ATTACHMENT 1

APA-ZZ-01003

OFFSITE DOSE CALCULATION MANUAL

The attached is a complete copy of the Offsite Dose Calculation Manual, APA-ZZ-01003, Revision 0, May, 1990.

Revision 0
February 28, 1990

NUCLEAR FUNCTION

ADMINISTRATIVE PROCEDURE

APA-ZZ-01003

OFFSITE DOSE CALCULATION MANUAL

RESPONSIBLE DEPARTMENT Health Physics

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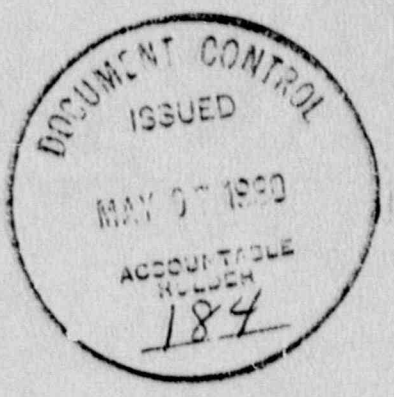

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Record of Revisions

Rev. 6	May 1989	Revised methodology for calculating maximum permissible liquid effluent discharge rates and liquid effluent monitor setpoints, provided methodology for calculating liquid effluent monitors response correction factors, provided an enhanced description of controls on liquid monitor background limits, provided additional liquid & gaseous dose conversion factors and bioaccumulation factors (Tables 1, 2, 4 & 5), provided description of the use of the setpoint required by Technical Specification 4.9.4.2 during Core Alterations, added discussion of gaseous & liquid monitor setpoint selection in the event that the sample contains no detectable activity, added minimum holdup requirements for Waste Gas Decay Tanks, revised dispersion parameters & accompanying description per FSAR Change Notice 88-42.
APA-ZZ-01003 Rev. 0	August 1989	Radiological Effluent Technical Specifications were moved from the Callaway Plant Standard Technical Specifications to Section 9.0, Radioactive Effluent Controls, of the ODCM as per NRC Generic Letter 89-01. At the same time, in order to formalize control of the entire ODCM, it was converted to APA-ZZ-01003, OFFSITE DOSE CALCULATION MANUAL.

OFFSITE DOSE CALCULATION MANUAL

1.0 PURPOSE AND SCOPE

1.1 The OFFSITE DOSE CALCULATION MANUAL (ODCM) describes the methodology and parameters used in the calculation of offsite doses resulting from radioactive gaseous and liquid effluents, in the calculation of gaseous and liquid effluent monitoring Alarm/Trip Setpoints, and in the conduct of the Environmental Radiological Monitoring Program. The ODCM also contains the Radioactive Effluent Controls and Radiological Environmental Monitoring Programs required by Technical Specification 6.8.4, and descriptions of the information that should be included in the Annual Radiological Environmental Operating and Semi-annual Radioactive Effluent Release Reports required by Technical Specifications 6.9.1.6 and 6.9.1.7. The ODCM also contains a list and description of the specific sample locations for the radiological environmental monitoring program.

2.0 LIQUID EFFLUENTS

2.1 RADIOACTIVE EFFLUENT CONTROLS (REC) SECTION 9.1.1.1

41838 The radioactive liquid effluent monitoring instrumentation channels shall be OPERABLE with their alarm/trip setpoints set to ensure that the limits of Section 9.3.1.1 are not exceeded. The
41840 alarm/trip setpoints of these channels shall be adjusted to the values determined in accordance with the methodology and parameters in the ODCM.

2.2 Liquid Effluent Monitors

Gross radioactivity monitors which provide for automatic termination of liquid effluent releases are present on the liquid effluent lines. Flow rate measurement devices are present on the liquid effluent lines and the discharge line (cooling tower blowdown). Setpoints, precautions, and limitations applicable to the operation of the Callaway Plant liquid effluent monitors are provided in the appropriate Plant Procedures. Setpoint values are calculated to assure that alarm and trip actions occur prior to exceeding the Maximum Permissible Concentration (MPC) limits in 10 CFR Part 20 at the release point to the UNRESTRICTED AREA. The calculated alarm and trip action setpoints for the liquid effluent line monitors and flow measuring devices must satisfy the following equation:

$$\frac{cf}{F + f} \leq C \qquad (2.1)$$

Where:

C = the liquid effluent concentration limit (MPC) implementing Section 9.3.1.1 for the site in (μCi/ml).

c = The setpoint, in (μCi/ml), of the radioactivity monitor measuring the radioactivity concentration in the effluent line prior to dilution and subsequent release; the setpoint, which is inversely related to the volumetric flow of the effluent line and directly related to the volumetric flow of the dilution stream plus the effluent stream, represents a value, which, if exceeded, would result in concentrations exceeding the limits of 10 CFR Part 20 in the UNRESTRICTED AREA.

f = The flow setpoint as measured at the radiation monitor location, in volume per unit time, but in the same units as F, below.

F = The dilution water flow setpoint as measured prior to the release point, in volume per unit time. (If (F) is large compared to (f), then F + f = F).

(Ref. 11.8.1)

If no dilution is provided, then $c \leq C$.

The radioactive liquid waste stream is diluted by the plant discharge line prior to entry into the Missouri River. Normally, the dilution flow is obtained from the cooling tower blowdown, but should this become unavailable, the plant water treatment facility supplies the necessary dilution flow via a bypass line. The batch release limiting concentration (c) which corresponds to the liquid radwaste effluent line monitor setpoint is to be calculated using methodology from the expression above.

Thus, the expression for determining the setpoint on the liquid radwaste effluent line monitor becomes:

$$c \leq \frac{C(F + f)}{f} \quad (\mu Ci/ml) \qquad (2.2)$$

The alarm/trip setpoint calculations are based on the minimum dilution flow rate (cooling tower blowdown, 5000 gpm), the maximum effluent stream flow rate, and the actual isotopic analysis. Due to the possibility of a simulataneous release from more than one release pathway, a portion of the total site release limit is allocated to each pathway. The determination and usage of the allocation factor is discussed in Section 2.3. In the event the alarm/trip setpoint is reached, an evaluation will be performed using actual dilution and effluent flow values and actual isotopic analysis to ensure that Section 9.3.1.1 limits were not exceeded.

2.2.1 Continuous Liquid Effluent Monitors

The radiation detection monitors associated with continuous liquid effluent releases are (Ref. 11.6.1, 11.6.2):

Monitor I.D.	Description
BM-RE-52	Steam Generator Blowdown Discharge Monitor
LE-RE-59	Turbine Building Drain Monitor

These effluent streams are not considered to be radioactive unless radioactivity has been detected by the associated effluent radiation monitor or by laboratory analysis. The sampling frequency, minimum analysis frequency, and type of analysis performed are as per Table 9.3-A. Since the Turbine Building Drain is not a designated liquid radioactive effluent discharge point, its setpoint is established as a function of background.

2.2.2 Radioactive Liquid Batch Release Effluent Monitors

The two radiation monitors which are associated with the liquid effluent batch release systems are (Ref. 11.6.4, 11.6.5):

MONITOR I.D.	Description
HB-RE-18	Liquid Radwaste Discharge Monitor
HF-RE-45	Secondary Liquid Waste System Monitor

These effluent streams are normally considered to be radioactive. The sampling frequency, minimum analysis frequency, and the type of analysis performed are as per Table 9.3-A.

2.3 Calculation of Liquid Effluent Monitor Setpoints

The dependence of the setpoint (c), on the radionuclide distribution, yields, calibration, and monitor parameters, requires that several variables be considered in setpoint calculations. (Ref. 11.8.1)

2.3.1 Calculation of the MPC Sum

The isotopic concentration of the release(s) being considered must be determined. This is obtained from the analyses required per Table 9.3-A, and is used to calculate an MPC sum (MPCSUM):

$$MPCSUM = \sum_i (C_g)_i/(MPC_g)_i + (C_a/MPC_a) + (C_s/MPC_s) + (C_t/MPC_t) + (C_f/MPC_f) \quad (2.3)$$

Where:

$(C_g)_i$ = the concentration (C_g) of each measured gamma emitting nuclide, i, observed by gamma-ray spectroscopy of the waste sample.

C_a* = the measured concentration (C_a) of alpna emitting nuclides observed by gross alpha analysis.

C_s* = the measured concentrations of Sr-89 and Sr-90 as determined by analysis of the quarterly composite sample.

C_t* = the measured concentration of H-3 in liquid effluents.

C_f* = the measured concentration of Fe-55 in liquid waste as determined by analysis of the quarterly composite sample.

*Values for these concentrations will be based on previous composite sample analyses as required by Table 9.3-A.

MPC_g, MPC_s, MPC_a, MPC_f, MPC_t = are the limiting concentrations of the appropriate radionuclides from 10CFR 20, Appendix B, Table II, Column 2. For dissolved or entrained noble gases, the concentration shall be limited to 2×10^{-4} µCi/ml total activity.

SF = the safety factor; an administrative factor used to compensate for statistical fluctuations and errors of measurements. This factor also provides a margin of safety in the calculation of the maximum liquid effluent discharge flowrate (f_{max}). The value of SF should be ≤ 1.

For the case MPCSUM $\leq$ 1, the monitor tank effluent concentration meets the limits of Section 9.3.1.1 without dilution and the effluent may be released at any desired flow rate. If MPCSUM > 1 then dilution is required to ensure compliance with Section 9.3.1.1 concentration limits. If simultaneous releases are occuring or are anticipated, an allocation fraction, N, must be applied so that available dilution flow may be apportioned among simultaneous discharge pathways. The value of N may be any value between 0 and 1 for a particular discharge point, provided that the sum total allocation fractions for all discharge points must be $\leq$ 1.

2.3.2 Calculation of the Maximum Permissible Liquid Effluent Discharge Flowrate

The maximum permissible liquid effluent discharge flowrate is calculated by:

$$f_{max} \leq (F + f_p)\ (SF)\ (N) + (MPCSUM) \qquad (2.4)$$

Where:

f_{max} = Maximum permissible liquid effluent discharge flowrate, in (gallons/minute);

f_p = the expected undiluted liquid effluent flowrate, in gpm.

N = the allocation fraction which apportions dilution flow among simultaneous discharge pathways (see discussion above)

F, SF, & MPCSUM, are as previously defined.

The minimum value of F is 5000 gpm, which is used as a default value. The dilution water supply is furnished with a flow monitor which isolates the liquid effluent discharge if the dilution flow rate falls below the 5000 gpm minimum value.

In the event that f_{max} is less than f_p, then the value of f_{max} is substituted into the equation for f_p and a new value of f_{max} is calculated. This substitution is performed for three iterations in order to calculate the correct value of f_{max}.

2.3.3 Calculation of Liquid Effluent Monitor Setpoint

The liquid effluent monitors are NaI(Tl) based systems and respond primarily to gamma radiation. Accordingly, their setpoint is based on the total concentration of gamma emitting nuclides in the effluent:

$$c = BKG + (\Sigma_i (C_g)_i + SF)\ \mu Ci/ml \qquad (2.5)$$

Where:

c = the monitor setpoint as previously defined, in (μCi/ml);

BKG = the monitor background prior to discharge, in (μCi/ml);

C_g and SF are as previously defined.

The monitor's background is controlled at an appropriate limit to ensure adequate sensitivity. Utilizing the methodology of ANSI N13.10-1974 (Ref. 11.21), the background must be maintained at a value of less than or equal to 2.23E-6 μCi/ml (relative to Cs-137) in order to detect a change of 1E-7 μCi/ml of I-134 (the most restrictive nuclide in Table 1 of reference 11.21).

In the event that there is no detectable gamma activity in the effluent or if the value of $(\Sigma_i (C_g)_i + SF)$ is less than the background of the monitor, then the monitor setpoint will be set at twice the current background of the monitor.

As previously stated, the monitor's response is dependent on the gamma emitting radionuclide distribution of the effluent. Accordingly, a new database conversion factor is calculated for each release based upon the results of the gamma spectrometric analysis of the effluent sample and the measured response of the monitor to the National Bureau of Standards (NBS) traceable calibration sources:

$$DBCF_c = (\Sigma(C_g)_i) \div (CMR) \times (ECF) \qquad (2.6)$$

Where:

$DBCF_c$ = the monitor data base conversion factor which converts count rate into concentration (μCi/ml);

CMR = the calculated response of the radiation monitor to the liquid effluent;

ECF = the conversion factor for Cs-137, which converts count rate into concentration (μCi/ml).

C_g is as previously defined.

The new value of the $DBCF_c$ is calculated and entered into the monitor data base prior to each discharge. A more complete discussion of the derivation and calculation of the CMR is given in reference 11.14.7.

2.4 Liquid Effluent Concentration Measurements

41846 4160 **2.4.1 REC Section 9.3.1.1**

The concentration of radioactive material released in liquid effluents to UNRESTRICTED AREAS shall be limited to the concentrations specified in 10 CFR Part 20, Appendix B, Table II, Column 2 for radionuclides other than dissolved or entrained noble gases. For dissolved or entrained noble gases, the concentration shall be limited to 2.0 E-04 µCi/ml total activity.

2.4.2 Liquid Effluent Concentration Measurements

Liquid batch releases are discharged as a discrete volume and each release is authorized based upon the sample analysis and the dilution flow rate existing in the discharge line at time of release. To assure representative sampling, each liquid monitor tank is isolated and thoroughly mixed by recirculation of tank contents prior to sample collection. The methods for mixing, sampling, and analyzing each batch are outlined in applicable plant procedures. The allowable release rate limit is calculated for each batch based upon the pre-release analysis, dilution flow-rate, and other procedural conditions, prior to authorization for release. The radwaste liquid effluent discharge is monitored prior to entering the dilution discharge line and will automatically be terminated if the pre-selected alarm/trip setpoint is exceeded. Concentrations are determined primarily from the gamma isotopic, H-3, & gross alpha analyses of the liquid batch sample. For Sr-89, Sr-90, & Fe-55, the measured concentration from the previous composite analysis is used. Composite samples are collected for each batch release and quarterly analyses are performed in accordance with Table 9.3-A.

Doses from liquids discharged as continuous releases are calculated by utilizing the last measured values of samples required in accordance with Table 9.3-A.

2.5 Dose Due to Liquid Effluents

41849 4160 2.5.1 REC Section 9.4.1.1

The dose or dose commitment to a MEMBER OF THE PUBLIC from radioactive materials in liquid effluents released, to UNRESTRICTED AREAS shall be limited:

a. During any calendar quarter to less than or equal to 1.5 mrem to the whole body and less than or equal to 5 mrem to any organ, and

b. During any calendar year to less than or equal to 3 mrem to the total body and to less than or equal to 10 mrem to any organ.

2.5.2 The Maximum Exposed Individual

The cumulative dose determination considers the dose contributions from the maximum exposed individual's consumption of fish and potable water, as appropriate. Normally, the adult is considered to be the maximum exposed individual. (Ref. 11.8.3)

The Callaway Plant's liquid effluents are discharged to the Missouri River. As there are no potable water intakes within 50 miles of the discharge point (Ref. 11.7.1, 11.6.6), this pathway does not require routine evaluation. Therefore, the dose contribution from fish consumption is expected to account for more than 95% of the total man-rem dose from discharges to the Missouri River. Dose from recreational activities is expected to contribute the additional 5%, which is considered to be negligible. (Ref. 11.6.7)

2.5.3 Calculation of Dose From Liquid Effluents

2.5.3.1 Calculation of Dose Contributions

The dose contributions for the total time period

$$\sum_{\ell=1}^{m} \Delta t_\ell$$

are calculated at least once each 31 days and a cumulative summation of the total body and individual organ doses is maintained for each calendar quarter. These dose contributions are calculated for all radionuclides identified in liquid effluents released to UNRESTRICTED AREAS using the following expression (Ref. 11.8.3)

$$D_\tau = \sum_i \left[A_{i\tau} \sum_{\ell=1}^{m} \Delta t_\ell \, C_{i\ell} \, F_\ell \right] \qquad (2.12)$$

Where:

D_τ = the cumulative dose commitment to the total body or any organ, τ, from the liquid effluents for the total 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. Δt_ℓ corresponds to the actual duration of the release(s).

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

$A_{i\tau}$ = the site related ingestion dose commitment factor to the total body or any organ τ for each identified principal gamma and beta emitter listed in Table 9.3-A, (in mrem/hr) per (μCi/ml). The calculation of the $A_{i\tau}$ values is detailed in Ref. 11.14.5 and are given in Table 1.

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

$$f_\ell = \frac{f_{max}}{(F + f_{max})\ 89.77}$$

Where:

f_{max} = maximum undiluted effluent flow rate during the release

F = average dilution flow

89.77 = site specific applicable factor for the mixing effect of the discharge structure. (Ref 11.5.1)

The term $C_{i\ell}$ is the undiluted concentration of radioactive material in liquid waste at the common release point determined in accordance with Section 9.3.1.1, Table 9.3-A, "Radioactive Liquid Waste Sampling and Analysis Program". All dilution factors beyond the sample point(s) are included in the F_ℓ term.

The nearest municipal potable water intake downstream from the liquid effluent discharge point into the Missouri River is located near the city of St. Louis, Mo., approximately 78 miles downstream. As there are currently no potable water intakes within 50 river miles of the discharge point, the drinking water pathway is not included in dose estimates to the maximally exposed individual, or in dose estimates to the population. Should future water intakes be constructed within 10 river miles downstream of the discharge point, then this manual will be revised to include this pathway in dose estimates. (Ref. 11.6.6).

2.5.4 Summary, Calculation of Dose Due to Liquid Effluents

The dose contribution for the total time period

$$\sum_{\ell=1}^{m} \Delta t_{\ell}$$

is determined by calculation at least once per 31 days and a cumulative summation of the total body and organ doses is maintained for each calendar quarter. The projected dose contribution from liquid effluents for which radionuclide concentrations are determined by periodic composite and grab sample analysis, may be approximated by using the last measured value. Dose contributions are determined for all radionuclides identified in liquid effluents released to UNRESTRICTED AREAS. Nuclides which are not detected in the analyses are reported as "less than" the nuclide's Minimum Detectable Activity (MDA) and are not reported as being present at the Lower Level of Detection (LLD) level for that nuclide. The "less than" values are not used in the required dose calculations.

TABLE 1

INGESTION DOSE COMMITMENT FACTOR (A_{it}) FOR ADULT AGE GROUP

(mrem/hr) per (uci/ml)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
H-3	No Data	2.26E-01	2.26E-01	2.26E-01	2.26E-01	2.26E-01	2.26E-01
Be-7	1.30E-02	2.98E-02	1.45E-02	No Data	3.15E-02	No Data	5.16E+00
C-14	3.13E+04	6.16E+03	6.26E+03	6.26E+03	6.26E+03	6.26E+03	6.26E+03
Na-24	4.07E+02	4.07E+02	4.07E+02	4.07E+02	4.07E+02	4.07E+02	4.07E+02
P-32	4.62E+07	2.87E+06	1.78E+06	No Data	No Data	No Data	5.19E+06
Cr-51	No Data	No Data	1.27E+00	7.62E-01	2.81-01	1.69E+00	3.20E+02
Mn-54	No Data	4.38E+03	8.35E+02	No Data	1.30E+03	No Data	1.34E+04
Mn-56	No Data	1.10E+02	1.95E+01	No Data	1.40E+02	No Data	3.52E+03
Fe-55	6.57E+02	4.54E+02	1.06E+02	No Data	No Data	2.53E+02	2.61E+02
Fe-59	1.04E+03	2.44E+03	9.34E+02	No Data	No Data	6.81E+02	8.13E+03
Co-57	No Data	2.09E+01	3.48E+01	No Data	No Data	No Data	2.31E+02
Co-58	No Data	8.94E+01	2.00E+02	No Data	No Data	No Data	1.81E+03
Co-60	No Data	2.57E+02	5.66E+02	No Data	No Data	No Data	4.82E+03
Ni-63	3.11E+04	2.15E+03	1.04E+03	No Data	No Data	No Data	4.49E+02
Ni-65	1.26E+02	1.64E+01	7.48E+00	No Data	No Data	No Data	4.16E+02
Cu-64	NO Data	1.00E+01	4.69E+00	No Data	2.52E+01	No Data	8.52E+02
Zn-65	2.32E+0	7.38E+04	3.33E+04	No Data	4.93E+04	No Data	4.65E+04
Zn-69	4.93E+	9.44E+01	6.56E+00	No Data	6.13E+01	No Data	1.42E+01
Br-82	No Data	No Data	2.27E+03	No Data	No Data	No Data	2.60E+03
Br-83	No Data	No Data	4.04E+01	No Data	No Data	No Data	5.81E+01
Br-84	No Data	No Data	5.26E+01	No Data	No Data	No Data	4.13E-04
Br-85	No Data	No Data	2.15E+00	No Data	No Data	No Data	0
Rb-86	No Data	1.01E+05	4.71E+04	No Data	No Data	No Data	1.99E+04
Rb-88	No Data	2.90E+02	1.54E+02	No Data	No Data	No Data	4.00E-09
Rb-89	No Data	1.92E+02	1.35E+02	No Data	No Data	No Data	1.12E-11
Sr-89	2.21E+04	No Data	6.35E+02	No Data	No Data	No Data	3.55E+03
Sr-90	5.44E+05	No Data	1.34E+05	No Data	No Data	No Data	1.57E+04
Sr-91	4.07E+02	No Data	1.64E+01	No Data	No Data	No Data	1.94E+03
Sr-92	1.54E+02	No Data	6.68E+00	No Data	No Data	No Data	3.06E+03
Y-90	5.75E-01	No Data	1.54E-02	No Data	No Data	No Data	6.10E+03
Y-91M	5.44E-03	No Data	2.10E-04	No Data	No Data	No Data	1.60E-02
Y-91	8.43E+00	No Data	2.25E-01	No Data	No Data	No Data	4.64E+03
Y-92	5.05E-02	No Data	1.48E-03	No Data	No Data	No Data	8.85E+02
Y-93	1.60E-01	No Data	4.42E-03	No Data	No Data	No Data	5.08E+03
Zr-95	2.40E-01	7.70E-02	5.21E-02	No Data	1.21E-01	No Data	2.44E+02
Zr-97	1.33E-02	2.68E-03	1.22E-03	No Data	4.04E-03	No Data	8.30E+02
Nb-95	4.47E+02	2.48E+02	1.34E+02	No Data	2.46E+02	No Data	1.51E+06
Mo-99	No Data	1.03E+02	1.96E+01	No Data	2.33E+02	No Data	2.39E+02
Tc-99M	8.87E-03	2.51E-02	3.19E-01	No Data	3.81E-01	1.23E-02	1.48E-01
Tc-101	9.11E-03	1.31E-02	1.29E-01	No Data	2.36E-01	6.70E-03	0
Ru-103	4.42E+00	No Data	1.90E+00	No Data	1.65E+01	No Data	5.17E+02
Ru-105	3.68E-01	No Data	1.45E-01	No Data	4.76E+00	No Data	2.25E+02
Ru-106	6.57E+01	No Data	8.32E+00	No Data	1.27E+02	No Data	4.25E+03
Cd-109	No Data	5.54E+02	1.94E+01	No Data	5.31E+02	No Data	5.59E+03
Sn-113	5.66E4	1.61E3	3.26E3	9.18E2	No Data	No Data	1.69E5
Sb-124	6.69E+00	1.26E-01	2.65E+00	1.62E-02	No Data	5.21E+00	1.90E+02

TABLE 1 (Continued)

INGESTION DOSE COMMITMENT FACTOR (A_{it}) FOR ADULT AGE GROUP

(mrem/hr) per (μci/ml)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Sb-125	4.28E+00	4.78E-02	1.02E+00	4.35E-03	No Data	3.30E+00	4.71E+01
Te-125M	2.57E+03	9.30E+02	3.44E+02	7.72E+02	1.04E+04	No Data	1.02E+04
Te-127M	6.47E+03	2.32E+03	7.90E+02	1.66E+03	2.63E+04	No Data	2.17E+04
Te-127	1.05E+02	3.78E+01	2.28E+01	7.80E+01	4.29E+02	No Data	8.30E+03
Te-129M	1.10E+04	4.11E+03	1.74E+03	3.78E+03	4.60E+04	No Data	5.54E+04
Te-129	3.01E+01	1.13E+01	7.33E+00	2.31E+01	1.26E+02	No Data	2.27E+01
Te-131M	1.66E+03	8.09E+02	6.75E+02	1.28E+03	8.21E+03	No Data	8.03E+04
Te-131	1.89E+01	7.88E+00	5.96E+00	1.55E+01	8.25E+01	No Data	2.67E+00
Te-132	2.41E+03	1.56E+03	1.47E+03	1.72E+03	1.50E+04	No Data	7.38E+04
I-130	2.71E+01	8.01E+01	3.16E+01	6.79E+03	1.25E+02	No Data	6.89E+01
I-131	1.49E+02	2.14E+02	1.22E+02	7.00E+04	3.66E+02	No Data	5.64E+01
I-132	7.29E+00	1.95E+01	6.82E+00	6.82E+02	3.11E+01	No Data	3.66E+00
I-133	5.10E+01	8.87E+01	2.70E+01	1.30E+04	1.55E+02	No Data	7.97E+01
I-134	3.81E+00	1.03E+01	3.70E+00	1.79E+02	1.64E+01	No Data	9.01E-03
I-135	1.59E+01	4.16E+01	1.54E+01	2.75E+03	6.68E+01	No Data	4.70E+01
Cs-134	2.98E+05	7.09E+05	5.80E+05	No Data	2.29E+05	7.62E+04	1.24E+04
Cs-136	3.12E+04	1.23E+05	8.86E+04	No Data	6.85E+04	9.39E+03	1.40E+04
Cs-137	3.82E+05	5.22E+05	3.42E+05	No Data	1.77E+05	5.89E+04	1.01E+04
Cs-138	2.64E+02	5.22E+02	2.59E+02	No Data	3.84E+02	3.79E+01	2.23E-03
Ba-139	9.29E-01	6.62E-04	2.72E-02	No Data	6.19E-04	3.76E-04	1.65E+00
Ba-140	1.94E+02	2.44E+01	1.27E+01	No Data	8.31E-02	1.40E-01	4.00E+02
Ba-141	4.50E-01	3.40E-04	1.52E-02	No Data	3.16E-04	1.93E-04	2.12E-10
Ba-142	2.04E-01	2.09E-04	1.28E-02	No Data	1.77E-04	1.19E-04	0
La-140	1.50E-01	7.53E-02	1.99E-02	No Data	No Data	No Data	5.53E+03
La-142	7.65E-03	3.48E-03	8.66E-04	No Data	No Data	No Data	2.54E+01
Ce-141	2.24E-02	1.51E-02	1.72E-03	No Data	7.03E-03	No Data	5.78E+01
Ce-143	3.94E-03	2.92E+00	3.23E-04	No Data	1.28E-03	No Data	1.09E+02
Ce-144	1.17E+00	4.88E-01	6.26E-02	No Data	2.89E-01	No Data	3.94E+02
Pr-143	5.50E-01	2.21E-01	2.73E-02	No Data	1.27E-01	No Data	2.41E+03
Nd-147	3.76E-01	4.35E-01	2.60E-02	No Data	2.54E-01	No Data	2.09E+03
Eu-154	3.67E1	4.52E0	3.21E0	No Data	2.16E1	No Data	3.27E3
Hf-181	3.99E-02	1.94E-01	1.80E-02	No Data	4.17E-02	No Data	2.21E+02
W-187	2.96E+02	2.47E+02	8.64E+01	No Data	No Data	No Data	8.09E+04
Np-239	2.84E-02	2.80E-03	1.54E-03	No Data	8.72E-03	No Data	5.74E+02

TABLE 2
BIOACCUMULATION FACTOR (BF_i) USED IN THE ABSENCE OF SITE-SPECIFIC DATA[a]
(pCi/kg) per (pCi/liter)

Element	BF_i Fish (Freshwater)
H	9.0 E - 01
Be	2.0 E + 00
C	4.6 E + 03
Na	1.0 E + 02
P	1.0 E + 05
Cr	2.0 E + 02
Mn	4.0 E + 02
Fe	1.0 E + 02
Co	5.0 E + 01
Ni	1.0 E + 02
Cu	5.0 E + 01
Zn	2.0 E + 03
Br	4.2 E + 02
Rb	2.0 E + 03
Sr	3.0 E + 01
Y	2.5 E + 01
Zr	3.3 E + 00
Nb	3.0 E + 04
Mo	1.0 E + 01
Tc	1.5 E + 01
Ru	1.0 E + 01
Rh	1.0 E + 01
Cd	2.0 E + 02
Sn	3.0 E + 03
Sb	1.0 E + 00
Te	4.0 E + 02
I	1.5 E + 01
Cs	2.0 E + 03
Ba	4.0 E + 00
La	2.5 E + 01
Ce	1.0 E + 00
Pr	2.5 E + 01
Nd	2.5 E + 01
Eu	2.5 E + 01
Hf	3.3 E + 00
W	1.2 E + 03
Np	1.0 E + 01

(a) Values from Regulatory Guide 1.109, Rev 1, Table A-1 and References 11.14.4 and 11.14.8.

2.6 LIQUID RADWASTE TREATMENT SYSTEM

4160 41851 **2.6.1 REC Section 9.5.1.1**

The LIQUID RADWASTE TREATMENT SYSTEM shall be OPERABLE and appropriate portions of the system shall be used to reduce releases of radioactivity when the projected doses due to the liquid effluent, to UNRESTRICTED AREAS, would exceed 0.06 mrem to the total body or 0.2 mrem to any organ in a 31 day period.

2.6.2 OPERABILITY Of The LIQUID RADWASTE TREATMENT SYSTEM

The LIQUID RADWASTE TREATMENT SYSTEM is capable of varying treatment, depending on waste type and product desired. It is capable of concentrating, gas stripping, and distillation of liquid wastes through the use of the evaporator system. The demineralization system is capable of removing radioactive ions from solutions to be reused as makeup water. Filtration is performed on certain liquid wastes and it may, in some cases, be the only required treatment prior to release. The system has the ability to absorb halides through the use of charcoal filters prior to their release.

The design and operation requirements of the LIQUID RADWASTE TREATMENT SYSTEM provide assurance that releases of radioactive materials in liquid effluents will be kept "As Low As Reasonably Achievable" (ALARA).

The OPERABILITY of the LIQUID RADWASTE TREATMENT SYSTEM ensures this system will be available for use when liquids require treatment prior to their release to the environment. OPERABILITY is demonstrated through compliance with Sections 9.3.1.1 and 9.4.1.1.

Projected doses due to liquid releases to UNRESTRICTED AREAS are determined each 31 days by dividing the cummulative annual total by the number of elapsed months.

2902 3.0 GASEOUS EFFLUENTS

41842 3.1 REC Section 9.2.1.1
4160

The radioactive gaseous effluent monitoring instrumentation channels shall be OPERABLE with their Alarm/Trip Setpoints set to ensure that the limits of Section 9.2.1.1 are not exceeded. The Alarm/Trip Setpoints of these channels shall be adjusted to the values determined in accordance with the methodology and parameters in the ODCM.

41853 3.2 REC Section 9.6.1.1
4160

The dose rate due to radioactive materials released in gaseous effluents from the site to areas at and beyond the SITE BOUNDARY shall be limited to the following:

a. For noble gases: Less than or equal to 500 mrem/yr to the total body and less than or equal to 3000 mrem/yr to the skin, and

b. For Iodine - 131 and 133, for tritium, and for all radionuclides in particulate form with half lives greater than 8 days: Less than or equal to 1500 mrem/yr. to any organ, from the inhalation pathway only.

3.3 Gaseous Effluent Monitors

Noble gas activity monitors are present on the containment building ventilation system, plant unit ventilation system, and radwaste building ventilation system.

The alarm/trip (alarm & trip) setpoint for any gaseous effluent radiation monitor is determined based on the instantaneous noble gas total body and skin dose rate limits of Section 9.6.1.1, at the SITE BOUNDARY location with the highest annual average X/Q value. (Figure 5.1B)

Each monitor channel is provided with a two level system which provides sequential alarms on increasing radioactivity levels. These setpoints are designated as alert setpoints and alarm/trip setpoints. (Ref. 11.6.3)

The radiation monitor alarm/trip setpoints for each release point are based on the radioactive noble gases in gaseous effluents. It is not considered practicable to apply instantaneous alarm/trip setpoints to integrating radiation monitors sensitive to radioiodines, radioactive materials in particulate form and radionuclides other than noble gases. Conservative assumptions may be necessary in establishing setpoints to account for system variables, such as the measurement system efficiency and detection capabilities during normal, anticipated, and unusual operating conditions, the variability in release flow and principal radionuclides, and the time lag between alarm/trip action and the final isolation of the radioactive effluent. (Ref. 11.8.5.) Table 9.2-B provides the instrument surveillance requirements, such as calibration, source checking, functional testing, and channel checking.

3.3.1 Continuous Release Gaseous Effluent Monitors

The radiation detection monitors associated with continuous gaseous effluent releases are (Ref. 11.6.8, 11.6.9):

Monitor I.D.	Description
GT-RE-21	Unit Vent
GH-RE-10	Radwaste Building Vent

Each of the above continuously monitors gaseous radioactivity concentrations downstream of the last point of potential influent, and therefore measures effluents and not inplant concentrations.

