and ≤20 mrad for beta radiation."

Technical Specification 3.11.2.3 deals with radioiodines and radioactive materials in particulate form, and requires that the dose to an individual from radioiodines, radioactive materials in particulate form, and radionuclides other than noble gases with half-lives greater than eight days in gaseous effluents released to unrestricted areas shall be limited to the following:

(a) "During any calendar quarter, to $\leq$7.5 mrem."

(b) "During any calendar year, to $\leq$15 mrem."

3.4.1 Noble Gases (Technical Specification 3.11.2.2)

The air dose at or beyond the site boundary due to noble gases released in the gaseous effluent will be determined by using the following equations.

a. During any calendar quarter, for gamma radiation:

$$3.17 \times 10^{-8} \sum_i M_i \left[(\overline{X/Q})_g Q_{ig} + (X/q)_g q_{ig} + (\overline{X/Q})_m Q_{im} + (X/q)_m q_{im} \right] \leq 5 \text{ mrad} \quad (8)$$

During any calendar quarter, for beta radiation:

$$3.17 \times 10^{-8} \sum_i N_i \left[(\overline{X/Q})_g Q_{ig} + (X/q)_g q_{ig} + (\overline{X/Q})_m Q_{im} + (X/q)_m q_{im} \right] \leq 10 \text{ mrad} \quad (9)$$

b. During any calendar year, for gamma radiation:

$$3.17 \times 10^{-8} \sum_i M_i \left[(\overline{X/Q})_g Q_{ig} + (X/q)_g q_{ig} + (\overline{X/Q})_m Q_{im} + (X/q)_m q_{im} \right] \leq 10 \text{ mrad} \quad (10)$$

During any calendar year, for beta radiation:

$$3.17 \times 10^{-8} \sum_i N_i \left[(\overline{X/Q})_g Q_{ig} + (X/q)_g q_{ig} + (\overline{X/Q})_m Q_{im} + (X/q)_m q_{im} \right] \leq 20 \text{ mrad} \quad (11)$$

where:

M_i = The air dose factor due to gamma emmissions for each identified noble gas radionuclide, in mrad/yr per $\mu Ci/m^3$ (M_i values are listed in Table 3-1).

N_i = The air dose factor due to beta emissions for each identified noble gas radionuclide, in mrad/yr per $\mu Ci/m^3$ (N_i values are listed in Table 3-1).

$(\overline{X/Q})_g$ = For ground level release points. The highest calculated annual average relative concentration for area at or beyond the site area boundary for long-term releases (greater than 500 hr/yr). (Sec/m^3)

$(X/q)_g$ = For ground level release points. The relative concentration for areas at or beyond the site area boundary for short-term releases (equal to or less than 500 hr/yr). (Sec/m^3)

$(\overline{X/Q})_m$ = For partially elevated release points. The highest calculated annual average relative concentration for areas at or beyond the site boundary for long-term releases (greater than 500 hr/yr). (Sec/m^3)

$(X/q)_m$ = For partially elevated release points. The relative concentration for areas at or beyond the site boundary for short-term releases (equal to or less than 500 hr/yr). (Sec/m^3)

q_{im} = The average release of noble gas radionuclides in gaseous effluents, i, for short-term releases (equal to or less than 500 hr/yr) from the main plant release point, in μCi. Releases shall be cumulative over the calendar quarter or year, as appropriate.

q_{ig} = The average release of noble gas radionuclides in gaseous effluents, i, for short-term releases (equal to or less than 500 hr/yr) from Radwaste and Turbine Building, in μCi. Releases shall be cumulative over the calendar quarter or year, as appropriate.

Q_{im} = The average release of noble gas radionuclides in gaseous releases, i, for long-term releases (greater than 500 hr/yr) from the main plant release point, in μCi. Release shall be cumulative over the calendar quarter or year, as appropriate.

Q_{ig} = The average release of noble gas radionuclides in gaseous effluents, i, for long-term releases (greater than 500 hr/yr) from Radwaste and Turbine Building, in μCi. Releases shall be cumulative over the calendar quarter or year, as appropriate.

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

3.4.2 Radioiodines, Tritium and Particulates (Technical Specification 3.11.2.3)

The following equation calculates the dose to an individual from radioiodines, tritium radioactive material in particulate form, and radionuclides other than noble gases with half-lives greater than eight days in gaseous effluents released to the unrestricted areas:

a. During any calendar quarter:

$$3.17 \times 10^{-8} \sum_i R_i \left[W_m Q_{im} + w_m q_{im} + W_g Q_{ig} + w_g q_{ig} \right] \leq 7.5 \text{ mrem} \qquad (12)$$

b. During any calendar year:

$$3.17 \times 10^{-8} \sum_i R_i \left[W_m Q_{im} + w_m q_{im} + W_g Q_{ig} + w_g q_{ig} \right] \leq 15 \text{ mrem} \qquad (13)$$

where:

Q_{im}, Q_{ig} = The releases of radionuclides, radioactive materials in particulate form, and radionuclides other than noble gases in gaseous effluents, i, for long-term releases greater than 500 hr/yr, in μCi. Releases shall be cumulative over the calendar quarter or year, as appropriate (m is for mixed mode releases, g is for ground level releases).

q_{im}, q_{ig} = The releases of radionuclides, radioactive materials in particulate form, and radionuclides other than noble gases in gaseous effluents, i, for short-term releases equal to or less than 500 hr/yr, in μCi. Releases shall be cumulative over the calendar quarter or year as appropriate (m is for mixed mode releases, g is for ground level releases).

W_m, W_g = The dispersion parameter for estimating the dose to an individual at the controlling location for long-term (>500 hr.) releases (m is for mixed mode releases, g is for ground level releases).

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

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

w_m, w_g = The dispersion parameter for estimating the dose to an individual at the controlling location for short-term (<500 hr.) releases (m is for mixed mode releases, g is for ground level releases).

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

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

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

R_i = The dose factor for each identified radionuclide, i, in m^2(mrem/yr per μCi/sec) or mrem/yr per μCi/m^3.

3.4.2.1 Dose Parameter for Radionuclide i (R_i)

The R_i values used in equations 12 and 13 of this section are calculated separately for each of the following potential exposure pathways:

- o Inhalation
- o Ground plane contamination
- o Grass-cow/goat-milk pathway
- o Grass-cow-meat pathway
- o Vegetation pathway

Monthly dose assessments for WNP-2 gaseous effluent will be done for all age groups.

Calculation of R_i^I (Inhalation Pathway Factor)

$$R_i^I \text{ (Inhalation)} = K' \,(BR)_a \,(DFA_i)_a \text{ (mrem/yr per } \mu Ci/m^3) \qquad (14)$$

where:

R_i^I = The inhalation pathway factor (mrem/yr per $\mu Ci/m^3$).

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

$(BR)_a$ = The breathing rate of the receptor of age group (a) in meter^3/yr. (Infant = 1400, child = 3,700, teen = 8,000, adult = 8,000. From P.32 NUREG-0133).

$(DFA_i)_a$ = The maximum organ inhalation dose factor for receptor of age group (a) for the ith radionuclide (mrem/pCi). The total body is considered as an organ in the selection of $(DFA_i)_a$. $(DFA_i)_a$ values are listed in Tables E-7 through E-10 of Regulatory Guide 1.109 manual, Revision 1 and NUREG/CR-4013. Values of R_i^I are listed in Table 3-5.

Calculation of R_i^G (Ground Plane Pathway Factor)

$$R_i^G\text{(Ground Plane)} = K^A K^B \text{ (SF)(DFG}_i\text{) } (1-e^{-\lambda_i t})/\lambda_i \text{ (m}^2 \text{ x mrem/yr per } \mu\text{Ci/sec)} \quad (15)$$

where:

R_i^G = Ground plane pathway factor (m^2 x mrem/yr per µCi/sec).

K^A = A conversion constant of (10^6 pCi/µCi).

K^B = A conversion constant - (8760 hr/yr).

λ_i = The decay constant for the ith radionuclide (sec^{-1}).

t = Exposure time, 6.31×10^8 sec (20 years).

DFG_i = The ground plane dose conversion factor for the ith radionuclide, as listed in Table E-6 of Regulatory Guide 1.109, Revision 1 and NUREG/CR-4013 (mrem/hr per pCi/m^2).

SF = Shielding Factor (dimensionless)--0.7 if building is present, as suggested in Table E-15 of Regulatory Guide 1.109, Revision 1.

The values of R_i^G are listed in Table 3-5 of this manual.

Calculation of R_i^C (Grass-Cow/Goat-Milk Pathway Factor)

R_i^C (Grass-Cow/Goat-Milk Factor) =

$$K' \frac{Q_F(U_{ap})}{\lambda_i + \lambda_w} F_m(r)(DFL_i)_a \left[\frac{f_p f_s}{Y_p} + \frac{(1-f_p f_s)e^{-\lambda_i t_h}}{Y_s}\right] e^{-\lambda_i t_f} \qquad (16)$$

(m^2 x mrem/yr per μCi/sec)

where:

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

Q_F = The cow/goat consumption rate, in kg/day (wet weight).

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

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

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

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

r = Fraction of deposited activity retained on feed grass.

$(DFL_i)_a$ = The maximum organ ingestion dose factor for the ith radionuclide for the receptor in age group (a), in mrem/pCi (Tables E-11 to E-14 of Regulatory Guide 1.109, Revision 1 and NUREG/CR-4013).

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

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

t_f = The transport time from pasture to animal, to milk, to receptor, in sec.

t_h = The transport time from pasture, to harvest, to animal, to milk, to receptor, in sec.

f_p = Fraction of the year that the cow/goat is on pasture (dimensionless).

f_s = Fraction of the cow/goat feed that is pasture grass while the cow is on pasture (dimensionless).

<u>NOTE</u>: For radioiodines, multiply R_i^C value by 0.5 to obtain the amount of elemental iodine present.

The input parameters used for calculating R_i^C are listed in Table 3-6 and the R_i^M values are tabulated in Table 3-7.

<u>For Tritium</u>:

In calculating R_T^C, pertaining to tritium in milk, the airborne concentration rather than the deposition will be used:

R_T^C (Grass-Cow/Goat-Milk Factor) =

$$K^A K^C F_m Q_F U_{ap} (DFL_i)_a \left[0.75(0.5/H)\right] \quad (\text{mrem/yr per } \mu\text{Ci/m}^3) \qquad (17)$$

where:

K^A = A constant unit conversion, 10^6 pCi/μCi.

K^C = A constant of unit conversion, 10^3 gm/kg.

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

0.75 = The fraction of total feed that is water.

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

Calculation of R_i^M (Grass-Cow-Meat Pathway Factor)

R_i^M (Grass-Cow-Meat Factor) =

$$K' \frac{Q_F(U_{ap})}{\lambda_i + \lambda_w} F_f(r)(DFL_i)_a \left[\frac{f_p f_s}{Y_p} + \frac{(1-f_p f_s)e^{-\lambda_i t_h}}{Y_s}\right] e^{-\lambda_i t_f} \quad (18)$$

(m^2 x mrem/yr per μCi/sec)

where:

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

F_f = The stable element transfer coefficients, in days/kg.

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

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

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

NOTE: For radioiodines, multiply R_i^M value by 0.5 to obtain the amount of elemental iodine present.

The input parameters needed for solving equation 18 are listed in Table 3-7.

For Tritium:

In calculating the R_T^M for tritium in meat, the airborne concentration is used rather than the deposition rate. The following equation is used to calculate the R_T^M values for tritium:

R_T^M (Grass-Cow-Meat Pathway) =

$$K^A K^C \left[F_f Q_F U_{ap} \, (DFL_i)_a \right] \left[0.75(0.5/H) \right] \quad (\text{mrem/yr per } \mu\text{Ci/m}^3) \qquad (19)$$

Where the terms are as defined in equations 16-18, R_i^M values for tritium pertaining to the infant age group is zero since there is no meat consumption by this age group.

Calculation of R_i^V (Vegetation Pathway Factor)

R_i^V (Vegetation Pathway Factor) =

$$K' \left[\frac{(r)}{Y_v(\lambda_i + \lambda_w)} \, (DFL_i)_a \right] \left[U_a^L f_L e^{-\lambda_i t_L} + U_a^S f_g e^{-\lambda_i t_h} \right] \qquad (20)$$

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

where:

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

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

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

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

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

t_L = The average time between harvest of leafy vegetation and its consumption, in seconds.

t_h = The average time between harvest of stored vegetation and its consumption, in seconds.

Y_v = The vegetation area density, in kg/m^2.

NOTE: For radioiodines, multiply R_i^V value by 0.5 to obtain the amount of elemental iodine present.

All other items are as defined in equations 16-18.

For Tritium:

In calculating the R_T^V for tritium, the concentration of tritium in vegetation is based on airborne concentration rather than the deposition rate. The following equation is used to calculate R_T^V for tritium:

R_T^V (Vegetation Pathway Factor) =

$$K^A K^C \left[\left(U_a^L f_L + U_a^S f_g\right) (DFL_i)_a\right] \left[0.75(0.5/H)\right] \text{ (mrem/yr per } \mu Ci/m^3) \quad (21)$$

Where all terms have been defined above and in equations 16-18, the R_i^V value for tritium is zero for the infant age group due to zero vegetation consumption rate by that age group. The input parameters needed for solving equations 20 and 21 are listed in Table 3-8.

3.4.3 Annual Doses At Special Locations

The Radioactive Effluent Release Report submitted within 60 days after January 1 of each year shall include an assessment of the radiation doses from radioactive gaseous effluents to, "Members of the Public", due to their activities inside the site boundary during the report period.

Annual doses within the site boundary have been determined for several locations using the NRC GASPAR computer code and source term data from Table 11.3-7 of the FSAR. These values are listed in Tables 3-16 and 3-17. Of the locations listed within the site boundary, only two, the DOE Train and WNP-2 Visitor Center are considered as being occupied by a "Member of the Public". Annual doses to the maximum exposed "Member of the Public" shall be determined for an individual at the WNP-2 Visitor Center based on occupancy of 8 hours per year due to it being the higher of the two locations.

3.5 Compliance with Standard Technical Specification 3.11.2.4

Standard Technical Specification 3.11.2.4 states:

> "The GASEOUS RADWASTE TREATMENT SYSTEM shall be in operation in either the normal or charcoal bypass mode. The charcoal bypass mode shall not be used unless the offgas post-treatment radiation monitor is OPERABLE as specified in Table 3.3.7.11-1."
>
> "APPLICABILITY: Whenever the main condenser steam jet air ejector (evacuation) system is in operation."

Prior to placing the Gaseous Radwaste Treatment System in the charcoal bypass mode, the alarm setpoints on the main plant vent release monitor shall be set to account for the increased percentages of short-lived noble gases. Noble gas percentages shall be based either on actual measured values or on primary coolant design base noble gas concentration percentages adjusted for 30-minute decay. Table 3-15 lists the percentage values for 30-minute decay.

3.5.1 Projection of Doses

The projected doses due to WNP-2 gaseous effluent releases will be determined at least once per 31 days as stated in Technical Specification 3.11.2.5. The projected dose when averaged over 31 days is not to exceed 0.3 mrem to any organ in a 31 day period to areas at and beyond the site boundary. Dose projection values will be determined by using a previous 31 day "Gaspar Output" (NRC Computer Code) for the site boundary and/or an area beyond the site boundary. Based on operating data, the projected dose should be adjusted accordingly to compensate for those anticipated changes in operations and/or source term values.

3.6 Calculation of Gaseous Effluent Monitor Alarm Setpoints

3.6.1 Introduction

The following procedure used to ensure that the dose rate in the unrestricted areas due to noble gases in the WNP-2 gaseous effluent do not exceed 500

mrem/yr to the whole body or 3000 mrem/yr to the skin. The initial setpoints determination is calculated using a conservative radionuclide mix obtained from the WNP-2 GALE code. Once the plant is operating and sufficient measurable process fission gases are in the effluent, then the actual radionuclide mix will be used to calculate the alarm setpoint.

3.6.2 Setpoint Determination for all Gaseous Release Paths

The setpoints for gaseous effluent are based on instantaneous noble gas dose rates. Sampling and analysis of radioiodines and radionuclides in particulate form will be performed in accordance with technical specifications to ensure compliance with 10 CFR 20 and 10 CFR 50 Appendix I limits. The three release points will be partitioned such that their sum does not exceed 100 percent of the limit. Originally, the setpoints will be set at 40 percent for the reactor building, 40 percent for the turbine building and 20 percent for the radwaste building. These percentages could vary at the plant discretion, should the operational conditions warrant such change. However, the combined releases due to variations in the setpoints will not result in doses which exceed the limit stated in technical specifica- tion. Both skin dose and whole body setpoints will be calculated and the lower limit will be used.

3.6.2.1 Setpoints Calculations Based on Whole Body Dose Limits

The fraction (π i) of the total gaseous radioactivity in each gaseous effluent release path (j) for each noble gas radionuclide i will be determined by using the following equation:

$$\pi_{ij} = \frac{M_{ij}}{M_{Tj}} \text{ (dimensionless)} \qquad (22)$$

where:

M_{ij} = The measured individual concentration of radionuclide i in the gaseous effluent release path j (μCi/cc).

M_{Tj} = The measured total concentration of all noble gases identified in the gaseous effluent release path j (µCi/cc).

Based on Technical Specification 3.11.2.1, the maximum acceptable release rate of all noble gases in the gaseous effluent release path j is calculated by using the following equation:

$$Q_{TJ} = \frac{Fj\ 500}{X/Q_j \sum_{i=1}^{m} (K_i)(\pi_{ij})} \ (\mu Ci/sec) \qquad (23)$$

where:

Q_{TJ} = The maximum acceptable release rate (µCi/sec) of all noble gases in the gaseous effluent release path j (µCi/cc).

Fj = Fraction of total dose allocated to release path j.