The Unit Vent monitor continuously monitors the effluent from the unit vent for gaseous radioactivity. The Unit Vent, via ventilation exhaust systems, continuously purges various tanks and sumps normally containing low-level radioactive aerated liquids that can potentially generate airborne activity.

The exhaust systems which supply air to the unit vent are from the fuel building, auxiliary building, the access control area, the containment purge, and the condenser air discharge.

The Unit Vent monitor provides alarm functions only, and does not terminate releases from the Unit Vent.

The Radwaste Building Ventilation effluent monitor continuously monitors for gaseous radioactivity in the effluent duct downstream of the exhaust filter and fans. The flow path provides ventilation exhaust for all parts of the building structure and components within the building and provides a discharge path for the waste gas decay tank release line. These components represent potential sources for the release of gaseous and air particulate and iodine activities in addition to the drainage sumps, tanks, and equipment purged by the waste processing system.

This monitor will isolate the waste gas decay tank discharge line upon a high gaseous radioactivity alarm.

The continuous gaseous effluent monitor setpoints are established using the methodology described in Section 3.4. Since there are two continuous gaseous effluent release points, a fraction of the total dose rate limit (DRL) will be allocated to each release point. Neglecting the batch releases, the plant Unit Vent monitor has been allocated 0.7 DRL and the Radwaste Building Vent monitor has been allocated 0.3 DRL. These allocation factors may be changed as required to support plant operational needs, but shall not be allowed to exceed unity (i.e. 1.0). Therefore, a particular monitor reaching the setpoint would not necessarily mean the dose rate limit at the SITE BOUNDARY is being exceeded; the alarm only indicates that the specific release point is contributing a greater fraction of the dose rate limit than was allocated to the associated monitor, and will necessitate an evaluation of both systems.

3.3.2 Batch Release Gaseous Monitors

The radiation monitors associated with batch release gaseous effluents are (Ref. 11.6.9, 11.6.10, 11.6.11):

Monitor I.D.	Description
GT-RE-22 GT-RE-33	Containment Purge System
GH-RE-10	Radwaste Building Vent

The Containment Purge System monitors continuously monitor the containment purge exhaust duct during purge operations for gaseous radioactivity. The primary purpose of these monitors is to isolate the containment purge system on high gaseous activity via the ESFAS.

The sample points are located outside the containment between the containment isolation

dampers and the containment purge filter adsorber unit.

The Radwaste Building Vent monitor was previously described in Section 3.3.1.

Setpoints for the batch gaseous effluent monitors are calculated using the methodology described in Section 3.4.

A pre-release isotopic analysis is performed for each batch release to determine the identity and quantity of the principal radionuclides. The alarm/trip setpoint(s) is adjusted accordingly to ensure that the limits of Section 9.6.1.1 are not exceeded.

3.4 Determination of Gaseous Effluent Monitor Setpoints

The alarm/trip setpoint for gaseous effluent monitors is determined based on the lesser of the total body dose rate and skin dose rate, as calculated for the SITE BOUNDARY.

During core alterations, the setpoint for the Containment Purge Monitors, GT-RE-22 and GT-RE-33 is set at a value of less than or equal to 5E-3 µCi/cc, as required by Technical Specification 4.9.4.2. The actual setpoint value will be reduced according to the Instrument Loop Uncertainty Estimate (ILUE). This value will also be utilized in the event that there is no detectable noble gas activity in the containment atmosphere sample analyzed in accordance with Section 9.6.1.1. The full derivation of this value is discussed in reference 11.14.6.

3.4.1 Total Body Dose Rate Setpoint Calculations

To ensure that the limits of Section 9.6.1.1 are met, the alarm/trip setpoint based on the total body dose rate is calculated according to:

$$S_{tb} \leq D_{tb} R_{tb} F_s F_a \qquad (3.1)$$

Where:

S_{tb} = the alarm/trip setpoint based on the total body dose rate (μCi/cc).

D_{tb} = Section 9.6.1.1 limit of 500 mrem/yr, conservatively interpreted as a continuous release over a one year period.

F_s = the safety factor; a conservative factor used to compensate for statistical fluctuations and errors of measurement. (For example, F_s = 0.5 corresponds to a 100% variation.) Default value is F_s = 1.0.

F_a = the allocation factor which will modify the required dilution factor such that simultaneous gaseous releases may be made without exceeding the limits of Section 9.6.1.1. The default value is 1/n, where n is the number of pathways planned for release.

R_{tb} = factor used to convert dose rate to the effluent concentration as measured by the effluent monitor, in (μCi/cc) per (mrem/yr) to the total body, determined according to:

$$R_{tb} = C \div [(\overline{X/Q}) \sum_i K_i Q_i] \qquad (3.2)$$

Where:

C = monitor reading of a noble gas monitor corresponding to the sample radionuclide concentrations for the batch to be released. Concentrations are determined in accordance with Table 9.6-A. The mixture of radionuclides determined via grab sampling of the effluent stream or source is correlated to a calibration factor to determine monitor response. The monitor response is based on concentrations, not release rate, and is in units of (μCi/cc).

$\overline{X/Q}$ = the highest calculated annual average relative concentration for any area at or beyond the SITE BOUNDARY in (sec/m^3). Refer to Tables 9, 10, and 12.

K_i = the total body dose factor due to gamma emissions for each identified noble gas radionuclide, in (mrem/yr) per (μCi/m^3). (Table 3)

Q_i = rate of release of noble gas radionuclide, i, in (μCi/sec).

Q_i is calculated as the product of the ventilation path design flow rate and the measured activity of the effluent stream as determined by grab sampling. Flow rates for the ventilation pathways can be found in references 11.6.18, 11.6.19, 11.6.20, and 11.6.21.

3.4.2 Skin Dose Rate Setpoint Calculation

To ensure that the limits of Section 9.6.1.1 are met, the alarm/trip setpoint based on the skin dose rate is calculated according to:

$$S_s \leq D_s R_s F_s F_a \qquad (3.3)$$

Where:

F_s and F_a are as previously defined in Section 3.4.1.1.

S_s = the alarm/trip setpoint based on the skin dose rate.

D_s = Section 9.6.1.1 limit of 3000 mrem/yr, conservatively interpreted as a continuous release over a one year period.

R_s = factor used to convert dose rate to the effluent concentration as measured by the effluent monitor, in (μCi/cc) per (mrem/yr) to the skin, determined according to:

$$R_s = C \div [(\overline{X/Q}) \sum_i (L_i + 1.1M_i)\, Q_i] \qquad (3.4)$$

Where:

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

1.1 = conversion factor: 1 mrad air dose = 1.1 mrem skin dose.

M_i = the air dose factor due to gamma emissions for each identified noble gas radionuclide, in (mrad/yr) per ($\mu Ci/m^3$). (Table 3)

C, $(\overline{X/Q})$ and Q_i are as previously defined.

3.4.3 Gaseous Effluent Monitors Setpoint Determination

The results of Equation (3.1) and Equation (3.3) are compared. The setpoint is then selected as the lesser of the two values.

TABLE 3

DOSE FACTORS FOR EXPOSURE TO A SEMI-INFINITE CLOUD OF NOBLE GASES[a]

Radionuclide	Total Body Dose Factor K_i (mrem/yr) per (μCi/m³)	Skin Dose Factor L_i (mrem/yr) per (μCi/m³)	Gamma Air Dose Factor M_i (mrad/yr) per (μCi/m³)	Beta Air Dose Factor N_i (mrad/yr) per (μCi/m³)
Kr-83m	7.56 E-02	- - -	1.93 E+01	2.88 E+02
Kr-85m	1.17 E+03	1.46 E+03	1.23 E+03	1.97 E+03
Kr-85	1.61 E+01	1.34 E+03	1.72 E+01	1.95 E+03
Kr-87	5.92 E+03	9.73 E+03	6.17 E+03	1.03 E+04
Kr-88	1.47 E+04	2.37 E+03	1.52 E+04	2.93 E+03
Kr-89	1.66 E+04	1.01 E+04	1.73 E+04	1.06 E+04
Kr-90	1.56 E+04	7.29 E+03	1.63 E+04	7.83 E+03
Xe-131m	9.15 E+01	4.76 E+02	1.56 E+02	1.11 E+03
Xe-133m	2.51 E+02	9.94 E+02	3.27 E+02	1.48 E+03
Xe-133	2.94 E+02	3.06 E+02	3.53 E+02	1.05 E+03
Xe-135m	3.12 E+03	7.11 E+02	3.36 E+03	7.39 E+02
Xe-135	1.81 E+03	1.86 E+03	1.92 E+03	2.46 E+03
Xe-137	1.42 E+03	1.22 E+04	1.51 E+03	1.27 E+04
Xe-138	8.83 E+03	4.13 E+03	9.21 E+03	4.75 E+03
Ar-41	8.84 E+03	2.69 E+03	9.30 E+03	3.28 E+03

(a) The listed dose factors are derived from Reg. Guide 1.109, Table B-1 (Rev. 1, 1977).

3.4.4 Summary, Gaseous Effluent Monitors Setpoint Determination

The gaseous effluent monitors setpoints are calculated according to equations (3.1) and (3.3), as described in Section 3.4. However, it should be noted that a batch release will alter the flow rate characteristics at the Unit Vent and therefore the concentration as sensed by the monitor. For example, in the case of a mini-purge, the setpoint for the Unit Vent monitor must be re-calculated to include both the continuous and batch sources.

3.5 Calculation of Dose From Gaseous Effluents

Dose rate calculations are performed for gaseous effluents to ensure compliance with Section 9.6.1.1.

3.5.1 Calculation of Dose Rate

The following methodology is applicable to the location (SITE BOUNDARY or beyond) characterized by the values of the parameter (X/Q) which results in the maximum total body or skin dose rate. In the event that the analysis indicates a different location for the total body and skin dose limitations, the location selected for consideration is that which minimizes the allowable release values. (Ref. 11.8.6)

The factors K_i, L_i, and M_i relate the radionuclide airborne concentrations to various dose rates, assuming a semi-infinite cloud model, and are tabulated in Table 3.

3.5.1.1 Noble Gases

The release rate limit for noble gases is determined according to the following general relationships (Ref. 11.8.6):

$$D_{tb} = \sum_i [K_i((\overline{X/Q})Q_i)] \leq 500 \text{ mrem/yr} \quad (3.5)$$

$$D_s = \sum_i [(L_i + 1.1\ M_i)((\overline{X/Q})Q_i)] \leq 3000 \text{ mrem/yr} \quad (3.6)$$

Where:

D_{tb} = Total body dose rate, conservatively averaged over a period of one year.

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

$(\overline{X/Q})$ = The highest calculated annual average relative concentration for any area at or beyond the SITE BOUNDARY. Refer to Tables 9, 10, and 12.

Q_i = The release rate of noble gas radionuclides, i, in gaseous effluents, from all vent releases in ($\mu Ci/sec$).

Q_i = is calculated as the product of the ventilation path design flow rate and the measured activity of the effluent stream as determined by grab sampling. Flow rates for the ventilation pathways can be found in references 11.6.18, 11.6.19, 11.6.20, and 11.6.21.

D_s = Skin dose rate, conservatively averaged over a period of one year.

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

1.1 = Units conversion factor; 1 mrad air dose = 1.1 mrem skin dose.

M_i = Air dose factor due to gamma emissions for each identified noble gas radionuclide, in (mrad/yr) per ($\mu Ci/m^3$) (Table 3).

3.5.1.2 Radionuclides Other Than Noble Gases

The release rate limit for Iodine-131 and-133, for tritium, and for all radioactive materials in particulate form with half lives greater than 8 days is determined according to (Ref. 11.8.7):

$$D_o = \sum_i P_i[(\overline{X/Q})Q_i] \leq 1500 \text{ mrem/yr} \qquad (3.7)$$

Where:

D_o = Dose rate to any critical organ, in (mrem/yr).

P_i = Dose parameter for radionuclides other than noble gases for the inhalation pathway for the child, based on the critical organ, in (mrem/yr) per ($\mu Ci/m^3$). (Table 4)

Q_i = The release rate of radionuclide, i, in gaseous effluents, from all vent releases, in ($\mu Ci/sec$). Q_i is calculated as the product of the ventilation path design flow rate and the measured activity of the effluent stream as determined by grab sampling. Flow rates for the ventilation pathways can be found in references 11.6.18, 11.6.19, 11.6.20, and 11.6.21.

$(\overline{X/Q})$ is as previously defined.

The dose parameter (P_i) includes the internal dosimetry of radionuclide, i, and the receptor's breathing rate, which are functions of the receptor's age. Therefore the child age group has been selected as the limiting age group.

For the child exposure, separate values of P_i are tabulated in Table 4 for the inhalation pathway. These values were calculated according to (Ref. 11.8.8):

$$P_i = K' (BR) DFA_i \qquad (3.8)$$

Where:

K' = Units conversion factor: 1μCi = 1E06 pCi.

BR= The breathing rate of the maximum exposed child age group, 3700 m^3/yr. (Regulatory Guide 1.109, Table E-5).

DFA_i = The maximum 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. (Ref. 11.11.5 and 11.14.4)

Note: All radioiodines are assumed to be released in elemental form. (Ref.11.8.7)

TABLE 4

DOSE PARAMETER (P_i) FOR RADIONUCLIDES OTHER THAN NOBLE GASES[a]

Inhalation Pathway

(mrem/yr) per ($\mu Ci/m^3$)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
H-3	ND	1.12E3	1.12E3	1.12E3	1.12E3	1.12E3	1.12E3
Be-7	8.47E2	1.44E3	9.25E2	ND	ND	6.48E4	2.55E3
C-14	3.59E4	6.73E3	6.73E3	6.73E3	6.73E3	6.73E3	6.73E3
Na-24	1.61E4	1.61E4	1.61E4	1.61E4	1.61E4	1.61E4	1.61E4
P-32	2.60E6	1.14E5	9.88E4	ND	ND	ND	4.22E4
Cr-51	ND	ND	1.54E2	8.55E1	2.43E1	1.70E4	1.08E3
Mn-54	ND	4.29E4	9.51E3	ND	1.00E4	1.58E6	2.29E4
Mn-56	ND	1.66E0	3.12E-1	ND	1.67E0	1.31E4	1.23E5
Fe-55	4.74E4	2.52E4	7.72E3	ND	ND	1.11E5	2.87E3
Fe-59	2.07E4	3.34E4	1.67E4	ND	ND	1.27E6	7.07E4
Co-57	ND	9.03E2	1.07E3	ND	ND	5.07E5	1.32E4
Co-58	ND	1.77E3	3.16E3	ND	ND	1.11E6	3.44E4
Co-60	ND	1.31E4	2.26E4	ND	ND	7.07E6	9.26E4
Ni-63	8.21E5	4.63E4	2.80E4	ND	ND	2.75E5	6.33E3
Ni-65	2.99E0	2.96E-1	1.64E-1	ND	ND	8.18E3	8.40E4
Cu-64	ND	1.99E0	1.07E0	ND	6.03E0	9.58E3	3.67E4
Zn-65	4.26E4	1.13E5	7.03E4	ND	7.14E4	9.95E5	1.63E4
Zn-69	6.70E-2	9.66E-2	8.92E-3	ND	5.85E-2	1.42E3	1.02E4
Br-82	ND	ND	2.09E4	ND	ND	ND	ND
Br-83	ND	ND	4.74E2	ND	ND	ND	0
Br-84	ND	ND	5.48E2	ND	ND	ND	0
Br-85	ND	ND	2.53E1	ND	ND	ND	0
Rb-86	ND	1.98E5	1.14E5	ND	ND	ND	7.99E3
Rb-88	ND	5.62E2	3.66E2	ND	ND	ND	1.72E1
Rb-89	ND	3.45E2	2.90E2	ND	ND	ND	1.89E0
Sr-89	5.99E5	ND	1.72E4	ND	ND	2.16E6	1.67E5
Sr-90	1.01E8	ND	6.44E6	ND	ND	1.48E7	3.43E5
Sr-91	1.21E2	ND	4.59E[illegible]	ND	ND	5.33E4	1.74E5
Sr-92	1.31E1	ND	5.25[illegible]-1	ND	ND	2.40E4	2.42E5
Y-90	4.11E3	ND	1.1[illegible]E2	ND	ND	2.62E5	2.68E5

TABLE 4

DOSE PARAMETER (P_i) FOR RADIONUCLIDES OTHER THAN NOBLE GASES[a]

Inhalation Pathway

(mrem/yr) per ($\mu Ci/m^3$)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
H-3	ND	1.12E3	1.12E3	1.12E3	1.12E3	1.12E3	1.12E3
Be-7	8.47E2	1.44E3	9.25E2	ND	ND	6.48E4	2.55E3
C-14	3.59E4	6.73E3	6.73E3	6.73E3	6.73E3	6.73E3	6.73E3
Na-24	1.61E4	1.61E4	1.61E4	1.61E4	1.61E4	1.61E4	1.61E4
P-32	2.60E6	1.14E5	9.88E4	ND	ND	ND	4.22E4
Cr-51	ND	ND	1.54E2	8.55E1	2.43E1	1.70E4	1.08E3
Mn-54	ND	4.29E4	9.51E3	ND	1.00E4	1.58E6	2.29E4
Mn-56	ND	1.66E0	3.12E-1	ND	1.67E0	1.31E4	1.23E5
Fe-55	4.74E4	2.52E4	7.72E3	ND	ND	1.11E5	2.87E3
Fe-59	2.07E4	3.34E4	1.67E4	ND	ND	1.27E6	7.07E4
Co-57	ND	9.03E2	1.07E3	ND	ND	5.07E5	1.32E4
Co-58	ND	1.77E3	3.16E3	ND	ND	1.11E6	3.44E4
Co-60	ND	1.31E4	2.26E4	ND	ND	7.07E6	9.26E4
Ni-63	8.21E5	4.63E4	2.80E4	ND	ND	2.75E5	6.33E3
Ni-65	2.99E0	2.96E-1	1.64E-1	ND	ND	8.18E3	8.40E4
Cu-64	ND	1.99E0	1.07E0	ND	6.03E0	9.58E3	3.67E4
Zn-65	4.26E4	1.13E5	7.03E4	ND	7.14E4	9.95E5	1.63E4
Zn-69	6.70E-2	9.66E-2	8.92E-3	ND	5.85E-2	1.42E3	1.02E4
Br-82	ND	ND	2.09E4	ND	ND	ND	ND
Br-83	ND	ND	4.74E2	ND	ND	ND	0
Br-84	ND	ND	5.48E2	ND	ND	ND	0
Br-85	ND	ND	2.53E1	ND	ND	ND	0
Rb-86	ND	1.98E5	1.14E5	ND	ND	ND	7.99E3
Rb-88	ND	5.62E2	3.66E2	ND	ND	ND	1.72E1
Rb-89	ND	3.45E2	2.90E2	ND	ND	ND	1.89E0
Sr-89	5.99E5	ND	1.72E4	ND	ND	2.16E6	1.67E5
Sr-90	1.01E8	ND	6.44E6	ND	ND	1.48E7	3.43E5
Sr-91	1.21E2	ND	4.59E0	ND	ND	5.33E4	1.74E5
Sr-92	1.31E1	ND	5.25E-1	ND	ND	2.40E4	2.42E5
Y-90	4.11E3	ND	1.11E2	ND	ND	2.62E5	2.68E5

TABLE 4 (Cont'd.)

DOSE PARAMETER (P_i) FOR RADIONUCLIDES OTHER THAN NOBLE GASES[a]

Inhalation Pathway

(mrem/yr) per ($\mu Ci/m^3$)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Y-91m	5.07E-1	ND	1.84E-2	ND	ND	2.81E3	1.72E3
Y-91	9.14E5	ND	2.44E4	ND	ND	2.63E6	1.84E5
Y-92	2.04E1	ND	5.81E-1	ND	ND	2.39E4	2.39E5
Y-93	1.86E2	ND	5.11E0	ND	ND	7.44E4	3.89E5
Zr-95	1.90E5	4.18E4	3.70E4	ND	5.96E4	2.23E6	6.1[illegible]4
Zr-97	1.88E2	2.72E1	1.60E1	ND	3.89E1	1.13E5	3.51E5
Nb-95	2.33E4	9.18E3	6.55E3	ND	8.62E3	6.14E5	3.70E4
Mo-99	ND	1.72E2	4.26E1	ND	3.92E2	1.35E5	1.27E5
Tc-99m	1.78E-3	3.48E-3	5.77E-2	ND	5.07E-2	9.51E2	4.81E3
Tc-101	8.10E-5	8.51E-5	1.08E-3	ND	1.45E-3	5.85E2	1.63E1
Ru-103	2.79E3	ND	1.07E3	ND	7.03E3	6.62E5	4.48E4
Ru-105	1.53E0	ND	5.55E-1	ND	1.34E0	1.59E4	9.95E4
Ru-106	1.36E5	ND	1.69E4	ND	1.84E5	1.43E7	4.29E5
Ag-110m	1.69E4	1.14E4	9.14E3	ND	2.12E4	5.48E6	1.00E5
Cd-109	ND	5.48E5	2.59E4	ND	4.96E5	1.05E6	2.78E4
Sn-113	1.13E5	3.12E3	8.62E3	2.33E3	ND	1.46E6	2.26E5
Sb-124	5.74E4	7.40E2	2.00E4	1.26E2	ND	3.24E6	1.64E5
Sb-125	9.84E4	7.59E2	2.07E4	9.10E1	ND	2.32E6	4.03E4
Te-125m	6.73E3	2.33E3	9.14E2	1.92E3	ND	4.77E5	3.38E4
Te-127m	2.49E4	8.55E3	3.02E3	6.07E3	6.36E4	1.48E6	7.14E4
Te-127	2.77E0	9.51E-1	6.11E-1	1.96E0	7.07E0	1.00E4	5.62E4
Te-129m	1.92E4	6.85E3	3.04E3	6.33E3	5.03E4	1.76E6	1.82E5
Te-129	9.77E-2	3.50E-2	2.38E-2	7.14E-2	2.57E-1	2.93E3	2.55E4
Te-131m	1.34E2	5.92E1	5.07E1	9.77E1	4.00E2	2.06E5	3.08E5
Te-131	2.17E-2	8.44E-3	6.59E-3	1.70E-2	5.88E-2	2.05E3	1.33E3
Te-132	4.81E2	2.72E2	2.63E2	3.17E2	1.77E3	3.77E5	1.38E5
I-130	8.18E3	1.64E4	8.44E3	1.85E6	2.45E4	ND	5.11E3
I-131	4.81E4	4.81E4	2.73E4	1.62E7	7.88E4	ND	2.84E3
I-132	2.12E3	4.07E3	1.88E3	1.94E5	6.25E3	ND	3.20E3
I-133	1.66E4	2.03E4	7.70E3	3.85E6	3.38E4	ND	5.48E3
I-134	1.17E3	2.16E3	9.95E2	5.07E4	3.30E3	ND	9.55E2
I-135	4.92E3	8.73E3	4.14E3	7.92E5	1.34E4	ND	4.44E3

TABLE 4 (Cont'd.)

DOSE PARAMETER (P_i) FOR RADIONUCLIDES OTHER THAN NOBLE GASES[a]

Inhalation Pathway

(mrem/yr) per ($\mu Ci/m^3$)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Cs-134	6.51E5	1.01E6	2.25E5	ND	3.03E5	1.21E5	3.85E3
Cs-136	6.51E4	1.71E5	1.16E5	ND	9.55E4	1.45E4	4.18E3
Cs-137	9.07E5	8.25E5	1.28E5	ND	2.72E5	1.04E5	3.62E3
Cs-138	6.33E2	8.40E2	5.55E2	ND	6.22E2	6.81E1	2.70E2
Ba-139	1.84E0	9.84E-4	5.37E-2	ND	8.62E-4	5.77E3	5.77E4
Ba-140	7.40E4	6.48E1	4.33E3	ND	2.11E1	1.74E6	1.02E5
Ba-141	2.19E-1	1.09E-4	6.36E-3	ND	9.47E-5	2.92E3	2.75E2
Ba-142	5.00E-2	3.60E-5	2.79E-3	ND	2.91E-5	1.64E3	2.74E0
La-140	6.44E2	2.25E2	7.55E1	ND	ND	1.83E5	2.26E5
La-142	1.30E0	4.11E-1	1.29E-1	ND	ND	8.70E3	7.59E4
Ce-141	3.92E4	1.95E4	2.90E3	ND	8.55E3	5.44E5	5.66E4
Ce-143	3.66E2	1.99E2	2.87E1	ND	8.36E1	1.15E5	1.27E5
Ce-144	6.77E6	2.12E6	3.61E5	ND	1.17E6	1.20E7	3.89E5
Pr-143	1.85E4	5.55E3	9.14E2	ND	3.00E3	4.33E5	9.73E4
Pr-144	5.96E-2	1.85E-2	3.00E-3	ND	9.77E-3	1.57E3	1.97E2
Nd-147	1.08E4	8.73E3	6.81E2	ND	4.81E3	3.28E5	8.21E4
Eu-154	1.01E7	9.21E5	8.40E5	ND	4.03E6	6.14E6	1.10E5
Hf-181	2.78E4	1.01E5	1.25E4	ND	2.05E4	1.06E6	6.62E4
W-187	1.63E1	9.66E0	4.33E0	ND	ND	4.11E4	9.10E4
Np-239	4.66E2	3.34E1	2.35E1	ND	9.73E1	5.81E4	6.40E4

(a) The child age group; refer to reference 11.14.5.

3.5.2 Dose Due To Gaseous Effluents

41858 3.5.2.1 REC Section 9.7.1.1
4160

The air dose due to noble gases released in gaseous effluents, to areas at and beyond the SITE BOUNDARY shall be limited to the following:

a. During any calendar quarter: Less than or equal to 5 mrad for gamma radiation and less than or equal to 10 mrad for beta radiation and,

b. During any calendar year: Less than or equal to 10 mrad for gamma radiation and less than or equal to 20 mrad for beta radiation.

3.5.2.1.1 Noble Gases

The air dose at the SITE BOUNDARY due to noble gases released from the site is calculated according to the following methodology (Ref. 11.8.9):

During any calendar quarter, for gamma radiation:

$$\gamma_g = 3.17E\text{-}08 \sum_i [M_i \{(\overline{X/Q})\ Q_i + (X/q)\ q_i\}] \leq 5 \text{ mrad} \qquad (3.9)$$

During any calendar quarter, for beta radiation:

$$D_b = 3.17E\text{-}08 \sum_i [N_i \{(\overline{X/Q})\ Q_i + (X/q)\ q_i\}] \leq 10 \text{ mrad} \qquad (3.10)$$

During any calendar year, for gamma radiation:

$$D_g = 3.17E\text{-}08 \sum_i [M_i \{(\overline{X/Q})\ Q_i + (X/q)\ q_i\}] \leq 10 \text{ mrad} \qquad (3.11)$$

During any calendar year, for beta radiation:

$$D_b = 3.17E\text{-}08 \sum_i [N_i \{(\overline{X/Q})\ Q_i + (X/q)\ q_i\}] \leq 20 \text{ mrad} \qquad (3.12)$$

Where:

D_g = Air dose from gamma radiation due to noble gases released in gaseous effluent.

D_b = Air dose from beta radiation due to noble gases released in gaseous effluents.

(X/q) = The relative concentration for areas at or beyond the SITE BOUNDARY for short-term releases (equal to or less than 500 hrs/year). Refer to Tables 9, 10, 11, and 12.

q_i = The average release of noble gas radionuclides, i, in gaseous effluents from all vent releases for short-term releases (equal to or less than 500 hrs/year), in (μCi). Releases are cumulative over the calendar quarter or year, as appropriate.

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

Q_i = The average release of noble gas radionuclides, i, in gaseous effluents from all vent releases for long-term releases (greater than 500 hrs/year), in (μCi). Releases are cumulative over the calendar quarter or year, as appropriate.

$(\overline{X/Q})$ = The highest calculated annual average relative concentration for areas at or beyond the SITE BOUNDARY for long-term releases (greater than 500 hrs/yr). Refer to Tables 9, 10, and 12.

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

M_i is as previously defined. (Refer to Section 3.4.1.2)

41860 3.5.2.2 REC Section 9.8.1.1
4160

The dose to a MEMBER OF THE PUBLIC from Iodine-131 and 133, tritium, and all radionuclides in particulate form with half-lives greater than 8 days in gaseous effluents released, to areas at and beyond the SITE BOUNDARY shall be limited to the following (Ref. 11.8.9):

a. During any calendar quarter: Less than or equal to 7.5 mrem to any organ and,

b. During any calendar year: Less than or equal to 15 mrem to any organ.

3.5.2.2.1 Radionuclides Other Than Noble Gases

The dose to a MEMBER OF THE PUBLIC from Iodine-131 and 133, tritium, and all radionuclides in particulate form with half-lives greater than 8 days in gaseous effluents released, to areas at and beyond the SITE BOUNDARY, is calculated according to the following expressions:

During any calendar quarter:

$$D_i = 3.17E\text{-}08 \sum_i R_i [W Q_i + w q_i] \leq 7.5 \text{ mrem} \quad (3.13)$$

During any calendar year:

$$D_i = 3.17E\text{-}08 \sum_i R_i [W Q_i + w q_i] \leq 15 \text{ mrem} \quad (3.14)$$

Where:

D_i = Dose to a MEMBER OF THE PUBLIC from radionuclides other than noble gases.

Q_i = The releases of radioiodines, radioactive materials in particulate form, and radionuclides other than noble gases, i, in gaseous effluents, for all long-term vent releases (greater than 500 hrs/yr), in (μCi). Releases are cumulative over the calendar quarter or year as appropriate.

q_i = The releases of radioiodines, radioactive materials in particulate form and radionuclides other than noble gases, i, in gaseous effluents for all short-term vent releases (equal to or less than 500 hrs/yr), in (μCi). Releases are cumulative over the calendar quarter or year as appropriate.

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). (Table 5)

W = The dispersion parameter for estimating the dose to an individual at the controlling location for long-term releases (greater than 500 hrs/yr):

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

W = $(\overline{D/Q})$ for the food and ground plane pathways, in(meters^{-2}).
Refer to Tables 9, 10, and 12.

w = The dispersion parameter for estimating the dose to an individual at the controlling location for short-term releases (equal to or less than 500 hrs/yr):

w = (X/q) for the inhalation pathway, in (sec/m^3)

w = (D/q) for the food and ground plane pathway, in ($meters^{-2}$). Refer to Tables 9, 10, 11, and 12.

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

$(\overline{D/Q})$ = the average relative deposition of the effluent at or beyond the SITE BOUNDARY, considering depletion of the plume during transport, for long term releases (greater than 500 hrs/yr), in ($meters^{-2}$).

(D/q) = the relative deposition of the effluent at or beyond the SITE BOUNDARY, considering depletion of the plume during transport, for short term releases (less than or equal to 500 hrs/yr), in ($meters^{-2}$).

Note: For the direction sectors with existing pathways within 5 miles from the site, the appropriate R_i values are used. If no real pathway exists within 5 miles from the center of the building complex, the cow-milk R_i value is used, and it is assumed that this pathway exists at the 4.5 to 5.0 mile distance in the limiting-case sector. If the R_i for an existing pathway within 5 miles is less than a cow-milk R_i at 4.5 to 5.0 miles, then the value of the cow-milk R_i at 4.5 to 5.0 miles is used. (Rev. 9.8.10.)

Although the annual average relative concentration (X/Q) and the average relative deposition rate (D/Q) are generally considered to be at the approximate receptor location in lieu of the SITE BOUNDARY for these calculations, it is acceptable to consider the ingestion, inhalation, and ground plane pathways to coexist at the location of the nearest residence with the highest value of (X/Q). (Ref. 11.8.9) The Total Body dose from ground plane deposition is added to the dose for each individual organ. (Ref. 11.11.3)

The cumulative critical organ doses for a monthly, quarterly or annual evaluation are based on the calculated dose contribution from each specified time period occurring during the reporting period.