500 = Whole body dose rate limit of 500 mrem/yr as specified in Technical Specification 3.11.2.1a.

X/Q_j = Maximum normalized diffusion coefficient of effluent release path j at the site boundary (sec/m^3). Turbine Building and Radwaste Building values are based on average annual ground level values. Main plant vent release values are for mixed mode and may be either short term or average annual value dependent upon type of release.

K_i = The total whole body dose factor due to gamma emission from noble gas nuclide i (mrem/yr per µCi/m^3) (as listed in Table B-1 of Regulatory Guide 1.109, Revision 1).

π_{ij} = As defined in equation 22.

m = Total number of radionuclides in the gaseous effluent.

j = Different release pathways.

The total maximum acceptable concentration (C_{Tj}) of noble gas radionuclides in the gaseous effluent release path j (µCi/cc) will be calculated by using the following equation:

$$C_{Tj} = \frac{Q_{Tj}}{R_j} \; (\mu Ci/cc) \qquad (24)$$

where:

C_{Tj} = The total allowed concentration of all noble gas radionuclides in the gaseous effluent release path j (µCi/cc).

Q_{Tj} = The maximum acceptable release rate (µCi/sec) of all noble gases in the gaseous effluent release path j.

R_j = The effluent release rate (cc/sec) at the point of release.

To determine the maximum acceptable concentration (C_{ij}) of noble gas radionuclide i in the gaseous effluent for each individual noble gas in the gaseous effluent (µCi/cc), the following equation will be used:

$$C_{ij} = \pi_{ij} C_{Tj} \; (\mu Ci/cc) \qquad (25)$$

where:

π_{ij} and C_{TJ} are as defined in equations 22 and 24 respectively, the gaseous effluent monitor alarm setpoint will then be calculated as follows:

$$C.R.j = \sum_{i=1}^{m} C_{ij} E_{ij} (cpm) \quad (26)$$

where:

C.R.j = Count rate above background (cpm) for gaseous release path j.

C_{ij} = The maximum acceptable concentration of noble gas nuclide i in the gaseous effluent release path j. μCi/cc.

E_{ij} = Detection efficiency of the gaseous effluent monitor j for noble gas i (cpm/μCi/cc).

3.6.2.2 Setpoints Calculations Based on Skin Dose Limits

The method for calculating the setpoints to ensure compliance with the skin dose limits specified in Technical Specification 3.11.2.1a is similar to the one described for whole body dose limits (Section 3.6.2.1 of this manual), except Eq. 27 will be used instead of Eq. 23 for determining maximum acceptable release rate (Q_{Tj}).

$$Q_{TJ} = \frac{Fj \quad 3000}{(X/Q_j) \sum_{i=1}^{m} (L_i + 1.1M_i)(\pi_{ij})} (\mu Ci/sec) \quad (27)$$

where:

Q_{TJ} = The maximum acceptable release rate of all noble gases in the gaseous effluent release path j in μCi/sec.

X/Qj = The maximum annual normalized diffusion coefficient for release path j at the site boundary (sec/m^3).

F_j = Fraction of total allowed dose.

L_i = The skin dose factor due to beta emission for each identified noble gas radionuclide i in mrem/yr per μCi/m^3 (L_i values are listed in Table 3-1).

M_i = The air dose factor due to gamma emmissions for each identified noble gas radionuclide, in mrad/yr per μCi/m^3 (M_i values are listed in Table 3-1).

1.1 = A conversion factor to convert dose in mrad to dose equivalent in mrem.

3000 = Skin dose rate limit of 3000 mrem/yr as specified in Technical Specification 3.11.2.1.

Table 3-1
DOSE FACTORS FOR NOBLE GASES AND DAUGHTERS*

Radionuclide	Total Body Dose Factor K_i (mrem/yr per $\mu Ci/m^3$)	Skin Dose Factor L_i (mrem/yr per $\mu Ci/m^3$)	Gamma Air Dose Factor M_i (mrad/yr per $\mu Ci/m^3$)	Beta Air Dose Factor N_i (mrad/yr per $\mu Ci/m^3$)
Kr-85m	1.17E+03**	1.46E+03	1.23E+03	1.97E+03
Kr-85	1.61E+01	1.34E+03	1.72E+01	1.95E+03
Kr-87	5.92E+03	9.73E+03	6.17E+03	1.03E+04
Kr-88	1.47E+04	2.37E+03	1.52E+04	2.93E+03
Kr-89	1.66E+04	1.01E+04	1.73E+04	1.06E+04
Kr-90	1.56E+04	7.29E+03	1.63E+04	7.83E+03
Xe-131m	9.15E+01	4.76E+02	1.56E+02	1.11E+03
Xe-133m	2.51E+02	9.94E+02.	3.27E+02	1.48E+03
Xe-133	2.94E+02	3.06E+02	3.53E+02	1.05E+03
Xe-135m	3.12E+03	7.11E+02	3.36E+03	7.39E+02
Xe-135	1.81E+03	1.86E+03	1.92E+03	2.46E+03
Xe-137	1.42E+03	1.22E+04	1.51E+03	1.27E+04
Xe-138	8.83E+03	4.13E+03	9.21E+03	4.75E+03
Ar-41	8.84E+03	2.69E+03	9.30E+03	3.28E+03

*The listed dose factors are for radionuclides that may be detected in gaseous effluents.

**7.56E-02 = 7.56×10^{-2}.

The values listed above were taken from Table B-1 of NRC Regulatory Guide 1.109, Revision 1. The values were multiplied by 10^6 to convert $picocuries^{-1}$ to $microcuries^{-1}$.

Table 3-2

DISTANCES (MILES) TO CONTROLLING LOCATIONS
AS MEASURED FROM CENTER OF WNP-2 CONTAINMENT BUILDING*

Location	Distance (miles)	Sector	Comments
Site Boundary	1.2	SE	Air dose measurement.
Taylor Flats	4.2	ESE	The nearest significant residence in the southern direction with vegetable gardens, milk, and meat production.
Ringold	4.0	ENE	The nearest significant residence in the northern direction with vegetable gardens, milk, and meat production.

*Selection of location sector is based on the highest annual average X/Q values.

Table 3-3

WNP-2 ANNUAL AVERAGE DISPERSION (X/Q)
AND DEPOSITION (D/Q) VALUES FOR SPECIAL LOCATIONS

Location	Sector	Distance (miles)	Point of Release	X/Q No Decay No Depletion (sec/m^3)	X/Q 2.3 Days Decay No Depletion (sec/m^3)	X/Q 8.0 Days Decay Depleted (sec/m^3)	D/Q (m^{-2})
Site Boundary	SE	1.2	Containment Bldg.	1.8E-06	1.8E-06	1.6E-06	1.0E-08
			Turbine Bldg.	1.1E-05	1.1E-05	1.0E-05	8.3E-08
			Radwaste Bldg.	1.1E-05	1.1E-05	1.0E-05	8.3E-08
Taylor Flats	ESE	4.2	Containment Bldg.	4.1E-07	4.1E-07	3.8E-07	8.2E-10
			Turbine Bldg.	8.9E-07	8.7E-07	6.8E-07	7.2E-10
			Radwaste Bldg.	8.9E-07	8.7E-07	6.8E-07	7.2E-10
Ringold	ENE	4.0	Containment Bldg.	2.5E-07	2.5E-07	1.9E-07	3.3E-10
			Turbine Bldg.	3.9E-07	3.8E-07	3.0E-07	3.3E-10
			Radwaste Bldg.	3.9E-07	3.8E-07	3.0E-07	3.3E-10
BPA Ashe Substation	N	0.5	Containment Bldg.	6.4E-06	6.4E-06	5.8E-06	3.7E-08
			Turbine Bldg.	3.0E-05	2.9E-05	2.7E-05	7.8E-08
			Radwaste Bldg.	3.0E-05	2.9E-05	2.7E-05	7.8E-08

Table 3-4

DOSE RATE PARAMETERS
IMPLEMENTATION OF 10 CFR 20, AIRBORNE RELEASES

		Child Dose Factor*		P_i^I
		DFA_i	DFG_i	Inhalation
Nuclide	λ sec^{-1}	mrem/pCi	mrem/hr / pCi/m^2	mrem/yr / µCi/m^3
H-3	1.8E-09	1.7E-07	0.0	6.3E+02
Na-24	1.3E-05	4.4E-06	2.9E-08	1.6E+04
Cr-51	2.9E-07	4.6E-06	2.6E-10	1.7E+04
Mn-54	2.6E-08	4.3E-04	6.8E-09	1.6E+06
Mn-56	7.5E-05	3.3E-05	1.3E-08	1.2E+05
Fe-55	8.5E-09	3.0E-05	0.0	1.1E+05
Fe-59	1.8E-07	3.4E-04	9.4E-09	1.3E+06
Co-58	1.1E-07	3.0E-04	8.2E-09	1.1E+06
Co-60	4.2E-09	1.9E-03	2.0E-08	7.0E+06
Cu-64	1.5E-05	9.9E-06	1.7E-09	3.7E+04
Zn-65	3.3E-08	2.7E-04	4.6E-09	1.0E+06
Zn-69m	1.4E-05	2.7E-05	3.4E-09	1.0E+05
As-76	7.3E-06	1.9E-05	1.7E-07	7.0E+04
Br-82	5.5E-06	5.7E-06	2.2E-08	2.1E+04
Sr-89	1.5E-07	5.8E-04	6.5E-13	2.2E+06
Sr-90	7.9E-10	1.0E-02	2.6E-12**	3.7E+07
Zr-95	1.2E-07	6.0E-04	5.8E-09	2.2E+06
Nb-95	2.3E-07	1.7E-04	6.0E-09	6.3E+05
Zr-97	1.1E-05	9.5E-05	6.4E-09	3.5E+05
Nb-97	1.6E-04	7.5E-06	5.4E-09	2.8E+04
Mo-99	2.9E-06	3.7E-05	2.2E-09	1.4E+05
Tc-99m	3.2E-05	1.3E-06	1.1E-09	4.8E+03
Ru-106	2.2E-08	3.9E-03	1.8E-09	1.4E+07
Ag-110m	3.2E-08	1.5E-03	2.1E-08	5.6E+06
Sb-124	1.3E-07	8.8E-04	1.5E-08	3.3E+06
Sb-125	7.9E-09	6.3E-04	3.5E-09	2.3E+06
Sb-126	6.5E-07	2.9E-04	1.0E-08	1.1E+06
Sb-127	2.1E-06	6.2E-05	6.6E-09	2.3E+05

Table 3-4

DOSE RATE PARAMETERS
IMPLEMENTATION OF 10 CFR 20, AIRBORNE RELEASES

		Child Dose Factor*		P_i^I
		DFA_i	DFG_i	Inhalation
Nuclide	λ sec^{-1}	mrem/pCi	mrem/hr / pCi/m^2	mrem/yr / $\mu Ci/m^3$
Te-127	2.1E-05	1.5E-05	1.1E-11	5.6E+04
Te-131m	6.4E-06	8.3E-05	9.9E-09	3.1E+05
I-131	1.0E-06	4.4E-03	3.4E-09	1.6E+07
I-132	8.4E-05	5.2E-05	2.0E-08	1.9E+05
I-133	9.2E-06	1.0E-03	4.5E-09	3.7E+06
I-135	2.9E-05	2.1E-04	1.4E-08	7.8E+05
Cs-134	1.1E-08	2.7E-04	1.4E-08	1.0E+06
Cs-137	7.3E-10	2.5E-04	4.9E-09	9.3E+05
Cs-138	3.6E-04	2.3E-07	2.4E-08	8.5E+02
Ba-140	6.3E-07	4.7E-04	2.4E-09	1.7E+06
La-140	4.8E-06	6.1E-05	1.7E-08	2.3E+05
Ce-141	2.4E-07	1.5E-04	6.2E-10	5.6E+05
Ce-144	2.8E-08	3.2E-03	3.7E-10	1.2E+07
Nd-147	7.2E-07	8.9E-05	1.2E-09	3.3E+05
Hf-179m	3.7E-02	2.0E-05	NO DATA	7.4E+04
Hf-181	1.8E-07	6.0E-05	1.2E-08	2.2E+05
W-185	1.1E-07	1.9E-04	0.0	7.0E+05

* Maximum Organ
**No data is listed for Sr-90 in Table E-6 of Regulatory Guide 1.109, Revision 1. Y-90 valves were used for dose conversion factor Sr-90.

TABLE 3-5 a

DOSE PARAMETERS FOR 10 CFR 50 EVALUATIONS, AIRBORNE RELEASES
AGE GROUP: ADULT ORGAN OF REFERENCE: MAXIMUM ORGAN
R(I), INDIVIDUAL PATHWAY DOSE PARAMETERS FOR RADIONUCLIDES OTHER THAN NOBLE GASES

RADIO-NUCLIDE	INHALATION (MREM/YR PER UCI/M3)	GROUND PLANE (M2.MREM/YR PER UCI/SEC)	COW-MILK (M2.MREM/YR PER UCI/SEC)	GOAT-MILK (M2.MREM/YR PER UCI/SEC)	ANIMAL-MEAT (M2.MREM/YR PER UCI/SEC)	VEGETABLES (M2.MREM/YR PER UCI/SEC)
H 3	7.2E+02	0.0E-01	5.8E+02	1.2E+03	2.4E+02	1.6E+03
NA 24	1.0E+04	1.2E+07	1.2E+06	2.2E+05	7.2E-04	1.1E+05
CR 51	1.4E+04	4.7E+06	3.3E+06	5.9E+05	8.2E+05	2.3E+07
MN 54	1.4E+06	1.4E+09	1.4E+07	2.1E+06	1.5E+07	9.4E+08
MN 56	2.0E+04	9.0E+05	6.2E-02	1.1E-02	0.0E-01	2.0E+02
FE 55	7.2E+04	0.0E-01	1.4E+07	2.2E+06	1.6E+08	1.9E+08
FE 59	1.0E+06	2.7E+08	1.1E+08	2.0E+07	9.8E+08	1.5E+09
CO 58	9.3E+05	3.8E+08	4.7E+07	7.6E+06	1.8E+08	8.0E+08
CO 60	6.0E+06	2.3E+10	1.7E+08	2.5E+07	8.0E+08	2.9E+09
CU 64	4.9E+04	6.1E+05	1.0E+06	1.7E+05	1.1E-05	3.3E+05
ZN 65	8.6E+05	7.5E+08	2.7E+09	4.0E+08	7.0E+08	1.3E+09
ZN 69M	1.4E+05	1.3E+06	1.3E+07	2.4E+06	1.2E-03	1.4E+06
AS 76	1.5E+05	3.8E+06	2.1E+07	3.8E+06	2.9E+01	8.0E+06
BR 82	1.4E+04	2.1E+07	1.9E+07	3.4E+06	7.0E+02	7.7E+05
SR 89	1.4E+06	2.2E+04	6.9E+08	2.0E+09	1.4E+08	1.5E+10
SR 90	2.9E+07	6.7E+06	3.4E+10	8.3E+10	8.9E+09	7.4E+11
ZR 95	1.8E+06	2.5E+08	4.6E+05	7.6E+04	9.2E+08	1.6E+09
NB 95	5.1E+05	1.4E+08	1.3E+08	2.2E+07	3.6E+09	8.4E+08
ZR 97	5.2E+05	3.0E+06	1.4E+04	2.4E+03	6.4E-01	8.8E+06
NB 97	2.4E+03	1.8E+05	1.6E-09	2.9E-10	0.0E-01	8.1E-04
MO 99	2.5E+05	4.0E+06	2.9E+07	5.2E+06	1.2E+05	9.3E+06
TC 99M	4.2E+03	1.8E+05	2.8E+03	5.0E+02	3.6E-18	2.2E+03
RU106	9.4E+06	4.2E+08	7.3E+05	1.1E+05	1.0E+11	1.2E+10
AG110M	4.6E+06	3.5E+09	1.2E+10	1.8E+09	1.4E+09	4.4E+09
SB124	2.5E+06	6.0E+08	3.5E+08	5.8E+07	2.7E+08	4.0E+09
SB125	1.7E+06	2.4E+09	1.3E+08	1.8E+07	1.2E+08	1.4E+09
SB126	7.7E+05	8.4E+07	2.2E+08	4.0E+07	7.6E+07	1.6E+09
SB127	3.0E+05	1.7E+07	5.2E+07	9.3E+06	1.9E+06	1.2E+08
TE127	5.7E+04	3.0E+03	2.6E+04	4.7E+03	8.4E-09	2.0E+05
TE131M	5.6E+05	8.0E+06	8.9E+06	1.6E+06	1.1E+04	2.0E+07
I 131	1.2E+07	8.6E+06	3.4E+10	6.1E+10	1.2E+09	4.4E+10
I 132	1.1E+05	6.2E+05	3.9E+00	6.9E+00	0.0E-01	1.1E+03
I 133	2.2E+06	1.2E+06	2.5E+08	4.5E+08	2.4E+01	1.1E+08
I 135	4.5E+05	1.3E+06	5.5E+05	9.8E+05	1.7E-15	1.4E+06
CS134	8.5E+05	6.9E+09	7.4E+09	2.7E+10	8.6E+08	1.0E+10
CS136	1.5E+05	1.5E+08	5.0E+08	2.2E+09	2.3E+07	4.6E+08
CS137	6.2E+05	1.3E+10	6.0E+09	2.1E+10	7.1E+08	8.6E+09
CS138	6.2E+02	3.6E+05	1.0E-23	4.6E-23	0.0E-00	3.0E-11
BA140	1.3E+06	2.1E+07	2.7E+07	4.8E+06	2.8E+07	7.3E+08
LA140	4.6E+05	1.9E+07	8.4E+04	1.5E+04	7.0E+02	3.3E+07
CE141	3.6E+05	1.4E+07	5.8E+06	1.0E+06	1.7E+07	9.3E+08
CE144	7.8E+06	7.0E+07	6.4E+07	9.6E+06	2.6E+08	1.1E+10
ND147	2.2E+05	8.5E+06	2.5E+05	4.6E+04	1.9E+07	5.1E+08
HF179M	1.6E+05	0.0E-01	0.0E-01	0.0E-01	0.0E-01	0.0E-01
HF181	4.8E+05	2.1E+08	5.5E+05	9.3E+04	1.2E+10	1.8E+09
W 185	4.5E+05	1.8E+04	2.4E+07	3.9E+06	1.9E+07	8.4E+08

TABLE 3-5 b

DOSE PARAMETERS FOR 10 CFR 50 EVALUATIONS, AIRBORNE RELEASES
AGE GROUP: TEEN ORGAN OF REFERENCE: MAXIMUM ORGAN
R(I), INDIVIDUAL PATHWAY DOSE PARAMETERS FOR RADIONUCLIDES OTHER THAN NOBLE GASES

RADIO-NUCLIDE	INHALATION (MREM/YR PER UCI/M3)	GROUND PLANE (M2.MREM/YR PER UCI/SEC)	COW-MILK (M2.MREM/YR PER UCI/SEC)	GOAT-MILK (M2.MREM/YR PER UCI/SEC)	ANIMAL-MEAT (M2.MREM/YR PER UCI/SEC)	VEGETABLES (M2.MREM/YR PER UCI/SEC)
H 3	7.3E+02	0.0E-01	7.5E+02	1.5E+03	1.5E+02	1.9E+03
NA 24	1.4E+04	1.2E+07	2.1E+06	3.9E+05	5.8E-04	1.0E+05
CR 51	2.1E+04	4.7E+06	3.9E+06	6.8E+05	4.4E+05	2.5E+07
MN 54	2.0E+06	1.4E+09	1.6E+07	2.3E+06	7.8E+06	9.6E+08
MN 56	5.7E+04	9.0E+05	2.3E-01	4.1E-02	0.0E-00	3.7E+02
FE 55	1.2E+05	0.0E-01	2.4E+07	3.8E+06	1.3E+08	3.0E+08
FE 59	1.5E+06	2.7E+08	1.3E+08	2.5E+07	5.5E+08	1.7E+09
CO 58	1.3E+06	3.8E+08	5.3E+07	8.7E+06	9.4E+07	8.3E+08
CO 60	8.7E+06	2.3E+10	2.1E+08	3.0E+07	4.3E+08	3.1E+09
CU 64	6.1E+04	6.1E+05	1.6E+06	2.7E+05	8.0E-06	2.7E+05
ZN 65	1.2E+06	7.5E+08	4.5E+09	6.7E+08	5.4E+08	2.0E+09
ZN 69M	1.7E+05	1.3E+06	2.1E+07	3.8E+06	9.1E-04	1.1E+06
AS 76	1.5E+05	3.8E+06	2.7E+07	4.9E+06	1.7E+01	5.3E+06
BR 82	1.8E+04	2.1E+07	2.8E+07	5.1E+06	4.9E+02	6.1E+05
SR 89	2.4E+06	2.2E+04	1.3E+09	3.7E+09	1.2E+08	2.4E+10
SR 90	3.3E+07	6.7E+06	5.1E+10	1.3E+11	6.2E+09	1.0E+12
ZR 95	2.7E+06	2.5E+08	5.8E+05	9.5E+04	5.3E+08	1.8E+09
NB 95	7.5E+05	1.4E+08	1.6E+08	2.7E+07	2.0E+09	9.1E+08
ZR 97	6.3E+05	3.0E+06	2.1E+04	3.8E+03	4.6E-01	7.0E+06
NB 97	3.9E+03	1.8E+05	1.9E-08	3.3E-09	0.0E-01	4.8E-03
MO 99	2.7E+05	4.0E+06	5.1E+07	9.2E+06	9.4E+04	1.1E+07
TC 99M	6.1E+03	1.8E+05	5.3E+03	9.5E+02	3.2E-18	2.1E+03
RU106	1.6E+07	4.2E+08	9.9E+05	1.5E+05	6.2E+10	1.5E+10
AG110M	6.8E+06	3.5E+09	1.4E+10	2.1E+09	7.6E+08	4.6E+09
SB124	3.8E+06	6.0E+08	4.5E+08	7.3E+07	1.6E+08	4.6E+09
SB125	2.7E+06	2.4E+09	1.6E+08	2.3E+07	6.8E+07	1.6E+09
SB126	1.2E+06	8.4E+07	2.8E+08	5.1E+07	4.5E+07	1.8E+09
SB127	3.2E+05	1.7E+07	6.9E+07	1.2E+07	1.2E+06	1.2E+08
TE127	8.1E+04	3.0E+03	4.8E+04	8.6E+03	7.0E-09	1.8E+05
TE131M	6.2E+05	8.0E+06	1.3E+07	2.3E+06	7.4E+03	1.5E+07
I 131	1.5E+07	8.6E+06	5.4E+10	9.7E+10	9.0E+08	6.1E+10
I 132	1.5E+05	6.2E+05	6.4E+00	1.2E+01	0.0E-00	9.3E+02
I 133	2.9E+06	1.2E+06	4.2E+08	7.5E+08	1.8E+01	9.6E+07
I 135	6.2E+05	1.3E+06	9.3E+05	1.7E+06	1.3E-15	1.2E+06
CS134	1.1E+06	6.9E+09	1.3E+10	4.6E+10	6.8E+08	1.6E+10
CS136	1.9E+05	1.5E+08	8.4E+08	3.8E+09	1.8E+07	7.0E+08
CS137	8.5E+05	1.3E+10	1.1E+10	3.8E+10	5.7E+08	1.4E+10
CS138	8.6E+02	3.6E+05	1.8E-23	8.1E-23	0.0E-00	2.7E-11
BA140	2.0E+06	2.1E+07	3.6E+07	6.4E+06	1.8E+07	8.8E+08
LA140	4.9E+05	1.9E+07	1.1E+05	2.1E+04	4.4E+02	2.4E+07
CE141	6.1E+05	1.4E+07	7.9E+06	1.4E+06	1.0E+07	1.1E+09
CE144	1.3E+07	7.0E+07	8.8E+07	1.3E+07	1.6E+08	1.3E+10
ND147	3.7E+05	8.5E+06	3.5E+05	6.2E+04	1.2E+07	6.1E+08
HF179M	7.1E+04	0.0E-01	0.0E-01	0.0E-01	0.0E-01	0.0E-01
HF181	4.8E+05	2.1E+08	7.1E+05	1.2E+05	7.0E+09	2.1E+09
W 185	7.7E+05	1.8E+04	3.3E+07	5.4E+06	1.2E+07	1.0E+09

TABLE 3-5 c

DOSE PARAMETERS FOR 10 CFR 50 EVALUATIONS, AIRBORNE RELEASES
AGE GROUP: CHILD ORGAN OF REFERENCE: MAXIMUM ORGAN
R(I), INDIVIDUAL PATHWAY DOSE PARAMETERS FOR RADIONUCLIDES OTHER THAN NOBLE GASES

RADIO-NUCLIDE	INHALATION (MREM/YR PER UCI/M3)	GROUND PLANE (M2.MREM/YR PER UCI/SEC)	COW-MILK (M2.MREM/YR PER UCI/SEC)	GOAT-MILK (M2.MREM/YR PER UCI/SEC)	ANIMAL-MEAT (M2.MREM/YR PER UCI/SEC)	VEGETABLES (M2.MREM/YR PER UCI/SEC)
H 3	6.4E+02	0.0E-01	1.2E+03	2.4E+03	1.8E+02	2.9E+03
NA 24	1.6E+04	1.2E+07	4.5E+06	8.0E+05	9.2E-04	1.6E+05
CR 51	1.7E+04	4.7E+06	2.5E+06	4.4E+05	2.2E+05	1.6E+07
MN 54	1.6E+06	1.4E+09	1.1E+07	1.7E+06	4.3E+06	6.9E+08
MN 56	1.2E+05	9.0E+05	8.8E-01	1.6E-01	0.0E-00	1.1E+03
FE 55	1.1E+05	0.0E-01	6.1E+07	9.6E+06	2.5E+08	7.6E+08
FE 59	1.3E+06	2.7E+08	9.5E+07	1.7E+07	3.0E+08	1.2E+09
CO 58	1.1E+06	3.8E+08	3.4E+07	5.6E+06	4.7E+07	5.3E+08
CO 60	7.1E+06	2.3E+10	1.4E+08	2.0E+07	2.2E+08	2.1E+09
CU 64	3.7E+04	6.1E+05	1.7E+06	2.9E+05	6.5E-06	2.2E+05
ZN 65	1.0E+06	7.5E+08	6.8E+09	1.0E+09	6.2E+08	3.0E+09
ZN 69M	1.0E+05	1.3E+06	2.2E+07	4.0E+06	7.2E-04	9.0E+05
AS 76	7.0E+04	3.8E+06	2.2E+07	4.0E+06	1.1E+01	3.3E+06
BR 82	2.1E+04	2.1E+07	5.8E+07	1.0E+07	7.6E+02	9.5E+05
SR 89	2.2E+06	2.2E+04	3.1E+09	9.2E+09	2.3E+08	6.0E+10
SR 90	3.8E+07	6.7E+06	1.0E+11	2.6E+11	9.8E+09	2.1E+12
ZR 95	2.2E+06	2.5E+08	4.2E+05	7.0E+04	3.0E+08	1.3E+09
NB 95	6.1E+05	1.4E+08	1.1E+08	1.8E+07	1.0E+09	6.2E+08
ZR 97	3.5E+05	3.0E+06	2.1E+04	3.8E+03	3.5E-01	5.2E+06
NB 97	2.8E+04	1.8E+05	4.2E-07	7.6E-08	0.0E-01	8.2E-02
MO 99	1.3E+05	4.0E+06	8.7E+07	1.6E+07	1.2E+05	1.6E+07
TC 99M	4.8E+03	1.8E+05	7.4E+03	1.3E+03	3.4E-18	2.2E+03
RU106	1.4E+07	4.2E+08	7.9E+05	1.2E+05	3.8E+10	1.2E+10
AG110M	5.5E+06	3.5E+09	9.4E+09	1.4E+09	3.8E+08	3.0E+09
SB124	3.2E+06	6.0E+08	3.3E+08	5.4E+07	8.8E+07	3.3E+09
SB125	2.3E+06	2.4E+09	1.2E+08	1.7E+07	3.8E+07	1.2E+09
SB126	1.1E+06	8.4E+07	2.2E+08	4.0E+07	2.7E+07	1.4E+09
SB127	2.3E+05	1.7E+07	5.5E+07	1.0E+07	7.2E+05	9.2E+07
TE127	5.6E+04	3.0E+03	5.9E+04	1.1E+04	6.7E-09	1.7E+05
TE131M	3.1E+05	8.0E+06	1.1E+07	2.1E+06	5.0E+03	9.9E+06
I 131	1.6E+07	8.6E+06	1.1E+11	1.9E+11	1.4E+09	1.2E+11
I 132	1.9E+05	6.2E+05	1.5E+01	2.7E+01	0.0E-00	1.6E+03
I 133	3.8E+06	1.2E+06	9.9E+08	1.8E+09	3.3E+01	1.7E+08
I 135	7.9E+05	1.3E+06	2.1E+06	3.8E+06	2.3E-15	2.1E+06
CS134	1.0E+06	6.9E+09	2.0E+10	7.5E+10	8.3E+08	2.6E+10
CS136	1.7E+05	1.5E+08	1.3E+09	6.0E+09	2.1E+07	1.1E+09
CS137	9.1E+05	1.3E+10	1.9E+10	6.8E+10	7.9E+08	2.5E+10
CS138	8.4E+02	3.6E+05	3.2E-23	1.4E-22	0.0E-00	3.6E-11
BA140	1.7E+06	2.1E+07	5.6E+07	1.0E+07	2.1E+07	1.4E+09
LA140	2.3E+05	1.9E+07	9.5E+04	1.7E+04	2.8E+02	1.6E+07
CE141	5.4E+05	1.4E+07	6.3E+06	1.1E+06	6.4E+06	9.0E+08
CE144	1.2E+07	7.0E+07	7.0E+07	1.1E+07	1.0E+08	1.1E+10
ND147	3.3E+05	8.5E+06	2.8E+05	5.0E+04	7.4E+06	4.8E+08
HF179M	7.4E+04	0.0E-01	0.0E-01	0.0E-01	0.0E-01	0.0E-01
HF181	2.2E+05	2.1E+08	5.9E+05	9.9E+04	4.4E+09	1.8E+09
W 185	6.9E+05	1.8E+04	2.7E+07	4.3E+06	7.3E+06	8.3E+08

TABLE 3-5 d

DOSE PARAMETERS FOR 10 CFR 50 EVALUATIONS, AIRBORNE RELEASES
AGE GROUP: INFANT ORGAN OF REFERENCE: MAXIMUM ORGAN
R(I), INDIVIDUAL PATHWAY DOSE PARAMETERS FOR RADIONUCLIDES OTHER THAN NOBLE GASES

RADIO-NUCLIDE	INHALATION (MREM/YR PER UCI/M3)	GROUND PLANE (M2.MREM/YR PER UCI/SEC)	COW-MILK (M2.MREM/YR PER UCI/SEC)	GOAT-MILK (M2.MREM/YR PER UCI/SEC)	ANIMAL-MEAT (M2.MREM/YR PER UCI/SEC)	VEGETABLES (M2.MREM/YR PER UCI/SEC)
H 3	3.7E+02	0.0E-01	1.8E+03	3.7E+03	0.0E-01	0.0E-01
NA 24	1.1E+04	1.2E+07	7.8E+06	1.4E+06	0.0E-01	0.0E-01
CR 51	1.3E+04	4.7E+06	2.2E+06	3.8E+05	0.0E-01	0.0E-01
MN 54	1.0E+06	1.4E+09	2.1E+07	3.1E+06	0.0E-01	0.0E-01
MN 56	7.2E+04	9.0E+05	1.3E+00	2.4E-01	0.0E-01	0.0E-01
FE 55	8.7E+04	0.0E-01	7.4E+07	1.2E+07	0.0E-01	0.0E-01
FE 59	1.0E+06	2.7E+08	1.8E+08	3.4E+07	0.0E-01	0.0E-01
CO 58	7.8E+05	3.8E+08	2.9E+07	4.8E+06	0.0E-01	0.0E-01
CO 60	4.5E+06	2.3E+10	1.2E+08	1.7E+07	0.0E-01	0.0E-01
CU 64	1.5E+04	6.1E+05	1.9E+06	3.2E+05	0.0E-01	0.0E-01
ZN 65	6.5E+05	7.5E+08	1.2E+10	1.7E+09	0.0E-01	0.0E-01
ZN 69M	4.1E+04	1.3E+06	2.4E+07	4.3E+06	0.0E-01	0.0E-01
AS 76	2.7E+04	3.8E+06	2.2E+07	4.0E+06	0.0E-01	0.0E-01
BR 82	1.3E+04	2.1E+07	9.8E+07	1.8E+07	0.0E-01	0.0E-01
SR 89	2.0E+06	2.2E+04	6.0E+09	1.8E+10	0.0E-01	0.0E-01
SR 90	1.6E+07	6.7E+06	1.2E+11	2.9E+11	0.0E-01	0.0E-01
ZR 95	1.8E+06	2.5E+08	4.0E+05	6.5E+04	0.0E-01	0.0E-01
NB 95	4.8E+05	1.4E+08	9.6E+07	1.7E+07	0.0E-01	0.0E-01
ZR 97	1.4E+05	3.0E+06	2.2E+04	4.0E+03	0.0E-01	0.0E-01
NB 97	2.7E+04	1.8E+05	1.1E-06	1.9E-07	0.0E-01	0.0E-01
MO 99	1.3E+05	4.0E+06	1.6E+08	2.8E+07	0.0E-01	0.0E-01
TC 99M	2.0E+03	1.8E+05	8.2E+03	1.5E+03	0.0E-01	0.0E-01
RU106	1.2E+07	4.2E+08	8.0E+05	1.2E+05	0.0E-01	0.0E-01
AG110M	3.7E+06	3.5E+09	8.2E+09	1.2E+09	0.0E-01	0.0E-01
SB124	2.6E+06	6.0E+08	3.1E+08	5.1E+07	0.0E-01	0.0E-01
SB125	1.6E+06	2.4E+09	1.1E+08	1.6E+07	0.0E-01	0.0E-01
SB126	9.6E+05	8.4E+07	2.1E+08	3.7E+07	0.0E-01	0.0E-01
SB127	2.2E+05	1.7E+07	5.5E+07	9.9E+06	0.0E-01	0.0E-01
TE127	2.4E+04	3.0E+03	6.8E+04	1.2E+04	0.0E-01	0.0E-01
TE131M	2.0E+05	8.0E+06	1.2E+07	2.1E+06	0.0E-01	0.0E-01
I 131	1.5E+07	8.6E+06	2.6E+11	4.7E+11	0.0E-01	0.0E-01
I 132	1.7E+05	6.2E+05	3.4E+01	6.1E+01	0.0E-01	0.0E-01
I 133	3.6E+06	1.2E+06	2.4E+09	4.3E+09	0.0E-01	0.0E-01
I 135	7.0E+05	1.3E+06	4.9E+06	8.9E+06	0.0E-01	0.0E-01
CS134	7.0E+05	6.9E+09	3.7E+10	1.4E+11	0.0E-01	0.0E-01
CS136	1.3E+05	1.5E+08	2.8E+09	1.2E+10	0.0E-01	0.0E-01
CS137	6.1E+05	1.3E+10	3.6E+10	1.3E+11	0.0E-01	0.0E-01
CS138	8.8E+02	3.6E+05	1.2E-22	5.6E-22	0.0E-01	0.0E-01
BA140	1.6E+06	2.1E+07	1.2E+08	2.1E+07	0.0E-01	0.0E-01
LA140	1.7E+05	1.9E+07	9.4E+04	1.7E+04	0.0E-01	0.0E-01
CE141	5.2E+05	1.4E+07	6.4E+06	1.1E+06	0.0E-01	0.0E-01
CE144	9.8E+06	7.0E+07	7.1E+07	1.1E+07	0.0E-01	0.0E-01
ND147	3.2E+05	8.5E+06	2.8E+05	5.0E+04	0.0E-01	0.0E-01
HF179M	2.8E+04	0.0E-01	0.0E-01	0.0E-01	0.0E-01	0.0E-01
HF181	8.4E+04	2.1E+08	5.9E+05	9.9E+04	0.0E-01	0.0E-01
W 185	6.3E+05	1.8E+04	2.7E+07	4.4E+06	0.0E-01	0.0E-01

Table 3-6

INPUT PARAMETERS FOR CALCULATING R_i^C

Parameter	Value	Table*
r (dimensionless)	1.0 for radioiodine	E-15
	0.2 for particulates	E-15
F_m (days/liter)	Each stable element	E-1
U_{ap} (liters/yr)--Infant	330	E-5
--Child	330	E-5
--Teen	400	E-5
--Adult	310	E-5
$(DFL_i)_a$ (mrem/pCi)	Each radionuclide	E-11 to E-14
Y_p (kg/m^2)	0.7	E-15
Y_s (kg/m^2)	2.0	E-15
t_f (seconds)	1.73×10^5 (2 days)	E-15
t_h (seconds)	7.78×10^6 (90 days)	E-15
Q_F (kg/day)	50 for cow	E-3
	6 for goat	E-3
fs (dimensionless)	1.0	NUREG-0133
fp (dimensionless)	0.5 for cow	Site specific
	0.75 for goat	Site specific

*Of Regulatory Guide 1.109, Revision 1 unless stated otherwise.