TABLE 5

PATHWAY DOSE FACTORS (R_i) FOR RADIONUCLIDES OTHER THAN NOBLE GASES[a]

Inhalation Pathway

(mrem/yr) per ($\mu Ci/m^3$)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
H-3	ND	1.12E3	1.12E3	1.12E3	1.12E3	1.12E3	1.12E3
Be-7	8.47E2	1.44E3	9.25E2	ND	ND	6.48E4	2.55E3
C-14	3.59E4	6.73E3	6.73E3	6.73E3	6.73E3	6.73E3	6.73E3
Na-24	1.61E4	1.61E4	1.61E4	1.61E4	1.61E4	1.61E4	1.61E4
P-32	2.60E6	1.14E5	9.88E4	ND	ND	ND	4.22E4
Cr-51	ND	ND	1.54E2	8.55E1	2.43E1	1.70E4	1.08E3
Mn-54	ND	4.29E4	9.51E3	ND	1.00E4	1.58E6	2.29E4
Mn-56	ND	1.66E0	3.12E-1	ND	1.67E0	1.31E4	1.23E5
Fe-55	4.74E4	2.52E4	7.72E3	ND	ND	1.11E5	2.87E3
Fe-59	2.07E4	3.34E4	1.67E4	ND	ND	1.27E6	7.07E4
Co-57	ND	9.03E2	1.07E3	ND	ND	5.07E5	1.32E4
Co-58	ND	1.77E3	3.16E3	ND	ND	1.11E6	3.44E4
Co-60	ND	1.31E4	2.26E4	ND	ND	7.07E6	9.26E4
Ni-63	8.21E5	4.63E4	2.80E4	ND	ND	2.75E5	6.33E3
Ni-65	2.99E0	2.96E-1	1.64E-1	ND	ND	8.18E3	8.40E4
Cu-64	ND	1.99E0	1.07E0	ND	6.03E0	9.58E3	3.67E4
Zn-65	4.26E4	1.13E5	7.03E4	ND	7.14E4	9.95E5	1.63E4
Zn-69	6.70E-2	9.66E-2	8.92E-3	ND	5.85E-2	1.42E3	1.02E4
Br-82	ND	ND	2.09E4	ND	ND	ND	ND
Br-83	ND	ND	4.74E2	ND	ND	ND	0
Br-84	ND	ND	5.48E2	ND	ND	ND	0
Br-85	ND	ND	2.53E1	ND	ND	ND	0
Rb-86	ND	1.98E5	1.14E5	ND	ND	ND	7.99E3
Rb-88	ND	5.62E2	3.66E2	ND	ND	ND	1.72E1
Rb-89	ND	3.45E2	2.90E2	ND	ND	ND	1.89E0
Sr-89	5.99E5	ND	1.72E4	ND	ND	2.16E6	1.67E5
Sr-90	1.01E8	ND	6.44E6	ND	ND	1.48E7	3.43E5
Sr-91	1.21E2	ND	4.59E0	ND	ND	5.33E4	1.74E5
Sr-92	1.31E1	ND	5.25E-1	ND	ND	2.40E4	2.42E5
Y-90	4.11E3	ND	1.11E2	ND	ND	2.62E5	2.68E5

TABLE 5 (Cont'd.)

PATHWAY DOSE FACTORS (R_i) FOR RADIONUCLIDES OTHER THAN NOBLE GASES[a]

Inhalation Pathway

(mrem/yr) per ($\mu Ci/m^3$)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Y-91m	5.07E-1	ND	1.84E-2	ND	ND	2.81E3	1.72E3
Y-91	9.14E5	ND	2.44E4	ND	ND	2.63E6	1.84E5
Y-92	2.04E1	ND	5.81E-1	ND	ND	2.39E4	2.39E5
Y-93	1.86E2	ND	5.11E0	ND	ND	7.44E4	3.89E5
Zr-95	1.90E5	4.18E4	3.70E4	ND	5.96E4	2.23E6	6.11E4
Zr-97	1.88E2	2.72E1	1.60E1	ND	3.89E1	1.13E5	3.51E5
Nb-95	2.33E4	9.18E3	6.55E3	ND	8.62E3	6.14E5	3.70E4
Mo-99	ND	1.72E2	4.26E1	ND	3.92E2	1.35E5	1.27E5
Tc-99m	1.78E-3	3.48E-3	5.77E-2	ND	5.07E-2	9.51E2	4.81E3
Tc-101	8.10E-5	[illegible]-5	1.08E-3	ND	1.45E-3	5.85E2	1.63E1
Ru-103	2.79E3	ND	1.07E3	ND	7.03E3	6.62E5	4.48E4
Ru-105	1.53E0	ND	5.55E-1	ND	1.34E0	1.59E4	9.95E4
Ru-106	1.36E5	ND	1.69E4	ND	1.84E5	1.43E7	4.29E5
Ag-110m	1.69E4	1.14E4	9.14E3	ND	2.12E4	5.48E6	1.00E5
Cd-109	ND	5.48E5	2.59E4	ND	4.96E5	1.05E6	2.78E4
Sn-113	1.13E5	3.12E3	8.62E3	2.33E3	ND	1.46E6	2.26E5
Sb-124	5.74E4	7.40E2	2.00E4	1.26E2	ND	3.24E6	1.64E5
Sb-125	9.84E4	7.59E2	2.07E4	9.10E1	ND	2.32E6	4.03E4
Te-125m	6.73E3	2.33E3	9.14E2	1.92E3	ND	4.77E5	3.38E4
Te-127m	2.49E4	8.55E3	3.02E3	6.07E3	6.36E4	1.48E6	7.14E4
Te-127	2.77E0	9.51E-1	6.11E-1	1.96E0	7.07E0	1.00E[illegible]	5.62E4
Te-129m	1.92E4	6.85E3	3.04E3	6.33E3	5.03E4	1.76E6	1.82E5
Te-129	9.77E-2	3.50E-2	2.38E-2	7.14E-2	2.57E-1	2.93E3	2.55E4
Te-131m	1.34E2	5.92E1	5.07E1	9.77E1	4.00E2	2.06E5	3.08E5
Te-131	2.17E-2	8.44E-3	6.59E-3	1.70E-2	5.88E-2	2.05E3	1.33E3
Te-132	4.81E2	2.72E2	2.63E2	3.17E2	1.77E3	3.77E5	1.38E5
I-130	8.18E3	1.64E4	8.44E3	1.85E6	2.45E4	ND	5.11E3
I-131	4.81E4	4.81E4	2.73E4	1.62E7	7.88E4	ND	2.84E3
I-132	2.12E3	4.07E3	1.88E3	1.94E5	6.25E3	ND	3.20E3
I-133	1.66E4	2.03E4	7.70E3	3.85E6	3.38E4	ND	5.48E3
I-134	1.17E3	2.16E3	9.95E2	5.07E4	3.30E3	ND	9.55E2

TABLE 5 (Cont'd.)

PATHWAY DOSE FACTORS (R_i) FOR RADIONUCLIDES OTHER THAN NOBLE GASES[a]

Inhalation Pathway

(mrem/yr) per ($\mu Ci/m^3$)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
I-135	4.92E3	8.73E3	4.14E3	7.92E5	1.34E4	ND	4.44E3
Cs-134	6.51E5	1.01E6	2.25E5	ND	3.03E5	1.21E5	3.85E3
Cs-136	6.51E4	1.71E5	1.16E5	ND	9.55E4	1.45E4	4.18E3
Cs-137	9.07E5	8.25E5	1.28E5	ND	2.72E5	1.04E5	3.62E3
Cs-138	6.33E2	8.40E2	5.55E2	ND	6.22E2	6.81E1	2.70E2
Ba-139	1.84E0	9.84E-4	5.37E-2	ND	8.62E-4	5.77E3	5.77E4
Ba-140	7.40E4	6.48E1	4.33E3	ND	2.11E1	1.74E6	1.02E5
Ba-141	2.19E-1	1.09E-4	6.36E-3	ND	9.47E-5	2.92E3	2.75E2
Ba-142	5.00E-2	3.60E-5	2.79E-3	ND	2.91E-5	1.64E3	2.74E0
La-140	6.44E2	2.25E2	7.55E1	ND	ND	1.83E5	2.26E5
La-142	1.30E0	4.11E-1	1.29E-1	ND	ND	8.70E3	7.59E4
Ce-141	3.92E4	1.95E4	2.90E3	ND	8.55E3	5.44E5	5.66E4
Ce-143	3.66E2	1.99E2	2.87E1	ND	8.36E1	1.15E5	1.27E5
Ce-144	6.77E6	2.12E6	3.61E5	ND	1.17E6	1.20E7	3.89E5
Pr-143	1.85E4	5.55E3	9.14E2	ND	3.00E3	4.33E5	9.73E4
Pr-144	5.96E-2	1.85E-2	3.00E-3	ND	9.77E-3	1.57E3	1.97E2
Nd-147	1.08E4	8.73E3	6.81E2	ND	4.81E3	3.28E5	8.21E4
Eu-154	1.01E7	1.21E5	8.40E5	ND	4.03E6	6.14E6	1.10E5
Hf-181	2.78E4	1.01E5	1.25E4	ND	2.05E4	1.06E6	6.62E4
W-187	1.63E1	9.66E0	4.33E0	ND	ND	4.11E4	9.10E4
Np-239	4.66E2	3.34E1	2.35E1	ND	9.73E1	5.81E4	6.40E4

(a) The child age group; refer to reference 11.14.5.

TABLE 5 (Cont'd.)

PATHWAY DOSE FACTORS (R_i) FOR RADIONUCLIDES OTHER THAN NOBLE GASES[a]

Ground Plane Pathway

(m^2 mrem/yr) per (μCi/sec)

Nuclide	Total Body	Skin
Be-7	2.24E7	3.21E7
Na-24	1.19E7	1.39E7
Cr-51	4.83E6	5.51E6
Mn-54	1.3[illegible]9	1.63E9
Mn-56	9.03E5	1.07E6
Fe-59	2.72E8	3.20E8
Co-57	2.98E8	4.37E8
Co-58	3.79E8	4.44E8
Co-60	2.15E10	2.53E10
Ni-65	2.97E5	3.45E5
Cu-64	6.07E5	6.88E5
Zn-65	7.47E8	8.59E8
Br-82	3.14E7	4.49E7
Br-83	4.87E3	7.08E3
Br-84	2.03E5	2.36E5
Rb-86	8.99E6	1.03E7
Rb-88	3.31E4	3.78E4
Rb-89	1.23E5	1.48E5
Sr-89	2.16E4	2.51E4
Sr-91	2.15E6	2.51E6
Sr-92	7.77E5	8.63E5
Y-90	4.49E3	5.31E3
Y-91m	1.00E5	1.16E5
Y-91	1.07E6	1.21E6
Y-92	1.80E5	2.14E5
Y-93	1.83E5	2.51E5
Zr-95	2.45E8	2.84E8
Zr-97	2.96E6	3.44E6
Nb-95	1.37E8	1.61E8
Mo-99	3.98E6	4.62E6

TABLE 5 (Cont'd.)

PATHWAY DOSE FACTORS (R_i) FOR RADIONUCLIDES OTHER THAN NOBLE GASES[a]

Ground Plane Pathway

(m^2 mrem/yr) per (μCi/sec)

Nuclide	Total Body	Skin
Tc-99m	1.84E5	2.11E5
Tc-101	2.04E4	2.26E4
Ru-103	1.08E8	1.26E8
Ru-105	6.36E5	7.21E5
Ru-106	4.22E8	5.07E8
Ag-110m	3.44E9	4.01E9
Cd-109	3.76E7	1.54E8
Sn-113	1.43E7	4.09E7
Sb-124	8.74E8	1.23E9
Sb-125	3.57E9	5.19E9
Te-125m	1.55E6	2.15E6
Te-127m	9.16E4	1.08E5
Te-127	2.98E3	3.28E3
Te-129m	1.98E7	2.31E7
Te-129	2.62E4	3.10E4
Te-131m	8.03E6	9.46E6
Te-131	2.92E4	3.45E4
Te-132	4.23E6	4.98E6
I-130	5.51E6	6.69E6
I-131	1.72E7	2.09E7
I-132	1.23E6	1.45E6
I-133	2.45E6	2.98E6
I-134	4.17E5	5.30E5
I-135	2.51E6	2.93E6
Cs-134	6.86E9	8.00E9
Cs-136	1.53E8	1.74E8
Cs-137	1.03E10	1.20E10
Cs-138	3.59E5	4.10E5
Ba-139	1.06E5	1.19E5
Ba-140	2.05E7	2.35E7

TABLE 5 (Cont'd.)

PATHWAY DOSE FACTORS (R_i) FOR RADIONUCLIDES OTHER THAN NOBLE GASES[a]

Ground Plane Pathway

(m^2 mrem/yr) per (μCi/sec)

Nuclide	Total Body	Skin
Ba-141	4.15E4	4.73E4
Ba-142	4.44E4	5.06E4
La-140	1.92E7	2.18E7
La-142	7.40E5	8.89E5
Ce-141	1.37E7	1.54E7
Ce-143	2.31E6	2.63E6
Ce-144	6.96E7	8.04E7
Pr-144	1.84E3	2.11E3
Nd-147	8.41E6	1.01E7
Eu-154	2.21E10	3.15E10
Hf-181	1.97E8	2.82E8
W-187	2.36E6	2.74E6
Np-239	1.71E6	1.98E6

(a) Refer to reference 11.14.5 for calculational details.

TABLE 5 (Cont'd.)

PATHWAY DOSE FACTORS (R_i) FOR RADIONUCLIDES OTHER THAN NOBLE GASES[a]

Meat Pathway

(m^2 mrem/yr) per (μCi/sec)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
H-3	ND	2.34E2	2.34E2	2.34E2	2.34E2	2.34E2	2.34E2
Be-7	7.37E3	1.26E4	8.06E3	ND	1.23E4	ND	7.00E5
C-14	3.83E8	7.67E7	7.67E7	7.67E7	7.67E7	7.67E7	7.67E7
Na-24	1.78E-3	1.78E-3	1.78E-3	1.78E-3	1.78E-3	1.78E-3	1.78E-3
P-32	7.41E9	3.47E8	2.86E8	ND	ND	ND	2.05E8
Cr-51	ND	ND	8.79E3	4.88E3	1.33E3	8.91E3	4.66E5
Mn-54	ND	8.01E6	2.13E6	ND	2.25E6	ND	6.72E6
Mn-56	ND	0	0	ND	0	ND	0
Fe-55	4.57E8	2.42E8	7.51E7	ND	ND	1.37E8	4.49E7
Fe-59	3.76E8	6.09E8	3.03E8	ND	ND	1.76E8	6.34E8
Co-57	ND	5.92E6	1.20E7	ND	ND	ND	4.85E7
Co-58	ND	1.54E7	5.02E7	ND	ND	ND	9.58E7
Co-60	ND	6.93E7	2.04E8	ND	ND	ND	3.84E8
Ni-63	2.91E10	1.56E9	9.91E8	ND	ND	ND	1.05E8
Ni-65	0	0	0	ND	ND	ND	0
Cu-64	ND	2.97E-7	1.79E-7	ND	7.17E-7	ND	1.39E-5
Zn-65	3.75E8	1.00E9	6.22E8	ND	6.30E8	ND	1.76E8
Zn-69	0	0	0	ND	0	ND	0
Br-82	ND	ND	1.52E3	ND	ND	ND	ND
Br-83	ND	ND	ND	ND	ND	ND	ND
Br-84	ND	ND	ND	ND	ND	ND	ND
Br-85	ND	ND	ND	ND	ND	ND	ND
Rb-86	ND	5.82E8	3.58E8	ND	ND	ND	3.74E7
Rb-88	ND	0	0	ND	ND	ND	0
Rb-89	ND	0	0	ND	ND	ND	0
Sr-89	4.82E8	ND	1.38E7	ND	ND	ND	1.86E7
Sr-90	1.04E10	ND	2.64E9	ND	ND	ND	1.40E8
Sr-91	2.40E-10	ND	0	ND	ND	ND	5.29E-10
Sr-92	0	ND	0	ND	ND	ND	0
Y-90	1.71E2	ND	4.59E0	ND	ND	ND	4.88E5

TABLE 5 (Cont'd.)

PATHWAY DOSE FACTORS (R_i) FOR RADIONUCLIDES OTHER THAN NOBLE GASES[a]

Meat Pathway

(m^2 mrem/yr) per (μCi/sec)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Y-91m	0	ND	0	ND	ND	ND	0
Y-91	1.30E6	ND	4.82E4	ND	ND	ND	2.40E8
Y-92	0	ND	0	ND	ND	ND	0
Y-93	0	ND	0	ND	ND	ND	1.55E-7
Zr-95	2.66E6	5.85E5	5.21E5	ND	8.38E5	ND	6.11E8
Zr-97	3.20E-5	4.63E-6	2.73E-6	ND	6.65E-6	ND	7.02E-1
Nb-95	3.09E6	1.20E6	8.61E5	ND	1.13E6	ND	2.23E9
Mo-99	ND	1.15E5	2.84E4	ND	2.46E5	ND	9.51E4
Tc-99m	0	0	0	ND	0	0	0
Tc-101	0	0	0	ND	0	0	0
Ru-103	1.55E8	ND	5.96E7	ND	3.90E8	ND	4.01E9
Ru-105	0	ND	0	ND	0	ND	0
Ru-106	4.44E9	ND	5.54E8	ND	5.99E9	ND	6.90E10
Ag-110m	8.40E6	5.67E6	4.53E6	ND	1.06E7	ND	6.75E8
Cd-109	ND	1.90E6	8.83E4	ND	1.70E6	ND	6.18E6
Sn-113	2.18E9	4.48E7	1.24E8	3.31E9	ND	ND	1.54E9
Sb-124	2.93E7	3.79E5	1.02E7	6.45E4	ND	1.62E7	1.83E8
Sb-125	2.85E7	2.20E5	5.97E6	2.64E4	ND	1.59E7	6.80E7
Te-125m	5.69E8	1.54E8	7.59E7	1.60E8	ND	ND	5.49E8
Te-127m	1.77E9	4.78E8	2.11E8	4.24E8	5.06E9	ND	1.44E9
Te-127	4.11E-10	1.11E-10	0	2.85E-10	1.17E-9	ND	1.61E-8
Te-129m	1.79E9	4.99E8	2.77E8	5.76E8	5.25E9	ND	2.18E9
Te-129	0	0	0	0	0	ND	0
Te-131m	7.00E2	2.42E2	2.58E2	4.98E2	2.34E3	ND	9.82E3
Te-131	0	0	0	0	0	ND	0
Te-132	2.09E6	9.26E5	1.12E6	1.35E6	8.60E6	ND	9.33E6
I-130	3.04E-6	6.13E-6	3.16E-6	6.76E-4	9.17E-6	ND	2.87E-6
I-131	1.66E7	1.66E7	9.46E6	5.50E9	2.73E7	ND	1.48E6
I-132	0	0	0	0	0	ND	0
I-133	6.16E-1	7.61E-1	2.88E-1	1.41E2	1.27E0	ND	3.07E-1
I-134	0	0	0	0	0	ND	0

TABLE 5 (Cont'd.)

PATHWAY DOSE FACTORS (R_i) FOR RADIONUCLIDES OTHER THAN NOBLE GASES[a]

Meat Pathway

(m^2 mrem/yr) per (μCi/sec)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
I-135	0	0	0	0	0	ND	0
Cs-134	9.22E8	1.51E9	3.19E8	ND	4.69E8	1.68E8	8.16E6
Cs-136	1.61E7	4.43E7	2.86E7	ND	2.36E7	3.51E6	1.56E6
Cs-137	1.33E9	1.28E9	1.88E8	ND	4.16E8	1.50E8	7.99E6
Cs-138	0	0	0	ND	0	0	0
Ba-139	0	0	0	ND	0	0	0
Ba-140	4.38E7	3.84E4	2.56E6	ND	1.25E4	2.29E4	2.22E7
Ba-141	0	0	0	ND	0	0	0
Ba-142	0	0	0	ND	0	0	0
La-140	5.69E-2	1.99E-2	6.70E-3	ND	ND	ND	5.54E2
La-142	0	0	0	ND	ND	ND	0
Ce-141	2.22E4	1.11E4	1.64E3	ND	4.85E3	ND	1.38E7
Ce-143	3.17E-2	1.72E1	2.49E-3	ND	7.21E-3	ND	2.52E2
Ce-144	2.32E6	7.26E5	1.24E5	ND	4.02E5	ND	1.89E8
Pr-143	3.35E4	1.00E4	1.66E3	ND	5.44E3	ND	3.61E7
Pr-144	0	0	0	ND	0	ND	0
Nd-147	1.17E4	9.50E3	7.35E2	ND	5.21E3	ND	1.50E7
Eu-154	1.12E7	1.01E6	9.20E5	ND	4.42E6	ND	2.34E8
Hf-181	4.76E6	1.73E7	2.15E6	ND	3.52E6	ND	6.40E9
W-187	3.35E-2	1.98E-2	8.91E-3	ND	ND	ND	2.79E0
Np-239	4.20E-1	3.02E-2	2.12E-2	ND	8.72E-2	ND	2.23E3

(a) The child age group; refer to reference 11.14.5.

TABLE 5 (Cont'd.)

PATHWAY DOSE FACTORS (R_i) FOR RADIONUCLIDES OTHER THAN NOBLE GASES[a]

Grass-Cow-Milk Pathway

(m^2 mrem/yr) per (μCi/sec)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
H-3	ND	1.57E3	1.57E3	1.57E3	1.57E3	1.57E3	1.57E3
Be-7	7.49E3	1.28E4	8.19E3	ND	1.25E4	ND	7.11E5
C-14	1.19E9	2.39E8	2.39E8	2.39E8	2.39E8	2.39E8	2.39E8
Na-24	8.89E6	8.89E6	8.89E6	8.89E6	8.89E6	8.89E6	8.89E6
P-32	7.77E10	3.64E9	3.00E9	ND	ND	ND	2.15E9
Cr-51	ND	ND	1.03E5	5.65E4	1.56E4	1.04E5	5.40E6
Mn-54	ND	2.10E7	5.59E6	ND	5.88E6	ND	1.76E7
Mn-56	ND	1.29E-2	2.90E-3	ND	1.56E-2	ND	1.86E0
Fe-55	1.12E8	5.93E7	1.84E7	ND	ND	3.35E7	1.10E7
Fe-59	1.20E8	1.94E8	9.69E7	ND	ND	5.64E7	2.02E8
Co-57	ND	3.84E6	7.76E6	ND	ND	ND	3.15E7
Co-58	ND	1.21E7	3.71E7	ND	ND	ND	7.07E7
Co-60	ND	4.32E7	1.27E8	ND	ND	ND	2.39E8
Ni-63	2.96E10	1.59E9	1.01E9	ND	ND	ND	1.07E8
Ni-65	1.66E0	1.56E-1	9.01E-2	ND	ND	ND	1.91E1
Cu-64	ND	7.46E4	4.51E4	ND	1.80E5	ND	3.50E6
Zn-65	4.13E9	1.10E10	6.85E9	ND	6.94E9	ND	1.93E9
Zn-69	0	0	0	ND	0	ND	1.12E-9
Br-82	ND	ND	1.15E8	ND	ND	ND	ND
Br-83	ND	ND	ND	ND	ND	ND	ND
Br-84	ND	ND	ND	ND	ND	ND	ND
Br-85	ND	ND	ND	ND	ND	ND	ND
Rb-86	ND	8.80E9	5.41E9	ND	ND	ND	5.66E8
Rb-88	ND	0	0	ND	ND	ND	0
Rb-89	ND	0	0	ND	ND	ND	0
Sr-89	6.62E9	ND	1.89E8	ND	ND	ND	2.56E8
Sr-90	1.12E11	ND	2.83E10	ND	ND	ND	1.51E9
Sr-91	1.30E5	ND	4.92E3	ND	ND	ND	2.88E5
Sr-92	2.18E0	ND	8.75E-2	ND	ND	ND	4.13E1
Y-90	3.22E2	ND	8.62E0	ND	ND	ND	9.17E5

TABLE 5 (Cont'd.)

PATHWAY DOSE FACTORS (R_i) FOR RADIONUCLIDES OTHER THAN NOBLE GASES[a]

Grass-Cow-Milk Pathway

(m^2 mrem/yr) per (μCi/sec)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Y-91m	0	ND	0	ND	ND	ND	0
Y-91	3.90E4	ND	1.04E3	ND	ND	ND	5.20E6
Y-92	2.53E-4	ND	7.24E-6	ND	ND	ND	7.31E0
Y-93	1.05E0	ND	2.90E-2	ND	ND	ND	1.57E4
Zr-95	3.83E3	8.42E2	7.50E2	ND	1.21E3	ND	8.79E5
Zr-97	1.92E0	2.77E-1	1.64E-1	ND	3.98E-1	ND	4.20E4
Nb-95	3.18E5	1.24E5	8.84E4	ND	1.16E5	ND	2.29E8
Mo-99	ND	8.14E7	2.01E7	ND	1.74E8	ND	6.73E7
Tc-99m	1.32E1	2.59E1	4.29E2	ND	3.76E2	1.32E1	1.47E4
Tc-101	0	0	0	ND	0	0	0
Ru-103	4.28E3	ND	1.65E3	ND	1.08E4	ND	1.11E5
Ru-105	3.82E-3	ND	1.39E-3	ND	3.36E-2	ND	2.49E0
Ru-106	9.24E4	ND	1.15E4	ND	1.25E5	ND	1.44E6
Ag-110m	2.09E8	1.41E8	1.13E8	ND	2.63E8	ND	1.68E10
Cd-109	ND	3.86E6	1.79E5	ND	3.45E6	ND	1.25E7
Sn-113	6.10E8	1.25E7	3.48E7	9.27E8	ND	ND	4.31E8
Sb-124	1.08E8	1.41E6	3.81E7	2.40E5	ND	6.03E7	6.79E8
Sb-125	8.70E7	6.71E5	1.83E7	8.06E4	ND	4.85E7	2.08E8
Te-125m	7.38E7	2.00E7	9.84E6	2.07E7	ND	ND	7.12E7
Te-127m	2.08E8	5.60E7	2.47E7	4.97E7	5.93E8	ND	1.68E8
Te-127	3.05E3	8.22E2	6.54E2	2.11E3	8.67E3	ND	1.19E5
Te-129m	2.71E8	7.57E7	4.21E7	8.74E7	7.96E8	ND	3.31E8
Te-129	0	0	0	0	2.90E-9	ND	6.17E-8
Te-131m	1.60E6	5.53E5	5.89E5	1.14E6	5.35E6	ND	2.24E7
Te-131	0	0	0	0	0	ND	0
Te-132	1.02E7	4.52E6	5.46E6	6.58E6	4.20E7	ND	4.55E7
I-130	1.73E6	3.49E6	1.80E6	3.84E8	5.22E6	ND	1.63E6
I-131	1.30E9	1.31E9	7.45E8	4.33E11	2.15E9	ND	1.17E8
I-132	6.02E-1	1.11E0	5.08E-1	5.13E1	1.69E0	ND	1.30E0
I-133	1.74E7	2.15E7	8.13E6	3.99E9	3.58E7	ND	8.66E6
I-134	0	0	0	0	0	ND	0

TABLE 5 (Cont'd.)

PATHWAY DOSE FACTORS (R_i) FOR RADIONUCLIDES OTHER THAN NOBLE GASES[a]

Grass-Cow-Milk Pathway

(m^2 mrem/yr) per (μCi/sec)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
I-135	5.40E4	9.72E4	4.60E4	8.61E6	1.49E5	ND	7.40E4
Cs-134	2.26E10	3.72E10	7.84E9	ND	1.15E10	4.13E9	2.00E8
Cs-136	1.01E9	2.77E9	1.79E9	ND	1.48E9	2.20E8	9.74E7
Cs-137	3.22E10	3.09E10	4.56E9	ND	1.01E10	3.62E9	1.93E8
Cs-138	0	0	0	ND	0	0	0
Ba-139	1.89E-7	0	5.48E-9	ND	0	0	1.09E-5
Ba-140	1.17E8	1.03E5	6.84E6	ND	3.34E4	6.12E4	5.93E7
Ba-141	0	0	0	ND	0	0	0
Ba-142	0	0	0	ND	0	0	0
La-140	1.95E1	6.80E0	2.29E0	ND	ND	ND	1.90E5
La-142	0	0	0	ND	ND	ND	2.90E-6
Ce-141	2.19E4	1.09E4	1.62E3	ND	4.78E3	ND	1.36E7
Ce-143	1.87E2	1.02E5	1.47E1	ND	4.26E1	ND	1.49E6
Ce-144	1.62E6	5.09E5	8.66E4	ND	2.82E5	ND	1.33E8
Pr-143	7.19E2	2.16E2	3.57E1	ND	1.17E2	ND	7.75E5
Pr-144	0	0	0	ND	0	ND	0
Nd-147	4.45E2	3.61E2	2.79E1	ND	1.98E2	ND	5.71E5
Eu-154	9.41E4	8.47E3	7.73E3	ND	3.72E4	ND	1.97E6
Hf-181	6.43E2	2.35E3	2.90E2	ND	4.75E2	ND	8.65E5
W-187	2.91E4	1.73E4	7.73E3	ND	ND	ND	2.42E6
Np-239	1.72E1	1.23E0	8.68E-1	ND	3.57E0	ND	9.14E4

(a) The child age group; refer to reference 11.14.5.

TABLE 5 (Contd.)

PATHWAY DOSE FACTORS (R_i) FOR RADIONUCLIDES OTHER THAN NOBLE GASES [a]

Grass-Goat-Milk Pathway

(m^2 mrem/yr) per (μCi/sec)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
H-3	ND	3.20E3	3.20E3	3.20E3	3.20E3	3.20E3	3.20E3
Be-7	8.98E2	1.53E3	9.82E2	ND	1.50E3	ND	8.53E4
C-14	1.19E9	2.39E8	2.39E8	2.39E8	2.39E8	2.39E8	2.39E8
Na-24	1.07E6	1.07E6	1.07E6	1.07E6	1.07E6	1.07E6	1.07E6
P-32	9.33E10	4.37E9	3.60E9	ND	ND	ND	2.58E9
Cr-51	ND	ND	1.23E4	6.78E3	1.87E3	1.25E4	6.48E5
Mn-54	ND	2.52E6	6.70E5	ND	7.06E5	ND	2.11E6
Mn-56	ND	1.54E-3	3.49E-4	ND	1.87E-3	ND	2.24E-1
Fe-55	1.45E6	7.71E5	2.39E5	ND	ND	4.36E5	1.43E5
Fe-59	1.56E6	2.53E6	1.26E6	ND	ND	7.33E5	2.63E6
Co-57	ND	4.60E5	9.31E5	ND	ND	ND	3.77E6
Co-58	ND	1.45E6	4.45E6	ND	ND	ND	8.49E6
Co-60	ND	5.18E6	1.53E7	ND	ND	ND	2.87E7
Ni-63	3.56E9	1.90E8	1.21E8	ND	ND	ND	1.28E7
Ni-65	1.99E-1	1.87E-2	1.09E-2	ND	ND	ND	2.29E0
Cu-64	ND	8.31E3	5.02E3	ND	2.01E4	ND	3.90E5
Zn-65	4.96E8	1.32E9	8.22E8	ND	8.33E8	ND	2.32E8
Zn-69	0	0	0	ND	0	ND	1.35E-10
Br-82	ND	ND	1.38E7	ND	ND	ND	ND
Br-83	ND	ND	ND	ND	ND	ND	ND
Br-84	ND	ND	ND	ND	ND	ND	ND
Br-85	ND	ND	ND	ND	ND	ND	ND
Rb-86	ND	1.06E9	6.50E8	ND	ND	ND	6.80E7
Rb-88	ND	0	0	ND	ND	ND	0
Rb-89	ND	0	0	ND	ND	ND	0
Sr-89	1.39E10	ND	3.97E8	ND	ND	ND	5.38E8
Sr-90	2.35E11	ND	5.95E10	ND	ND	ND	3.16E9
Sr-91	2.74E5	ND	1.13E4	ND	ND	ND	6.04E5

TABLE 5 (Contd.)

PATHWAY DOSE FACTORS (R_i) FOR RADIONUCLIDES OTHER THAN NOBLE GASES [a]

Grass-Goat-Milk Pathway

(m^2 mrem/yr) per (μCi/sec)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Sr-92	4.58E0	ND	1.84E-1	ND	ND	ND	8.68E1
Y-90	3.87E1	ND	1.03E0	ND	ND	ND	1.10E5
Y-91m	0	ND	0	ND	ND	ND	0
Y-91	4.68E3	ND	1.25E2	ND	ND	ND	6.24E-5
Y-92	3.04E-5	ND	8.69E-7	ND	ND	ND	8.77E-1
Y-93	1.27E-1	ND	3.48E-3	ND	ND	ND	1.89E3
Zr-95	4.60E2	1.01E2	9.00E1	ND	1.45E[illegible]	ND	1.05E5
Zr-97	2.30E-1	3.33E-2	1.96E-2	ND	4.78E-2	ND	5.04E3
Nb-95	3.81E4	1.48E4	1.06E4	ND	1.39E4	ND	2.75E7
Mo-99	ND	9.76E6	2.42E6	ND	2.09E7	ND	8.08E6
Tc-99m	1.59E0	3.11E0	5.15E1	ND	4.52E1	1.58E0	1.77E3
Tc-101	0	0	0	ND	0	0	0
Ru-103	5.14E2	ND	1.98E2	ND	1.29E3	ND	1.33E4
Ru-105	4.58E-4	ND	1.66E-4	ND	4.03E-3	ND	2.99E-1
Ru-106	1.11E4	ND	1.38E3	ND	1.50E4	ND	1.72E5
Ag-110m	2.51E7	1.69E7	1.35E7	ND	3.15E7	ND	2.01E9
Cd-109	ND	4.63E5	2.15E4	ND	4.13E5	ND	1.50E6
Sn-113	7.32E7	1.50E6	4.17E6	1.11E8	ND	ND	5.17E7
Sb-124	1.30E7	1.69E5	4.56E6	2.87E4	ND	7.22E6	8.14E7
Sb-125	1.04E7	8.04E4	2.19E6	9.66E3	ND	5.81E6	2.49E7
Te-125m	8.85E6	2.40E6	1.18E6	2.48E6	ND	ND	8.54E6
Te-127m	2.50E7	6.72E6	2.96E6	5.97E6	7.12E7	ND	2.02E7
Te-127	3.66E2	9.86E1	7.85E1	2.53E2	1.04E3	ND	1.43E4
Te-129m	3.25E7	9.09E6	5.05E6	1.05E7	9.55E7	ND	3.97E7
Te-129	0	0	0	0	0	ND	7.40E-9
Te-131m	1.92E5	6.64E4	7.07E4	1[illegible]7E5	6.43E5	ND	2.69E6
Te-131	0	0	0	0	0	ND	0
Te-132	1.23E6	5.42E5	6.55E5	7.90E5	5.04E6	ND	5.46E6
I-130	2.07E6	4.19E6	2.16E6	4.61E8	6.26E6	ND	1.96E6

TABLE 5 (Contd.)

PATHWAY DOSE FACTORS (R_i) FOR RADIONUCLIDES OTHER THAN NOBLE GASES[a]

Grass-Goat-Milk Pathway

(m^2 mrem/yr) per (μCi/sec)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
I-131	1.56E9	1.57E9	8.94E8	5.20E11	2.58E9	ND	1.40E8
I-132	7.22E-1	1.33E0	6.10E-1	6.15E1	2.03E0	ND	1.56E0
I-133	2.09E7	2.58E7	9.76E6	4.79E9	4.30E7	ND	1.04E7
I-134	0	0	0	0	0	ND	0
I-135	6.48E4	1.17E5	5.52E4	1.03E7	1.79E5	ND	8.88E4
Cs-134	6.79E10	1.11E11	2.35E10	ND	3.45E10	1.24E10	6.01E8
Cs-136	3.03E9	8.32E9	5.38E9	ND	4.43E9	6.61E8	2.92E8
Cs-137	9.67E10	9.26E10	1.37E10	ND	3.02E10	1.09E10	5.80E8
Cs-138	0	0	0	ND	0	0	0
Ba-139	2.27E-8	0	0	ND	0	0	1.31E-6
Ba-140	1.41E7	1.23E4	8.20E3	ND	4.01E3	7.[illegible]4E3	7.12E6
Ba-141	0	0	0	ND	0	[illegible]	0
Ba-142	0	0	0	ND	0	[illegible]	0
La-140	2.34E0	8.17E-1	2.75E-1	ND	ND	ND	2.28E4
La-142	0	0	0	ND	ND	ND	3.49E-7
Ce-141	2.62E3	1.31E3	1.94E2	ND	5.74E2	ND	1.63E6
Ce-143	2.25E1	1.22E4	1.77E[illegible]	ND	5.12E0	ND	1.79E5
Ce-144	1.95E5	6.[illegible]1E4	1.04E4	ND	3.38E4	ND	1.59E7
Pr-143	8.62E1	2.[illegible]9E1	4.28E0	ND	1.40E1	ND	9.30E4
Pr-144	0	0	0	ND	0	ND	0
Nd-147	5.34E1	4.33E1	3.35E0	ND	2.37E1	ND	6.85E4
Eu-154	1.13E4	1.02E3	9.27E2	ND	4.46E3	ND	2.36E5
Hf-181	7.71E1	2.81E2	3.48E1	ND	5.70E1	ND	1.04E5
W-187	3.49E3	2.07E3	9.27E2	ND	ND	ND	2.90E5
Np-239	2.06E0	1.48E-1	1.04E-1	ND	4.28E-1	ND	1.10E4

(a) The child age group; refer to reference 11.14.5.

TABLE 5 (Contd.)

PATHWAY DOSE FACTORS (R_i) FOR RADIONUCLIDES OTHER THAN NOBLE GASES[a]

Vegetation Pathway

(m^2 mrem/yr) per (μCi/sec)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
H-3	ND	4.01E3	4.01E3	4.01E3	4.01E3	4.01E3	4.01E3
Be-7	3.38E5	5.76E5	3.70E5	ND	5.64E5	ND	3.21E7
C-14	8.89E8	1.78E8	1.78E8	1.78E8	1.78E8	1.78E8	1.78E8
Na-24	3.75E5	3.75E5	3.75E5	3.75E5	3.75E5	3.75E5	3.75E5
P-32	3.37E9	1.57E8	1.30E8	ND	ND	ND	9.30E7
Cr-51	ND	ND	1.17E5	6.50E4	1.78E4	1.19E5	6.21E6
Mn-54	ND	6.65E8	1.77E8	ND	1.86E8	ND	5.58E8
Mn-56	ND	1.88E1	4.24E0	ND	2.27E1	ND	2.72E3
Fe-55	8.01E8	4.25E8	1.32E8	ND	ND	2.40E8	7.87E7
Fe-59	3.97E8	6.43E8	3.20E8	ND	ND	1.86E8	6.69E8
Co-57	ND	2.98E7	6.04E7	ND	ND	ND	2.45E8
Co-58	ND	6.44E7	1.97E8	ND	ND	ND	3.76E8
Co-60	ND	3.78E8	1.12E9	ND	ND	ND	2.10E9
Ni-63	3.95E10	2.11E9	1.34E9	ND	ND	ND	1.42E8
Ni-65	1.05E2	9.89E0	5.77E0	ND	ND	ND	1.21E3
Cu-64	ND	1.10E4	6.64E3	ND	2.66E4	ND	5.16E5
Zn-65	8.12E8	2.16E9	1.35E9	ND	1.36E9	ND	3.80E8
Zn-69	1.09E-5	1.57E-5	1.45E-6	ND	9.52E-6	ND	9.11E-4
Br-82	ND	ND	2.04E6	ND	ND	ND	ND
Br-83	ND	ND	5.37E0	ND	ND	ND	0
Br-84	ND	ND	0	ND	ND	ND	0
Br-85	ND	ND	0	ND	ND	ND	0
Rb-86	ND	4.58E8	2.82E8	ND	ND	ND	2.94E7
Rb-88	ND	0	0	ND	ND	ND	0
Rb-89	ND	0	0	ND	ND	ND	0
Sr-89	3.59E10	ND	1.03E9	ND	ND	ND	1.39E9
Sr-90	1.24E12	ND	3.15E11	ND	ND	ND	1.67E10
Sr-91	5.24E5	ND	1.98E4	ND	ND	ND	1.16E6
Sr-92	7.28E2	ND	2.92E1	ND	ND	ND	1.38E4
Y-90	2.31E4	ND	6.18E2	ND	ND	ND	8.57E7

TABLE 5 (Contd.)

PATHWAY DOSE FACTORS (R_i) FOR RADIONUCLIDES OTHER THAN NOBLE GASES[a]

Vegetation Pathway

(m^2 mrem/yr) per (μCi/sec)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Y-91m	8.87E-9	ND	3.23E-10	ND	ND	ND	1.74E-5
Y-91	1.86E7	ND	4.99E5	ND	ND	ND	2.48E9
Y-92	1.58E0	ND	4.53E-2	ND	ND	ND	4.58E4
Y-93	3.01E2	ND	8.25E0	ND	ND	ND	4.48E6
Zr-95	3.86E6	8.45E5	7.55E5	ND	1.21E6	ND	8.84E8
Zr-97	5.70E2	8.24E1	4.86E1	ND	1.18E2	ND	1.25E7
Nb-95	4.10E5	1.59E5	1.14E5	ND	1.50E5	ND	2.95E8
Mo-99	ND	7.71E6	1.91E6	ND	1.65E7	ND	6.38E6
Tc-99m	4.71E0	9.24E0	1.53E2	ND	1.34E2	4.69E0	5.26E3
Tc-101	0	0	0	ND	0	0	0
Ru-103	1.54E7	ND	5.90E6	ND	3.87E7	ND	3.97E8
Ru-105	9.16E1	ND	3.32E1	ND	8.05E2	ND	5.98E4
Ru-106	7.45E8	ND	9.30E7	ND	1.01E9	ND	1.16E10
Ag-110m	3.22E7	2.17E7	1.74E7	ND	4.05E7	ND	2.58E9
Cd-109	ND	2.45E8	1.13E7	ND	2.18E8	ND	7.94E8
Sn-113	1.58E9	3.25E7	9.00E7	2.40E9	ND	ND	1.12E9
Sb-124	3.52E8	4.56E6	1.23E8	7.76E5	ND	1.95E8	2.20E9
Sb-125	4.99E8	3.85E6	1.05E8	4.62E5	ND	2.78E8	1.19E9
Te-125m	3.51E8	9.50E7	4.67E7	9.84E7	ND	ND	3.38E8
Te-127m	1.32E9	3.56E8	1.57E8	3.16E8	3.77E9	ND	1.07E9
Te-127	1.00E4	2.69E3	2.14E3	6.81E3	2.84E4	ND	3.90E5
Te-129m	8.38E8	2.34E8	1.30E8	2.70E8	2.46E9	ND	1.02E9
Te-129	1.16E-3	3.23E-4	2.75E-4	8.26E-4	3.39E-3	ND	7.20E-2
Te-131m	1.54E6	5.33E5	5.68E5	1.10E6	5.16E6	ND	2.16E7
Te-131	0	0	0	0	0	ND	0
Te-132	6.98E6	3.09E6	3.73E6	4.50E6	2.87E7	ND	3.11E7
I-130	6.16E5	1.24E6	6.38E5	1.37E8	1.86E6	ND	5.79E5
I-131	1.43E8	1.44E8	8.17E7	4.75E10	2.36E8	ND	1.28E7
I-132	8.58E1	1.58E2	7.25E1	7.31E3	2.41E2	ND	1.86E2
I-133	3.56E6	4.40E6	1.67E6	8.18E8	7.34E6	ND	1.77E6
I-134	1.55E-4	2.88E-4	1.32E-4	6.62E-3	4.40E-4	ND	1.91E-4
I-135	6.62E4	1.13E5	5.33E4	9.97E6	1.70E5	ND	8.58E4

TABLE 5 (Contd.)

PATHWAY DOSE FACTORS (R_i) FOR RADIONUCLIDES OTHER THAN NOBLE GASES[a]

Vegetation Pathway

(m^2 mrem/yr) per (μCi/sec)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Cs-134	1.60E10	2.63E10	5.55E9	ND	8.15E9	2.93E9	1.42E8
Cs-136	8.17E7	2.25E8	1.45E8	ND	1.20E8	1.78E7	7.90E6
Cs-137	2.39E10	2.29E10	3.38E9	ND	7.46E9	2.68E9	1.43E8
Cs-138	0	0	0	ND	0	0	0
Ba-139	4.80E-2	2.56E-5	1.39E-3	ND	2.24E-5	1.51E-5	2.77E0
Ba-140	2.77E8	2.42E5	1.62E7	ND	7.89E4	1.45E5	1.40E8
Ba-141	0	0	0	ND	0	0	0
Ba-142	0	0	0	ND	0	0	0
La-140	3.25E3	1.14E3	3.83E2	ND	ND	ND	3.17E7
La-142	2.50E-4	7.98E-5	2.50E-5	ND	ND	ND	1.58E1
Ce-141	6.56E5	3.27E5	4.86E4	ND	1.43E5	ND	4.08E8
Ce-143	1.72E3	9.31E5	1.35E2	ND	3.91E2	ND	1.36E7
Ce-144	1.27E8	3.98E7	6.78E6	ND	2.21E7	ND	1.04E10
Pr-143	1.46E5	4.38E4	7.25E3	ND	2.37E4	ND	1.58E8
Pr-144	0	0	0	ND	0	ND	0
Nd-147	7.17E4	5.81E4	4.50E3	ND	3.19E4	ND	9.20E7
Eu-154	1.66E8	1.50E7	1.37E7	ND	6.57E7	ND	3.48E9
Hf-181	4.90E5	1.79E6	2.21E5	ND	3.62E5	ND	6.59E8
W-187	6.47E4	3.83E4	1.72E4	ND	ND	ND	5.38E6
Np-239	2.55E3	1.83E2	1.29E2	ND	5.30E2	ND	1.36E7

(a) The child age group; refer to reference 11.14.5.

TABLE 5 (Contd.)

ADULT PATHWAY DOSE FACTORS (R_i) FOR RADIONUCLIDES OTHER THAN NOBLE GASES

Inhalation Pathway

(mrem/yr) per ($\mu Ci/m^3$)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
H-3	ND	1.26E+03	1.26E+03	1.26E+03	1.26E+03	1.26E+03	1.26E+03
Be-7	4.27E+02	9.68E+02	4.70E+02	ND	ND	4.21E+04	5.35E+03
C-14	1.82E+04	3.41E+03	3.41E+03	3.41E+03	3.41E+03	3.41E+03	3.41E+03
Na-24	1.02E+04	1.02E+04	1.02E+04	1.02E+04	1.02E+04	1.02E+04	1.02E+04
P-32	1.32E+06	7.71E+04	5.01E+04	ND	ND	ND	8.64E+04
Cr-51	ND	ND	1.00E+02	5.95E+01	2.28E+01	1.44E+01	3.32E+03
Mn-54	ND	3.96E+04	6.30E+03	ND	9.84E+03	1.40E+06	7.74E+04
Mn-56	ND	1.24E+00	1.83E-01	ND	1.30E+00	9.44E+03	2.02E+04
Fe-55	2.46E+04	1.70E+04	3.94E+03	ND	ND	7.21E+04	6.03E+03
Fe-59	1.18E+04	2.78E+04	1.06E+04	ND	ND	1.02E+06	1.88E+05
Co-57	ND	6.92E+02	6.71E+02	ND	ND	3.70E+05	3.14E+04
Co-58	ND	1.58E+03	2.07E+03	ND	ND	9.28E+05	1.06E+05
Co-60	ND	1.15E+04	1.48E+04	ND	ND	5.97E+06	2.85E+05
Ni-63	4.32E+05	3.14E+04	1.45E+04	ND	ND	1.78E+05	1.34E+04
Ni-65	1.54E+00	2.10E-01	9.12E-02	ND	ND	5.60E+03	1.23E+04
Cu-64	ND	1.46E+00	6.15E-01	ND	4.62E+00	6.78E+03	4.90E+04
Zn-65	3.24E+04	1.03E+05	4.66E+04	ND	6.90E+04	8.64E+05	5.34E+04
Zn-69	3.38E-02	6.51E-02	4.52E-03	ND	4.22E-02	9.20E+02	1.63E+01
Br-82	ND	ND	1.35E+04	ND	ND	ND	1.04E+04
Br-83	ND	ND	2.41E+02	ND	ND	ND	2.32E+02
Br-84	ND	ND	3.13E+02	ND	ND	ND	1.64E-03
Br-85	ND	ND	1.28E+01	ND	ND	ND	0.00E+00
Rb-86	ND	1.35E+05	5.90E+04	ND	ND	ND	1.66E+04
Rb-88	ND	3.87E+02	1.93E+02	ND	ND	ND	3.34E-09
Rb-89	ND	2.56E+02	1.70E+02	ND	ND	ND	0.00E+00
Sr-89	3.04E+05	ND	8.72E+03	ND	ND	1.40E+06	3.50E+05
Sr-90	9.92E+07	ND	6.10E+06	ND	ND	9.60E+06	7.22E+05
Sr-91	6.19E+01	ND	2.50E+00	ND	ND	3.65E+04	1.91E+05
Sr-92	6.74E+00	ND	2.91E-01	ND	ND	1.65E+04	4.30E+04
Y-90	2.09E+03	ND	5.61E+01	ND	ND	1.70E+05	5.06E+05

TABLE 5 (Contd.)

ADULT PATHWAY DOSE FACTORS (R_i) FOR RADIONUCLIDES OTHER THAN NOBLE GASES

Inhalation Pathway

(mrem/yr) per ($\mu Ci/m^3$)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Y-91m	2.61E-01	ND	1.02E-02	ND	ND	1.92E+03	1.33E+00
Y-91	4.62E+05	ND	1.24E+04	ND	ND	1.70E+06	3.85E+05
Y-92	1.03E+01	ND	3.02E-01	ND	ND	1.57E+04	7.35E+04
Y-93	9.44E+01	ND	2.61E+00	ND	ND	4.85E+04	4.22E+05
Zr-95	1.07E+05	3.44E+04	2.33E+04	ND	5.42E+04	1.77E+06	1.50E+05
Zr-97	9.68E+01	1.96E+01	9.04E+00	ND	2.97E+01	7.87E+04	5.23E+05
Nb-95	1.41E+04	7.82E+03	4.21E+03	ND	7.74E+03	5.05E+05	1.04E+05
Mo-99	ND	1.21E+02	2.30E+01	ND	2.91E+02	9.12E+04	2.48E+05
Tc-99m	1.03E-03	2.91E-03	3.70E-02	ND	4.42E-02	7.64E+02	4.16E+03
Tc-101	4.18E-05	6.02E-05	5.90E-04	ND	1.08E-03	3.99E+02	0.00E+00
Ru-103	1.53E+03	ND	6.58E+02	ND	5.83E+03	5.05E+05	1.10E+05
Ru-105	7.90E-01	ND	3.11E-01	ND	1.02E+00	1.10E+04	4.82E+04
Ru-106	6.91E+04	ND	8.72E+03	ND	1.34E+05	9.36E+06	9.12E+05
Ag-110m	1.08E+04	1.00E+04	5.94E+03	ND	1.97E+04	4.63E+06	3.02E+05
Cd-109	ND	3.67E+05	1.31E+04	ND	3.57E+05	6.83E+05	5.82E+04
Sn-113	5.72E+04	2.18E+03	4.39E+03	1.24E+03	ND	9.44E+05	1.18E+05
Sb-124	3.12E+04	5.89E+02	1.24E+04	7.55E+01	ND	2.48E+06	4.06E+05
Sb-125	5.34E+04	5.95E+02	1.26E+04	5.40E+01	ND	1.74E+06	1.01E+05
Te-125m	3.42E+03	1.58E+03	4.67E+02	1.05E+03	1.24E+04	3.14E+05	7.06E+04
Te-127m	1.26E+04	5.77E+03	1.57E+03	3.29E+03	4.58E+04	9.60E+05	1.50E+05
Te-127	1.40E+00	6.42E-01	3.10E-01	1.06E+00	5.10E+00	6.51E+03	5.74E+04
Te-129m	9.76E+03	4.67E+03	1.58E+03	3.44E+03	3.66E+04	1.16E+06	3.83E+05
Te-129	4.98E-02	2.39E-02	1.24E-02	3.90E-02	1.87E-01	1.94E+03	1.57E+02
Te-131m	6.99E+01	4.36E+01	2.90E+01	5.50E+01	3.09E+02	1.46E+05	5.56E+05
Te-131	1.11E-02	5.95E-03	3.59E-03	9.36E-03	4.37E-02	1.39E+03	1.84E+01
Te-132	2.60E+02	2.15E+02	1.62E+02	1.90E+02	1.46E+03	2.88E+05	5.10E+05
I-130	4.58E+03	1.34E+04	5.28E+03	1.14E+06	2.09E+04	ND	7.69E+03
I131	2.52E+04	3.58E+04	2.05E+04	1.19E+07	6.13E+04	ND	6.28E+03
I-132	1.16E+03	3.26E+03	1.16E+03	1.14E+05	5.18E+03	ND	4.06E+02
I-133	8.64E+03	1.48E+04	4.52E+03	2.15E+06	2.58E+04	ND	8.88E+03
I-134	6.44E+02	1.73E+03	6.15E+02	2.98E+04	2.75E+03	ND	1.01E+00

TABLE 5 (Contd.)

ADULT PATHWAY DOSE FACTORS (R_i) FOR RADIONUCLIDES OTHER THAN NOBLE GASES

Inhalation Pathway

(mrem/yr) per ($\mu Ci/m^3$)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
I-135	2.68E+03	6.98E+03	2.57E+03	4.48E+05	1.11E+04	ND	5.25E+03
Cs-134	3.73E+05	8.48E+05	7.28E+05	ND	2.87E+05	9.76E+04	1.04E+04
Cs-136	3.90E+04	1.46E+05	1.10E+05	ND	8.56E+04	1.20E+04	1.17E+04
Cs-137	4.78E+05	6.21E+05	4.28E+05	ND	2.22E+05	7.52E+04	8.40E+03
Cs-138	3.31E+02	6.21E+02	3.24E+02	ND	4.80E+02	4.86E+01	1.86E-03
Ba-139	9.36E-01	6.66E-04	2.74E-02	ND	6.22E-04	3.76E+03	8.96E+02
Ba-140	3.90E+04	4.90E+01	2.57E+03	ND	1.67E+01	1.27E+06	2.18E+05
Ba-141	1.00E-01	7.53E-05	3.36E-03	ND	7.00E-05	1.94E+03	1.16E-07
Ba-142	2.63E-02	2.70E-05	1.66E-03	ND	2.29E-05	1.19E+03	0.00E+00
La-140	3.44E+02	1.74E+02	4.58E+01	ND	ND	1.36E+05	4.58E+05
La-142	6.83E-01	3.10E-01	7.72E-02	ND	ND	6.33E+03	2.11E+03
Ce-141	1.99E+04	1.35E+04	1.53E+03	ND	6.26E+03	3.62E+05	1.20E+05
Ce-143	1.86E+02	1.38E+02	1.53E+01	ND	6.08E+01	7.98E+04	2.26E+05
Ce-144	3.43E+06	1.43E+06	1.84E+05	ND	8.48E+05	7.78E+06	8.16E+05
Pr-143	9.36E+03	3.75E+03	4.64E+02	ND	2.16E+03	2.81E+05	2.00E+05
Pr-144	3.01E-02	1.25E-02	1.53E-03	ND	7.05E-03	1.02E+03	2.15E-08
Nd-147	5.27E+03	6.10E+03	3.65E+03	ND	3.56E+03	2.21E+05	1.73E+05
Eu-154	5.92E+06	7.28E+05	5.18E+05	ND	3.49E+06	4.67E+06	2.72E+05
Hf-181	1.41E+04	6.82E+04	6.32E+03	ND	1.48E+04	6.85E+05	1.39E+05
W-187	8.48E+00	7.08E+00	2.48E+00	ND	ND	2.90E+04	1.55E+05
Np-239	2.30E+02	2.26E+01	1.24E+01	ND	7.00E+01	3.76E+04	1.19E+05

TABLE 5 (Contd.)

ADULT PATHWAY DOSE FACTORS (R_i) FOR RADIONUCLIDES OTHER THAN NOBLE GASES

Inhalation Pathway

(mrem/yr) per ($\mu Ci/m^3$)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
I-135	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00
Cs-134	6.57E+08	1.56E+09	1.28E+09	ND	5.06E+08	1.68E+08	2.74E+07
Cs-136	1.20E+07	4.76E+07	3.42E+07	ND	2.65E+07	3.63E+06	5.40E+06
Cs-137	8.71E+08	1.19E+09	7.81E+08	ND	4.04E+08	1.34E+08	2.31E+07
Cs-138	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00	0.00E+00	0.00E+00
Ba-139	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00	0.00E+00	0.00E+00
Ba-140	2.87E+07	3.61E+04	1.88E+06	ND	1.23E+04	2.07E+04	5.91E+07
Ba-141	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00	0.00E+00	0.00E+00
Ba-142	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00	0.00E+00	0.00E+00
La-140	3.71E-02	1.87E-02	4.95E-03	ND	ND	ND	1.37E+03
La-142	0.00E+00	0.00E+00	0.00E+00	ND	ND	ND	0.00E+00
Ce-141	1.40E+04	9.49E+03	1.08E+03	ND	4.41E+03	ND	3.63E+07
Ce-143	2.01E-02	1.49E+01	1.64E-03	ND	6.54E-03	ND	5.55E+02
Ce-144	1.46E+06	6.09E+05	7.82E+04	ND	3.61E+05	ND	4.92E+08
Pr-143	2.10E+04	8.40E+03	1.04E+03	ND	4.85E+03	ND	9.18E+07
Pr-144	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00	ND	0.00E+00
Nd-147	7.07E+03	8.17E+03	4.89E+02	ND	4.77E+03	ND	3.92E+07
Eu-154	8.02E+06	9.86E+05	7.01E+05	ND	4.72E+06	ND	7.14E+08
Hf-181	3.01E+06	1.46E+07	1.35E+06	ND	3.14E+06	ND	1.66E+10
W-187	2.07E-02	1.73E-02	6.05E-03	ND	ND	ND	5.67E+00
Np-239	2.63E-01	2.59E-02	1.43E-02	ND	8.07E-02	ND	5.30E+03

TABLE 5 (Contd.)

ADULT PATHWAY DOSE FACTORS (R_i) FOR RADIONUCLIDES OTHER THAN NOBLE GASES

Grass-Cow-Milk Pathway

(m^2 mrem/yr) per (μCi/sec)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
H-3	ND	7.63E+02	7.63E+02	7.63E+02	7.63E+02	7.63E+02	7.63E+02
Be-7	1.63E+03	3.72E+03	1.81E+03	ND	3.93E+03	ND	6.45E+05
C-14	2.63E+08	5.27E+07	5.27E+07	5.27E+07	5.27E+07	5.27E+07	5.27E+07
Na-24	2.44E+06	2.44E+06	2.44E+06	2.44E+06	2.44E+06	2.44E+06	2.44E+06
P-32	1.71E+10	1.06E+09	6.61E+08	ND	ND	ND	1.92E+09
Cr-51	ND	ND	2.86E+04	1.71E+04	6.30E+03	3.79E+04	7.19E+06
Mn-54	ND	8.42E+06	1.61E+06	ND	2.50E+06	ND	2.58E+07
Mn-56	ND	4.20E-03	7.45E-04	ND	5.33E-03	ND	1.34E-01
Fe-55	2.51E+07	1.74E+07	4.05E+06	ND	ND	9.68E+06	9.96E+06
Fe-59	2.97E+07	6.98E+07	2.68E+07	ND	ND	1.95E+07	2.33E+08
Co-57	ND	1.28E+06	2.13E+06	ND	ND	ND	3.25E+07
Co-58	ND	4.72E+06	1.06E+07	ND	ND	ND	9.56E+07
Co-60	ND	1.64E+07	3.62E+07	ND	ND	ND	3.08E+08
Ni-63	6.73E+09	4.76E+08	2.26E+08	ND	ND	ND	9.73E+07
Ni-65	3.71E-01	4.82E-02	2.20E-02	ND	ND	ND	1.22E+00
Cu-64	ND	2.39E+04	1.12E+04	ND	6.01E+04	ND	2.03E+06
Zn-65	1.37E+09	4.37E+09	1.97E+09	ND	2.92E+09	ND	2.75E+09
Zn-69	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00	ND	0.00E+00
Br-82	ND	ND	3.23E+07	ND	ND	ND	3.71E+07
Br-83	ND	ND	9.75E-02	ND	ND	ND	1.40E-01
Br-84	ND	ND	0.00E+00	ND	ND	ND	0.00E+00
Br-85	ND	ND	0.00E+00	ND	ND	ND	0.00E+00
Rb-86	ND	2.60E+09	1.21E+09	ND	ND	ND	5.12E+08
Rb-88	ND	0.00E+00	0.00E+00	ND	ND	ND	0.00E+00
Rb-89	ND	0.00E+00	0.00E+00	ND	ND	ND	0.00E+00
Sr-89	1.45E+09	ND	4.17E+07	ND	ND	ND	2.33E+08
Sr-90	4.68E+10	ND	1.15E+10	ND	ND	ND	1.35E+09
Sr-91	2.90E+04	ND	1.17E+03	ND	ND	ND	1.38E+05
Sr-92	4.90E-01	ND	2.12E-02	ND	ND	ND	9.71E+00
Y-90	7.09E+01	ND	1.90E+00	ND	ND	ND	7.52E+05

TABLE 5 (Contd.)

ADULT PATHWAY DOSE FACTORS (R_i) FOR RADIONUCLIDES OTHER THAN NOBLE GASES

Grass-Cow-Milk Pathway

(m^2 mrem/yr) per (μCi/sec)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Y-91m	0.00E+00	ND	0.00E+00	ND	ND	ND	0.00E+00
Y-91	8.59E+03	ND	2.30E+02	ND	ND	ND	4.73E+06
Y-92	5.59E-05	ND	1.63E-06	ND	ND	ND	9.80E-01
Y-93	2.24E-01	ND	6.18E-03	ND	ND	ND	7.09E+03
Zr-95	9.44E+02	3.03E+02	2.05E+02	ND	4.75E+02	ND	9.59E+05
Zr-97	4.34E-01	8.75E-02	4.00E-02	ND	1.32E-01	ND	2.71E+04
Nb-95	8.26E+04	4.59E+04	2.47E+04	ND	4.54E+04	ND	2.79E+08
Mo-99	ND	2.48E+07	4.72E+06	ND	5.61E+07	ND	5.74E+07
Tc-99m	3.33E+00	9.40E+00	1.20E+02	ND	1.43E+02	4.61E+00	5.56E+03
Tc-101	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00	0.00E+00	0.00E+00
Ru-103	1.02E+03	ND	4.39E+02	ND	3.89E+03	ND	1.19E+05
Ru-105	8.58E-04	ND	3.39E-04	ND	1.11E-02	ND	5.25E-01
Ru-106	2.04E+04	ND	2.58E+03	ND	3.94E+04	ND	1.32E+06
Ag-110m	5.82E+07	5.39E+07	3.20E+07	ND	1.06E+08	ND	2.20E+10
Cd-109	ND	1.13E+06	3.95E+04	ND	1.08E+06	ND	1.14E+07
Sn-113	1.34E+08	3.81E+06	7.73E+06	2.18E+06	ND	ND	4.02E+08
Sb-124	2.57E+07	4.86E+05	1.02E+07	6.24E+04	ND	2.00E+07	7.31E+08
Sb-125	2.04E+07	2.28E+05	4.87E+06	2.08E+04	ND	1.58E+07	2.25E+08
Te-125m	1.63E+07	5.90E+06	2.18E+06	4.90E+06	6.63E+07	ND	6.51E+07
Te-127m	4.58E+07	1.64E+07	5.58E+06	1.17E+07	1.86E+08	ND	1.54E+08
Te-127	6.54E+02	2.35E+02	1.41E+02	4.84E+02	2.66E+03	ND	5.16E+04
Te-129m	6.02E+07	2.25E+07	9.53E+06	2.07E+07	2.51E+08	ND	3.03E+08
Te-129	2.84E-10	1.07E-10	0.00E+00	2.18E-10	1.19E-09	ND	2.15E-10
Te-131m	3.61E+05	1.77E+05	1.47E+05	2.80E+05	1.79E+06	ND	1.75E+07
Te-131	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00
Te-132	2.40E+06	1.55E+06	1.46E+06	1.72E+06	1.50E+07	ND	7.35E+07
I-130	4.21E+05	1.24E+06	4.91E+05	1.05E+08	1.94E+06	ND	1.07E+06
I-131	2.97E+08	4.25E+08	2.43E+08	1.39E+11	7.28E+08	ND	1.12E+08
I-132	1.65E-01	4.42E-01	1.55E-01	1.55E+01	7.04E-01	ND	8.30E-02
I-133	3.88E+06	6.75E+06	2.06E+06	9.92E+08	1.18E+07	ND	6.07E+06
I-134	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00

TABLE 5 (Contd.)

ADULT PATHWAY DOSE FACTORS (R_i) FOR RADIONUCLIDES OTHER THAN NOBLE GASES

Grass-Cow-Milk Pathway

(m^2 mrem/yr) per (μCi/sec)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
I-135	1.29E+04	3.37E+04	1.25E+04	2.23E+06	5.41E+04	ND	3.81E+04
Cs-134	5.65E+09	1.35E+10	1.10E+10	ND	4.35E+09	1.45E+09	2.35E+08
Cs-136	2.63E+08	1.04E+09	7.48E+08	ND	5.79E+08	7.93E+07	1.18E+08
Cs-137	7.38E+09	1.01E+10	6.61E+09	ND	3.43E+09	1.14E+09	1.95E+08
Cs-138	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00	0.00E+00	0.00E+00
Ba-139	4.44E-08	0.00E+00	1.30E-09	ND	0.00E+00	0.00E+00	7.88E-08
Ba-140	2.69E+07	3.38E+04	1.76E+06	ND	1.15E+04	1.93E+04	5.54E+07
Ba-141	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00	0.00E+00	0.00E+00
Ba-142	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00	0.00E+00	0.00E+00
La-140	4.51E+00	2.28E+00	6.01E-01	ND	ND	ND	1.67E+05
La-142	1.87E-11	8.49E-12	2.12E-12	ND	ND	ND	6.20E-08
Ce-141	4.85E+03	3.28E+03	3.72E+02	ND	1.52E+03	ND	1.25E+07
Ce-143	4.16E+01	3.08E+04	3.40E+00	ND	1.35E+01	ND	1.15E+06
Ce-144	3.58E+05	1.50E+05	1.92E+04	ND	8.87E+04	ND	1.21E+08
Pr-143	1.58E+02	6.34E+01	7.83E+00	ND	3.66E+01	ND	6.92E+05
Pr-144	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00	ND	0.00E+00
Nd-147	9.42E+01	1.09E+02	6.51E+00	ND	6.36E+01	ND	5.23E+05
Eu-154	2.37E+04	2.91E+03	2.07E+03	ND	1.39E+04	ND	2.11E+06
Hf-181	1.42E+02	6.92E+02	6.41E+01	ND	1.49E+02	ND	7.87E+05
W-187	6.52E+03	5.45E+03	1.91E+03	ND	ND	ND	1.78E+06
Np-239	3.69E+00	3.62E-01	2.00E-01	ND	1.13E+00	ND	7.43E+04

TABLE 5 (Contd.)