Table 3-8

INPUT PARAMETERS FOR CALCULATING R_i^V

Parameter	Value	Table*
r (dimensionless)	1.0 for radioiodine	E-1
	0.2 for particulates	E-1
$(DFL_i)_a$ (mrem/pCi)	Each radionuclide	E-11 to E-14
U_a^L (kg/yr)--Infant	0	E-5
--Child	26	E-5
--Teen	42	E-5
--Adult	64	E-5
U_a^S (kg/yr)--Infant	0	E-5
--Child	520	E-5
--Teen	630	E-5
--Adult	520	E-5
f_L (dimensionless)	Site specific (default = 1.0)	E-5
f_g (dimensionless)	Site specific (default = 0.76)	RG 1.109, p 28
t_L (seconds)	8.6×10^4 (1 day)	E-15
t_h (seconds)	5.18×10^6 (60 days)	E-15
Y_v (kg/m^2)	2.0	E-15

*Of Regulatory Guide 1.109, Revision 1.

Table 3-9

INPUT PARAMETERS NEEDED FOR CALCULATING DOSE SUMMARIES TO THE MAXIMUM INDIVIDUAL AND THE POPULATION WITHIN 50 MILES FROM WNP-2 GASEOUS EFFLUENT

Input Parameter	Value	Reference*
Distance to Maine (miles)	3000	Ref 1
Fraction of year leafy vegetables are grown	0.42	Ref 2
Fraction of year cows are on pasture	0.5	Ref 2
Fraction of crop from garden	0.76	Ref 3
Fraction of daily intake of cows derived from pasture while on pasture	1.0	Ref 2
Annual average relative humidity (%)	53.8	Ref 4
Annual average temperature (F^{o})	53.0	Ref 5
Fraction of year goats are on pasture	0.75	Ref 2
Fraction of daily intake of goats derived from pasture while on pasture	1.0	Ref 2
Fraction of year beef cattle are on pasture	0.5	Ref 2
Fraction of daily intake of beef cattle derived from pasture while on pasture	1.0	Ref 2
Population within 50 miles of plant by direction and radii interval in miles.	252,356	Ref 6
Annual 50-mile milk production (liters/yr)	2.8E+08	Refs 7 & 9
Annual 50-mile meat production (kg/yr)	2.3E+07	Refs 7 & 9
Annual 50-mile vegetable production (kg/yr)	3.5E+09	Refs 7 & 9
Source terms		Ref 8

Table 3-9 (contd.)

Input Parameter	Value	Reference
X/Q values by sector for each distance (recirculation, no decay) (sec/m^3)	See Tables 3-11 through 3-12	Ref 10
X/Q values by sector for each distance (recirculation, 2.26 days decay, undepleted) (sec/m^3)	See Tables 3-11 through 3-12	Ref 10
X/Q values by sector for each distance (recirculation, 8.0 days decay, depleted) (sec/m^3)	See Table 3-11 through 3-12	Ref 10
D/Q values by sector for each distance (1/m^2)	See Table 3-11 through 3-12	Ref 10

*References are listed in Table 3-14.

Table 3-10

REACTOR BUILDING STACK X/Q AND D/Q VALUES*

a) No Decay, Undepleted

CHI/Q (sec/meter cubed) for each segment

Direction From Site	Segment Boundaries in Miles from the Site									
	.5-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
S	1.103E-06	3.229E-07	1.153E-07	6.291E-08	4.151E-08	2.056E-08	6.109E-08	4.956E-08	3.370E-08	2.530E-08
SSW	8.824E-07	2.569E-07	9.106E-08	4.941E-08	3.243E-08	1.607E-08	5.267E-08	4.304E-08	2.930E-08	2.201E-08
SW	7.484E-07	2.220E-07	8.257E-08	4.646E-08	3.098E-08	4.101E-08	6.486E-08	4.274E-08	2.917E-08	2.195E-08
WSW	5.687E-07	1.717E-07	6.362E-08	3.543E-08	2.341E-08	2.882E-08	4.367E-08	2.851E-08	1.940E-08	1.457E-08
W	2.201E-07	7.362E-08	2.829E-08	1.604E-08	1.065E-08	5.201E-09	2.986E-08	2.489E-08	1.695E-08	1.274E-08
WNW	3.037E-07	1.024E-07	3.926E-08	2.208E-08	1.459E-08	7.801E-09	2.680E-08	2.168E-08	1.471E-08	1.104E-08
NW	9.434E-07	2.769E-07	9.967E-08	5.427E-08	3.563E-08	1.789E-08	3.036E-08	2.344E-08	1.582E-08	1.183E-08
NNW	3.010E-06	8.542E-07	3.077E-07	1.684E-07	1.121E-07	5.498E-08	5.529E-08	4.004E-08	2.706E-08	2.023E-08
N	3.675E-06	1.034E-06	3.712E-07	2.037E-07	1.343E-07	1.060E-07	8.208E-08	4.484E-08	3.033E-08	2.269E-08
NNE	2.430E-06	6.639E-07	2.313E-07	1.237E-07	8.113E-08	9.852E-08	5.491E-08	2.952E-08	1.980E-08	1.473E-08
NE	1.308E-06	3.571E-07	1.242E-07	6.798E-08	7.999E-08	9.512E-08	4.486E-08	2.428E-08	1.634E-08	1.219E-08
ENE	1.086E-06	3.381E-07	2.229E-07	2.754E-07	2.056E-07	9.895E-08	4.020E-08	2.168E-08	1.455E-08	1.082E-08
E	1.218E-06	3.665E-07	2.195E-07	2.582E-07	1.926E-07	9.269E-08	3.768E-08	2.036E-08	1.369E-08	1.020E-08
ESE	2.409E-06	7.211E-07	4.124E-07	4.440E-07	3.242E-07	1.423E-07	5.594E-08	3.335E-08	2.231E-08	1.656E-08
SE	3.043E-06	8.555E-07	3.108E-07	2.844E-07	3.417E-07	1.677E-07	8.760E-08	5.311E-08	3.586E-08	2.680E-08
SSE	1.842E-06	5.373E-07	1.943E-07	1.064E-07	7.011E-08	3.471E-08	7.245E-08	5.737E-08	3.891E-08	2.917E-08

*Desert Sigmas, Building wake effect. All stability classes A through G.

Table 3-10 (contd.)

b) 2.26-Day Decay, Undepleted

CHI/Q (sec/meter cubed) for each segment

Direction From Site	Segment Boundaries in Miles from the Site									
	.5-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
S	1.101E-06	3.218E-07	1.146E-07	6.238E-08	4.106E-08	2.202E-08	5.876E-08	4.683E-08	3.113E-08	2.285E-08
SSW	8.810E-07	2.561E-07	9.054E-08	4.900E-08	3.208E-08	1.580E-08	5.064E-08	4.064E-08	2.704E-08	1.985E-08
SW	7.471E-07	2.212E-07	8.208E-08	4.608E-08	3.065E-08	4.023E-08	6.259E-08	4.036E-08	2.692E-08	1.980E-08
WSW	5.678E-07	1.711E-07	6.326E-08	3.515E-08	2.317E-08	2.827E-08	4.213E-08	2.691E-08	1.789E-08	1.313E-08
W	2.197E-07	7.334E-08	2.810E-08	1.589E-08	1.053E-08	5.107E-09	2.859E-08	2.338E-08	1.553E-08	1.138E-08
WNW	3.031E-07	1.020E-07	3.899E-08	2.187E-08	1.442E-08	7.652E-09	2.570E-08	2.039E-08	1.350E-08	9.877E-09
NW	9.419E-07	2.760E-07	9.911E-08	5.383E-08	3.527E-08	1.760E-08	2.929E-08	2.223E-08	1.469E-08	1.074E-08
NNW	3.006E-06	8.520E-07	3.063E-07	1.673E-07	1.111E-07	5.422E-08	5.369E-08	3.830E-08	2.542E-08	1.867E-08
N	3.671E-06	1.031E-06	3.696E-07	2.024E-07	1.332E-07	1.044E-07	7.996E-08	4.291E-08	2.852E-08	2.096E-08
NNE	2.427E-06	6.624E-07	2.303E-07	1.230E-07	8.050E-08	9.700E-08	5.336E-08	2.812E-08	1.850E-08	1.350E-08
NE	1.307E-06	3.562E-07	1.236E-07	6.753E-08	7.927E-08	9.359E-08	4.343E-08	2.300E-08	1.514E-08	1.104E-08
ENE	1.085E-06	3.371E-07	2.217E-07	2.733E-07	2.036E-07	9.737E-08	3.890E-08	2.051E-08	1.346E-08	9.792E-09
E	1.216E-06	3.655E-07	2.185E-07	2.563E-07	1.907E-07	9.125E-08	3.649E-08	1.928E-08	1.268E-08	9.243E-09
ESE	2.406E-06	7.193E-07	4.104E-07	4.408E-07	3.212E-07	1.403E-07	5.420E-08	3.164E-08	2.072E-08	1.506E-08
SE	3.039E-06	8.532E-07	3.093E-07	2.825E-07	3.389E-07	1.655E-07	8.498E-08	5.050E-08	3.341E-08	2.446E-08
SSE	1.839E-06	5.356E-07	1.932E-07	1.055E-07	6.939E-08	3.414E-08	6.983E-08	5.436E-08	3.608E-08	2.646E-08

Table 3-10 (contd.)

c) 8.0-Day Decay, Depleted

CHI/Q (sec/meter cubed) for each segment

Direction From Site	Segment Boundaries in Miles from the Site .5-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
S	1.006E-06	2.858E-07	9.773E-08	5.164E-08	3.323E-08	1.572E-08	5.545E-08	4.289E-08	2.735E-08	1.946E-08
SSW	8.039E-07	2.269E-07	7.694E-08	4.035E-08	2.578E-08	1.221E-08	4.794E-08	3.733E-08	2.383E-08	1.697E-08
SW	6.775E-07	1.942E-07	6.924E-08	3.784E-08	2.462E-08	3.644E-08	5.757E-08	3.520E-08	2.246E-08	1.597E-08
WSW	5.169E-07	1.515E-07	5.398E-08	2.923E-08	1.886E-08	2.562E-08	3.875E-08	2.347E-08	1.493E-08	1.060E-08
W	2.038E-07	6.726E-08	2.521E-08	1.407E-08	9.223E-09	4.395E-09	2.772E-08	2.189E-08	1.399E-08	9.964E-09
WNW	2.813E-07	9.369E-08	3.505E-08	1.938E-08	1.263E-08	6.663E-09	2.393E-08	1.828E-08	1.161E-08	8.239E-09
NW	8.584E-07	2.450E-07	8.465E-08	4.468E-08	2.865E-08	1.391E-08	2.688E-08	1.987E-08	1.257E-08	8.893E-09
NNW	2.714E-06	7.416E-07	2.547E-07	1.345E-07	8.724E-08	4.071E-08	4.583E-08	3.202E-08	2.021E-08	1.427E-08
N	3.312E-06	8.954E-07	3.060E-07	1.619E-07	1.037E-07	8.674E-08	6.796E-08	3.375E-08	2.123E-08	1.495E-08
NNE	2.196E-06	5.789E-07	1.924E-07	9.939E-08	6.360E-08	8.587E-08	4.544E-08	2.222E-08	1.387E-08	9.713E-09
NE	1.186E-06	3.134E-07	1.045E-07	5.570E-08	7.080E-08	8.611E-08	3.736E-08	1.841E-08	1.153E-08	8.096E-09
ENE	9.883E-07	3.011E-07	1.866E-07	2.147E-07	1.554E-07	7.012E-08	2.504E-08	1.187E-08	7.208E-09	4.925E-09
E	1.107E-06	3.252E-07	1.832E-07	2.013E-07	1.456E-07	6.569E-08	2.347E-08	1.115E-08	6.784E-09	4.643E-09
ESE	2.182E-06	6.364E-07	3.437E-07	3.464E-07	2.451E-07	1.014E-07	3.460E-08	1.827E-08	1.107E-08	7.548E-09
SE	2.747E-06	7.450E-07	2.593E-07	2.509E-07	3.134E-07	1.463E-07	6.976E-08	3.884E-08	2.434E-08	1.709E-08
SSE	1.671E-06	4.722E-07	1.634E-07	8.657E-08	5.559E-08	2.633E-08	5.975E-08	4.484E-08	2.835E-08	2.003E-08

Table 3-10 (contd.)

d) Reactor Building Stack Relative Deposition Rate, (D/Q), Per Unit Area (meter^{-2})

Direction From Site	Segment Boundaries in Miles from the Site									
	.5-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
S	7.256E-09	1.756E-09	5.194E-10	2.494E-10	1.466E-10	5.865E-11	3.375E-11	1.798E-11	9.603E-12	5.944E-12
SSW	5.752E-09	1.380E-09	4.082E-10	1.959E-10	1.150E-10	4.626E-11	2.608E-11	1.395E-11	7.448E-12	4.610E-12
SW	3.176E-09	7.513E-10	2.191E-10	1.035E-10	6.028E-11	3.817E-11	2.414E-11	9.646E-12	5.151E-12	3.188E-12
WSW	2.757E-09	6.889E-10	2.061E-10	9.796E-11	5.718E-11	3.358E-11	1.980E-11	7.927E-12	4.233E-12	2.620E-12
W	1.601E-09	4.334E-10	1.358E-10	6.565E-11	3.861E-11	1.524E-11	1.094E-11	6.220E-12	3.321E-12	2.056E-12
WNW	2.215E-09	5.797E-10	1.816E-10	8.829E-11	5.204E-11	2.856E-11	1.697E-11	7.175E-12	3.831E-12	2.372E-12
NW	4.901E-09	1.218E-09	3.728E-10	1.813E-10	1.068E-10	4.328E-11	2.419E-11	1.286E-11	6.869E-12	4.252E-12
NNW	1.235E-08	2.845E-09	8.198E-10	3.873E-10	2.303E-10	9.105E-11	4.558E-11	2.363E-11	1.262E-11	7.811E-12
N	1.914E-08	4.304E-09	1.213E-09	5.660E-10	3.273E-10	1.707E-10	7.090E-11	2.810E-11	1.501E-11	9.288E-12
NNE	2.034E-08	4.577E-09	1.284E-09	5.961E-10	3.471E-10	1.810E-10	6.374E-11	2.526E-11	1.349E-11	8.350E-12
NE	1.338E-08	2.986E-09	8.341E-10	3.918E-10	2.819E-10	1.483E-10	4.323E-11	1.713E-11	9.150E-12	5.663E-12
ENE	9.298E-09	2.169E-09	7.730E-10	4.579E-10	2.604E-10	1.001E-10	2.897E-11	1.148E-11	6.132E-12	3.795E-12
E	1.017E-08	2.355E-09	8.239E-10	4.749E-10	2.699E-10	1.038E-10	3.003E-11	1.190E-11	6.355E-12	3.934E-12
ESE	1.832E-08	4.190E-09	1.440E-09	8.177E-10	4.647E-10	1.780E-10	5.136E-11	2.049E-11	1.094E-11	6.773E-12
SE	2.006E-08	4.525E-09	1.262E-09	7.531E-10	6.421E-10	2.467E-10	7.197E-11	2.872E-11	1.534E-11	9.492E-12
SSE	9.321E-09	2.265E-09	6.764E-09	3.250E-10	1.905E-10	7.633E-11	4.186E-11	2.224E-11	1.187E-11	7.350E-12