ADULT PATHWAY DOSE FACTORS (R_i) FOR RADIONUCLIDES OTHER THAN NOBLE GASES

Grass-Goat-Milk Pathway

(m^2 mrem/yr) per (μCi/sec)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
H-3	ND	1.56E+03	1.56E+03	1.56E+03	1.56E+03	1.56E+03	1.56E+03
Be-7	1.96E+02	4.47E+02	2.17E+02	ND	4.72E+02	ND	7.74E+04
C-14	2.64E+08	5.27E+07	5.27E+07	5.27E+07	5.27E+07	5.27E+07	5.27E+07
Na-24	2.93E+05	2.93E+05	2.93E+05	2.93E+05	2.93E+05	2.93E+05	2.93E+05
P-32	2.05E+10	1.28E+09	7.94E+08	ND	ND	ND	2.31E+09
Cr-51	ND	ND	3.43E+03	2.05E+03	7.56E+02	4.56E+03	8.63E+05
Mn-54	ND	1.01E+06	1.93E+05	ND	3.01E+05	ND	3.10E+06
Mn-56	ND	5.04E-04	8.94E-05	ND	6.40E-04	ND	1.61E-02
Fe-55	3.27E+05	2.26E+05	5.26E+04	ND	ND	1.26E+05	1.30E+05
Fe-59	3.87E+05	9.08E+05	3.48E+05	ND	ND	2.54E+05	3.03E+06
Co-57	ND	1.54E+05	2.56E+05	ND	ND	ND	3.90E+06
Co-58	ND	5.66E+05	1.27E+06	ND	ND	ND	1.15E+07
Co-60	ND	1.97E+06	4.35E+06	ND	ND	ND	3.70E+07
Ni-63	8.08E+08	5.60E+07	2.71E+07	ND	ND	ND	1.17E+07
Ni-65	4.46E-02	5.79E-03	2.64E-03	ND	ND	ND	1.47E-01
Cu-64	ND	2.66E+03	1.25E+03	ND	6.71E+03	ND	2.27E+05
Zn-65	1.65E+08	5.24E+08	2.37E+08	ND	3.51E+08	ND	3.30E+08
Zn-69	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00	ND	0.00E+00
Br-82	ND	ND	3.88E+06	ND	ND	ND	4.45E+06
Br-83	ND	ND	1.17E-02	ND	ND	ND	1.69E-02
Br-84	ND	ND	0.00E+00	ND	ND	ND	0.00E+00
Br-85	ND	ND	0.00E+00	ND	ND	ND	0.00E+00
Rb-86	ND	3.12E+08	1.45E+08	ND	ND	ND	6.15E+07
Rb-88	ND	0.00E+00	0.00E+00	ND	ND	ND	0.00E+00
Rb-89	ND	0.00E+00	0.00E+00	ND	ND	ND	0.00E+00
Sr-89	3.05E+09	ND	8.75E+07	ND	ND	ND	4.89E+08
Sr-90	9.84E+10	ND	2.41E+10	ND	ND	ND	2.84E+09
Sr-91	6.09E+04	ND	2.46E+03	ND	ND	ND	2.90E+05
Sr-92	1.03E+00	ND	4.45E-02	ND	ND	ND	2.04E+01
Y-90	8.51E+00	ND	2.28E-01	ND	ND	ND	9.03E+01

TABLE 5 (Contd.)

ADULT PATHWAY DOSE FACTORS (R_i) FOR RADIONUCLIDES OTHER THAN NOBLE GASES

Grass-Goat-Milk Pathway

(m^2 mrem/yr) per (μCi/sec)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Y-91m	0.00E+00	ND	0.00E+00	ND	ND	ND	0.00E+00
Y-91	1.03E+03	ND	2.76E+01	ND	ND	ND	5.68E+05
Y-92	6.72E-06	ND	1.96E-07	ND	ND	ND	1.18E-01
Y-93	2.69E-02	ND	7.42E-04	ND	ND	ND	8.52E+02
Zr-95	1.13E+02	3.63E+01	2.46E+01	ND	5.70E+01	ND	1.15E+05
Zr-97	5.21E-02	1.05E-02	4.80E-03	ND	1.59E-02	ND	3.25E+03
Nb-95	9.92E+03	5.52E+03	2.97E+03	ND	5.45E+03	ND	3.35E+07
Mo-99	ND	2.98E+06	5.66E+05	ND	6.74E+06	ND	6.90E+06
Tc-99m	3.99E-01	1.13E+00	1.44E+01	ND	1.71E+01	5.53E-01	6.68E+02
Tc-101	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00	0.00E+00	0.00E+00
Ru-103	1.22E+02	ND	5.27E+01	ND	4.67E+02	ND	1.43E+04
Ru-105	1.03E-04	ND	4.07E-05	ND	1.33E-03	ND	6.31E-02
Ru-106	2.45E+03	ND	3.10E+02	ND	4.73E+03	ND	1.59E+05
Ag-110m	6.99E+06	6.47E+06	3.84E+06	ND	1.27E+07	ND	2.64E+09
Cd-109	ND	1.36E+05	4.74E+03	ND	1.30E+05	ND	1.37E+06
Sn-113	1.61E+07	4.58E+05	9.28E+05	2.62E+05	ND	ND	4.83E+07
Sb-124	3.09E+06	5.84E+04	1.23E+06	7.50E+03	ND	2.41E+06	8.78E+07
Sb-125	2.46E+06	2.74E+04	5.84E+05	2.50E+03	ND	1.89E+06	2.70E+07
Te-125m	1.96E+06	7.09E+05	2.62E+05	5.89E+05	7.96E+06	ND	7.81E+06
Te-127m	5.50E+06	1.97E+06	6.70E+05	1.41E+06	2.23E+07	ND	1.84E+07
Te-127	7.85E+01	2.82E+01	1.70E+01	5.82E+01	3.20E+02	ND	6.19E+03
Te-129m	7.23E+06	2.70E+06	1.14E+06	2.48E+06	3.02E+07	ND	3.64E+07
Te-129	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.43E-10	ND	0.00E+00
Te-131m	4.34E+04	2.12E+04	1.77E+04	3.36E+04	2.15E+05	ND	2.11E+06
Te-131	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00
Te-132	2.89E+05	1.87E+05	1.75E+05	2.06E+05	1.80E+06	ND	8.83E+06
I-130	5.05E+05	1.49E+06	5.88E+05	1.26E+08	2.32E+06	ND	1.28E+06
I-131	3.56E+08	5.09E+08	2.92E+08	1.67E+11	8.72E+08	ND	1.34E+08
I-132	1.98E-01	5.29E-01	1.85E-01	1.85E+01	8.43E-01	ND	9.95E-02
I-133	4.65E+06	8.09E+06	2.47E+06	1.19E+09	1.41E+07	ND	7.27E+06
I-134	0.00E+00	0.00E+00	0.00E+00	1.15E-10	0.00E+00	ND	0.00E+00

TABLE 5 (Contd.)

ADULT PATHWAY DOSE FACTORS (R_i) FOR RADIONUCLIDES OTHER THAN NOBLE GASES

Grass-Goat-Milk Pathway

(m^2 mrem/yr) per (μCi/sec)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
I-135	1.54E+04	4.04E+04	1.49E+04	2.67E+06	6.48E+04	ND	4.57E+04
Cs-134	1.70E+10	4.04E+10	3.30E+10	ND	1.31E+10	4.34E+09	7.07E+08
Cs-136	7.91E+08	3.12E+09	2.25E+09	ND	1.74E+09	2.38E+08	3.55E+08
Cs-137	2.22E+10	3.03E+10	1.99E+10	ND	1.03E+10	3.42E+09	5.87E+08
Cs-138	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00	0.00E+00	0.00E+00
Ba-139	5.34E-09	3.08E-12	1.56E-10	ND	3.55E-12	2.16E-12	9.46E-09
Ba-140	3.23E+06	4.06E+03	2.12E+05	ND	1.38E+03	2.32E+03	6.65E+06
Ba-141	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00	0.00E+00	0.00E+00
Ba-142	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00	0.00E+00	0.00E+00
La-140	5.42E-01	2.73E-01	7.22E-02	ND	ND	ND	2.01E+04
La-142	0.00E+00	0.00E+00	0.00E+00	ND	ND	ND	7.45E-09
Ce-141	5.82E+02	3.94E+02	4.46E+01	ND	1.83E+02	ND	1.50E+06
Ce-143	4.99E+00	3.69E+03	4.09E-01	ND	1.63E+00	ND	1.38E+05
Ce-144	4.30E+04	1.80E+04	2.31E+03	ND	1.07E+04	ND	1.45E+07
Pr-143	1.90E+01	7.61E+00	9.40E-01	ND	4.39E+00	ND	8.31E+04
Pr-144	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00	ND	0.00E+00
Nd-147	1.13E+01	1.31E+01	7.82E-01	ND	7.64E+00	ND	6.28E+04
Eu-154	2.84E+03	3.49E+02	2.49E+02	ND	1.67E+03	ND	2.53E+05
Hf-181	1.71E+01	8.31E+01	7.70E+00	ND	1.79E+01	ND	9.46E+04
W-187	7.83E+02	6.54E+02	2.29E+02	ND	ND	ND	2.14E+05
Np-239	4.43E-01	4.35E-02	2.40E-02	ND	1.36E-01	ND	8.93E+03

TABLE 5 (Contd.)

ADULT PATHWAY DOSE FACTORS (R_i) FOR RADIONUCLIDES OTHER THAN NOBLE GASES

Vegetation Pathway

(m^2 mrem/yr) per (μCi/sec)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
H-3	ND	2.26E+03	2.26E+03	2.26E+03	2.26E+03	2.26E+03	2.26E+03
Be-7	9.24E+04	2.11E+05	1.03E+05	ND	2.23E+05	ND	3.66E+07
C-14	2.28E+08	4.55E+07	4.55E+07	4.55E+07	4.55E+07	4.55E+07	4.55E+07
Na-24	2.69E+05	2.69E+05	2.69E+05	2.69E+05	2.69E+05	2.69E+05	2.69E+05
P-32	1.40E+09	8.74E+07	5.43E+07	ND	ND	ND	1.58E+08
Cr-51	ND	ND	4.64E+04	2.78E+04	1.02E+04	6.16E+04	1.17E+07
Mn-54	ND	3.13E+08	5.97E+07	ND	9.31E+07	ND	9.59E+08
Mn-56	ND	1.60E+01	2.84E+00	ND	2.03E+01	ND	5.10E+02
Fe-55	2.10E+08	1.45E+08	3.38E+07	ND	ND	8.08E+07	8.31E+07
Fe-59	1.26E+08	2.96E+08	1.14E+08	ND	ND	8.28E+07	9.88E+08
Co-57	ND	1.17E+07	1.95E+07	ND	ND	ND	2.97E+08
Co-58	ND	3.07E+07	6.89E+07	ND	ND	ND	6.23E+08
Co-60	ND	1.67E+08	3.69E+08	ND	ND	ND	3.14E+09
Ni-63	1.04E+10	7.21E+08	3.49E+08	ND	ND	ND	1.50E+08
Ni-65	6.16E+01	8.00E+00	3.65E+00	ND	ND	ND	2.03E+02
Cu-64	ND	9.20E+03	4.32E+03	ND	2.32E+04	ND	7.84E+05
Zn-65	3.17E+08	1.01E+09	4.56E+08	ND	6.75E+08	ND	6.36E+08
Zn-69	5.52E-06	1.05E-05	7.34E-07	ND	6.85E-06	ND	1.59E-06
Br-82	ND	ND	1.50E+06	ND	ND	ND	1.72E+06
Br-83	ND	ND	3.11E+00	ND	ND	ND	4.48E+00
Br-84	ND	ND	0.00E+00	ND	ND	ND	0.00E+00
Br-85	ND	ND	0.00E+00	ND	ND	ND	0.00E+00
Rb-86	ND	2.19E+08	1.02E+08	ND	ND	ND	4.33E+07
Rb-88	ND	0.00E+00	0.00E+00	ND	ND	ND	0.00E+00
Rb-89	ND	0.00E+00	0.00E+00	ND	ND	ND	0.00E+00
Sr-89	9.97E+09	ND	2.86E+08	ND	ND	ND	1.60E+09
Sr-90	6.05E+11	ND	1.48E+11	ND	ND	ND	1.75E+10
Sr-91	3.05E+05	ND	1.23E+04	ND	ND	ND	1.45E+06
Sr-92	4.27E+02	ND	1.85E+01	ND	ND	ND	8.46E+03
Y-90	1.33E+04	ND	3.57E+02	ND	ND	ND	1.41E+08

TABLE 5 (Contd.)

ADULT PATHWAY DOSE FACTORS (R_i) FOR RADIONUCLIDES OTHER THAN NOBLE GASES

Vegetation Pathway

(m^2 mrem/yr) per (μCi/sec)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
Y-91m	5.24E-09	ND	2.03E-10	ND	ND	ND	1.54E-08
Y 91	5.11E+06	ND	1.37E+05	ND	ND	ND	2.81E+09
Y-92	9.16E-01	ND	2.68E-02	ND	ND	ND	1.60E+04
Y-93	1.70E+02	ND	4.68E+00	ND	ND	ND	5.38E+06
Zr-95	1.17E+06	3.77E+05	2.55E+05	ND	5.91E+05	ND	1.19E+09
Zr-97	3.37E+02	6.81E+01	3.11E+01	ND	1.03E+02	ND	2.11E+07
Nb-95	1.42E+05	7.92E+04	4.26E+04	ND	7.83E+04	ND	4.81E+08
Mo-99	0.00E+00	6.15E+06	1.17E+06	ND	1.39E+07	ND	1.43E+07
Tc-99m	3.10E+00	8.77E+00	1.12E+02	ND	1.33E+02	4.30E+00	5.19E+03
Tc-101	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00	0.00E+00	0.00E+00
Ru-103	4.77E+06	ND	2.06E+06	ND	1.82E+07	ND	5.57E+08
Ru-105	5.39E+01	ND	2.13E+01	ND	6.97E+02	ND	3.30E+04
Ru-106	1.93E+08	ND	2.44E+07	ND	3.72E+08	ND	1.25E+10
Ag-110m	1.05E+07	9.75E+06	5.79E+06	ND	1.92E+07	ND	3.98E+09
Cd-109	0.00E+00	8.36E+07	2.92E+06	ND	8.00E+07	ND	8.43E+08
Sn-113	4.16E+08	1.18E+07	2.40E+07	6.75E+06	ND	ND	1.25E+09
Sb-124	1.04E+08	1.96E+06	4.11E+07	2.51E+05	ND	8.07E+07	2.94E+09
Sb-125	1.37E+08	1.53E+06	3.25E+07	1.39E+05	ND	1.05E+08	1.50E+09
Te-125m	9.66E+07	3.50E+07	1.29E+07	2.90E+07	3.93E+08	ND	3.86E+08
Te-127m	3.49E+08	1.25E+08	4.26E+07	8.92E+07	1.42E+09	ND	1.17E+09
Te-127	5.66E+03	2.03E+03	1.23E+03	4.20E+03	2.31E+04	ND	4.47E+05
Te-129m	2.51E+08	9.38E+07	3.98E+07	8.64E+07	1.05E+09	ND	1.27E+09
Te-129	7.65E-04	2.87E-04	1.86E-04	5.87E-04	3.22E-03	ND	5.77E-04
Te-131m	9.12E+05	4.46E+05	3.72E+05	7.07E+05	4.52E+06	ND	4.43E+07
Te-131	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00
Te-132	4.30E+06	2.78E+06	2.61E+06	3.07E+06	2.68E+07	ND	1.32E+08
I-130	3.93E+05	1.16E+06	4.57E+05	9.81E+07	1.81E+06	ND	9.97E+05
I-131	8.08E+07	1.16E+08	6.62E+07	3.79E+10	1.98E+08	ND	3.05E+07
I-132	5.77E+01	1.54E+02	5.40E+01	5.40E+03	2.46E+02	ND	2.90E+01
I-133	2.09E+06	3.63E+06	1.11E+06	5.33E+08	6.33E+06	ND	3.26E+06
I-134	9.69E-05	2.63E-04	9.42E-05	4.56E-03	4.19E-04	ND	2.30E-07

TABLE 5 (Contd.)

ADULT PATHWAY DOSE FACTORS (R_i) FOR RADIONUCLIDES OTHER THAN NOBLE GASES

Vegetation Pathway

(m^2 mrem/yr) per (μCi/sec)

Nuclide	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
I-135	3.90E+04	1.02E+05	3.77E+04	6.74E+06	1.64E+05	ND	1.15E+05
Cs-134	4.67E+09	1.11E+10	9.08E+09	ND	3.59E+09	1.19E+09	1.94E+08
Cs-136	4.27E+07	1.69E+08	1.21E+08	ND	9.38E+07	1.29E+07	1.91E+07
Cs-137	6.36E+09	8.70E+09	5.70E+09	ND	2.95E+09	9.81E+08	1.68E+08
Cs-138	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00	0.00E+00	0.00E+00
Ba-139	2.86E-02	2.04E-05	8.39E-04	ND	1.91E-05	1.16E-05	5.08E-02
Ba-140	1.29E+08	1.61E+05	8.42E+06	ND	5.49E+04	9.24E+04	2.65E+08
Ba-141	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00	0.00E+00	0.00E+00
Ba-142	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00	0.00E+00	0.00E+00
La-140	1.98E+03	9.97E+02	2.63E+02	ND	ND	ND	7.32E+07
La-142	2.03E-04	9.21E-05	2.29E-05	ND	ND	ND	6.72E-01
Ce-141	1.97E+05	1.33E+05	1.51E+04	ND	6.19E+04	ND	5.10E+08
Ce-143	9.98E+02	7.38E+05	8.17E+01	ND	3.25E+02	ND	2.76E+07
Ce-144	3.29E+07	1.38E+07	1.77E+06	ND	8.16E+06	ND	1.11E+10
Pr-143	6.26E+04	2.51E+04	3.10E+03	ND	1.45E+04	ND	2.74E+08
Pr-144	0.00E+00	0.00E+00	0.00E+00	ND	0.00E+00	ND	0.00E+00
Nd-147	3.33E+04	3.85E+04	2.31E+03	ND	2.25E+04	ND	1.85E+08
Eu-154	4.85E+07	5.97E+06	4.25E+06	ND	2.86E+07	ND	4.32E+09
Hf-181	1.40E+05	6.82E+05	6.32E+04	ND	1.47E+05	ND	7.76E+08
W-187	3.80E+04	3.18E+04	1.11E+04	ND	ND	ND	1.04E+07
Np-239	1.43E+03	1.41E+02	7.76E+01	ND	4.39E+02	ND	2.89E+07

3.6 Gaseous Radwaste Treatment System

41862 4160 **3.6.1 REC 9.9.1.1**

The VENTILATION EXHAUST TREATMENT SYSTEM and the WASTE GAS HOLDUP SYSTEM shall be OPERABLE and appropriate portions of these systems shall be used to reduce releases of radioactivity when the projected doses in 31 days due to gaseous effluent releases, from each unit, to areas at and beyond the SITE BOUNDARY would exceed:

a. 0.2 mrad to air from gamma radiation, or

b. 0.4 mrad to air from beta radiation, or

c. 0.3 mrem to any organ of an Individual

3.6.2 Description of the Gaseous Radwaste Treatment System

The gaseous radwaste treatment system and the ventilation exhaust system are available for use whenever gaseous effluents require treatment prior to being released to the environment. The gaseous radwaste treatment system is designed to allow for the retention of all gaseous fission products to be discharged from the reactor coolant system. The retention system consists of eight (8) waste gas decay tanks, six (6) for use during normal operations and two (2) for use during shutdown conditions. Normally, waste gases will be retained for at least 60 days prior to discharge. These systems will provide reasonable assurance that the releases of radioactive materials in gaseous effluents will be kept ALARA.

3.6.3 Operability of the Gaseous Radwaste Treatment System

The OPERABILITY of the gaseous radwaste treatment system ensures this system will be available for use when gases require treatment prior to their release to the environment. OPERABILITY is demonstrated through compliance with Sections 9.6.1.1, 9.7.1.1, and 9.8.1.1.

Projected doses (gamma air, beta air, and organ dose) due to gaseous effluents at or beyond the SITE BOUNDARY are determined each 31 days by dividing the cumulative annual total by the number of elapsed months.

4.0 DOSE AND DOSE COMMITMENT FROM URANIUM FUEL CYCLE SOURCES

41864 4160 4.1 REC Section 9.10.1.1

The annual (calendar year) dose or dose commitment to any MEMBER OF THE PUBLIC due to releases of radioactivity and to radiation from uranium fuel cycle sources shall be limited to less than or equal to 25 mrem to the total body or any organ, except the thyroid, which shall be limited to less than or equal to 75 mrem.

4.2 Calculation of Dose and Dose Commitment from Uranium Fuel Cycle Sources

The annual dose or dose commitment to a MEMBER OF THE PUBLIC for Uranium Fuel Cycle Sources is determined as:

a) Dose to the total body and internal organs due to gamma ray exposure from submersion in a cloud of radioactive noble gases, ground plane exposure, and direct radiation from the Unit and outside storage tanks;

b) Dose to the skin due to beta radiation from submersion in a cloud of radioactive noble gases, and ground plane exposure;

c) Thyroid dose due to inhalation and ingestion of radioiodines; and

d) Organ dose due to inhalation and ingestion of radioactive material.

It is assumed that total body dose from sources of gamma radiation irradiates internal body organs at the same numerical rate. (Ref. 11.12.5)

The dose from gaseous effluents is considered to be the summation of the dose at the individual's residence and the dose to the individual from activities within the SITE BOUNDARY.

Since the doses via liquid releases are very conservatively evaluated, there is reasonable assurance that no real individual will receive a significant dose from radioactive liquid release pathways. Therefore, only doses to individuals via airborne pathways and doses resulting from direct radiation are considered in determining compliance to 40 CFR 190. (Ref. 11.12.3)

It should be noted that there are no other Uranium Fuel Cycle Sources within 8km of the Callaway Plant.

4.2.1 Identification of the MEMBER OF THE PUBLIC

The MEMBER OF THE PUBLIC is considered to be a real individual, including all persons not occupationally associated with the Callaway Plant, but who may use portions of the plant site for recreational or other purposes not associated with the plant. (Ref. 11.4 and 11.8.10.) Accordingly, it is necessary to characterize this individual with respect to his utilization of areas both within and at or beyond the SITE BOUNDARY and identify, as far as possible, major assumptions which could be reevaluated if necessary to demonstrate continued compliance with 40 CFR 190 through the use of more realistic assumptions. (Ref. 11.12.3 and 11.12.4)

The evaluation of Total Dose from the Uranium Fuel Cycle should consider the dose to two Critical Receptors: a) The Nearest Resident, and b) The Critical Receptor within the SITE BOUNDARY.

4.2.2 Total Dose to the Nearest Resident

The dose to the Nearest Resident is due to plume exposure from noble gases, ground plane exposure, and inhalation and ingestion pathways. It is conservatively assumed that each ingestion pathway (meat, milk, and vegetation) exists at the location of the Nearest Resident.

It is assumed that direct radiation dose from operation of the Unit and outside storage tanks, and dose from gaseous effluents due to activities within the SITE BOUNDARY, is negligible for the Nearest Resident. The total Dose from the Uranium Fuel Cycle to the Nearest Resident is calculated using the methodology discussed in Section 3, using concurrent meteorological data for the location of the Nearest Resident with the highest value of X/Q.

The location of the Nearest Resident in each meteorological sector is determined from the Annual Land Use Census conducted in accordance with the Requirements of Section 9.12.1.1.

4.2.3 Total Dose to the Critical Receptor Within the SITE BOUNDARY

The Union Electric Company has entered into an agreement with the State of Missouri Department of Conservation for management of the residual lands surrounding the Callaway Plant, including some areas within the SITE BOUNDARY. Under the terms of this agreement, certain areas have been opened to the public for low intensity recreational uses (hunting, hiking, sightseeing, etc.) but recreational use is excluded in an area immediately surrounding the plant site (Refer to Figure 4.1). Much of the residual lands within the SITE BOUNDARY are leased to area farmers by the Department of Conservation to provide income to support management and development costs. Activities conducted under these leases are primarily comprised of farming (animal feed), grazing, and forestry. (Ref 11.7.2, 11.7.3, 11.13, 11.13.1).

Based on the utilization of areas within the SITE BOUNDARY, it is reasonable to assume that the critical receptor within the SITE BOUNDARY is a farmer, and that his dose from activities within the SITE BOUNDARY is due to exposure incurred while conducting his farming activities. The current tenant has estimated that he spends approximately 1100 hours per year working in this area (Ref 11.5.5). Occupancy of areas within the SITE BOUNDARY is assumed to be averaged over a period of one year.

Any reevaluation of assumptions should include a reevaluation of the occupancy period at the locations of real exposure (e.g. a real individual would not simultaneously exist at each point of maximum exposure).

4.2.3.1 Total Dose to the Farmer from Gaseous Effluents

The Total Dose to the farmer from gaseous effluents is calculated using the methodology discussed in Section 3, utilizing concurrent meteorological data at the farmer's residence and historical meteorlogical data from Table 10 for activities within the SITE BOUNDARY. These dispersion parameters were calculated by assuming that the farmer's time is equally distributed over the areas farmed within the SITE BOUNDARY, and already have the total occupancy of 1100 hours/year factored into their value (Ref. 11.5.6).

The residence of the current tenant is located at a distance of 3830 meters in the SE sector. No meat or milk animals or vegetable gardens were identified by the 1987 Land Use Census for this location, therefore, the gaseous effluents dose at the farmer's residence is due to plume exposure from Noble Gases and the ground plane and inhalation pathways.

It is assumed that food ingestion pathways do not exist within the SITE BOUNDARY, therefore the gaseous effluents dose within the SITE BOUNDARY is due to plume exposure from Noble Gases and the ground plane and inhalation pathways.

4.2.3.2 Total Dose from Direct Radiation

4.2.3.2.1 Direct Radiation Dose from Outside Storage Tanks

The Refueling Water Storage Tank (RWST) has the highest potential for receiving significant amounts of radioactive materials, and constitutes the only potentially significant source of direct radiation dose from outside storage tanks to a MEMBER OF THE PUBLIC. (Ref. 11.6.14, 11.6.15, 11.6.16, and 11.6.17.)

Direct radiation dose from the RWST to a MEMBER OF THE PUBLIC is determined at the nearest point of the Owner Controlled Area fence which is not obscured by significant plant structures. This has been determined to be 450 meters from the RWST.

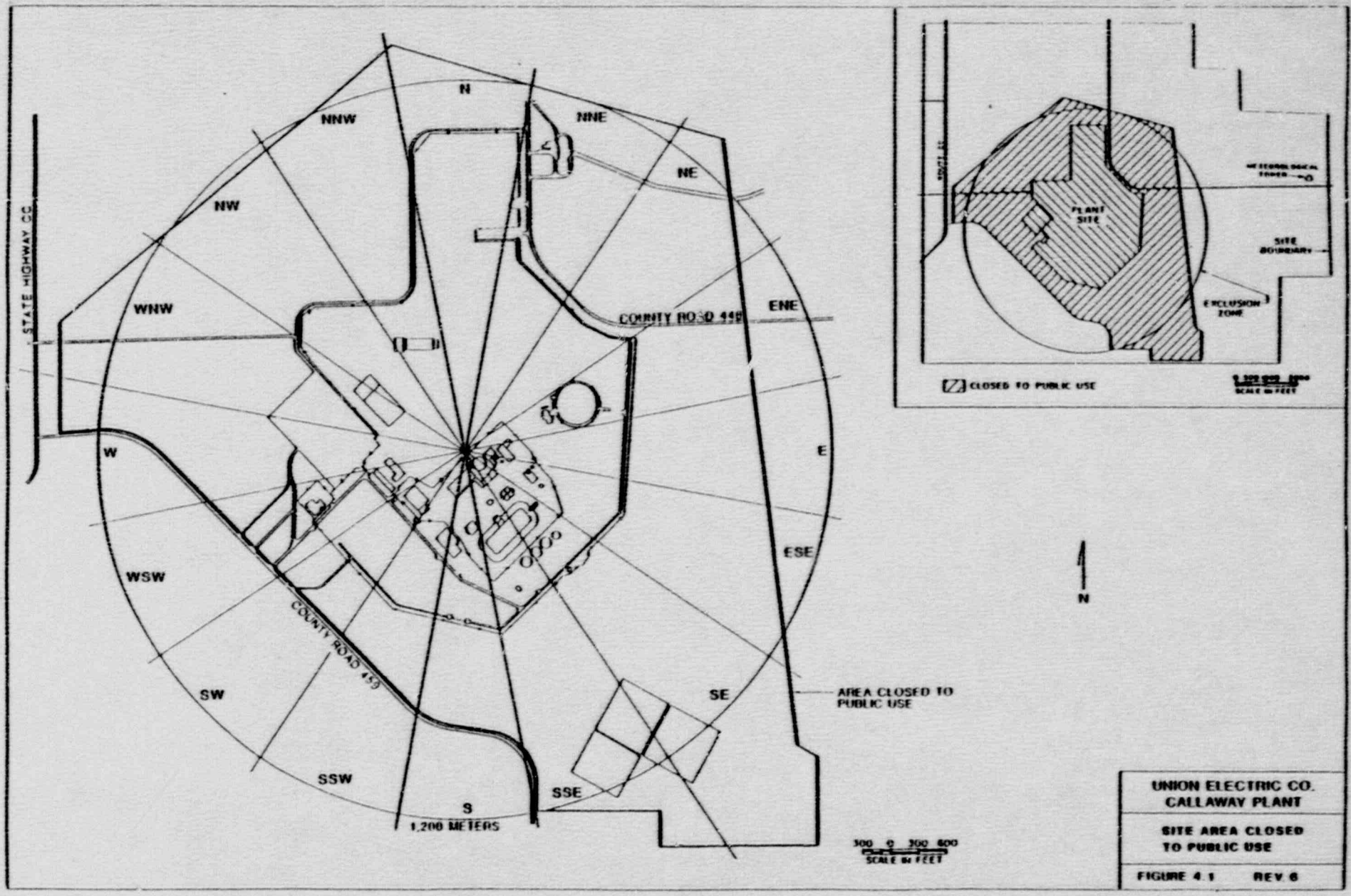
The RWST is a right circular cylinder approximately 12 meters in diameter, 14 meters in height with a capacity of approximately 1,514,000 liters. (Ref. 11.6.17.) The walls are of type 304 stainless steel and have an average thickness of .87 cm. (Ref. 11.14.1.)

The direct radiation dose from the RWST is calculated based on the tank's average isotopic content and the parameters discussed above, considering buildup and attenuation within the volume source. Appropriate methodology for calculating the dose rate from a volume source is given in TID-7004, "Reactor Shielding Design Manual" (Ref. 11.17). The computer program ISOSHLD (Ref. 11.18, 11.19, 11.20) will normally be utilized to perform this calculation.

4.2.3.2.2 Direct Radiation Dose from the Reactor

The maximum direct radiation dose from the Unit to a MEMBER OF THE PUBLIC has been determined to be 7E-2 mrads/calendar year, based on a point source of primary coolant N-16 in the steam generators. This source term was then projected onto the inside surface of the containment dome, taking credit for shielding provided by the containment dome and for distance attenuation. No credit was allowed for shielding by other structures or components. The number of gammas per second was generated and then converted to a dose rate at the given distance by use of ANSI/ANS-6.6.1, "Calculation and Measurement of Direct and Scattered Gamma Radiation from LWR Nuclear Power Plant 1979", which considers attenuation and buildup in air. The final value is based on one unit operating at 100% Power. The distance was determined to be 367 meters, which is approximately the closest point of the boundary of the Owner Controlled Area fence which is not obscurred by significant plant structures. (Ref. 11.14.3.)

The maximum direct radiation dose from the Unit to a MEMBER OF THE PUBLIC due to activities within the SITE BOUNDARY is thus approximately 9E-3 mrads per year, assuming a maximum occupancy of 1100 hours per year.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CALLAWAY PLANT
SITE AREA CLOSED TO PUBLIC USE
FIGURE 4.1 REV 6

41835 3535 5.0 RADIOLOGICAL ENVIRONMENTAL MONITORING

41866 5.1 REC Section 9.11.1.1

The radiological environmental monitoring program shall be conducted as specified in Table 9.11-A.

5.2 Description of the Radiological Environmental Monitoring Program

The Radiological Environmental Monitoring Program is intended to act as a background data base for preoperation and to supplement the radiological effluent release monitoring program during plant operation. Radiation exposure to the public from the various specific pathways and direct radiation can be adequately evaluated by this program.

Some deviations from the sampling frequency may be necessary due to seasonal unavailability, hazardous conditions, or other legitimate bases. Efforts are made to obtain all required samples within time frame outlines. Any deviation(s) in sampling frequency or location is documented in the Annual Radiological Environmental Operating Report.

The Environmental samples are collected and analyzed at the frequency outlined in Table 6. Reporting levels and lower limits of detection (LLD) are given in Tables 7 and 8.

Airborne, waterbore, and ingestion samples collected under the monitoring program are analyzed by an independent, third-party laboratory. This laboratory is required to participate in the Environmental Protection Agency's (EPA) Environmental Radioactivity Laboratory Intercomparison Studies (Crosscheck) Program or an equivalent program. Participation includes all of the determinations (sample medium - radionuclide combination) that are offered by the EPA and that are also included in the monitoring program.

5.3 Performance Testing of Environmental Thermoluminescence Dosimeters

Thermoluminescence Detectors (TLD's) used in the Environmental Monitoring Program are tested for accuracy and precision to demonstrate compliance with Regulatory Guide 4.13. (Ref. 11.16).

Energy dependence is tested at several energies between 30keV and 3MeV corresponding to the approximate energies of the predominant Noble Gases (80, 160, 200 keV), Cs-137 (662 keV), Co-60 (1225 keV), and at least one energy less than 80 keV. Other testing is performed relative to either Cs-137 or Co-60.

TABLE 6

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

EXPOSURE PATHWAY AND/OR SAMPLE	NUMBER OF REPRESENTATIVE SAMPLES AND SAMPLE LOCATIONS	SAMPLING AND COLLECTION FREQUENCY	TYPE AND FREQUENCY OF ANALYSIS
1. Direct Radiation	40 routine monitoring stations either with two or more dosimeters or with one instrument for measuring and recording dose rate continuously, placed as follows: An inner ring of sixteen stations, one in each meteorological sector in the general area of the SITE BOUNDARY.	At least once per 92 days	Gamma Dose

Station Code	Sector	Site Description	Location
04	A	0.3 Miles East of Hwy O and CC Junction, Callaway Electric Coop. Utility Pole No. 18892	1.9 mi. @ 349° N
47	B	County Road 448, 0.9 Miles South of Hwy O, Callaway Electric Coop. Utility Pole No. 28151	0.9 mi. @ 17° NNE
48	C	County Road 448, 1.5 Miles South of Hwy O, Plant Security Area Sign Post	0.4 mi. @ 45° NE
05	D	Primary Meteorological Tower	1.3 mi. @ 78° ENE
49	E	County Road 448, Callaway Electric Coop Utility Pole No. 06959. Reform Wildlife Management Parking Area	1.7 mi. @ 98° E
52	F	Light Pole Near East Plant Security fence	0.4 mi. @ 114° ESE
51	G	Located in the "Y" of the abandoned Railroad spur, northwest of sludge lagoon	0.7 mi. @ 137° SE
50	H	County Road 459, 3.3 Miles North of Hwy 94, Callaway Electric Coop. Utility Pole No. 35086	0.9 mi. @ 163° SSE
07	J	County Road 459, 2.6 Miles North of Hwy 94, Callaway Electric Coop. Utility Pole No. 35097	1.3 mi. @ 181° S
37	K	County Road 459, 0.9 Miles South of Hwy CC, Callaway Electric Coop. Utility Pole No. 35077	0.7 mi. @ 202° SSW
43	L	County Road 459, 0.7 Miles South of Hwy CC, Callaway Electric Coop Utility Pole No. 35073	0.5 mi. @ 230° SW
44	M	Highway CC, 1.0 Miles South of County Road 459, Callaway Electric Coop. Utility Pole No. 18769	1.7 mi. @ 257° WSW
06	N	County Road 428, 1.2 Miles West of Hwy CC, Callaway Electric Coop. Utility Pole No. 18609	2.0 mi. @ 277° W

TABLE 6 (Continued)

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Station Code	Sector	Site Description	location
45	P	County Road 428, 0.1 Miles West of Hwy CC, Callaway Electric Coop. Utility Pole No. 18580	1.0 mi. @ 290° WNW
03	Q	0.1 Miles West of Hwy CC on Gravel Road 0.8 Miles South Hwy O, Callaway Electric Coop. Utility Pole No. 18559	1.3 mi. @ 308° NW
46	R	North-East side of Hwy CC and County Road 446 Intersection Callaway Electric Coop. Utility Pole No. 28242	1.5 mi @ 333° NNW
An outer ring of sixteen stations, one in each meteorological sector in the 6- to 8-km range from the site.			
36	A	County Road 155, 0.8 Miles South of County Road 132, Callaway Electric Coop. Utility Pole No. 19137	5.2 mi. @ 7° N
21	B	County Road 155, 1.9 miles north of Hwy O, Callaway Electric Coop. Utility Pole No. 19100	4.0 mi @ 23° NNE
20	C	Highway D, 0.4 Miles North of Hwy K, Callaway Electric Coop. Utility Pole No. 12830	4.8 mi. @ 47° NE
18	D	Highway D, 0.4 Miles South of Hwy O, Callaway Electric Coop. Utility Pole No. 12952	3.8 mi @ 63° ENE
17	E	County Road 4053, 0.3 Miles East of Hwy D, Kingdom Telephone Company Pole No. 3 X 12	4.0 mi. @ 89° E
14	F	South-East Side of Hwy 94 and Hwy D Intersection Callaway Electric Coop. Utility Pole No. 11940	5.0 mi @ 121° ESE
11	G	City of Portland, Callaway Electric Coop. Utility Pole No. 12112	4.8 mi. @ 139° SE
10	H	Highway 94, 1.8 Miles East of County Road 459 Callaway Electric Coop. Utility Pole No. 12182	4.0 mi. @ 157° SSE
09	J	North-West Side of Hwy 94 and County Road 459 Junction, Callaway Electric Coop. Utility Pole No. 06754	3.7 mi. @ 183° S
30	K	West Side of County Road 447 at the Junction with County Road 463, Kingdom Telephone Company Pole No. 2K1	4.6 mi. @ 208° SSW
42	L	County Road 447, 2.6 Miles North of County Road 463, Callaway Electric Coop. Utility Pole No. 06326	4.4 mi. @ 233° SW

TABLE 6 (Continued)

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Station Code	Sector	Site Description	Location
32	M	Highway VV, 0.6 Miles West of County Road 447, Callaway Electric Coop. Utility Pole No. 27031	5.4 mi. @ 251° WSW
41	N	Highway AD, 2.8 Miles East of Hwy C, Callaway Electric Coop. Utility Pole No. 18239	4.8 mi. @ 279° W
40	P	North-East Side of County Road 112 and Hwy O Junction Callaway Electric Coop. Utility Pole No. 06326	4.2 mi. @ 294° WNW
39	Q	County Road 112, 0.7 Miles East of County Road 111 Callaway Electric Coop. Utility Pole No. 17516	5.4 mi. @ 315° NW
38	R	County Road 133, 1.5 Miles South of Hwy UU Callaway Elelctric Coop. Utility Pole No. 34708	4.8 mi. @ 337° NNW
Eight Stations to be placed in special interest areas such as population centers, nearby residences, schools, and in 1 or 2 areas to serve as control stations.			
33	N	City of Hams Prairie, South-East of the Hwy C and Hwy AD Junction	7.4 mi. @ 273° W
31	L	City of Mokane, Callaway Electric Coop. Utility Pole No. 06039	7.4 mi. @ 218° SW
26	E	Town of Americus, Callaway Electric Coop. Utility Pole No. 11159	12.1 mi. @ 82° E
27	F	Town of Bluffton, Callaway Electric Coop. Utility Pole No. 11496	9.6 mi. @ 110° ESE
35	R	City of Toledo, Callaway Electric Coop. Utility Pole No. 17684	5.8 mi. @ 342° NNW
23	B	City of Yucatan, Callaway Electric Coop. Utility Pole No. 12670	6.8 mi. @ 16° NNE
11	G	City of Portland, Callaway Electric Coop. Utility Pole No. 12112	4.8 mi. @ 139° SE
20	C	City of Readsville, Callaway Electric Coop. Utility Pole No. 12830	4.8 mi. @ 47° NE
34 (P-Control)	P	North-East Side of Hwy C and County Road 408 Junction	9.7 mi. @ 293° WNW

TABLE 6 (Continued)

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

		Station Code	Sector	Site Description	Location
		01 (Q-Control)	Q	Highway Z, 0.8 Miles East of Business 54, Callaway Electric Coop. Utility Pole No. 21544	1.0 mi. @ 312° NW
2. Airborne					Radioiodine Canister:
	Radioiodine and Particulates	Samples from five locations		Continuous operations of sampler with sample collection as required by dust loading, but at least once per 7 days.	Analyze at least once per 7 days for I-131.
		Three samples from close to the three SITE BOUNDARY locations, in different sectors, of the highest calculated annual average ground level D/Q.			Particulate Sample: Analyze for gross beta radioactivity > 24 hours following filter change. Perform gamma isotopic analysis[d] on those samples for which the gross beta activity is >10 times the yearly mean of control samples. Perform gamma isotopic analysis[d] on composite samples (by location) at least once per 92 days.
		A1	D	Primary Meteorological Tower	1.3 mi. @ 78° ENE
		A8	B	County Road 448, 1.0 Miles South of Hwy O	0.8 mi @ 24° NNE
		B3	A	0.3 Miles East of Hwy O and Hwy CC Junction	1.9 mi. @ 349° N
		One sample from the community with the highest D/Q.			
		A9	R	Community of Reform	1.7 mi. @ 338° NNW

TABLE 6 (Continued)

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

		Station Code	Sector	Site Description	Location
	One sample from a control location, as for example 15-30 km distant and in the least prevalent wind direction.				
		A7	Q	C. Bartley farm	9.5 mi. @ 312° NW
3. Waterborne					
a. Surface[e]	One sample upstream			Composite sample[f] over a period of less than or equal to 31 days.	Gamma isotopic analysis[d] of each sample. Tritium analysis of composite sample at least once per 92 days.
		S01	H	84 feet upstream of discharge, north bank	4.8 mi. @ 144° SE
	One sample downstream				
		S02	G	1.1 miles downstream of discharge, north bank	5.2 mi. @ 133° SE
b. Drinking	One sample of each one to three of the nearest water supplies within 10 miles downstrea, that could be affected by its discharge.			Composite sample over 2-week period when I-131 analysis is performed, monthly composite otherwise.	I-131 analysis on each composite when the dose calculated for the comsumption of the water is greater than 1 mrem per year. Composite for gross beta and gamma isotopic analysis monthly. Composite for tritium analysis quarterly.
	One sample from a control location.				
	As there are no drinking water intakes within 10 miles downstream of the discharge point, the drinking water pathway is currently not included as part of the Callaway Plant Radiological Environmental Monitoring Program. Should future water intakes be constructed within 10 river miles downstream of the discharge point, then the program will be revised to include this pathway. (Ref. 11.6.6)				
c. Sediment from Shoreline	One sample from downstream area with existing or potential recreational value.			Semiannually	Gamma isotopic analysis (d) semiannually.
		C	G	1.0 river mile downstream of discharge, north bank	5.1 mi. @ 135° SE

TABLE 6 (Continued)

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

	Station Code	Sector	Site Description		Location
4. Ingestion					
a. Milk			Samples from milking animals in three location within 5 km distance having the highest dose potential[9]. If there are none, then one sample from milking animals in each of three areas between 5 to 8 km distant where doses are calculated to be greater than 1 mrem per year	Semimonthly when animals are on pasture, monthly at other times.	Gamma isotopic[d] and I-131 analysis semimonthly when animals are on pasture; monthly at other times.
			Due to a lack of milk animals which satisfy these requirements, the milk pathway is currently not included as a part of the Callaway Plant Radiological Environmental Monitoring Program. Should the Annual Land Use Census identify the existence of milking animals in locations which satisfy these requirements, then the program will be revised to include this pathway.		
b. Fish			One sample of each commercially and recreationally important species in vicinity of plant discharge area.	Sample in season, or semiannually if they are not seasonal.	Gamma isotopic analysis[d] on edible portions.
	C	G	1.0 river mile downstream of discharge, north bank		5.1 mi. @ 135° SE
			One sample of same species in areas not influenced by plant discharge.		
	A	H	0.6 river miles upstream of discharge, north bank		4.9 mi. @ 154° SSE

TABLE 6 (Continued)

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

	Station Code	Sector	Site Description		location
c. Food Products			One sample of each principal class of products from any area that is irrigated by water in which liquid plant wastes have been discharged.	At time of harvest (h)	Gamma isotopic analysis[d] on edible portion.

As there are no areas irrigated by water in which liquid plant wastes have been discharged within 50 river miles downstream of the discharge point, this sample type is not currently included as part of the Callaway Plant Radiological Environmental Monitoring Program. Should future irrigation water intakes be constructed within 10 river miles downstream of the discharge point, then the program will be revised to include this sample type. (Ref. 11.7.4 and 11.7.5)

			Samples of three different kinds of broad leaf vegatation grown nearest each of two different offsite locations of highest predicted annual average ground-level D/Q if milk sampling is not performed.	Monthly when available	Gamma isotopic[d] and I-131 analysis.

Station Code	Sector	Site Description	location
V6	R	Becker's farm	1.8 mi. @ 344° NNW
V7	A	Meehan's farm	1.8 mi. @ 356° N

			One sample of each of similar broad leaf vegetation grown 15 to 30 km distant in the least prevalent wind direction (if milk sampling is not performed).	Monthly when available	Gamma isotopic[d] analysis.

Station Code	Sector	Site Description	location
V3	I	Beazley's farm	15.0 mi. @ 227° SW

TABLE 7

REPORTING LEVELS FOR RADIOACTIVITY CONCENTRATIONS IN ENVIRONMENTAL SAMPLES

Analysis	Reporting levels				
	Water (pCi/l)	Airborne Particulate or Gases (pCi/m³)	Fish (pCi/kg), wet	Milk (pCi/l)	Food Product (pCi/kg, wet)
H-3	20,000 *				
Mn-54	1,000		30,000		
Fe-59	400		10,000		
Co-58	1,000		30,000		
Co-60	300		10,000		
Zr-Nb-95	400 **				
I-131	2	0.9		3	100
Cs-134	30	10	1,000	60	1,000
Cs-137	50	20	2,000	70	2,000
Ba-La-140	200 **			300**	

* for drinking water samples. For surface water samples a value of 30,000 pCi/l is used.

** Total activity, parent plus daughter activity.

TABLE 8

MAXIMUM VALUES FOR THE LOWER LIMITS OF DETECTION (LLD)[a,b]

Analysis	Water (pCi/l)	Airborne Particulate or Gases (pCi/m³)	Fish (pCi/kg), wet	Milk (pCi/l)	Food Product (pCi/kg, wet)	Sediment (pCi/Kg, dry)
Gross Beta	4	.01				
H-3	2000 *					
Fe-54	15		130			
Fe-59	30		260			
Co-58,60	15		130			
Zr-Nb-95	15 **					
I-131	1(d)	.07		1	60	
Cs-134	15	.05	130	15	60	150
Cs-137	18	.06	150	18	80	180
Ba-La-140	15 **			15**		

* for surface water samples, a value of 3000 pCi/l is used.

** Total activity, parent plus daughter activity.

TABLE 8 (CONTINUED)
TABLE NOTATION

(a) The LLD is defined for purposes of compliance with the Radioactive Effluent Controls as the smallest concentration of radioactive material in a sample that will yield a net count, above system background, that will be detected with 95% probability with 5% probability of falsely concluding that a blank observation represents a "real" signal.

For a particular measurement system (which may include radiochemical separation):

$$LLD = \frac{4.66\ S_b}{E \cdot V \cdot 2.22 \cdot Y \cdot \exp(-\lambda \Delta t)}$$

Where:

LLD = The lower limit of detection as defined above (as picocurie per unit mass or volume).

S_b = The standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (as counts per minute).

E = The counting efficiency (as counts per disintegration).

V = The sample size (in units of mass or volume).

2.22 = The number of disintegrations per minute per picocurie.

Y = The fractional radiochemical yield (when applicable).

λ = The radioactive decay constant for the particular radionuclide and,

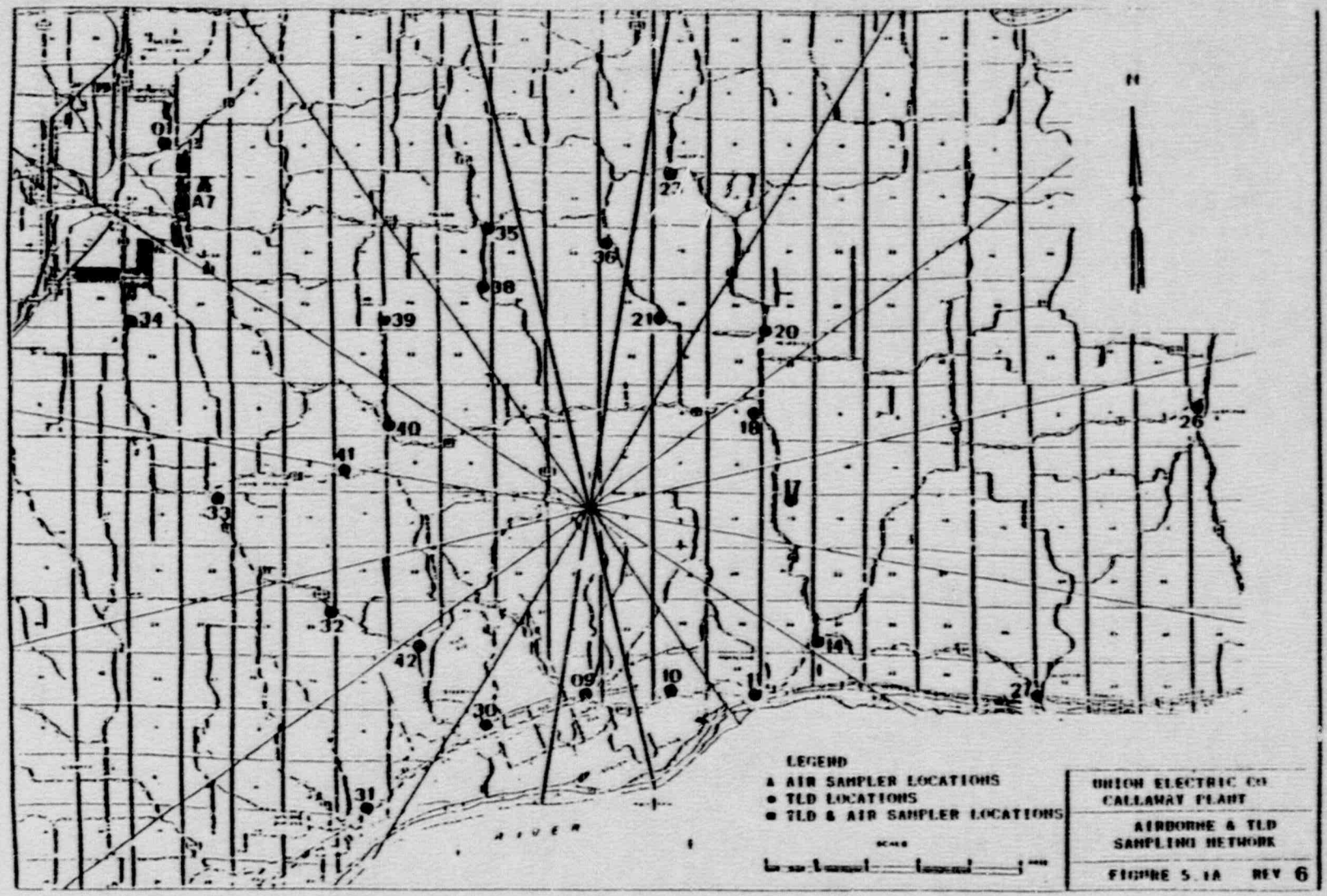
Δt = the elapsed time between sample collection (or end of the smaple collection period) and time of counting (for environmental samples, not plant effluent samples).

Typical values of E, V, Y and Δt shall be used in the calculations.

It should be recognized that the LLD is defined as a a priori (before the fact) limit representing the capability of a measurement system and not as an a posteriori (after the fact) limit for a particular measurement. Analyses are performed in such a manner that the stated LLDs are achieved under routine conditions. Occassionally background fluctuations, unavoidable small sample sizes, the presence of interfering nuclides, or other uncontrollable circumstances may render these LLDs unachievable. In such cases, the contributing factors shall be identified and described in the Annual Radiological Environmental Operating Report.

(b) This list does not mean that only these nuclides are to be considered. Other peaks that are identifiable, together with those of the above nuclides, shall also be analyzed and reported in the Annual Radiological Environmental Operating Report.

(c) Required detection capabilities for thermoluminescent dosimeters used for environmental measurements shall be in accordance with the recommendations of Regulatory Guide 4.13, Revision 1, July 1977. (Refer to Section 5.3)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LEGEND
A AIR SAMPLER LOCATIONS
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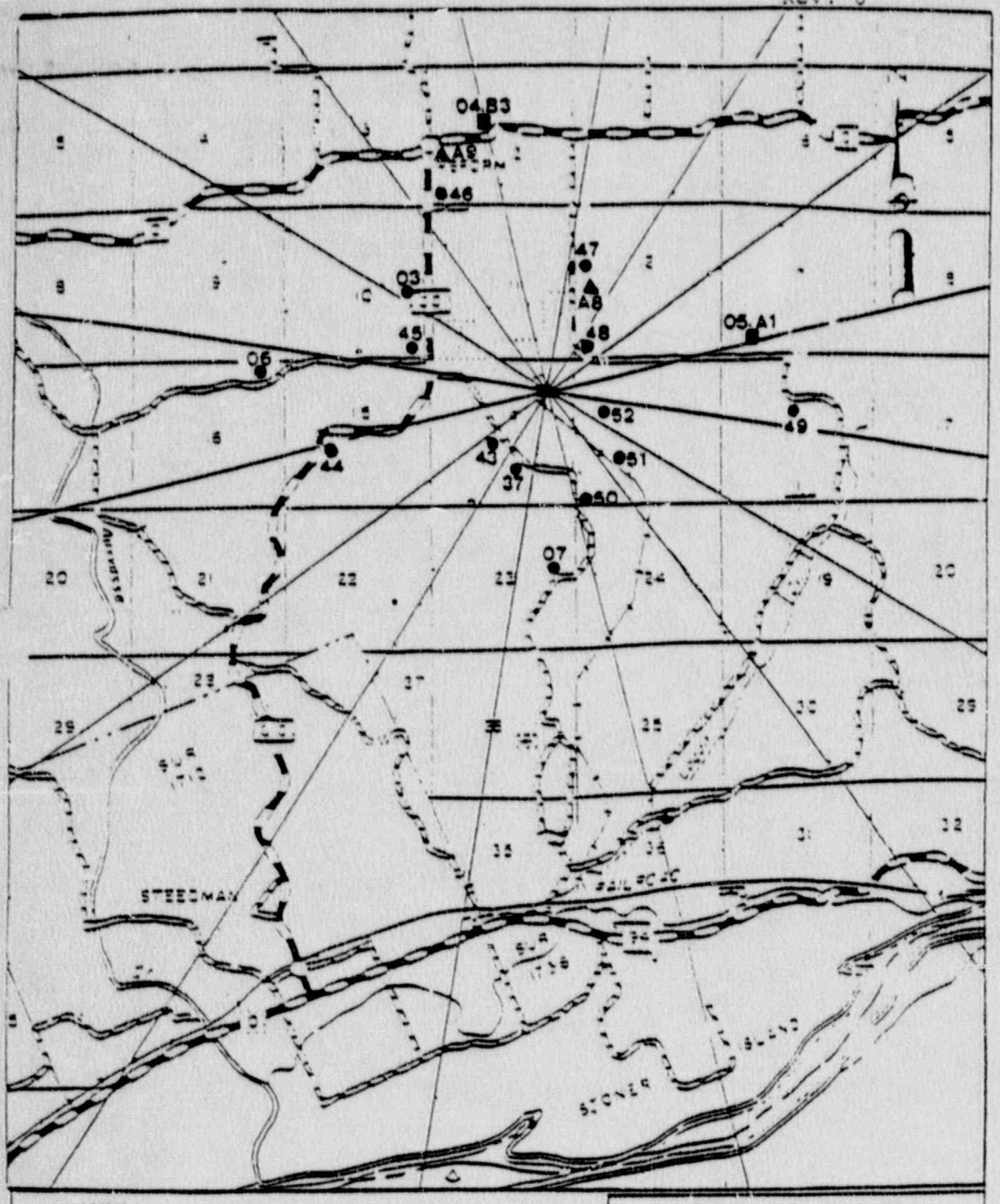
UNION ELECTRIC CO
CALLAWAY PLANT
AIRBORNE & TLD
SAMPLING NETWORK
FIGURE 5.1A REV 6



LEGEND
- ▲ AIR SAMPLER LOCATIONS
- ● TLD LOCATIONS
- ■ TLD & AIR SAMPLER LOCATIONS

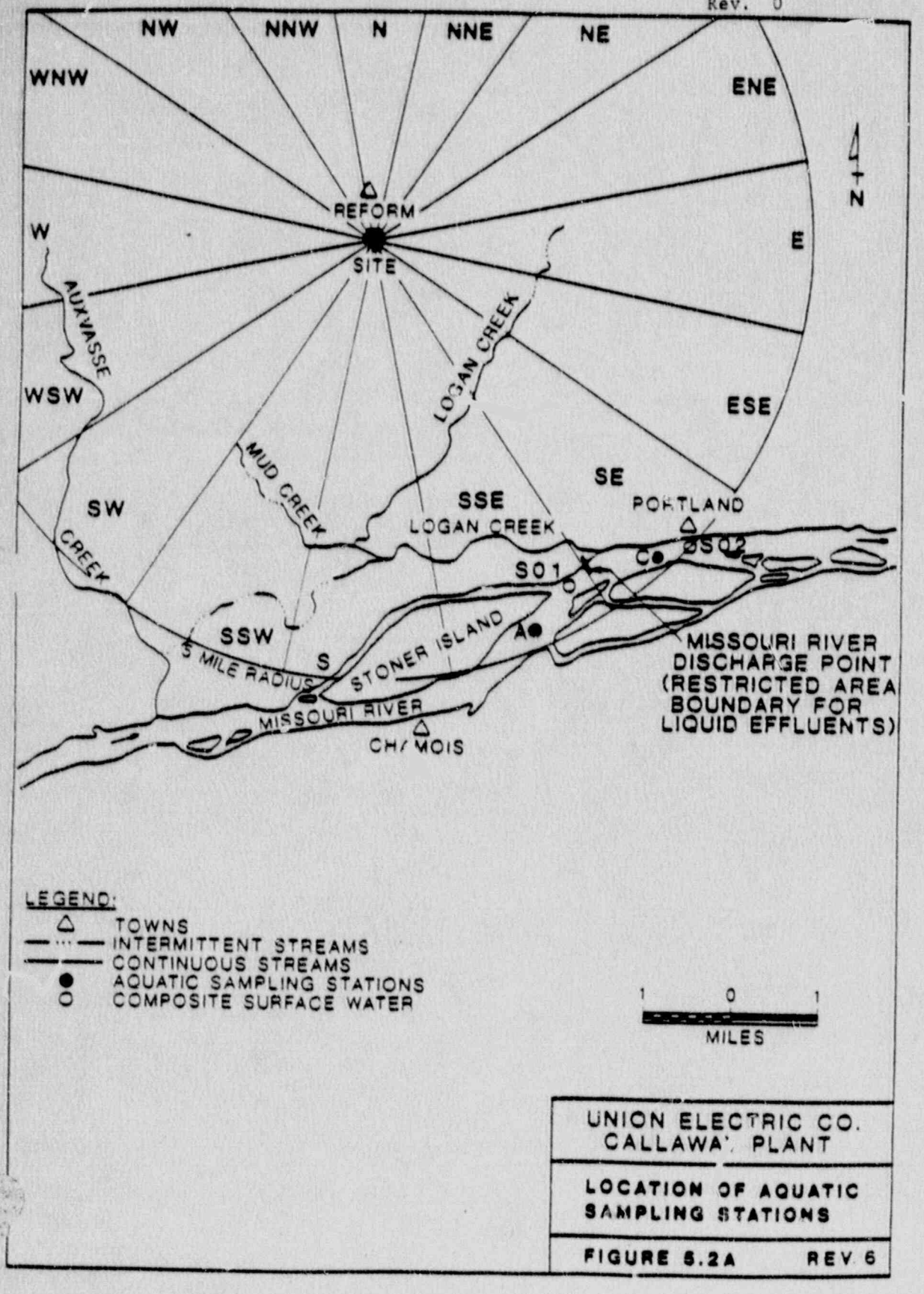
SCALE

0 1 2 3

UNION ELECTRIC CO.
CALLAWAY PLANT

AIRBORNE & TLD
SAMPLING NETWORK

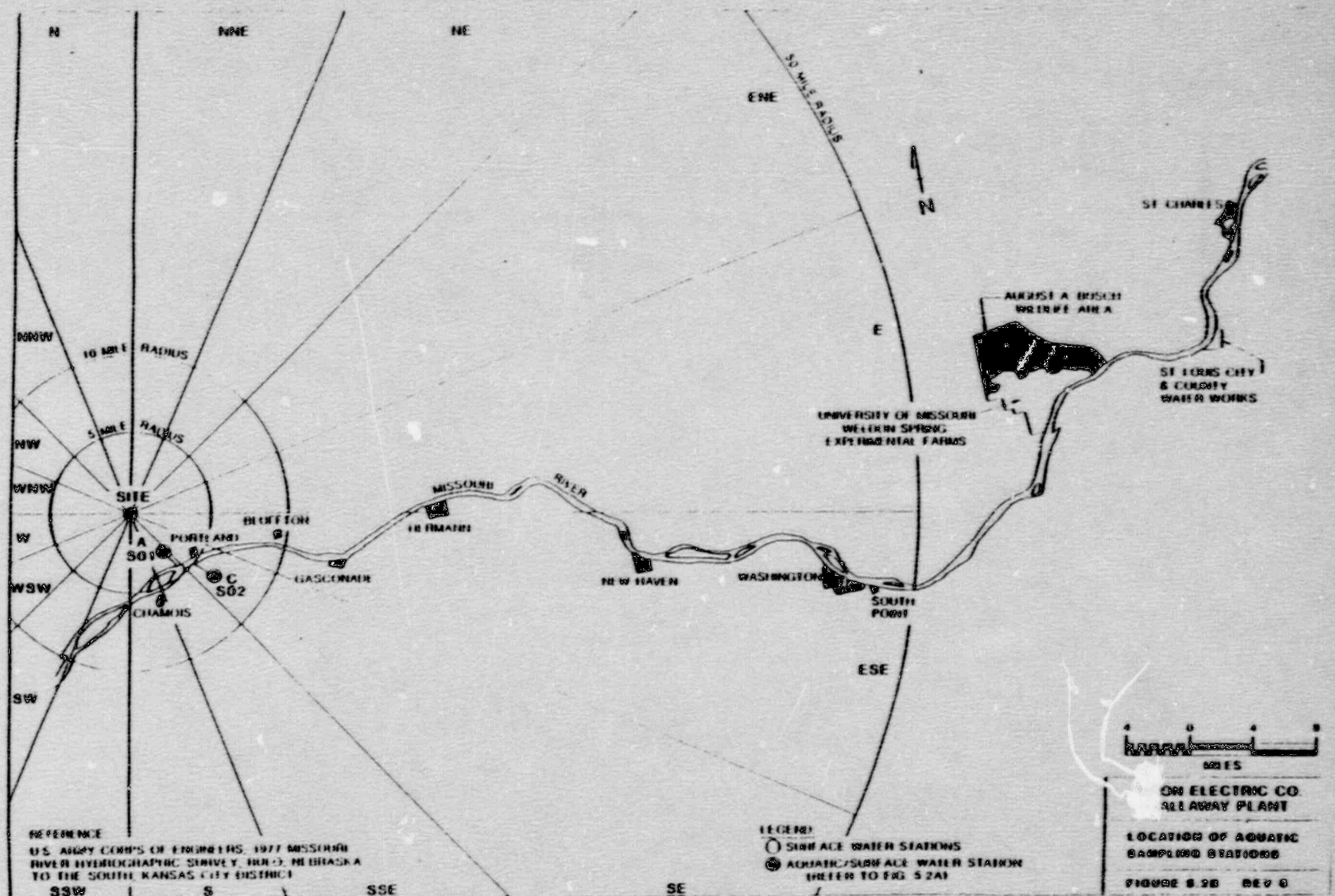
FIGURE 5.1B REV 6



UNION ELECTRIC CO.
CALLAWA' PLANT

LOCATION OF AQUATIC SAMPLING STATIONS

FIGURE 5.2A REV 6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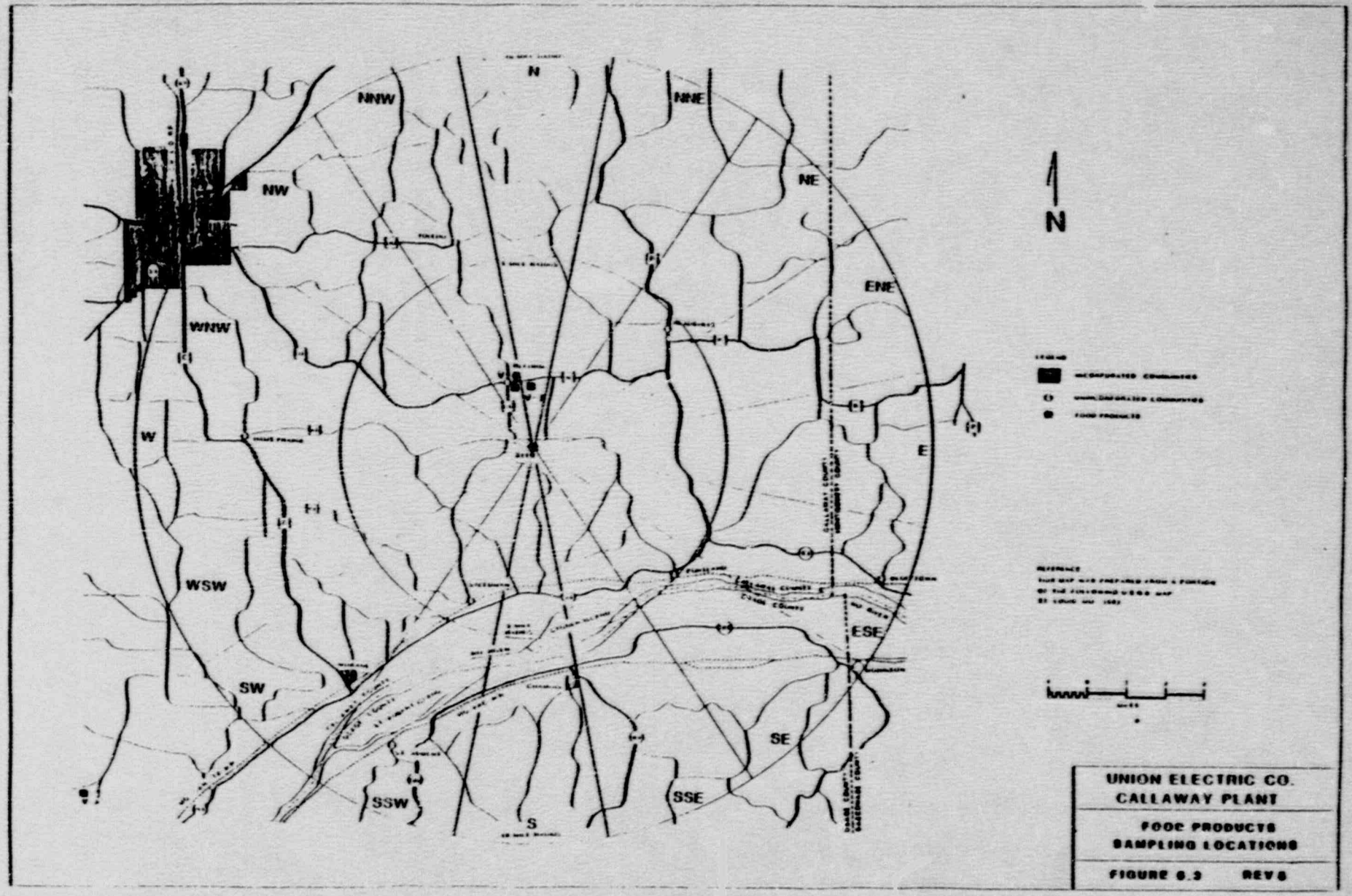
ST CHARLES
ST LOUIS CITY & COUNTY WATER WORKS
MILES
REFERENCE
U.S. ARMY CORPS OF ENGINEERS, 1977 MISSOURI RIVER HYDROGRAPHIC SURVEY, ROAD, NEBRASKA TO THE SOUTH KANSAS CITY DISTRICT
LEGEND
SURFACE WATER STATIONS
AQUATIC/SURFACE WATER STATION
(REFER TO FIG 5.2A1)
ON ELECTRIC CO.
LLAWAY PLANT
LOCATION OF AQUATIC
SAMPLING STATIONS
FIGURE 5.2B REV 0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UNION ELECTRIC CO.
CALLAWAY PLANT
FOOD PRODUCTS
SAMPLING LOCATIONS
FIGURE 6.3 REV 0

6.0 DETERMINATION OF ANNUAL AVERAGE AND SHORT TERM ATMOSPHERIC DISPERSION PARAMETERS

6.1 Atmospheric Dispersion Parameters

The values presented in Table 9 and Table 10 were determined through the analysis of on-site meteorological data collected during the three year period of May 4, 1973 to May 5, 1975 and March 16, 1978 to March 16, 1979.