Table 3-11
TURBINE BUILDING X/Q AND D/Q VALUES*

a) No Decay, Undepleted

CHI/Q (sec/meter cubed) for each segment

Direction From Site	Segment Boundaries in Miles from the Site .5-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
S	1.791E-05	5.032E-06	1.836E-06	1.019E-06	6.765E-07	3.337E-07	1.405E-07	7.800E-08	5.333E-08	4.018E-08
SSW	1.513E-05	4.282E-06	1.568E-06	8.729E-07	5.803E-07	2.781E-07	1.214E-07	6.758E-08	4.627E-08	3.489E-08
SW	1.419E-05	4.080E-06	1.513E-06	8.468E-07	5.651E-07	2.811E-07	1.198E-07	6.690E-08	4.584E-08	3.457E-08
WSW	1.004E-05	2.847E-06	1.044E-06	5.811E-07	3.862E-07	1.909E-07	8.059E-08	4.481E-08	3.066E-08	2.311E-08
W	8.834E-06	2.512E-06	9.240E-07	5.149E-07	3.426E-07	1.695E-07	7.171E-08	3.988E-08	2.728E-08	2.056E-08
WNW	8.324E-06	2.320E-06	8.416E-07	4.654E-07	3.080E-07	1.511E-07	6.317E-08	3.489E-08	2.380E-08	1.791E-08
NW	9.578E-06	2.620E-06	9.367E-07	5.135E-07	3.377E-07	1.639E-07	6.739E-08	3.687E-08	2.506E-08	1.881E-08
NNW	1.520E-05	4.196E-06	1.494E-06	8.198E-07	5.393E-07	2.620E-07	1.078E-07	5.905E-08	4.107E-08	3.015E-08
N	1.661E-05	4.558E-06	1.636E-06	8.987E-07	6.918E-07	2.881E-07	1.189E-07	6.518E-08	4.435E-08	3.329E-08
NNE	1.259E-05	3.378E-06	1.189E-06	6.456E-07	4.217E-07	2.025E-07	8.191E-08	4.445E-08	3.015E-08	2.260E-08
NE	1.019E-05	2.764E-06	9.837E-07	5.377E-07	3.528E-07	1.707E-07	6.978E-08	3.804E-08	2.581E-08	1.935E-08
ENE	9.328E-06	2.528E-06	8.989E-07	4.907E-07	3.215E-07	1.550E-07	6.302E-08	3.426E-08	2.322E-08	1.739E-08
E	8.659E-06	2.344E-06	8.336E-07	4.553E-07	2.985E-07	1.441E-07	5.868E-08	3.191E-08	2.162E-08	1.619E-08
ESE	1.452E-05	3.919E-06	1.391E-06	7.573E-07	4.950E-07	2.375E-07	9.577E-08	5.173E-08	3.494E-08	2.611E-08
SE	2.052E-05	5.657E-06	2.038E-06	1.121E-06	7.387E-07	3.595E-07	1.482E-07	8.123E-08	5.519E-08	4.141E-08
SSE	2.128E-05	5.940E-06	2.156E-06	1.193E-06	7.895E-07	3.875E-07	1.619E-07	8.949E-08	6.108E-08	4.596E-08

*Ground level release, Desert Sigmas. All stability classes A through G

Table 3-11 (Contd)

b) 2.26-Day Decay, Undepleted

CHI/Q (sec/meter cubed) for each segment

Direction From Site	Segment Boundaries in Miles from the Site									
	.5-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
S	1.783E-05	4.991E-06	1.809E-06	9.984E-07	6.586E-07	3.195E-07	1.287E-07	6.725E-08	4.334E-08	3.079E-08
SSW	1.506E-05	4.246E-06	1.545E-06	8.547E-07	5.647E-07	2.746E-07	1.110E-07	5.810E-08	3.745E-08	2.660E-08
SW	1.413E-05	4.046E-06	1.490E-06	8.292E-07	5.500E-07	2.689E-07	1.095E-07	5.754E-08	3.712E-08	2.637E-08
WSW	9.992E-06	2.823E-06	1.029E-06	5.689E-07	3.758E-07	1.825E-07	7.359E-08	3.846E-08	2.475E-08	1.756E-08
W	8.792E-06	2.489E-06	9.089E-07	5.030E-07	3.324E-07	1.614E-07	6.487E-08	3.368E-08	2.152E-08	1.515E-08
WNW	8.286E-06	2.300E-06	8.282E-07	4.549E-07	2.990E-07	1.441E-07	5.731E-08	2.961E-08	1.891E-08	1.332E-08
NW	9.550E-06	2.600E-06	9.244E-07	5.040E-07	3.295E-07	1.576E-07	6.218E-08	3.220E-08	2.073E-08	1.475E-08
NNW	1.515E-05	4.145E-06	1.479E-06	8.080E-07	5.293E-07	2.541E-07	1.013E-07	5.321E-08	3.473E-08	2.503E-08
N	1.656E-05	4.532E-06	1.619E-06	8.858E-07	5.808E-07	2.794E-07	1.117E-07	5.878E-08	3.839E-08	2.769E-08
NNE	1.255E-05	3.356E-06	1.175E-06	6.350E-07	4.128E-07	1.956E-07	7.628E-08	3.941E-08	2.548E-08	1.821E-08
NE	1.015E-05	2.743E-06	9.705E-07	5.274E-07	3.441E-07	1.638E-07	6.419E-08	3.303E-08	2.117E-08	1.500E-08
ENE	9.291E-06	2.508E-06	8.865E-07	4.810E-07	3.133E-07	1.487E-07	5.788E-08	2.966E-08	1.897E-08	1.342E-08
E	8.626E-06	2.326E-06	8.225E-07	4.467E-07	2.912E-07	1.384E-07	5.403E-08	2.774E-08	1.777E-08	1.259E-08
ESE	1.446E-05	3.891E-06	1.373E-06	7.435E-07	4.834E-07	2.285E-07	8.846E-08	4.521E-08	2.893E-08	2.049E-08
SE	2.045E-05	5.618E-06	2.013E-06	1.102E-06	7.222E-07	3.446E-07	1.376E-07	7.159E-08	4.625E-08	3.301E-08
SSE	2.120E-05	5.895E-06	2.127E-06	1.170E-06	7.700E-07	3.721E-07	1.491E-07	7.790E-08	5.030E-08	3.583E-08

Table 3-11 (Contd)

c) 8.0-Day Decay, Depleted

CHI/Q (sec/meter cubed) for each segment

Direction From Site	Segment Boundaries in Miles from the Site									
	.5-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
S	1.602E-05	4.299E-06	1.468E-06	7.920E-07	5.081E-07	2.342E-07	8.603E-08	4.155E-08	2.544E-08	1.742E-08
SSW	1.353E-05	3.657E-06	1.269E-06	6.782E-07	4.358E-07	2.014E-07	7.428E-08	3.596E-08	2.205E-08	1.510E-08
SW	1.269E-05	3.485E-06	1.224E-06	6.579E-07	4.244E-07	1.972E-07	7.328E-08	3.561E-08	2.184E-08	1.497E-08
WSW	8.976E-06	2.432E-06	8.448E-07	4.515E-07	2.901E-07	1.339E-07	4.930E-08	2.384E-08	1.460E-08	9.995E-09
W	7.901E-06	2.145E-06	7.473E-07	3.998E-07	2.571E-07	1.188E-07	4.375E-08	2.112E-08	1.291E-08	8.819E-09
WNW	7.446E-06	1.982E-06	6.808E-07	3.614E-07	2.312E-07	1.060E-07	3.858E-08	1.850E-08	1.129E-08	7.701E-09
NW	8.579E-06	2.239E-06	7.584E-07	3.993E-07	2.538E-07	1.152E-07	4.137E-08	1.971E-08	1.201E-08	8.205E-09
NNW	1.360E-05	3.564E-06	1.211E-06	6.382E-07	4.061E-07	1.847E-07	6.652E-08	3.185E-08	1.950E-08	1.337E-08
N	1.487E-05	3.897E-06	1.326E-06	6.996E-07	4.456E-07	2.030E-07	7.334E-08	3.516E-08	2.153E-08	1.477E-08
NNE	1.127E-05	2.888E-06	9.630E-07	5.023E-07	3.173E-07	1.426E-07	5.042E-08	2.386E-08	1.454E-08	9.933E-09
NE	9.117E-06	2.362E-06	7.964E-07	4.180E-07	2.651E-07	1.199E-07	4.280E-08	2.030E-08	1.235E-08	8.415E-09
ENE	8.348E-06	2.160E-06	7.277E-07	3.814E-07	2.416E-07	1.089E-07	3.864E-08	1.827E-08	1.109E-08	7.752E-09
E	7.750E-06	2.003E-06	6.749E-07	3.539E-07	2.243E-07	1.013E-07	3.601E-08	1.704E-08	1.035E-08	7.046E-09
ESE	1.299E-05	3.349E-06	1.126E-06	5.889E-07	3.722E-07	1.671E-07	5.883E-08	2.766E-08	1.676E-08	1.139E-08
SE	1.836E-05	4.834E-06	1.650E-06	8.720E-07	5.555E-07	2.529E-07	9.116E-08	4.353E-08	2.656E-08	1.815E-08
SSE	1.904E-05	5.075E-06	1.745E-06	9.273E-07	5.933E-07	2.723E-07	9.932E-08	4.779E-08	2.925E-08	2.002E-08

Table 3-11 (contd.)

d) Turbine Building Relative Deposition Rate, (D/Q), Per Unit Area ($meter^{-2}$)

Direction From Site	Segment Boundaries in Miles from the Site									
	.5-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
S	2.244E-08	4.597E-09	1.200E-09	5.390E-10	3.049E-10	1.173E-10	3.392E-11	1.344E-11	7.180E-12	4.444E-12
SSW	1.749E-08	3.583E-09	9.353E-10	4.201E-10	2.376E-10	9.138E-11	3.644E-11	1.048E-11	5.595E-12	3.463E-12
SW	1.218E-08	2.496E-09	6.515E-10	2.926E-10	1.655E-10	6.366E-11	1.842E-11	7.299E-12	3.898E-12	2.413E-12
WSW	1.010E-08	2.069E-09	5.402E-10	2.426E-10	1.372E-10	5.178E-11	1.527E-11	6.051E-12	3.231E-12	2.000E-12
W	7.468E-09	1.530E-09	3.993E-10	1.794E-10	1.015E-10	3.902E-11	1.129E-11	4.474E-12	2.389E-12	1.479E-12
WNW	8.961E-09	1.836E-09	4.792E-10	2.152E-10	1.218E-10	4.682E-11	1.355E-11	5.368E-12	2.867E-12	1.774E-12
NW	1.615E-08	3.309E-09	8.638E-10	3.880E-10	2.195E-10	8.440E-11	2.442E-11	9.677E-12	5.168E-12	3.199E-12
NNW	3.066E-08	6.280E-09	1.639E-09	7.363E-10	4.165E-10	1.602E-10	4.634E-11	1.837E-11	9.808E-12	6.070E-12
N	3.891E-08	7.970E-09	2.081E-09	9.345E-10	5.287E-10	2.033E-10	5.881E-11	2.331E-11	1.245E-11	7.705E-11
NNE	3.647E-08	7.471E-09	1.950E-09	8.760E-10	4.956E-10	1.906E-10	5.513E-11	2.185E-11	1.167E-11	7.222E-12
NE	2.492E-08	5.104E-09	1.333E-09	5.985E-10	3.386E-10	1.302E-10	3.766E-11	1.493E-11	7.972E-12	4.934E-12
ENE	1.906E-08	3.905E-09	1.019E-09	4.578E-10	2.590E-10	9.960E-11	2.881E-11	1.142E-11	6.098E-12	3.775E-12
E	1.977E-08	4.050E-09	1.057E-09	4.748E-10	2.686E-10	1.033E-10	2.988E-10	1.184E-11	6.325E-12	3.915E-12
ESE	3.404E-08	6.972E-09	1.820E-09	8.175E-10	4.624E-10	1.778E-10	5.145E-11	2.039E-11	1.089E-11	6.740E-12
SE	4.158E-08	8.518E-09	2.224E-09	9.987E-10	5.650E-10	2.173E-10	6.285E-11	2.491E-11	1.330E-11	8.234E-12
SSE	2.983E-08	6.111E-09	1.595E-09	7.165E-10	4.053E-10	1.559E-10	4.509E-11	1.787E-11	9.543E-12	5.907E-12

Table 3-12

RADWASTE BUILDING X/Q AND D/Q VALUES*

a) No Decay, Undepleted

CHI/Q (sec/meter cubed) for each segment

Direction From Site	Segment Boundaries in Miles from the Site .5-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
S	1.791E-05	5.032E-06	1.836E-06	1.019E-06	6.765E-07	3.337E-07	1.405E-07	7.800E-08	5.333E-08	4.018E-08
SSW	2.513E-05	4.282E-06	1.568E-06	8.729E-07	5.765E-07	2.871E-07	1.214E-07	6.758E-08	4.627E-08	3.489E-08
SW	1.419E-05	4.080E-06	1.513E-06	8.468E-07	5.651E-07	2.811E-07	1.198E-07	6.690E-08	4.584E-08	3.457E-08
WSW	1.004E-05	2.847E-06	1.044E-06	5.811E-07	3.862E-07	1.909E-07	8.059E-08	4.481E-08	3.066E-08	2.311E-08
W	8.834E-06	2.512E-06	9.240E-07	5.149E-07	3.426E-07	1.695E-07	7.171E-08	3.988E-08	2.728E-08	2.056E-08
WNW	8.324E-06	2.320E-06	8.416E-07	4.654E-07	3.080E-07	1.511E-07	6.317E-08	3.489E-08	2.380E-08	1.791E-08
NW	9.587E-06	2.620E-06	9.367E-07	5.135E-07	3.377E-07	1.639E-07	6.739E-08	3.687E-08	2.506E-08	1.881E-08
NNW	1.520E-05	4.169E-06	1.494E-06	8.198E-07	5.393E-07	2.620E-07	1.078E-07	5.905E-08	4.017E-08	3.015E-08
N	1.661E-05	4.558E-06	1.636E-06	8.987E-07	5.918E-07	2.881E-07	1.198E-07	6.518E-08	4.435E-08	3.329E-08
NNE	1.259E-05	3.378E-06	1.189E-06	6.456E-07	4.217E-07	2.025E-07	8.191E-08	4.445E-08	3.015E-08	2.260E-08
NE	1.019E-05	2.764E-06	9.837E-07	5.377E-07	3.528E-07	1.707E-07	6.978E-08	3.804E-08	2.581E-08	1.935E-08
ENE	9.328E-06	2.528E-06	8.989E-07	4.907E-07	3.215E-07	1.550E-07	6.302E-08	3.426E-08	2.322E-08	1.739E-08
E	8.659E-06	2.344E-06	8.336E-07	4.553E-07	2.985E-07	1.441E-07	5.868E-08	3.191E-08	2.162E-08	1.619E-08
ESE	1.452E-05	3.919E-06	1.391E-06	7.573E-07	4.950E-07	2.375E-07	9.577E-08	5.173E-08	3.494E-08	2.611E-08
SE	2.052E-05	5.657E-06	2.038E-06	1.121E-06	7.387E-07	3.595E-07	1.483E-07	8.123E-08	5.519E-08	4.141E-08
SSE	2.128E-05	5.940E-06	2.156E-06	1.193E-06	7.895E-07	3.875E-07	1.619E-07	8.949E-08	6.108E-08	4.596E-08

*Ground Level release. Desert sigmas. All stability classes A through G.

Table 3-12 (Cont'd)

b) 2.26-Day Decay, Undepleted

CHI/Q (sec/meter cubed) for each segment

Direction From Site	Segment Boundaries in Miles from the Site									
	.5-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
S	1.783E-05	4.991E-06	1.809E-06	9.984E-07	6.586E-07	3.195E-07	1.287E-07	6.725E-08	4.334E-08	3.079E-08
SSW	1.506E-05	4.246E-06	1.545E-06	8.547E-07	5.647E-07	2.746E-07	1.110E-07	5.810E-08	3.745E-08	2.660E-08
SW	1.413E-05	4.056E-06	1.490E-06	8.292E-07	5.500E-07	2.689E-07	1.095E-07	5.754E-08	3.712E-08	2.637E-08
WSW	9.992E-06	2.823E-06	1.029E-06	5.689E-07	3.758E-07	1.825E-07	7.359E-08	3.846E-08	2.475E-08	1.756E-08
W	8.792E-06	2.489E-06	9.089E-07	5.030E-07	3.324E-07	1.614E-07	6.487E-08	3.368E-08	2.152E-08	1.515E-08
WNW	8.286E-06	2.300E-06	8.282E-07	4.549E-07	2.990E-07	1.441E-07	5.731E-07	2.961E-08	1.891E-08	1.332E-08
NW	9.550E-06	2.600E-06	9.244E-07	5.040E-07	3.295E-07	1.576E-07	6.218E-08	3.220E-08	2.073E-08	1.475E-08
NNW	1.515E-05	4.145E-06	1.479E-06	8.080E-07	5.293E-07	2.541E-07	1.013E-07	5.321E-08	3.473E-08	2.503E-08
N	1.656E-05	4.532E-06	1.619E-06	8.858E-07	5.808E-07	2.794E-07	1.117E-07	5.878E-08	3.839E-08	2.769E-08
NNE	1.255E-05	3.356E-06	1.175E-06	6.350E-07	4.128E-07	1.956E-07	7.628E-08	3.941E-08	2.548E-08	1.821E-08
NE	1.015E-05	2.743E-06	9.705E-07	5.274E-07	3.441E-07	1.638E-07	6.419E-08	3.303E-08	2.117E-08	1.500E-08
ENE	9.291E-06	2.508E-06	8.865E-07	4.810E-07	3.133E-07	1.487E-07	5.788E-08	2.966E-08	1.897E-08	1.342E-08
E	8.626E-06	2.326E-06	8.225E-07	4.467E-07	2.912E-07	1.384E-07	5.403E-08	2.774E-08	1.777E-08	1.259E-08
ESE	1.446E-05	3.891E-06	1.383E-06	7.435E-07	4.834E-07	2.285E-07	8.846E-08	4.521E-08	2.893E-08	2.049E-08
SE	2.045E-05	5.618E-06	2.013E-06	1.103E-06	7.222E-07	3.466E-07	1.376E-07	7.159E-08	4.625E-08	3.301E-08
SSE	2.120E-05	5.895E-06	2.127E-06	1.170E-06	7.700E-07	3.721E-07	1.491E-07	7.790E-08	5.030E-80	3.583E-08

Table 3-12 (Cont'd)

c) 8.0 Day Decay, Depleted (Corrected for Open Terrain Recirculation)

CHI/Q (sec/meter cubed) for each segment

Direction From Site	Segment Boundaries in Miles from the Site									
	.5-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
S	1.602E-05	4.299E-06	1.486E-06	7.920E-07	5.081E-07	2.342E-07	8.603E-08	4.155E-08	2.544E-08	1.742E-08
SSW	1.353E-05	3.657E-06	1.269E-06	6.782E-07	4.358E-07	2.014E-07	7.428E-08	3.596E-08	2.205E-08	1.510E-08
SW	1.269E-05	3.485E-06	1.224E-06	6.579E-07	4.244E-07	1.972E-07	7.328E-08	3.561E-08	1.460E-08	1.497E-08
WSW	8.976E-06	2.432E-06	8.448E-07	4.515E-07	2.901E-07	1.339E-07	4.930E-08	2.384E-08	1.460E-08	9.995E-09
W	7.901E-06	2.145E-06	7.473E-07	3.998E-07	2.571E-07	1.188E-07	4.375E-08	2.112E-08	1.291E-08	8.819E-09
WNW	7.446E-06	1.982E-06	6.808E-07	3.614E-07	2.312E-07	1.060E-07	3.858E-08	1.850E-08	1.129E-08	7.701E-09
NW	8.579E-06	2.239E-06	7.584E-07	3.993E-07	2.538E-07	1.152E-07	4.137E-08	1.971E-08	1.201E-08	8.205E-09
NNW	1.360E-05	3.564E-06	1.211E-06	6.382E-07	4.061E-07	1.847E-07	6.652E-08	3.185E-08	1.950E-08	1.337E-08
N	1.487E-05	3.897E-06	1.326E-06	6.996E-07	4.456E-07	2.030E-07	7.334E-08	3.516E-08	2.153E-08	1.477E-08
NNE	1.127E-05	2.888E-06	9.630E-07	5.023E-07	3.173E-07	1.426E-07	5.042E-08	2.386E-08	1.454E-08	9.933E-09
NE	9.117E-06	2.362E-06	7.964E-07	4.180E-07	2.651E-07	1.199E-07	4.280E-08	2.030E-08	1.235E-08	8.415E-09
ENE	8.348E-06	2.160E-06	7.277E-07	3.814E-07	2.416E-07	1.089E-07	3.864E-08	1.827E-08	1.109E-08	7.552E-09
E	7.750E-06	2.003E-06	6.749E-07	3.539E-07	2.243E-07	1.013E-07	3.601E-08	1.704E-08	1.035E-08	7.046E-09
ESE	1.299E-05	3.349E-06	1.126E-06	5.889E-07	3.722E-07	1.671E-07	5.883E-08	2.766E-08	1.676E-08	1.139E-08
SE	1.836E-05	4.834E-06	1.650E-06	8.720E-07	5.555E-07	2.529E-07	9.116E-08	4.353E-08	2.656E-08	1.815E-08
SSE	1.904E-05	5.075E-06	1.745E-06	9.273E-07	5.933E-07	2.723E-07	9.932E-08	4.779E-08	2.925E-08	2.002E-08

Table 3-12 (Cont'd)

d) Radwaste Building Relative Deposition Rate, (D/Q), Per Unit Area (Meter^{-2})

Direction From Site	Segment Boundaries in Miles from the Site									
	.5-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50
S	2.244E-08	4.597E-09	1.200E-09	5.390E-10	3.049E-10	1.173E-10	3.392E-11	1.344E-11	7.180E-12	4.444E-12
SSW	1.749E-08	3.583E-09	9.353E-10	4.201E-10	2.376E-10	9.138E-11	2.644E-11	1.048E-11	5.595E-12	3.463E-12
SW	1.218E-08	2.496E-09	6.515E-10	2.926E-10	1.655E-10	6.366E-11	1.842E-11	7.299E-12	3.898E-12	2.413E-12
WSW	1.010E-08	2.069E-09	5.402E-10	2.426E-10	1.372E-10	5.278E-11	1.527E-11	6.051E-12	3.231E-12	2.000E-12
W	7.468E-09	1.530E-09	3.993E-10	1.794E-10	1.015E-10	3.902E-11	1.129E-11	4.474E-12	2.389E-12	1.479E-12
WNW	8.961E-09	1.836E-09	4.792E-10	2.152E-10	1.218E-10	4.682E-11	1.355E-11	5.368E-12	2.867E-12	1.774E-12
NW	1.615E-08	3.309E-09	8.638E-10	3.880E-10	2.195E-10	8.440E-11	2.442E-11	9.677E-12	5.168E-12	3.199E-12
NNW	3.066E-08	6.280E-09	1.639E-09	7.363E-10	4.165E-10	1.602E-10	4.634E-11	1.837E-11	9.808E-12	6.070E-12
N	3.891E-08	7.970E-09	2.081E-09	9.345E-10	5.287E-10	2.033E-10	5.881E-11	2.331E-11	1.245E-11	7.705E-12
NNE	3.647E-08	7.471E-09	1.950E-09	8.760E-10	4.956E-10	1.906E-10	5.513E-11	2.185E-11	1.167E-11	7.222E-12
NE	2.492E-08	5.104E-09	1.333E-09	5.985E-10	3.386E-10	1.302E-10	3.766E-11	1.493E-11	7.972E-12	4.934E-12
ENE	1.906E-08	3.905E-09	1.019E-09	4.578E-10	2.590E-10	9.960E-11	2.881E-11	1.142E-11	6.098E-12	3.775E-12
E	1.977E-08	4.050E-09	1.057E-09	4.748E-10	2.686E-10	1.033E-10	2.988E-11	1.184E-11	6.325E-12	3.915E-12
ESE	3.404E-08	6.972E-09	1.820E-09	8.175E-10	4.624E-10	1.778E-10	5.145E-11	2.039E-11	1.089E-11	6.740E-12
SE	4.158E-08	8.518E-09	2.224E-09	9.987E-10	5.650E-10	2.173E-10	6.285E-11	2.491E-11	1.330E-11	8.234E-12
SSE	2.983E-08	6.111E-09	1.595E-09	7.165E-10	4.053E-10	1.559E-10	4.509E-11	1.787E-11	9.543E-12	5.907E-12

Table 3-13

CHARACTERISTICS OF WNP-2 GASEOUS EFFLUENT RELEASE POINTS

	Reactor Building	Radwaste Building	Turbine Building
Height of release point above ground level (m)	70.6m	31.1	27.7
Annual average rate of air flow from release point (m3/sec)	44.8	38.7	125.6
Annual average heat flow from release point (cal/sec)	1.06×10^6	2.9×10^6	9.1×10^5
Type and size of release point (m)	Duct 1.14 x 3.05	3 Louver houses 1.4 x 2.4 x 0.8 Each	4 Exhaust fans 1.45 x 2.01 Each
Effective vent area (m^2)	3.48	2 x 2.7	3 x 2.91
Vent velocity (m/sec)*	12.9	2 x 525 cfm**	14.4
Effective diameter (m) (πr^2 = area)	1.1	--	1.0
Building height (m)	70.1	70.1	70.1

*Reactor Building exhaust in vertical direction. Radwaste and Turbine Building exhaust in horizontal plane.

**FSAR Drawing 6-41, 525 cfm x 2 out of 3, will run at any one time.

Table 3-14

REFERENCES FOR VALUES LISTED IN TABLE 3-9

Reference 1	U.S. Map
Reference 2	Site Specific
Reference 3	Regulatory Guide 1.109, Revision 1, Table E-15
Reference 4	Section 2.3, WNP-2 FSAR, Table 2.3-1
Reference 5	Section 2.3, WNP-2 FSAR, page 2.3-3
Reference 6	WNP-1 & WNP-2 Emergency Preparedness Plan Table 12.1, Permanent Population Distribution, Rev 5, Feb. 88
Reference 7	1986 50-Mile Land Use Census, WPPSS REMP
Reference 8	WNP-2 Effluent Analysis for Applicable Time Period
Reference 9	Radiological Programs Calculation Log No. 88-3
Reference 10	WNP-2 XOQDOQ Computer Run

Table 3-15

DESIGN BASE PERCENT NOBLE GAS (30-MINUTE DECAY)*

Isotope	Percent of Total Activity
Kr-83M	2.9
Kr-85M	5.6
Kr-85	0
Kr-87	15
Kr-88	18
Kr-89	0.2
Xe-131M	0.02
Xe-133M	0.3
Xe-133	8.2
Xe-135M	6.9
Xe-135	22
Xe-137	0.7
Xe-138	21

*From Table 11.3-1 WNP-2 FSAR

TABLE 3-16 ANNUAL DOSES AT SPECIAL LOCATIONS WITHIN WNP-2 SITE BOUNDARY

Source: WNP-2 Gaseous Effluent

Location	Distance (Miles)	Occupancy (hrs/yr)	Whole Body Dose (mrem/yr)	Thyroid Dose (mrem/yr)
BPA Ashe Substation	0.5 N	2080	1.1E+00	1.7E+00
DOE Train	0.5 SE*	78	6.7E-02	1.0E-01
Wye Burial Site	0.5 WNW	8	4.1E-03	6.5E-03
WNP-1	1.2 ESE	2080	3.8E-02	1.3E-01
WNP-4	1.0 ENE	2080	7.0E-02	1.1E-01
WNP-2 Visitor Center	0.08 ESE	8	8.6E-02	1.3E-01
Taylor Flats**	4.2 ESE	8760	3.1E-02	5.2E+00
Site Boundary***	1.2 SE	8760	1.1E+00	1.7E+00

*The sector with the highest X/Q values (within 0-0.5 mile radius) was used.

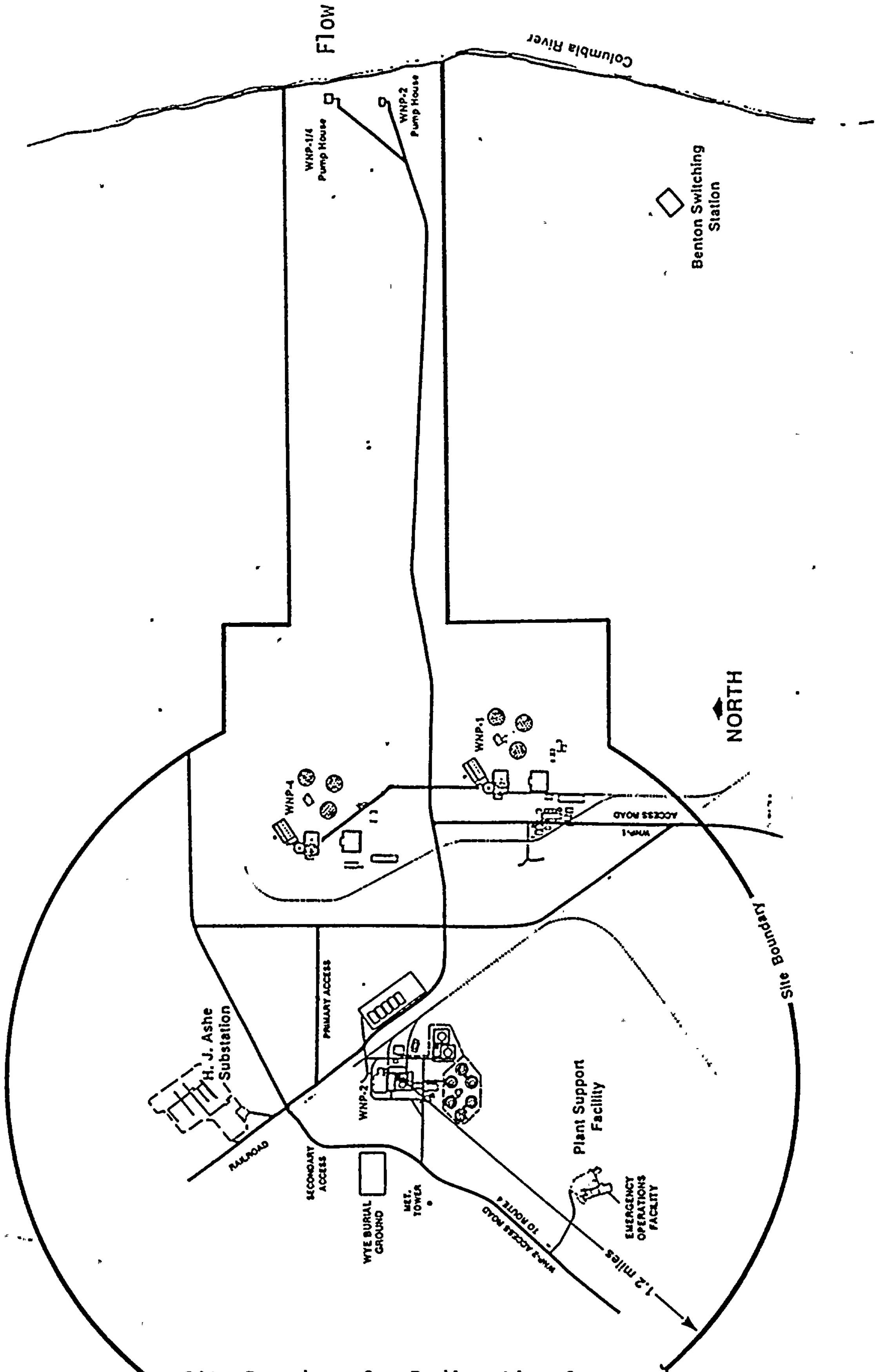
**Not within site boundary. Closest residental area representative of maximum individual dose from plume, ground, ingestion, and inhalation exposure pathways. Included for comparison.

***Assumed continuously occupied. Actual occupancy is very low. Doses from Inhalation and Ground Exposure pathways. No food crops.

TABLE 3-17 ANNUAL OCCUPIED AIR DOSE AT SPECIAL LOCATIONS WITHIN WNP-2 SITE BOUNDARY

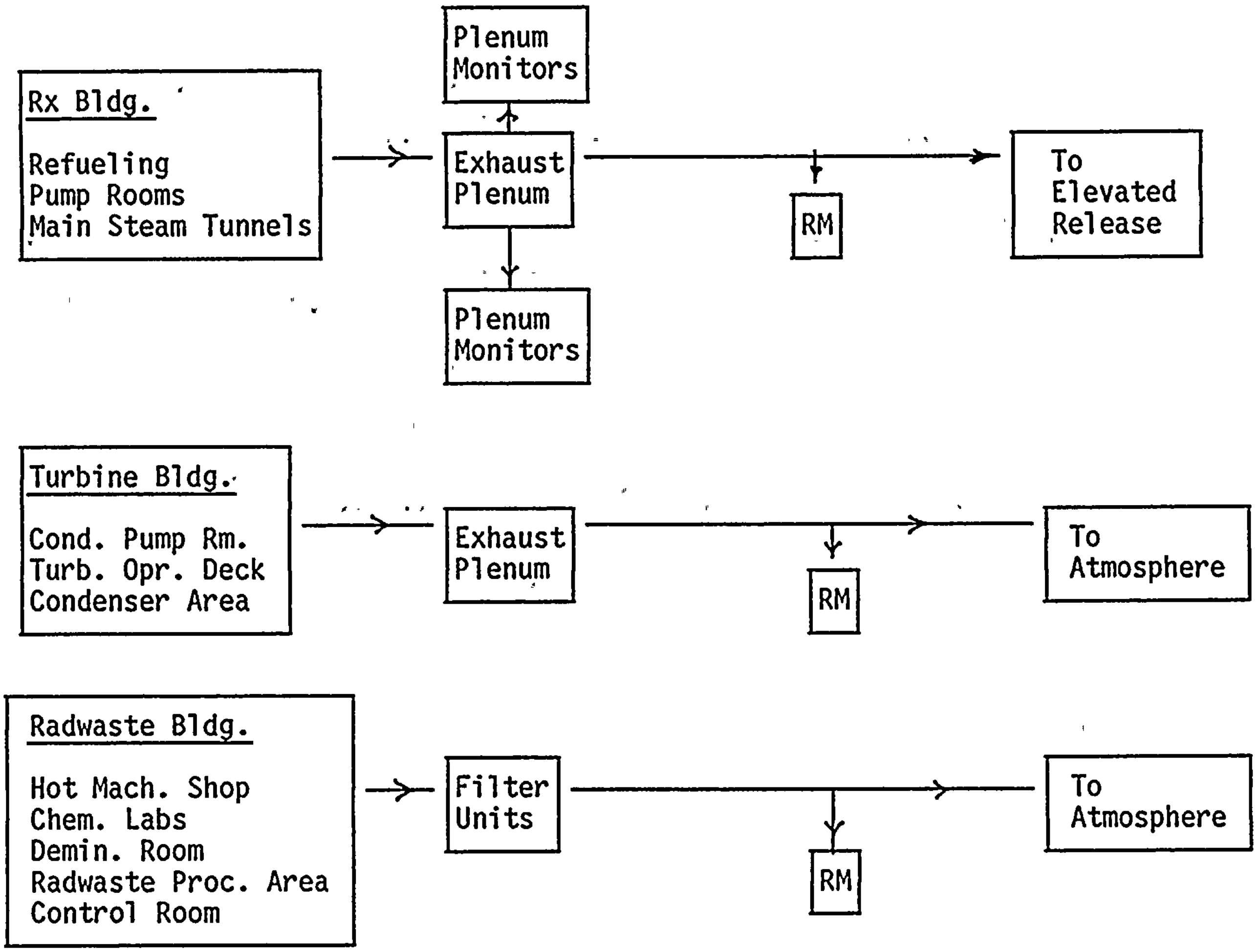
Location	Annual Beta Air dose (mrad)	Annual Gamma Air Dose (mrad)
BPA Ashe Substation	8.9E-01	1.5E+00
DOE Train	5.3E-02	9.2E-02
Wye Burial Site	3.2E-03	5.7E-03
WNP-1	3.3E-02	2.8E-02
WNP-4	5.3E-02	8.5E-02
WNP-2 Visitor Center	7.0E-02	1.2E-01
Taylor Flats*	2.3E-02	1.4E-02
Site Boundary	8.7E-01	1.5E+00

*Not within site boundary. Closest residential area. Included for comparison.