6.1.1 Long-Term Dispersion Estimates

The variable trajectory plume segment atmospheric transport model MESODIF-II (NUREG/CR-0523) and the straight-line Gaussian dispersion model XOQDOQ (NUREG/CR-2919) were used for determination of the long-term atmospheric dispersion parameters. A more detailed discussion of the methodology and data utilized to calculate these parameters can be found elsewhere (Ref. 11.6.12).

The Unit Vent and Radwaste Building Vent releases are at elevations 66.5 meters and 20 meters above grade, respectively. Both release points are within the building wake of the structures on which they are located, and the Unit Vent is equipped with a rain cover which effectively eliminates the possibility of the exit velocity exceeding five times the horizontal wind speed. All gaseous releases are thus considered to be ground-level releases, and therefore no mixed mode or elevated release dispersion parameters were determined. (Ref. 11.5.2)

6.1.2 Determination of Long-Term Dispersion Estimates for Special Receptor Locations

Calculations utilizing the PUFF model were performed for 22 standard distances to obtain the desired dispersion parameters. Dispersion parameters at the SITE BOUNDARY and at special receptor locations were estimated by logarithmic interpolation according to (Ref. 11.6.13):

$$X = X_1 \left(\frac{d}{d_1}\right)^B \qquad (6.1)$$

Where:

$B = \ln (X_2/X_1)/\ln (d_2/d_1)$.

X_1, X_2 = Atmospheric concentrations at distances d_1 and d_2, respectively, from the source (in Ci/m^3).

The distances d_1 and d_2 were selected such that $d_1 < d < d_2$.

6.1.3 Short Term Dispersion Estimates

Airborne releases are classified as short term if they are less than or equal to 500 hours during a calendar year and not more than 150 hours in any quarter. Short term dispersion estimates are determined by multiplying the appropriate long term dispersion estimate by a correction factor (Ref. 11.9.1 and 11.15.1):

$$F = (T_s/T_a)^S \qquad (6.2)$$

Where:

T_S = The total number of hours of the short term release.

T_a = The total number of hours in the data collection period from which the long term diffusion estimate was determined (Refer to Section 6.1).

Values of the slope factor (S), are presented in TABLE 11.

Short term dispersion estimates are applicable to short term releases which are not sufficiently random in both time of day and duration (e.g., the short term release periods are not dependent solely on atmospheric conditions or time of day) to be represented by the annual average dispersion conditions. (Ref. 11.8.11.)

6.1.3.1 The Determination of the Slope Factor (S).

The general approach employed by subroutine PURGE of XOQDOQ (Ref. 11.15.1) was utilized to produce values of the slope of the (X/Q) curves (Slope Factor (S)) for both the Radwaste Building Vent and the Unit Vent. However, instead of using approximation procedures to produce the 15 precentile (X/Q) values, the 15 percentile (X/Q) value for each release and at each location was determined by ranking all the 1-hour $(X/Q)_1$ values for that release and at the location in descending order. The $(X/Q)_1$ value which corresponded to the 15 percentile of all the calculated (X/Q) values within a sector was extracted for use in the intermittent release (X/Q) calculation.

The intermittent release (X/Q) curve was constructed using the calculated 1-hour 15 percentile $(X/Q)_1$ and its corresponding annual average $(X/Q)_a$. A graphic representation, of how the computational procedure works is illustrated by Figure 4.8 of reference 11.15.1. The straight line connecting these points represents $(X/Q)_i$ values for intermittent releases, ranging in duration from one (1) hour to 8760 hours. The slope (S) of the curve is expressed as:

$$S = \frac{-\log \left((X/Q)_1 / (X/Q)_a \right)}{\log (Ta/T_1)} \qquad (6.3)$$

or

$$S = \frac{-(\log (X/Q)_1 - \log (X/Q)_a)}{\log Ta - \log T_1} \qquad (6.4)$$

6.2 Atmospheric Dispersion Parameters for Farming Areas Within The SITE BOUNDARY

The dispersion parameters for farming areas within the SITE BOUNDARY are intended for a narrow scope application: That of calculating the dose to the current tennant farmer from gaseous effluents while he conducts farming activities within the SITE BOUNDARY.

For the purpose of these calculations, it was assumed that all of the farmer's time, approximately 1100 hours per year, is spent on croplands within the SITE BOUNDARY, and that his time is divided evenly over all of the croplands. Fractional acreage/time - weighted dispersion parameters were calculated for each plot as described in reference 11.5.6. The weighted dispersion parameters for each plot were then summed (according to type) in order to produce a composite value of the dispersion parameters. The dispersion parameters presented in Tables 9 & 10 therefore represent the distributed activities of the farmer within the SITE BOUNDARY and his estimated occupancy period.

TABLE 9

HIGHEST ANNUAL AVERAGE ATMOSPHERIC DISPERSION PARAMETERS (a)

RADWASTE BUILDING VENT

LOCATION (b)	SECTOR	DISTANCE (METERS)	X/Q (sec/m³)	X/Q Decayed/Undepleted (sec/m³)	X/Q Decayed/Depleted (sec/m³)	D/Q (m⁻²)
SITE BOUNDARY	NNW	2200	1.3E-6	1.3E-6	1.1E-6	4.3E-9
Nearest Cow (c)	WSW	2172	5.7E-7	5.7E-7	4.9E-7	1.6E-9
Nearest Goat (c)	WSW	2172	5.7E-7	5.7E-7	4.9E-7	1.6E-9
Nearest Meat Animal (d)	NNW	2864	8.7E-7	8.7E-7	7.2E-7	2.6E-9
Nearest Vegtable (c) Garden	NNW	2864	8.7E-7	8.7E-7	7.2E-7	2.6E-9
Nearest Residence(c)	NNW	2864	8.7E-7	8.7E-7	7.2E-7	2.6E-9
Farming Areas Within Site Boundary (c)(e)	N/A	N/A	2.9E-7	2.9E-7	2.6E-7	1.1E-9

(a) Values given are from FSAR Table 2.3-84

(b) Data from 1988 Land Use Census

(c) Values derived from FSAR Table 2.3-81, using the methodology presented in Equation (6.4) (Ref. 11.5.6)

(d) The nearest meat animal is assumed to exist at the location of the nearest resident.

(e) These values were derived for a narrow scope application. Extreme caution should be exercised when determining their suitability for use in other applications.

Building Shape Parameter (C) = 0.5 (Ref. 11.5.3)
Vertical Height of Highest Adjacent Building (V) = 19.96 meters (Ref. 11.5.3)

TABLE 10

HIGHEST ANNUAL AVERAGE ATMOSPHERIC DISPERSION PARAMETERS (a)

UNIT VENT

LOCATION (b)	SECTOR	DISTANCE (METERS)	X/Q	X/Q Decayed/Undepleted	X/Q Decayed/Depleted	D/Q
		(sec/m^3)		(sec/m^3)	(sec/m^3)	(m^{-2})	
SITE BOUNDARY	NNW	2200	1.0E-6	9.9E-7	8.5E-7	4.3E-9
Nearest Cow (c)	WSW	2172	4.4E-7	4.4E-7	3.8E-7	1.6E-9
Nearest Goat (c)	WSW	2172	4.4E-7	4.4E-7	3.8E-7	1.6E-9
Nearest Meat Animal (d)	NNW	2864	6.8E-7	6.8E-7	5.7E-7	2.6E-9
Nearest Vegtable (c) Garden	NNW	2864	6.8E-7	6.8E-7	5.7E-7	2.6E-9
Nearest Residence(c)	NNW	2864	6.8E-7	6.8E-7	5.7E-7	2.6E-9
Farming Areas Within the Site Boundary(c)(e)	N/A	N/A	2.1E-7	2.1E-7	1.9E-7	1.1E-9

(a) Values given are from FSAR Table 2.3-82
(b) Data from 1988 Land Use Censes
(c) Values derived from FSAR Table 2.3-83, using the methodology presented in Equation (6.1) (Ref. 11.5.6)
(d) The nearest meat animal is assumed to exist at the location of the nearest resident.
(e) These values were derived for a narrow scope application. Extreme caution should be exercised when determining their suitability for use in other applications.

Building Shape Parameter (C) = 0.5 (Ref. 11.5.1)
Vertical Height of Highest Adjacent Building (v) = 66.45 meters (Ref. 11.5.3)

TABLE 11

SHORT TERM DISPERSION PARAMETERS (a) (c)

Location (b)	Sector	Distance (meters)	Slope Factor(S) Unit Vent	Radwaste Building Vent
Site Boundary	S	1300	-.328	-.320
Nearest Cow	NW	5053	-.263	-.266
Nearest Goat	NW	5053	-.263	-.266
Nearest Meat Animal	NNW	2736	-.262	-.268
Nearest Vegetable Garden	NNW	2865	-.264	-.268
Nearest Residence	NNW	2865	-.264	-.268

(a) Reference 11.5.3
(b) Data from 1987 Land Use Census
(c) Recirculation Factor = 1.0

TABLE 12

APPLICATION OF ATMOSPHERIC DISPERSION PARAMETERS

DOSE PATHWAY	ODCM REFERENCE	DISPERSION PARAMETER	CONTROLLING AGE GROUP	CONTROLLING LOCATION
Noble Gas, Beta Air	3.5.2.1	X/Q, decayed/undepleted (2.26 day halflife)	--	Site Boundary
Noble Gas, Gamma Air	3.5.2.1	X/Q, decayed/undepleted (2.26 day halflife)	--	Site Boundary
Noble Gas, Total Body	3.4.1 & 3.5.1.1	X/Q, decayed/undepleted (2.26 day halflife)	--	Site Boundary
Noble Gas, Skin	3.4.2 & 3.5.1.1	X/Q, decayed/undepleted (2.26 day halflife)	--	Site Boundary
Ground Plane Deposition	3.5.2.2	D/Q	--	Nearest Resident
Inhalation	3.5.2.2	X/Q, decayed/depleted (8 day halflife)	Child	Nearest Resident
Vegetation	3.5.2.2	D/Q*	Child	Nearest Resident
Milk	3.5.2.2	D/Q*	Child	Nearest Resident
Meat	3.5.2.2	D/Q*	Child	Nearest Resident

*For H-3 and C-14, X/Q, decayed/depleted is used instead of D/Q (Reference 11.11.1).

7.0 REPORTING REQUIREMENTS

7.1 ANNUAL RADIOLOGICAL ENVIRONMENTAL OPERATING REPORT

Routine Annual Radiological Environmental Operating Reports covering the operation of the unit during the previous calendar year shall be submitted prior to May 1 of each year. The initial report shall be submitted prior to May 1 of the year following initial criticality.

The Annual Radiological Environmental Operating Reports shall include summaries, interpretations, and an analysis of trends of the results of the radiological environmental surveillance activities for the report period, including a comparison with preoperational studies, with operational controls and with previous environmental surveillance reports, and an assessment of the observed impacts of the plant operation on the environment. The reports shall also include the results of Land Use Censuses required by Section 9.12.

The Annual Radiological Environmental Operating Reports shall include the results of analysis of all radiological environmental samples and of all environmental radiation measurements taken during the period pursuant to the locations specified in the Table and Figures in the ODCM, as well as summarized the tabulated results of these analyses and measurements in the format of the table in the Radiological Assessment Branch Technical Position, Revision 1, November 1979. In the event that some individual results are not available for inclusion with the report, the report shall be submitted noting and explaining the reasons for the missing results. The missing data shall be submitted as soon as possible in a supplementary report.

The reports shall also include the following: a summary description of the radiological environmental monitoring program; at least two legible maps* covering all sampling locations keyed to a table giving distances and directions from the centerline of one reactor; the results of licensee participation in the Interlaboratory Comparison Program and the corrective action being taken if the specified program is not being performed as required by Section 9.13.1; reasons for not conducting the Radiological Environmental Monitoring Program as required by Section 9.11.1 and discussion of all deviations from the sampling schedule of Table 9.11-A, discussion of environmental sample measurements that exceed the reporting levels of Table 9.11-B, but are not the result of the plant effluents, pursuant to Section 9.11.1; and discussion of all analyses in which the LLD required by Table 9.11-C was not achievable.

*One map shall cover stations near the SITE BOUNDARY; a second shall include the more distant stations.

7.2 SEMIANNUAL RADIOACTIVE EFFLUENT RELEASE REPORT

Routine Semiannual Radioactive Effluent Release Reports covering the operation of the unit during the previous 6 months of operation shall be submitted within 60 days after January 1 and July 1 of each year. The period of the first report shall begin with the date of initial criticality.

The Semiannual Radioactive Effluent Release Reports shall include a summary of the quantities of radioactive liquid and gaseous effluents and solid waste released from the unit as outlined in Regulatory Guide 1.21, "Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants, "Revision 1, June 1974, with data summarized on a quarterly basis following the format of Appendix B thereof. For solid wastes, the format for Table 3 in Appendix B shall be supplemented with three additional categories: class of solid waste (as defined by 10 CFR Part 60), type of container (e.g., LSA, Type A, Type B, Large Quantity), and SOLIDIFICATION agent or absorbent (e.g., cement, urea formaldehyde).

The Semiannual Radioactive Effluent Release Report to be submitted within 60 days after January 1 of each year shall include an annual summary of hourly meteorological data collected over the previous year. This annual summary may be either in the form of an hour-by-hour listing on magnetic tape of wind speed, wind direction, atmospheric stability, and precipitation (if measured), or in the form of joint frequency distributions of wind speed, wind direction, and atmospheric stability*. This same report shall include an assessment of the radiation doses due to the radioactive liquid and gaseous effluents released from the unit or station during the previous calendar year. This same report shall also include 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 (Technical Specifications, Figures 5.1-3 and 5.1-4) during the report period using historical average atmospheric conditions. All assumptions used in making these assessments, i.e., specific activity, exposure time and location, shall be included in these reports. The meteorological conditions concurrent with the time of release of radioactive materials in gaseous effluents, as determined by sampling frequency and measurement, shall be used for determining the gaseous pathway doses. The assessment of radiation doses shall be performed in accordance with the methodology and parameters in the OFFSITE DOSE CALCULATION MANUAL (ODCM).

*In lieu of submission with the Semiannual Radioactive Effluent Release Report, Union Electric has the option of retaining this summary of required meteorological data on site in a file that shall be provided to the NRC upon request.

The Semiannual Radioactive Effluent Release Report to be submitted within 60 days after January 1 of each year shall also include an assessment of radiation doses to the likely most exposed MEMBER OF THE PUBLIC from 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 Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operation." Acceptable methods for calculating the dose contribution from liquid and gaseous effluents are given in Regulatory Guide 1.109, Rev. 1, October 1977.

The Semiannual 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 effluents made during the reporting period.

The Semiannual Radioactive Effluent Release Reports shall include any major changes made during the reporting period to any Liquid or Gaseous Treatment Systems, pursuant to Section 10.1. It shall also include a listing of new locations for dose calculations and/or environmental monitoring identified by the Land Use Census pursuant to Section 9.12.1.

The Semiannual Radioactive Effluent Release Reports shall also include the following information: An explanation as to why the inoperability of liquid or gaseous effluent monitoring instrumentation was not corrected within the time specified in Section 9.1.1 or 9.2.1, respectively; and description of the events leading to liquid holdup tanks or gas storage tanks exceeding the limits of Technical Specification 3.11.1.4 or 3.11.2.6, respectively.

2815 The Semiannual Radioactive Effluent Release Reports shall also include as a part of or submitted concurrent with, a complete and legible copy of all revisions of the ODCM that occurred during the reporting period pursuant to Specification 6.14.2.

8.0 IMPLEMENTATION OF ODCM METHODOLOGY

The ODCM provides the mathematical relationships used to implement the Radioactive Effluent Controls.

For routine effluent release and dose assessment, computer codes are utilized to implement the ODCM methodologies. These codes have been evaluated by a qualified independent reviewer to ensure that they produce results consistent with the methodologies presented in the ODCM. (Ref. 11.5.4.)

9.0 RADIOACTIVE EFFLUENT CONTROLS (REC)

NOTE 1. The terms in this section that appear in CAPITALIZED TYPE are defined in Technical Specifications.
2. All frequency notations are per Table 1.1 of Technical Specifications.

9.0.1 Compliance with the Controls contained in the succeeding Controls is required during the OPERATIONAL MODES or other conditions specified therein; except that upon failure to meet the Control, the associated ACTION requirements shall be met.

9.0.2 Noncompliance with a Control shall exist when the requirements of the Control and associated ACTION requirements are not met within the specified time intervals. If the Control is restored prior to expiration of the specified time intervals, completion of the ACTION requirements is not required.

9.0.3 When a Control is not met, except as provided in the associated ACTION requirements, within 1 hour ACTION shall be initiated to place the unit in a MODE in which the Control does not apply by placing it, as applicable, in:

a. At least HOT STANDBY within the next 6 hours,

b. At least HOT SHUTDOWN within the following 6 hours, and

c. At least COLD SHUTDOWN within the subsequent 24 hours.

Where corrective measures are completed that permit operation under the ACTION requirements, the action may be taken in accordance with the specified time limits as measured from the time of failure to meet the Control. Exceptions to these requirements are stated in the individual Controls.

This Control is not applicable in MODE 5 or 6.

9.0.4 Entry into an OPERATIONAL MODE or other specified condition shall not be made unless the conditions for the Control are met without reliance on provisions contained in the ACTION requirements. This provision shall not prevent passage through or to OPERATIONAL MODES as required to comply with ACTION requirements. Exceptions to these requirements are stated in the individual Controls.

9.0.5 Operability of equipment included in Section 9.0 must be tracked in the Equipment Out-Of-Service Log (EOSL) as per ODP-ZZ-00002, Equipment Status Control.

9.1 RADIOACTIVE LIQUID EFFLUENT MONITORING INSTRUMENTATION

41838 **9.1.1 Controls**

9.1.1.1 The radioactive liquid effluent monitoring instrumentation channels shown in Table 9.1-A shall be OPERABLE with their Alarm/Trip Setpoints set to ensure that the limits of Section 9.3.1.1 are not exceeded. The Alarm/Trip Setpoints of these channels shall be determined and adjusted in accordance with the methodology and parameters in the OFFSITE DOSE CALCULATION MANUAL (ODCM).

APPLICABILITY: At all times.

ACTION:

a. With a radioactive liquid effluent monitoring instrumentation channel Alarm/Trip Setpoint less conservative than required by the above Control, immediately suspend the release of radioactive liquid effluents monitored by the affected channel, or declare the channel inoperable.

b. With less than the minimum number of radioactive liquid effluent monitoring instrumentation channels OPERABLE, take the ACTION shown in Table 9.1-A. Restore the inoperable instrumentation to OPERABLE status within the time specified in the ACTION, or explain in the next Semiannual Radioactive Effluent Release Report, pursuant to Section 7.2, why this inoperability was not corrected within the time specified.

c. The provisions of Sections 9.0.3 and 9.0.4 are not applicable.

41839 **9.1.2 Surveillance Requirements**

9.1.2.1 Each radioactive liquid effluent monitoring instrumentation channel shall be demonstrated OPERABLE by the performance of the CHANNEL CHECK, SOURCE CHECK, CHANNEL CALIBRATION and ANALOG CHANNEL OPERATIONAL TEST at the frequencies shown in Table 9.1-B.

41840 9.1.3 Bases

9.1.3.1 Radioactive Liquid Effluent Monitoring Instrumentation

The radioactive liquid effluent instrumentation is provided to monitor and control, as applicable, the releases of radioactive materials in liquid effluents during actual or potential releases of liquid effluents. The Alarm/Trip Setpoints for these instruments shall be calculated and adjusted in accordance with the methodology and parameters in the ODCM to ensure that the alarm/trip will occur prior to exceeding the limits of 10 CFR Part 20. The OPERABILITY and use of this instrumentation is consistent with the requirements of General Design Criteria 60, 63, and 64 of Appendix A to 10 CFR Part 50.

TABLE 9.1-A

RADIOACTIVE LIQUID EFFLUENT MONITORING INSTRUMENTATION

	INSTRUMENT	MINIMUM CHANNELS OPERABLE	ACTION
1.	Radioactivity Monitors Providing Alarm and Automatic Termination of Release		
	a. Liquid Radwaste Discharge Monitor (HB-RE-18)	1	31
	b. Steam Generator Blowdown Discharge Monitor (BM-RE-52)	1	32
	c. Turbine Building Drain Monitor (LE-RE-59)	1	32
	d. Secondary Liquid Waste System Monitor (HF-RE-45)	1	33
2.	Flow Rate Measurement Devices		
	a. Liquid Radwaste Discharge Line		
	1) Waste Monitor Tank A Discharge Line	1	34
	2) Waste Monitor Tank B Discharge Line	1	34
	b. Steam Generator Blowdown Discharge Line	1	34
	c. Secondary Liquid Waste System Discharge Line	1	34
	d. Combined Cooling Tower Blowdown and Bypass Flow	1	34

Table 9.1-A (Continued)

ACTION STATEMENTS

ACTION 31 - With the number of channels OPERABLE less than required by the Minimum Channels OPERABLE requirement, effluent releases via this pathway may continue for up to 14 days provided that prior to initiating a release:

a. At least two independent samples are analyzed in accordance with Section 9.3.2.1, and

b. At least two technically qualified members of the facility staff independently verify the release rate calculations and discharge line valving.

Otherwise, suspend release of radioactive effluents via this pathway.

ACTION 32 - With the number of channels OPERABLE Less than required by the Minimum Channels OPERABLE requirement, effluent releases via this pathway may continue for up to 30 days provided grab samples are analyzed for principal gamma emitters and I-131 at a lower limit of detection as specified in Table 9.3-A:

a. At least once per 12 hours when the specific activity of the secondary coolant is greater than 0.01 microCurie/gram DOSE EQUIVALENT I-131, or

b. At least once per 24 hours when the specific activity of the secondary coolant is less than or equal to 0.01 microCurie/gram DOSE EQUIVALENT I-131.

Table 9.1-A (Continued)

ACTION STATEMENTS

ACTION 33 - With the number of channels OPERABLE Less than required by the Minimum Channels OPERABLE requirement, effluent releases via this pathway may continue for up to 30 days provided that prior to initiating a release:

a. At least two independent samples are analyzed in accordance with Section 9.3.2.1, and

b. At least two technically qualified members of the facility staff independently verify the release rate calculations and discharge line valving.

Otherwise, suspend release of radioactive effluents via this pathway.

ACTION 34 - With the number of channels OPERABLE less than required by the Minimum Channels OPERABLE requirement, effluent releases via this pathway may continue for up to 30 days provided the flow rate is estimated at least once per 4 hours during actual releases. Pump performance curves generated in place may be used to estimate flow.

TABLE 9.1-8

RADIOACTIVE LIQUID EFFLUENT MONITORING INSTRUMENTATION SURVEILLANCE REQUIREMENTS

INSTRUMENT	CHANNEL CHECK	SOURCE CHECK	CHANNEL CALIBRATION	ANALOG CHANNEL OPERATIONAL TEST
1. Radioactivity Monitors Providing Alarm and Automatic Termination of Release				
a. Liquid Radwaste Discharge Monitor (HB-RE-18)	D	P	R(2)	Q(1)
b. Steam Generator Blowdown Discharge Monitor (BM-RE-52)	D	M	R(2)	Q(1)
c. Turbine Building Drain Monitor (LE-RE-59)	D	M	R(2)	Q(1)
d. Secondary Liquid Waste System Monitor (HF-RE-45)	D	P	R(2)	Q(1)
2. Flow Rate Measurement Devices				
a. Liquid Radwaste Discharge Line	D(3)	N.A.	R	N.A.
b. Steam Generator Blowdown Discharge Line	D(3)	N.A.	R	N.A.
c. Secondary Liquid Waste System Discharge Line	D(3)	N.A.	R	N.A.
d. Combined Cooling Tower Blowdown and Bypass Flow	D(3)	N.A.	R	N.A.

TABLE 9.1-B (Continued)

TABLE NOTATIONS

41841

(1) The ANALOG CHANNEL OPERATIONAL TEST shall also demonstrate that automatic isolation of this pathway and control room alarm annunciation occur as appropriate if any of the following conditions exists:

a. Instrument indicates measured levels above the Alarm/Trip Setpoint (isolation and alarm), or

b. Circuit failure (alarm only), or

c. Instrument indicates a downscale failure (alarm only), or

d. Instrument controls not set in operate mode (alarm only).

(2) The initial CHANNEL CALIBRATION shall be performed using one or more of the reference (gas or liquid and solid) standards certified by the National Bureau of Standards (NBS) or using standards that have been obtained from suppliers that participate in measurement assurance activities with NBS. These standards shall permit calibrating the system over its intended range of energy, measurement range, and establish monitor response to a solid calibration source. For subsequent CHANNEL CALIBRATION, NBS traceable standard (gas, liquid, or solid) may be used; or a gas, liquid, or solid source that has been calibrated by relating it to equipment that was previously (within 30 days) calibrated by the same geometry and type of source standard traceable to NBS.

(3) CHANNEL CHECK shall consist of verifying indication of flow during periods of release. CHANNEL CHECK shall be made at least once per 24 hours on days on which continuous, periodic, or batch releases are made.

9.2 RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION

41872 ### 9.2.1 Controls

9.2.1.1 The radioactive gaseous effluent monitoring instrumentation channels shown in Table 9.2-A shall be OPERABLE with their Alarm/Trip Setpoints set to ensure that the limits of Section 9.6.1.1 and Technical Specification 3.11.2.5 are not exceeded. The Alarm/Trip Setpoints of these channels meeting Section 9.6.1.1 shall be determined and adjusted in accordance with the methodology and parameters in the ODCM.

APPLICABILITY: As shown in Table 9.2-A.

ACTION:

a. With a radioactive gaseous effluent monitoring instrumentation channel Alarm/Trip Setpoint less conservative than required by the above specification, immediately suspend the release of radioactive gaseous effluents monitored by the affected channel, or declare the channel inoperable.

b. With less than the minimum number of radioactive gaseous effluent monitoring instrumentation channels OPERABLE, take the ACTION shown in Table 9.2-A. Restore the inoperable instrumentation to OPERABLE status within the time specified in the ACTION, or explain in the next Semiannual Radioactive Effluent Release Report, pursuant to Technical Specification 6.9.1.7, why this inoperability was not corrected within the time specified.

c. The provisions of Sections 9.0.3 and 9.0.4 are not applicable.

41843 ### 9.2.2 Surveillance Requirements

9.2.2.1 Each radioactive gaseous effluent monitoring instrumentation channel shall be demonstrated OPERABLE by performance of the CHANNEL CHECK, SOURCE CHECK, CHANNEL CALIBRATION and ANALOG CHANNEL OPERATIONAL TEST at the frequencies shown in Table 9.2-B.

9.2.3 Bases

41844 9.2.3.1 Radioactive Gaseous Effluent Monitoring Instrumentation

The radioactive gaseous effluent instrumentation is provided to monitor and control, as applicable, the releases of radioactive materials in gaseous effluents during actual or potential releases of gaseous effluents. The Alarm/Trip Setpoints for these instruments shall be calculated and adjusted in accordance with the methodology and parameters in the ODCM to ensure that the alarm/trip will occur prior to exceeding the limits of 10 CFR Part 20. The OPERABILITY and use of this instrumentation is consistent with the requirements of General Design Criteria 60, 63, and 64 of Appendix A to 10 CFR Part 50. The sensitivity of any noble gas activity monitor used to show compliance with the gaseous effluent release requirements of Section 9.7.1.1 shall be such that concentrations as low as 1 x 10-^{4} µCi/cc are measurable.

TABLE 9.2-A

RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION

	INSTRUMENT	MINIMUM CHANNELS OPERABLE	APPLICABILITY	ACTION
1.	Unit Vent System			
	a. Noble Gas Activity Monitor - Providing Alarm (GT-RE-21)	1	*	40
	b. Iodine Sampler	1	*	43
	c. Particulate Sampler	1	*	43
	d. Flow Rate	1	*	45
	e. Sampler Flow Rate Monitor	1	*	39
2.	Containment Purge System			
	a. Noble Gas Activity Monitor - Providing Alarm and Automatic Termination of Release (GT-RE-22, GT-RE-33)	2	*	41
	b. Iodine Sampler	1	*	43
	c. Particulate Sampler	1	*	43
	d. Flow Rate	N.A.	*	45
	e. Sampler Flow Rate Monitor	1	*	39
3.	Radwaste Building Vent System			
	a. Noble Gas Activity Monitor Providing Alarm and Automation Termination of Release (GH-RE-10)	1	*	38, 40
	b. Iodine Sampler	1	*	43
	c. Particulate Sampler	1	*	43
	d. Flow Rate	N.A.	*	45
	e. Sampler Flow Rate Monitor	1	*	39

TABLE 9.2-A (Continued)

TABLE NOTATIONS

* At all times.

ACTION STATEMENTS

ACTION 38 - With the number of channels OPERABLE less than required by the Minimum Channels OPERABLE requirement, the contents of the tank(s) may be released to the environment for up to 14 days provided that prior to initiating the release:

a. At least two independent samples of the tank's contents are analyzed, and

b. At least two technically qualified members of the facility staff independently verify the release rate calculations and discharge valve lineup.