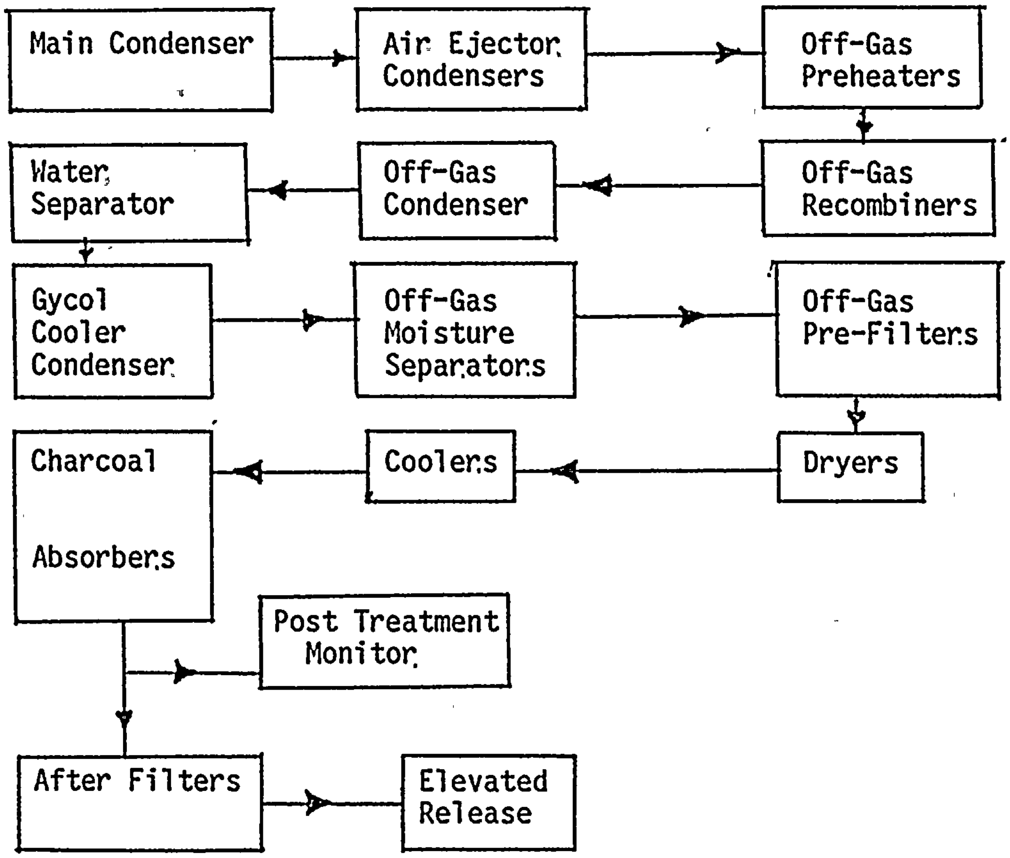
Site Boundary for Radioactive Gaseous and Liquid Effluents

Figure 3-1



SIMPLIFIED BLOCK DIAGRAM
OF
GASEOUS WASTE SYSTEM

Figure 3-2



SIMPLIFIED BLOCK DIAGRAM
OF
OFF-GAS TREATMENT SYSTEM

Figure 3-3

4.0 COMPLIANCE WITH 40 CFR 190

4.1 Technical Specification Requirement

Technical Specification 3.11.4 states, "The annual (calendar year) dose or dose commitment to any Member of the Public, due to release of radioactivity and radiation, from uranium fuel cycle sources shall be limited to less than or equal to 25 mrems to the total body or any organ, except the thyroid, which shall be limited to less than or equal to 75 mrems.

4.2 ODCM Methodology for Determining Dose and Dose Commitment from Uranium Fuel Cycle Sources

The annual dose or dose commitment to a Member of the Public for the uranium fuel cycle sources is determined as:

a) Dose to the total body due to the release of radioactive materials in liquid effluents.

b) Dose to any organ due to the release of radioactive materials in liquid effluents.

c) Air doses due to noble gases released in gaseous effluents.

d) Dose to any organ due to the release of radioiodines, tritium and radionuclides in particulate form with half-lives greater than 8 days in gaseous effluents.

e) Dose due to direct radiation from the plant.

The annual dose or dose commitment to a Member of the Public from the uranium fuel cycle sources is determined whenever the calculated doses from the release of radioactive materials in liquid or gaseous effluents exceed twice the limits in Technical Specification 3.11.1.2a, 3.11.1.2b, 3.11.2.2a, 3.11.2.2b, 3.11.2.3a, or 3.11.2.3b. Direct radiation measurements will also be made to determine if the limits of Specification 3.11.4 have been exceeded.

4.2.1 Total Dose from Liquid Effluents

The annual dose to a Member of the Public from liquid effluents will be determined using NRC LADTAP computer code, and methodology presented by equation (5) in Section 2.4. It is assumed that dose contribution pathways to a Member of the Public do not exist for areas within the site boundary.

4.2.2 Total Dose from Gaseous Effluents

The annual dose to a Member of the Public from gaseous effluents will be determined using NRC GASPAR computer code, and methodology presented by equations (10), (11) and (13) in Section 3.4. Appropriate atmospheric dispersion parameters will be used.

4.2.3 Direct Radiation Contribution

The dose to a Member of the Public due to direct radiation from the reactor plant will be determined using thermoluminescent dosimeters (TLDs) or may be calculated. TLDs are placed at sample locations and analyzed as per Table 5-1. The direct radiation contribution will be documented in the Radioactive Effluent Release Report submitted 60 days after January 1 of each year.

TLD stations 1S-16S are special interest stations and will not be used for direct radiation dose determinations to a Member of the Public.

5.0 RADIOLOGICAL ENVIRONMENTAL MONITORING

Radiological environmental monitoring is intended to supplement radiological effluent monitoring by verifying that measurable concentrations of radioactive materials and levels of radiation in the environment are not greater than expected based on effluent measurement and dose modeling of environmental exposure pathways. The Radiological Environmental Monitoring Program (REMP) for WNP-2 provides for measurements of radiation and radioactive materials in those exposure pathways and for those radionuclides for which the highest potential dose commitment to a member of the public would result due to plant operations.

The WNP-2 REMP is designed to conform to regulatory guidance provided by Regulatory Guide 4.1, 4.8 and the Radiological Assessment Branch Technical Position (BTP), taking into consideration certain site specific characteristics. The unique nature of the WNP-2 site on Federally owned and administered land (Hanford Reservation) dedicated to energy facilities, research, waste management and as a natural reserve, forms the basis for many of the site specific parameters. Amongst the many site specific parameters considered is demographic data such as:

1) No significant clusters of population including schools, hospitals, business facilities or primary public transportation routes are located within 8 km (5 mile) radius of the plant.

2) No private residences are located on the Hanford Reservation.

3) The closest resident is east of the Columbia River at a distance of approximately 4 miles.

Additional site information is available in the WNP-2 Environmental Report, Operating License Stage.

Radiological environmental monitoring activities implemented by PPM 1.11.1 "Radiological Environmental Monitoring Program (REMP) Implementation Procedure", as detailed in the following sections, meet or exceed the criteria of the REMP plan as specified by Plant Technical Specifications, 3/4.12.

5.1 Radiological Environmental Monitoring Program (REMP)

Environmental samples for the REMP are collected in accordance with Table 5-1. This table provides a detailed outline of the environmental sampling plan including both Technical Specification and non Technical Specification items by sample type, sample location code, sampling and collection frequency, and type and frequency of analysis of samples collected within exposure pathway. Deviations from the sampling frequency detailed in Table 5-1 may occur due to circumstances such as hazardous conditions, malfunction of automatic sampling equipment, seasonal unavailability, or other legitimate reasons. When sample media is unobtainable due to equipment malfunction, special actions per program instruction shall be taken to ensure that corrective action is implemented prior to the end of the next sampling period. In some cases, alternate sample collection may be substituted for the missing specimen. All deviations from the sampling plan Technical Specification items detailed in Table 5-1 shall be documented and reported in the Annual Radiological Environmental Operating Report in accordance with PPM 1.10.2, "Routine or Periodic Reports Required by Regulatory Agencies", Regulatory Guide 4.8 and BTP.

In the event that it becomes impossible or impractical to continue sampling a media of choice at currently established location(s) or time, an evaluation shall be made to determine a suitable alternative media and/or location to provide appropriate exposure pathway evaluations. The evaluation and any substitution made shall be implemented in the sampling program within 30 days of identification of the problem. All changes implemented in the sampling program due to unavailability of samples shall be fully documented in the next Semiannual Radioactive Effluent Release Report and ODCM per PPM 1.10.1, "Reportable Events and Occurrences Required by Regulatory Agencies". Revised sampling plan table(s) and figure(s) reflecting the new locations and/or media shall be included with the documentation.

WNP-2 sampling stations are described in Table 5-2. Each station is identified by an assigned number or alphanumeric designation, meteorological sector (16 different, 22-1/2° compass sections) in which the station is located, and radial distance from WNP-2 containment as estimated from map positions. Also included in Table 5-2 is information identifying the type(s) of samples collected at each station and whether or not the specific sample type satisfies a Technical Specification criteria. Figures 5-1 and 5-2 depict the geographical locations of each of the sample stations listed in Table 5-2.

5.2 Land Use Census

A land use census shall be conducted in accordance with the requirements of Plant Technical Specifications. Field activities pertaining to the land use census (LUC) will be initiated during the growing season and completed no later than September 30 each year. The information obtained during the field survey is used along with other demographic data to assess population changes in the unrestricted area that might require modifications in the sampling plan to ensure adequate evaluation of dose committment. More specific data within each of the 16 meteorological sectors, such as distance to nearest resident, nearest milk animal, and nearest garden greater than $50 m^2$ ($500 ft^2$) in size producing broad leaf vegetation shall be identified to support recalculation of maximum individual dose estimates. Site-specific considerations such as the Department of Energy's Hanford Reservation Site Boundary, within which WNP-2 is located, may require that specific information be collected beyond a 5-mile (8 km) radius in certain meteorological sectors to adequately identify pertinent data.

The results of the land use census will be submitted no later than October 31 of each year for evaluation of individual and population doses. All changes, such as a location yielding a greater estimated dose or different location with a 20 percent greater estimated dose than a currently sampled location,

will be reported in the next Semiannual Radiological Effluent Report in accordance with PPM 1.10.2 and Technical Specification. The REMP plan, ODCM, will be changed to reflect new sampling locations.

The best available census information, whether obtained by aerial survey, door-to-door survey, or consultation with local authorities, shall be used to complete the Land Use Survey and the results reported in the Annual Radiological Environmental Operating Report in accordance with PPM 1.10.2 and Technical Specification requirements.

5.3 Laboratory Intercomparison Program

Analysis of REMP samples is contracted to a provider of radiological analytical services. By contract, this analytical service vendor is required to conduct all activities in accordance with Regulatory Guides 4.1, 4.8, and 4.15 and to include in each quarterly report, actions pertinent to their participation in the Environmental Protection Agency's (EPA) Environmental Radioactivity Laboratory Intercomparison Studies (Crosscheck) Program. A precontract award survey and annual audit at the contractor's facility ensure that the contractor is participating in the Crosscheck Program, as reported.

The results of the contractor's analysis of Crosscheck samples shall be included in the Annual Radiological Environmental Operating Report in accordance with PPM 1.10.2 and Technical Specification.

Besides the vendor's required participation in the EPA's Crosscheck Program, the Department of Social and Health Services (DSHS) of the State of Washington oversees an analytical program for the Energy Facility Site Evaluation Council (EFSEC) to provide an independent test of WNP-2 REMP sample analyses. The WNP-2/DSHS split samples are analyzed by Washington State's Office of Public Health Laboratories and Epidemiology, Environmental Radiation Laboratory (ERL). The State's ERL participates in the EPA Crosscheck Program, as well as

inclusion in the annual report within the specified time frame. The missing data shall be submitted as soon as possible upon receipt of the results. Along with the missing data, the supplementary report shall include an explanation as to the cause for the delay in completion of the analysis within the report period.

A nonroutine radiological environmental operating report is required to be submitted within 30 days from the end of any quarter in which a confirmed measured radionuclide concentration in an environmental sample averaged over the quarter sampling period exceeds a reporting level. Table 5-4 specifies the reporting level (RL) for most radionuclides of environmental importance due to potential impact from plant operations. When more than one of the nuclides listed in Table 5-4 is detected in a sample, the reporting level is considered to be exceeded and a nonroutine report required if the following conditions are satisfied:

$$\frac{\text{Concentration (1)}}{\text{Reporting Level (1)}} + \frac{\text{Concentration (2)}}{\text{Reporting Level (2)}} + \text{--------} \geq 1$$

For radionuclides other than those listed in Table 5-4, the reporting level is considered to have been exceeded if the potential annual dose to an individual is greater than or equal to the design objective doses of Appendix I, 10 CFR 50. When a nonroutine report on an unlisted (Table 5-4) radionuclide must be issued, it shall include an evaluation of any release conditions, environmental factors, or other aspects necessary to explain the anomalous sample results.

When it can be demonstrated that the anomolous sample result(s) exceeding reporting levels is not the result of plant effluents, a nonroutine report does not have to be submitted. A full discussion of the sample result and subsequent evaluation or investigation of the anomolous result will be included in the Annual Radiological Environmental Operational Report.

TABLE 5-1

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM PLAN

Sample Type[11]	Sample Location Code*	Sampling and Collection Frequency[1]	Type and Frequency of Analysis[1]
1. AIRBORNE			
a. Particulates and radioiodine (6/12)	1, 4-9, 21, 23, 40, 48 and 57	Continuous sampling Weekly collection	Particulate: Gross beta[2], weekly; gamma isotopic[3], quarterly composite (by location) Radioiodine: I-131 analysis, weekly
b. Soil[10] (0/5)	9, 1, 7, 21, and 23	Annually	Gamma isotopic[3]
2. DIRECT RADIATION			
TLD[4] (34/56)	1-9, 10-25, 40-47, 49-51, 53-56, 1S-16S	Quarterly, annually	Gamma, quarterly data review
3. WATERBORNE			
a. Surface/ Drinking[6] (3/4)	26, 27, 28 and 29	Composite aliquots[5], monthly	Gamma isotopic[3], Gross , tritium quarterly composite
b. Ground water (2/3)	31, 32, and 52	Quarterly	Gamma isotopic[3] and tritium, quarterly

TABLE 5-1 (contd.)

Sample Type[11]	Sample Location Code*	Sampling and Collection Frequency[1]	Type and Frequency of Analysis[1]
WATERBORNE (contd.)			
c. Sediment from shoreline (1/2)	33 and 34	Semiannually	Gamma isotopic[3]
4. INGESTION			
a. Milk[7] (4/5)	9, 36, 40, 59 and 96	Semimonthly during grazing season, monthly at other times	Gamma isotopic[3] Iodine-131
b. Fish[8] (2/2)	30, 38, or 39	Seasonal or Semiannually	Gamma isotopic[3]
c. Garden produce[9] (2/2)	9, 37 and 91	Monthly during growing season in the Riverview area of Pasco and a control near Grandview. Annually for the apple sample collection at Station 91	Gamma isotopic[3]

*Sample locations are graphically depicted in Figures 5-1 and 5-2.

[1]Deviations are permitted if samples are unobtainable due to hazardous conditions, seasonal availability, malfunction of automatic sampling equipment, or other legitimate reasons. All deviations will be documented in the Annual Radiological Environmental Monitoring Report.

[2]Particulate sample filters will be analyzed for gross beta after at least 24-hour decay. If gross beta activity is greater than 10 times the mean of the control sample, gamma isotopic analysis should be performed on the individual sample.

[3]Gamma isotopic means identification and quantification of gamma-emitting radionuclides that may be attributable to the effluents of the facility.

TABLE 5-1 (contd.)

[4]TLD refers to thermoluminescent dosimeter. For purposes of WNP-2 REMP, a TLD is a phosphor card (32mm x 45mm x 0.5mm) with eight individual read-out areas (four main dosimeter areas and four back-up dosimeter areas) in each badge case. TLDs used in REMP meet the requirements of Regulatory Guide 4.13 (ANSI N545-1975), except for specified energy-dependence response. Correction factors are available for energy ranges with response outside of the specified tolerances. TLD stations 1S-16S are special interest stations and are not included amongst the 34 routine TLD stations required by Plant Technical Specification, Table 3.12-1.

[5]Composite samples will be collected with equipment which is capable of collecting an aliquot at time intervals which are short relative to the compositing period.

[6]Station 26, WNP-2 makeup water intake from the Columbia River, satisfies the Technical Specification criteria for upstream surface water and drinking water control samples. The discharge water (Station 27) samples are used to fulfill the Technical Specification criteria for a downstream sample. However, they provide very conservative estimates of downstream concentrations. Drinking water samples are not routinely analyzed for I-131 from two week composite. I-131 analysis will be performed when the calculated dose for the consumption of water is greater than 1 mrem per year to the maximum organ.

[7]Milk samples will be obtained from farms or individual milk animals which are located in sectors with high calculated annual average ground-level D/Qs and high dose potential. There are no milk animals located within 5 km of WNP-2. If Cesium-134 or Cesium-137 is measured in an individual milk sample in excess of 30 pCi/l, then Strontium-90 analysis should be performed.

[8]There are no commercially important species in the Hanford reach of the Columbia River. Most recreationally important species in the area are anadromous, primarily salminoids. Four fish specimen will normally be collected by electroshock technique in the vicinity of the plant discharge (Station 30). If electroshocking produces insufficient fish samples, anadromous species may be obtained from Ringold Fish Hatchery (Station 39). Control samples are normally collected in the vicinity of Ice Harbor Dam (salminoids may be obtained through the National Marine Fisheries Service at Lower Granite Dam).

[9]Garden produce will routinely be obtained from farms or gardens using Columbia River water for irrigation. One sample of a root crop, leafy vegetable, and a fruit should be collected each sample period if available. The variety of the produce sample will be dependent on seasonal availability.

[10]Soil samples are collected to satisfy the requirements of the Site Certification Agreement (SCA), WNP-2.

TABLE 5-1 (contd.)

[11]The fraction in parenthesis under each sample type gives the ratio of the number of Technical Specificaton sample locations to the total number of sample locations for the sample type that is currently included in the overall WNP-2 radiological environmental monitoring program.

TABLE 5-2

WNP-2 REMP LOCATIONS

Station	Sector	Radial Miles[a]	TLD	AP/AI	SW	DW	GW	SE	MI	FI	GP	SO[b]
1	S	1.3	0	X								X
2	NNE	1.8	0									
3	SE	2.0	X									
4	SSE	9.3	0	0								
5	ESE	7.7	0	X								
6	S	7.7	0	X								
7	WNW	2.7	0	X								X
8	ESE	4.7	0	0								
9A*	WSW	30.0	0	0								
9B*	WSW	35.0									0	
9C	WSW	33.0							0			X
10	E	3.1	0									
11	ENE	3.1	X									
12	NNW	6.1	X									
13	SW	1.4	0									
14	WSW	1.4	0									
15	W	1.4	0									
16	WNW	1.4	0									
17	NNW	1.2	0									

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TABLE 5-2
(Continued)

Station	Sector	Radial Miles[a]	TLD	AP/AI	SW	DW	GW	SE	MI	FI	GP	SO[b]
18	N	1.1	0									
19	NE	1.8	0									
20	ENE	1.9	0									
21	ENE	1.5	X	X								X
22	E	2.1	0									
23	ESE	3.0	X	X								X
24	SE	1.9	0									
25	SSE	1.6	0									
26*	E	3.2			0	0						
27	E	3.2			X							
28	SSE	7.4			0	0						
29	SSE	11.0				0						
30	E	3.5								0		
31	E	1.1					0					
32	E	1.2					X					
33*	ENE	3.3						X				
34	ESE	3.3						0				
35	ENE	10.5							0			
36	ESE	7.2							0			
37A	SSE	17.0									0	
37B	SSE	16.0									X	
38*	E	26.5 (95.0)								0		

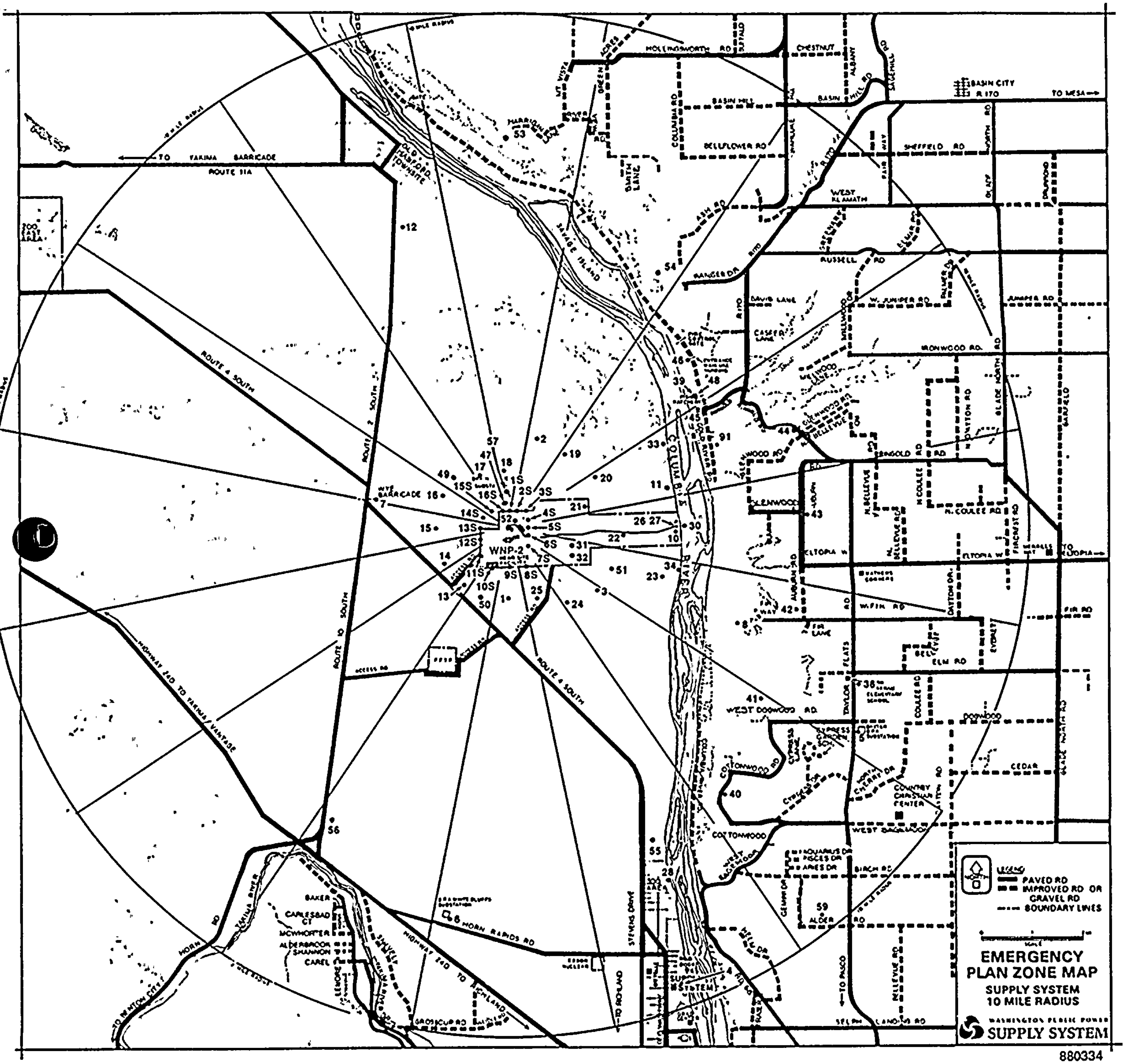
TABLE 5-2
(Continued)

Station	Sector	Radial Miles[a]	TLD	AP/AI	SW	DW	GW	SE	MI	FI	GP	SO[b]
39	NE	4.3								X		
40	SE	6.4	0	0					0			
41	SE	5.8	0									
42	ESE	5.6	0									
43	E	5.7	0									
44	ENE	5.7	0									
45	ENE	4.2	0									
46	NE	4.7	0									
47	N	0.5	X									
48	NE	4.3		0								
49	NW	1.2	0									
50	SSW	1.2	0									
51	ESE	2.1	0									
52	N	0.1					0					
53	N	7.5	0									
54	NNE	6.5	0									
55	SSE	7.0	0									
56	SSW	7.0	0									
57	N	0.7		0								
59	SE	9.6							0			
91	ESE	4.5									X	
96	WSW	36.0							0			

TABLE 5-2
(Continued)

Station	Sector	Radial Miles[a]	TLD	AP/AI	SW	DW	GW	SE	MI	FI	GP	SO[b]
1S	N	0.3	X									
2S	NNE	0.4	X									
3S	NE	0.5	X									
4S	ENE	0.4	X									
5S	E	0.4	X									
6S	ESE	0.4	X									
7S	SE	0.5	X									
8S	SSE	0.7	X									
9S	S	0.7	X									
10S	SSW	0.8	X									
11S	SW	0.7	X									
12S	WSW	0.5	X									
13S	W	0.5	X									
14S	WNW	0.5	X									
15S	NW	0.5	X									
16S	NNW	0.4	X									

*Control location.
X-Sample collected at station (non-RETS)
O-Radiological Environmental Technical Specification (RETS) sample collected at station.
[a]Estimated from center of WNP-2 Containment from map positions.
[b]Included in sampling program to satisfy requirements for Site Certification Agreement with the State of Washington.
AP/AI = Air Particulate and Iodine
SW = Surface Water (River Water)
DW = Drinking Water
GW = Ground Water
SE = Shoreline Sediment
MI = Milk
FI = Fish
GP = Garden Produce
SO = Soil



RADIOLOGICAL ENVIRONMENTAL MONITORING SAMPLE LOCATIONS INSIDE OF 10 MILE RADIUS

Figure 5-1

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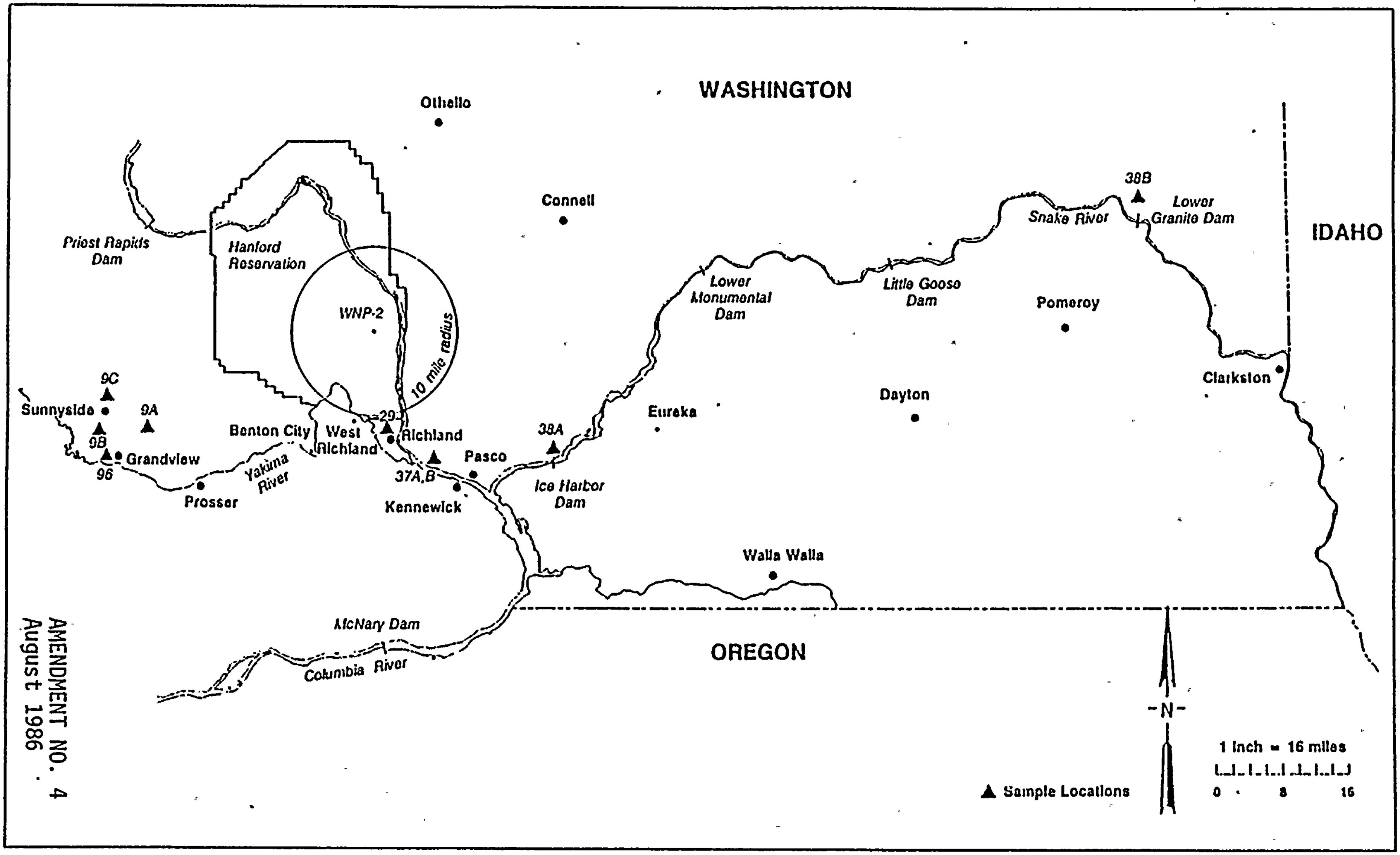

Radiological Environmental Monitoring Sample Locations Outside of 10-Mile Radius

Figure 5-2

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TABLE 5-3

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM ANNUAL SUMMARY[a]

Name of Facility ______________________ Docket No. ____________

Location of Facility ______________________ Reporting Period ____________
(County, State)

Medium or Pathway Sampled (Unit of Measurement)	Type and Total Number of Analyses Performed	Lower Limit of Detection (LLD)	All Indicator Locations Mean (f)[c] Range	Location with Highest Annual Mean: Name, Distance and Direction	Location with Highest Annual Mean: Mean (f)[c] Range	Control Locations Mean (f)[c] Range	Number of Nonroutine Reported Measurements
Air particulates (pCi/m^3)	Gross 416	0.01	0.08 (200/312) (0.05-2.0)	Middletown 5 mi. 340°	0.10 (5/52) (0.08-2.0)	0.08 (8/104) (1.05-1.40)	1
	-Spec 32						
	^{137}Cs	0.01	0.05 (4/24) (0.03-0.13)	Smithville 2.5 mi. 160°	0.08 (2/4) (0.03-2.0)	LLD	4
	^{131}I	0.07	0.12 (2/24) (0.09-0.18)	Podunk 4.0 mi. 270°	0.20 (2/4) (0.10-0.31)	0.02 (2/4)	1
Fish (pCi/kg) (wet weight)	-Spec. 8						
	^{137}Cs	130	LLD		LLD	90 (1/4)	0
	^{134}Cs	130	LLD		LLD	LLD	0
	^{60}Co	130	180 (3/4) (150-225)	River Mile 35	See Column 4	LLD	0

[a]Summary Table is taken from the NRC's Branch Technical Position, Rev. 1, Nov. 1979, and provided for illustrative purposes only.

[c]Mean and range based upon detectable measurements only. Fraction of detectable measurements at specified locations is indicated in parentheses (f).

TABLE 5-4

REPORTING LEVELS FOR NONROUTINE OPERATING REPORTS

Reporting Level (RL)

Analysis	Water (pCi/l)	Airborne Particulate or Gases (pCi/m^3)	Fish (pCi/kg, wet)	Milk (pCi/l)	Broad Leaf Vegetation (pCi/Kg, wet)
H-3	2×10^4*				
Mn-54	1×10^3		3×10^4		
Fe-59	4×10^2		1×10^4		
Co-58	1×10^3		3×10^4		
Co-60	3×10^2		1×10^4		
Zn-65	3×10^2		2×10^4		
Zr-Nb-95	4×10^2				
I-131	2	0.9		3	1×10^2
Cs-134	30	10	1×10^3	60	1×10^3
Cs-137	50	20	2×10^3	70	2×10^3
Ba-La-140	2×10^2			3×10^2	

*For drinking water samples. This is 40 CFR Part 141 value.

6.0 SEMI-ANNUAL RADIOACTIVE EFFLUENT RELEASE REPORT

Routine Radioactive Effluent Release Reports covering the operation of WNP-2 during the previous 6 months of operation are submitted within 60 days after January 1 and July 1 of each year.

These reports shall include a summary of the quantities of radioactive liquid and gaseous effluents released from the unit (WNP-2). Reports shall include each class of soild waste (as defined by 10 CFR 61) shipped offsite during the reporting period with the following information; container volume, total curie quantity, principal radionuclides, source of waste and processing employed, container type, and solidification agent or absorbent.

The Radioactive Effluent Release Reports shall include a list and description of unplanned releases from the site to unrestricted areas of radioactive materials in gaseous and liquid made during the reporting period.

The Radioactive Effluent Release Reports include any changes made during the reporting period to the Process Control Program and to the ODCM pursuant to Technical Specification 6.13 and 6.14, respectively, as well as any major change to Liquid, Gaseous, or Solid Radwaste Treatment System, pursuant to Technical Specification 6.15. It also includes a listing of new locations for dose calculations and or environmental monitoring identified by the Land Use Census pursuant to Technical Specification 3.12.2.

The Radioactive Effluent Release Reports also include an explanation as to why the inoperability of liquid or gaseous effluent monitoring instrumentation was not corrected within the time specified in Technical Specification 3.3.7.11 or 3.3.7.12, respectively; and a description of the events leading to liquid holdup tanks exceeding the limits of Technical Specification 3.11.1.4.

The Radioactive Effluent Report to be submitted within 60 days after January 1 of each year includes an annual summary of meteorological data collected over the previous year. This annual summary will be in the form of joint frequency distributions of wind speed, wind direction, and atmospheric stability. This same report includes an assessment of the radiation doses due to the radioactive liquid and gaseous effluents released from the unit during the previous calendar year. This same report also includes, an assessment of the radiation doses from radioactive liquid and gaseous effluents to Members of the Public due to their activities inside the Site Boundary during the report period. All assumptions used in making these assessments, i.e., specific activity, exposure time and location, are included in these reports.

The assessment of radiation doses is performed in accordance with the methodology and parameters in the ODCM.

The Radioactive Effluent Release Report to be submitted 60 days after January 1 of each year also includes, as required by Technical Specification 3.11.4, an assessment of radiation doses to the likely most exposed Member of the Public from WNP-2 reactor releases and other nearby uranium fuel cycle sources, including doses from primary effluent pathways and direct radiation, for the previous calendar year to show conformance with 40 CFR 190, "Environmental Radiation Protection Standards for Nuclear Power Operation".