Otherwise, suspend release of radioactive effluents via this pathway.

ACTION 39 - With the number of channels OPERABLE less than required by the Minimum Channels OPERABLE requirement, effluent releases via this pathway may continue provided the flow rate is estimated based on fan status and operating curves or actual measurements at least once per 4 hours.

ACTION 40 - With the number of channels OPERABLE less than required by the Minimum Channels OPERABLE requirement, effluent releases via this pathway may continue for up to 30 days provided grab samples are taken at least once per 12 hours and these samples are analyzed for radioactivity within 24 hours.

ACTION 41 - With the number of channels OPERABLE less than required by the Minimum Channels OPERABLE requirement, immediately suspend PURGING of radioactive effluents via this pathway.

TABLE 9.2-A (Continued)

TABLE NOTATIONS

ACTION 43 - With the number of channels OPERABLE less than required by the Minimum Channels OPERABLE requirement, effluent releases via the affected pathway may continue for up to 30 days provided samples are continuously collected with auxiliary sampling equipment as required in Table 9.6-A.

ACTION 45 - Flow rate for this system shall be based on far status and operating curves or actual measurements.

TABLE 9.2-8

RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION SURVEILLANCE REQUIREMENTS

INSTRUMENT	CHANNEL CHECK	SOURCE CHECK	CHANNEL CALIBRATION	ANALOG CHANNEL OPERATIONAL TEST	MODES FOR WHICH SURVEILLANCE IS REQUIRED
1. Unit Vent System					
a. Noble Gas Activity Monitor Providing Alarm (GT-RE-21)	D	M	R(3)	Q(2)	*
b. Iodine Sampler	W	N.A.	N.A.	N.A.	*
c. Particulate Sampler	W	N.A.	N.A.	N.A.	*
d. Flow Rate	N.A.	N.A.	R(4)	Q	*
e. Sampler Flow Rate Monitor	D	N.A.	R	Q	*
2. Containment Purge System					
a. Noble Gas Activity Monitor - Providing Alarm and Automatic Termination of Release (GT-RE-22, GT-RE-33)	D	P	R(3)	Q(1)	*
b. Iodine Sampler	W	N.A.	N.A.	N.A.	*
c. Particulate Sampler	W	N.A.	N.A.	N.A.	*
d. Flow Rate	N.A.	N.A.	R(4)	N.A.	*
e. Sampler Flow Rate Monitor	D	N.A.	R	N.A.	*
3. Radwaste Building Vent System					
a. Noble Gas Activity Monitor - Providing Alarm and Automatic Termination of Release (GH-RE-10)	D, P	M, P	R(3)	Q(1)	*
b. Iodine Sampler	W	N.A.	N.A.	N.A.	*
c. Particulate Sampler	W	N.A.	N.A.	N.A.	*
d. Flow Rate	N.A.	N.A.	R(4)	N.A.	*
e. Sampler Flow Rate Monitor	D	N.A.	R	N.A.	*

TABLE 9.2-B (Continued)

TABLE NOTATIONS

41845

* At all times.

(1) The ANALOG CHANNEL OPERATIONAL TEST shall also demonstrate that automatic isolation of this pathway and control room alarm annunciation occur as appropriate if any of the following conditions exists:

a. Instrument indicates measured levels above the Alarm/Trip Setpoint (isolation and alarm), or

b. Circuit failure (alarm only), or

c. Instrument indicates a downscale failure (alarm only), or

d. Instrument controls not set in operate mode (alarm only).

(2) The ANALOG CHANNEL OPERATIONAL TEST shall also demonstrate that control room alarm annunciation occurs if any of the following conditions exists:

a. Instrument indicates measured levels above the Alarm Setpoint, or

b. Circuit failure, or

c. Instrument indicates a downscale failure, or

d. Instrument controls not set in operate mode.

TABLE 9.2-B (Continued)

TABLE NOTATIONS

(3) The initial CHANNEL CALIBRATION shall be performed using one or more of the reference (gas or liquid and solid) standards certified by the National Bureau of Standards (NBS) or using standards that have been obtained from suppliers that participate in measurement assurance activities with NBS. These standards shall permit calibrating the system over its intended range of energy, measurement range, and establish monitor response to a solid calibration source. For subsequent CHANNEL CALIBRATION, NBS traceable standard (gas, liquid, or solid) may be used; or a gas, liquid, or solid source that has been calibrated by relating it to equipment that was previously (within 30 days) by the same geometry and type of source traceable to NBS.

(4) If flow rate is determined by exhaust fan status and fan performance curves, the following surveillance operations shall be performed at least once per 18 months:

a. The specific vent flows by direct measurement, or

b. The differential pressure across the exhaust fan and vent flow established by the fan's "flow-ΔP" curve, or

c. The fan motor horsepower measured and vent flow established by the fan's "flow-horsepower" curve.

2881 9.3 LIQUID EFFLUENTS CONCENTRATION

41846 9.3.1 Controls

4160 9.3.1.1 The concentration of radioactive material released in liquid effluents to UNRESTRICTED AREAS (see Technical Specification's Figure 5.1-4) shall be limited to the concentrations specified in 10 CFR Part 20, Appendix B, Table II, Column 2, for radionuclides other than dissolved or entrained noble gases. For dissolved or entrained noble gases, the concentration shall be limited to 2 x 10-4 microCurie/ml total activity.

APPLICABILITY: At all times.

ACTION:

a. With the concentration of radioactive material released in liquid effluents to UNRESTRICTED AREAS exceeding the above limits, immediately restore the concentration to within the above limits.

b. The provisions of Sections 9.0.3 and 9.0.4 are not applicable.

41847 9.3.2 Surveillance Requirements

2895 9.3.2.1 Radioactive liquid wastes shall be sampled and analyzed according to the sampling and analysis program of Table 9.3-A.

9.3.2.2 The results of the radioactivity analysis shall be used in accordance with the methodology and parameters in the ODCM to assure that the concentrations at the point of release are maintained within the limits of Section 9.3.1.1.

9.3.3 Bases

9.3.3.1 This section is provided to ensure that the concentration of radioactive materials released in liquid waste effluents to UNRESTRICTED AREAS will be less than the concentration levels specified in 10 CFR Part 20, Appendix B, Table II, Column 2. This limitation provides additional assurance that the levels of radioactive materials in bodies of water in UNRESTRICTED AREAS will result in exposures within: (1) the Section II.A design objectives of Appendix I, 10 CFR Part 50, to a MEMBER OF THE PUBLIC, and (2) the limits of 10 CFR Part 20.106(e) to the population. The concentration limit for dissolved or entrained noble gases is based upon the assumption that Xe-135 is the controlling radioisotope and its MPC in air (submersion) was converted to an equivalent concentration in water using the methods described in International Commission on Radiological Protection (ICRP) Publication 2.

9.3.3.2 The required detection capabilities for radioactive materials in liquid waste samples are tabulated in terms of the lower limits of detection (LLDs). Detailed discussion of the LLD, and other detection limits can be found in HASL Procedures Manual, HASL-300 (revised annually), Currie, L. A., "Limits for Qualitative Detection and Quantitative Determination - Application to Radiochemistry", Anal. Chem. 40, 586-93 (1968), and Hartwell, J. K., "Detection Limits for Radioanalytical Counting Techniques", Atlantic Richfield Hanford Company Report ARH-SA-215 (June 1975).

TABLE 9.3-A
RADIOACTIVE LIQUID WASTE SAMPLING AND ANALYSIS PROGRAM

LIQUID RELEASE TYPE	SAMPLING FREQUENCY	MINIMUM ANALYSIS FREQUENCY	TYPE OF ACTIVITY ANALYSIS	LOWER LIMIT OF DETECTION (LLD)[1] (μCi/ml)
1. Batch Waste Release Tanks[2]	P Each Batch	P Each Batch	Principal Gamma Emitters[3]	5×10^{-7}
			I-131	1×10^{-6}
a. Waste Monitor Tank	P One Batch/M	M	Dissolved and Entrained Gases (Gamma Emitters)	1×10^{-5}
b. Secondary Liquid Waste Monitor Tank	P Each Batch	M Composite[4]	H-3	1×10^{-5}
			Gross Alpha	1×10^{-7}
c. Discharge Monitor Tank	P Each Batch	Q Composite[4]	Sr-89, Sr-90	5×10^{-8}
			Fe-55	1×10^{-6}
2. Continuous Releases[5]	Daily[6] Grab Sample	W Composite[4]	Principal Gamma Emitters[3]	5×10^{-7}
			I-131	1×10^{-6}
Steam Generator Blowdown	M Grab Sample	M	Dissolved and Entrained Gases (Gamma Emitters)	1×10^{-5}
	Daily[6] Grab Sample	M Composite[4]	H-3	1×10^{-5}
			Gross Alpha	1×10^{-7}
	Daily[6] Grab Sample	Q Composite[4]	Sr-89, Sr-90	5×10^{-8}
			Fe-55	1×10^{-6}

TABLE 9.3-A (Continued)

TABLE NOTATIONS

(1) The LLD is defined, for purposes of these controls, as the smallest concentration of radioactive material in a sample that will yield a net count, above system background, that will be detected with 95% probability with only 5% probability of falsely concluding that a blank observation represents a "real" signal.

For a particular measurement system, which may include radiochemical separation:

$$LLD = \frac{4.66\ s_b}{E \cdot V \cdot 2.22 \times 10^6 \cdot Y \cdot \exp(-\lambda \Delta t)}$$

Where:

LLD = the "a priori" lower limit of detection (microCuries per unit mass of volume),

s_b = the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (counts per minute),

E = the counting efficiency (counts per disintegration),

V = the sample size (units of mass or volume),

2.22×10^6 = the number of disintegrations per minute per microCurie,

Y = the fractional radiochemical yield, when applicable,

λ = the radioactive decay constant for the particular radionuclide (s^{-1}), and

Δt = the elapsed time between the midpoint of sample collection and the time of counting (s).

Typical values of E, V, Y and Δt should be used in the calculation.

TABLE 9.3-A (Continued)

TABLE NOTATIONS

41848

It should be recognized that the LLD is defined as a a priori (before the fact) limit representing the capability of a measurement system and not as an a posteriori (after the fact) limit for a particular measurement.

(2) A batch release is the discharge of liquid wastes of a discrete volume. Prior to sampling for analyses, each batch shall be isolated, and then thoroughly mixed by a method described in the ODCM to assure representative sampling.

(3) The principal gamma emitters for which the LLD control applies include the following radionuclides: Mn-54, Fe-59, Co-58, Co-60, Zn-65, Mo-99, Cs-134, Cs-137, Ce-141, and Ce-144. This list does not mean that only these nuclides are to be considered. Other gamma peaks that are identifiable, together with those of the above nuclides, shall also be analyzed and reported in the Seminannual Radioactive Effluent Release Report pursuant to Technical Specification 6.9 1.7, in the format outlined in Regulatory Guide 1.21, Appendix B, Revision 1, June 1974.

(4) A composite sample is one in which the quantity of liquid sampled is proportional to the quantity of liquid waste discharged and in which the method of sampling employed results in a specimen that is representative of the liquids released. Prior to analysis, all samples taken for the composite shall be thoroughly mixed in order for the composite samples to be representative of the effluent release.

(5) A continuous release is the discharge of liquid wastes of a nondiscrete volume, e.g., from a volume of a system that has an input flow during the continuous release.

TABLE 9.3-A (Continued)

TABLE NOTATIONS

(6) Samples shall be taken at the initiation of effluent flow and at least once per 24 hours thereafter while the release is occurring. To be representative of the liquid effluent, the sample volume shall be proportioned to the effluent stream discharge volume. The ratio of sample volume to effluent discharge volume shall be maintained constant for all samples taken for the composite sample.

9.4 DOSE

41849 9.4.1 Controls

4160 9.4.1.1 The dose or dose commitment to a MEMBER OF THE PUBLIC from radioactive materials in liquid effluents released, from each unit, to UNRESTRICTED AREAS (see Technical Specification's Figure 5.1-4) shall be limited:

a. During any calendar quarter to less than or equal to 1.5 mrems to the whole body and to less than or equal to 5 mrems to any organ, and

b. During any calendar year to less than or equal to 3 mrems to the whole body and to less than or equal to 10 mrems to any organ.

APPLICABILITY: At all times.

ACTION:

a. With the calculated dose from the release of radioactive materials in liquid effluents exceeding any of the above limits, prepare and submit to the Commission within 30 days, pursuant to Technical Specification 6.9.2, a Special Report that identifies the cau) for exceeding the limit(s) and defines the corrective actions that have been taken to reduce the releases and the proposed corrective actions to be taken to assure that subsequent releases will be in compliance with the above limits. This Special Report shall also include: (1) the results of radiological analyses of the drinking water source, and (2) the radiological impact on finished drinking water supplies with regard to the requirements of 40 CFR Part 141, Clean Drinking Water Act.*

b. The provisions of Sections 9.0.3 and 9.0.4 are not applicable.

*The requirements of ACTION a.(1) and (2) are applicable only if drinking water supply is taken from the receiving water body within 3 miles of the plant discharge. In the case of river-sited plants this is 3 miles downstream only.

9.4.2 Surveillance Requirements

9.4.2.1 Cumulative dose contributions from liquid effluents for the current calendar quarter and the current calendar year shall be determined in accordance with the methodology and parameters in the ODCM at least once per 31 days.

41850 9.4.3 Bases

9.4.3.1 This section is provided to implement the requirements of Sections II.A, III.A and IV.A of Appendix I, 10 CFR Part 50. The Limiting Condition for Operation implements the guides set forth in Section II.A of Appendix I. The ACTION statements provide the required operating flexibility and at the same time implement the guides set forth in Section IV.A of Appendix I to assure that the releases of radioactive material in liquid effluents to UNRESTRICTED AREAS will be kept "as low as is reasonably achievable". Also, for fresh water sites with drinking water supplies that can be potentially affected by plant operations, there is reasonable assurance that the operation of the facility will not result in radionuclide concentrations in the finished drinking water that are in excess of the requirements of 40 CFR part 141. The dose calculation methodology and parameters in the ODCM implement the requirements in Section III.A of Appendix I which specify that conformance with the guides of Appendix I be shown by calculational procedures based on models and data, such that the actual exposure of a MEMBER OF THE PUBLIC through appropriate pathways is unlikely to be substantially underestimated. The equations specified in the ODCM for calculating the doses due to the actual release rates of radioactive materials in liquid effluents are consistent with the methodology provided in Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I", Revision 1, October 1977 and Regulatory Guide 1.113, "Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I", April 1977.

9.5 LIQUID RADWASTE TREATMENT SYSTEM

41851 9.5.1 Controls

4160 9.5.1.1 The Liquid Radwaste Treatment System shall be OPERABLE and appropriate portions of the system shall be used to reduce releases of radioactivity when the projected doses due to the liquid effluent, from each unit, to UNRESTRICTED AREAS (see Technical Specification's Figure 5.1-4) would exceed 0.06 mrem to the whole body or 0.2 mrem to any organ in a 31 day period.

APPLICABILITY: At all times.

ACTION:

a. With radioactive liquid waste being discharged without treatment and in excess of the above limits and any portion of the Liquid Radwaste Treatment System not in operation, prepare and submit to the Commission within 30 days, pursuant to Technical Specification 6.9.2, a Special Report that includes the following information:

   1. Explanation of why liquid radwaste was being discharged without treatment, identification of any inoperable equipment or subsystems, and the reason for the inoperability,

   2. Action(s) taken to restore the inoperable equipment to OPERABLE status, and

   3. Summary description of action(s) taken to prevent a recurrence.

b. The provisions of Sections 9.0.3 and 9.0.4 are not applicable.

41852 9.5.2 Surveillance Requirements

9.5.2.1 Doses due to liquid releases from each unit to UNRESTRICTED AREAS shall be projected at least once per 31 days in accordance with the methodology and parameters in the ODCM when Liquid Radwaste Treatment Systems are not being fully utilized.

9.5.2.2 The installed Liquid Radwaste Treatment System shall be considered OPERABLE by meeting Sections 9.3.1.1 and 9.4.1.1.

9.5.3 Bases

9.5.3.1 The OPERABILITY of the Liquid Radwaste Treatment System ensures that this system will be available for use whenever liquid effluents require treatment prior to release to the environment. The requirement that the appropriate portions of this system be used when specified provides assurance that the releases of radioactive materials in liquid effluents will be kept "as low as is reasonabley achievable". This section implements the requirements of 10 CFR Part 50.36a, General Design Criterion 60 of Appendix A to 10 CFR Part 50 and the design objective given in Section II.D of Appendix I to 10 CFR Part 50. The specified limits governing the use of appropriate portions of the Liquid Radwaste Treatment System were specified as a suitable fraction of the dose design objectives set forth in Section 11.A of Appendix I, 10 CFR Part 50, for liquid effluents.

9.6 GASEOUS EFFLUENTS DOSE RATE

41853 9.6.1 Controls

4160 9.6.1.1 The dose rate due to radioactive materials released in gaseous effluents from the site to areas at and beyond the SITE BOUNDARY (see Technical Specification's Figure 5.1-3) shall be limited to the following:

a. For noble gases: Less than or equal to 500 mrems/yr to the whole body and less than or equal to 3000 mrems/yr to the skin, and

b. For Iodine-131 and 133, for tritium, and for all radionuclides in particulate form with half-lives greater than 8 days: Less than or equal to 1500 mrems/yr to any organ.

APPLICABILITY: At all times.

ACTION:

a. With the dose rate(s) exceeding the above limits, immediately restore the release rate to within the above limit(s).

b. The provisions of Sections 9.0.3 and 9.0.4 are not applicable.

41854 9.6.2 Surveillance Requirements

9.6.2.1 The dose rate due to noble gases in gaseous effluents shall be determined to be within the above limits in accordance with the methodology and parameters in the ODCM.

9.6.2.2 The dose rate due to Iodine-131 and 133, tritium, and all radionuclides in particulate form with half-lives greater than 8 days in gaseous effluents shall be determined to be within the above limits in accordance with the methodology and parameters in the ODCM by obtaining representative samples and performing analyses in accordance with the sampling and analysis program specified in Table 9.6-A.

9.6.3 Bases

41855 9.6.3.1 This section is provided to ensure that the dose at any time at and beyond the SITE BOUNDARY from gaseous effluents from all units on the site will be within the annual dose limits of 10 CFR Part 20 to UNRESTRICTED AREAS. The annual dose limits are the doses associated with the concentrations of 10 CFR Part 20, Appendix B, Table II, Column 1. These limits provide reasonable assurance that radioactive material discharged in gaseous effluents will not result in the exposure of a MEMBER OF THE PUBLIC in an UNRESTRICTED AREA, either within or outside the SITE BOUNDARY, to annual average concentrations exceeding the limits specified in Appendix B, Table II of 10 CFR Part 20 (10 CFR 20.106(b)). For MEMBERS OF THE PUBLIC who may at times be within the SITE BOUNDARY, the occupancy of that MEMBER OF THE PUBLIC will usually be sufficiently low to compensate for any increase in the atmospheric diffusion factor above that for the SITE BOUNDARY. Examples of calculations for such MEMBERS OF THE PUBLIC, with the appropriate occupancy factors, shall be given in the ODCM. The specified release rate limits restrict, at all times, the corresponding gamma and beta dose rates above background to a MEMBER OF THE PUBLIC at or beyond SITE BOUNDARY to less than or equal to 500 mrems/year to the whole body or to less than or equal to 3000 mrems/year to the skin. These release rate limits also restrict, at all times, the corresponding thyroid dose rate above background to a child via the inhalation pathway to less than or equal to 1500 mrems/year.

9.6.3.2 The required detection capabilities for radioactive materials in gaseous waste samples are tabulated in terms of the lower limits of detection (LLDs). Detailed discussion of the LLD, and other detection limits can be found in HASL Procedures Manual, HASL-300 (revised annually), Currie, L. A., "Limits for Qualitative Detection and Quantitative Determination - Application to Radiochemistry", Anal. Chem. 40, 586-93 (1968), and Hartwell, J. K., "Detection Limits for Radioanalytical Counting Techniques", Atlantic Richfield Hanford Company Report ARH-SA-215 (June 1975).

TABLE 9.6-A

RADIOACTIVE GASEOUS WASTE SAMPLING AND ANALYSIS PROGRAM

GASEOUS RELEASE TYPE	SAMPLING FREQUENCY	MINIMUM ANALYSIS FREQUENCY	TYPE OF ACTIVITY ANALYSIS	LOWER LIMIT OF DETECTION (LLD) (1) (μCi/ml)
1. Waste Gas Decay Tank	P Each Tank Grab Sample	P Each Tank	Principal Gamma Emitters (2)	1×10^{-4}
2. Containment Purge (3) or Vent	P Each PURGE (3) Grab Sample	P Each PURGE (3)	Principal Gamma Emitters (2)	1×10^{-4}
		M	H-3 (oxide)	1×10^{-6}
3. Unit Vent	M Grab Sample (3),(4)	M (3)	Principal Gamma Emitters (2)	1×10^{-4}
		M (4)	H-3 (oxide)	1×10^{-6}
4. Spent Fuel Building Exhaust	M Grab Sample (5)	M	Principal Gamma Emitters (2)	1×10^{-4}
		M (5)	H-3 (oxide)	1×10^{-6}
5. Radwaste Building Vent	M Grab Sample	M	Principal Gamma Emitters (2)	1×10^{-4}
6. All Release Types as listed in 1., 2., 3., 4., and 5. above	Continuous (6) (8)	W (7) Charcoal Sample	I-131	1×10^{-12}
			I-133	1×10^{-10}
	Continuous (6) (8)	W (7) Particulate Sample	Principal Gamma Emitters (2)	1×10^{-11}
	Continuous (6) (8)	M Composite Particulate Sample	Gross Alpha	1×10^{-11}
	Continuous (6) (8)	Q Composite Particulate Sample	Sr-89, Sr-90	1×10^{-11}

TABLE 9.6-A (Continued)

TABLE NOTATIONS (Continued)

(1) The LLD is defined, for purposes of these controls, as the smallest concentration of radioactive material in a sample that will yield a net count, above system background, that will be detected with 95% probability with only 5% probability of falsely concluding that a blank observation represents a "real" signal.

For a particular measurement system, which may include radiochemical separation:

$$LLD = \frac{4.66\ s_b}{E \cdot V \cdot 2.22 \times 10^6 \cdot Y \cdot \exp(-\lambda \Delta t)}$$

Where:

LLD = the "a priori" lower limit of detection (microCuries per unit mass of volume),

s_b = the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (counts per minute),

E = the counting efficiency (counts per disintegration),

V = the sample size (units of mass or volume),

2.22×10^6 = the number of disintegrations per minute per microCurie,

Y = the fractional radiochemical yield, when applicable,

λ = the radioactive decay constant for the particular radionuclide (s^{-1}), and

Δt = the elapsed time between the midpoint of sample collection and the time of counting(s).

Typical values of E, V, Y, and Δt should be used in the calculation.

TABLE 9.6-A (Continued)

TABLE NOTATIONS (Continued)

41857

It should be recognized that the LLD is defined as a a priori (before the fact) limit representing the capability of a measurement system and not as an a posteriori (after the fact) limit for a particular measurement.

(2) The principal gamma emitters for which the LLD specification applies include the following radionuclides: Kr-87, Kr-88, Xe-133, Xe-133m, Xe-135, and Xe-138 in noble gas releases and Mn-54, Fe-59, Co-58, Co-60, Zn-65, Mo-99, I-131, Cs-134, Cs-137, Ce-141, and Ce-144 in iodine and particulate releases. This list does not mean that only these nuclides are to be considered. Other gamma peaks that are identifiable, together with those of the above nuclides, shall also be analyzed and reported in the Semiannual Radioactive Effluent Release Report pursuant to Section 7.2, in the format outlined in Regulatory Guide 1.21, Appendix B, Revision 1, June 1974.

(3) Sampling and analysis shall also be performed following shutdown, startup, or a THERMAL POWER change exceeding 15% of RATED THERMAL POWER within 1 hour period.

(4) Tritium grab samples shall be taken and analyzed at least once per 24 hours when the refueling canal is flooded.

(5) Tritium grab samples shall be taken and analyzed at least once per 7 days from the ventilation exhaust from the spent fuel pool area, whenever spent fuel is in the spent fuel pool. Grab samples need to be taken only when spent fuel is in the spent fuel pool.

(6) The ratio of the sample flow rate to the sampled stream flow rate shall be known for the time period covered by each dose or dose rate calculation made in accordance with Sections 9.6.1.1, 9.7.1.1, and 9.8.1.1.

TABLE 9.6-A (Continued)

TABLE NOTATIONS (Continued)

(7) Samples shall be changed at least once per 7 days and analyses shall be completed within 48 hours after changing, or after removal from sampler. For unit vent, sampling shall also be performed at least once per 24 hours for at least 7 days following each shutdown, STARTUP or THERMAL POWER change exceeding 15% of RATED THERMAL POWER within a 1-hour period and analyses shall be completed within 48 hours of changing. When samples collected for 24 hours are analyzed, the corresponding LLDs may be increased by a factor of 10. This requirement does not apply if: (1) analysis shows that the DOSE EQUIVALENT I-131 concentration in the reactor coolant has not increased more than a factor of 3, and (2) the noble gas monitor shows that effluent activity has not increased more than a factor of 3.

(8) Continuous sampling of the spent fuel building exhaust needs to be performed only when spent fuel is in the spent fuel pool.

9.7 DOSE - NOBLE GASES

41858 9.7.1 Controls

4160 9.7.1.1 The air dose due to noble gases released in gaseous effluents, from each unit, to areas at and beyond the SITE BOUNDARY (see Technical Specification's Figure 5.1-3) shall be limited to the following:

a. During any calendar quarter: Less than or equal to 5 mrads for gamma radiation and less than or equal to 10 mrads for beta radiation, and

b. During any calendar year: Less than or equal to 10 mrads for gamma radiation and less than or equal to 20 mrads for beta radiation.

APPLICABILITY: At all times.

ACTION:

a. With the calculated air dose from radioactive noble gases in gaseous effluetns exceeding any of the above limits, prepare and submit to the Commission within 30 days, pursuant to Technical Specification 6.9.2, a Special Report that identifies the cause(s) for exceeding the limit(s) and defines the corrective actions that have been taken to reduce the releases and the proposed corrective actions to be taken to assure that subsequent releases will be in compliance with the above limits.

b. The provisions of Sections 9.0.3 and 9.0.4 are not applicable.

41859 9.7.2 Surveillance Requirements

9.7.2.1 Cumulative dose contributions for the current calendar quarter and current calendar year for noble gases shall be determined in accordance with the methodology and parameters in the ODCM at least once per 31 days.

9.7.3 Bases

9.7.3.1 This section is provided to implement the requirements of Sections II.B, III.A, and IV.A of Appendix I, 10 CFR Part 50. The Limiting Conditions for Operation implements the guides set forth in Section II.B of Appendix I. The ACTION statements provide the required operating flexibility and at the same time implement the guides set forth in Section IV.A of Appendix I to assure that the releases of radioactive material in gaseous effluents to UNRESTRICTED AREAS will be kept "as low as is reasonably achievable". The Surveillance Requirements implement the requirements in Section III.A of Appendix I that conformance with the guides of Appendix I be shown by calculational procedures based on models and data such that the actual exposure of a MEMBER OF THE PUBLIC through appropriate pathways is unlikely to be substantially underestimated. The dose calculation methodology and parameters established in the ODCM for calculating the doses due to the actual release rates of radioactive noble gases in gaseous effluents are consistent with the methodology provided in Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I", Revision 1, October 1977 and Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water Cooled Reactors", Revision 1, July 1977. The ODCM equations provided for determining the air doses at and beyond the SITE BOUNDARY are based upon the historical average atmospheric conditions.

9.8 DOSE - IODINE-131 AND 133, TRITIUM, AND RADIOACTIVE MATERIAL IN PARTICULATE FORM

41860 9.8.1 Controls

4160 9.8.1.1 The dose to a MEMBER OF THE PUBLIC from Iodine-131 and 133, tritium, and all radionuclides in particulate form with half-lives greater than 8 days in gaseous effluents released, from each unit, to areas at and beyond the SITE BOUNDARY (see Technical Specification's Figure 5.1-3) shall be limited to the following:

a. During any calendar quarter: Less than or equal to 7.5 mrems to any organ, and

b. During any calendar year: Less than or equal to 15 mrems to any organ.

APPLICABILITY: At all times.

ACTION:

a. With the calculated dose from the release of Iodine-131 and 133, tritium, and radionuclides in particulate form with half-lives greater than 8 days, in gaseous effluents exceeding any of the above limits, prepare and submit to the Commission within 30 days, pursuant to Technical Specification 6.9.2, a Special Report that identifies the cause(s) for exceeding the limits and defines the corrective actions that have been taken to reduce the releases and the proposed corrective actions to be taken to assure that subsequent releases will be in compliance with the above limits.

b. The provisions of Sections 9.0.3 and 9.0.4 are not applicable.

41861 9.8.2 Surveillance Requirements

9.8.2.1 Cumulative dose contributions for the current calendar quarter and current calendar year for Iodine-131 and 133, tritium, and radionuclides in particulate form with half-lives greater than 8 days shall be determined in accordance with the methodology and parameters in the ODCM at least once per 31 days.

9.8.3 Bases

9.8.3.1 This section is provided to implement the requirements of Sections II.C, III.A, and IV.A of Appendix I, 10 CFR Part 50. The Limiting Conditions for Operation are the guides set forth in Section II.C of Appendix I. The ACTION statements provide the required operating flexibility and at the same time implement the guides set forth in Section IV.A of Appendix I to assure that the releases of radioactive material in gaseous effluents to UNRESTRICTED AREAS will be kept "as low as is reasonably achievable". The Surveillance Requirements implement in Section III.A of Appendix I that conformance with the guides of Appendix I be shown by calculational procedures based on models and data such that the actual exposure of a MEMBER OF THE PUBLIC through appropriate pathways is unlikely to be substantially underestimated. The dose calculation methodology and parameters established in the ODCM for calculating the doses due to the actual release rates of radioactive noble gases in gaseous effluents are consistent with the methodology provided in Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I", Revision 1, October 1977 and Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water Cooled Reactors", Revision 1, July 1977. These equations also provide for determining the actual doses based upon the historical average atmospheric conditions. The release rate controls for Iodine-131 and 133, tritium, and radionuclides in particulate form with half-lives greater than 8 days are dependent upon the existing radionuclide pathways to man, in the areas at and beyond the SITE BOUNDARY. The pathways that were examined in the development of these calculations were: (1) individual inhalation of airborne radionuclides, (2) deposition of radionuclides onto green leafy vegetation with subsequent consumption by man, (3) desposition of radionuclides onto grassy areas where milk animals and meat-producing animals graze with consumption of the milk and meat by man, and (4) deposition on the ground with subsequent exposure of man.

9.9 GASEOUS RADWASTE TREATMENT SYSTEM

41862 9.9.1 Controls

4160 9.9.1.1 The VENTILATION EXHAUST TREATMENT SYSTEM and the WASTE GAS HOLDUP SYSTEM shall be OPERABLE and appropriate portions of these systems shall be used to reduce releases of radioactivity when the projected doses in 31 days due to gaseous effluent releases, from each unit, to areas at and beyond the SITE BOUNDARY (see Figure Technical Specification's 5.1-3) would exceed:

a. 0.2 mrad to air from gamma radiation, or

b. 0.4 mrad to air from beta radiation, or

c. 0.3 mrem to any organ of a MEMBER OF THE PUBLIC.

APPLICABILITY: At all times.

ACTION:

a. With radioactive gaseous waste being discharged without treatment and in excess of the above limits, prepare and submit to the Commission within 30 days, pursuant to Technical Specification 6.9.2, a Special Report that includes the following information:

   1. Identification of any inoperable equipment or subsystems, and the reason for the inoperability,

   2. Action(s) taken to restore the inoperable equipment to OPERABLE status, and

   3. Summary description of action(s) taken to prevent a recurrence.

b. The provisions of Sections 9.0.3 and 9.0.4 are not applicable.

9.9.2 Surveillance Requirements

41863 9.9.2.1 Doses due to gaseous releases from each unit to areas at and beyond the SITE BOUNDARY shall be projected at least once per 31 days in accordance with the methodology and parameters in the ODCM when Gaseous Radwaste Treatment Systems are not being fully utilized.

9.9.2.2 The installed VENTILATION EXHAUST TREATMENT SYSTEM and the WASTE GAS HOLDUP SYSTEMS shall be considered OPERABLE by meeting Sections 9.6.1.1 and 9.7.1.1 or 9.8.1.1.

9.9.3 Bases

9.9.3.1 The OPERABILITY of the WASTE GAS HOLDUP SYSTEM and the VENTILATION EXHAUST TREATMENT SYSTEM ensures that the systems will be available for use whenever gaseous effluents require treatment prior to release to the environment. The requirement that the appropriate portions of these systems be used, when specified, provides reasonable assurance that the releases of radioactive materials in gaseous effluents will be kept "as low as is reasonably achievable". This control implements the requirements of 10 CFR Part 50.36a, General Design Criterion 60 of Appendix A to 10 CFR Part 50, and the design objectives given in Section II.D of Appendix I to 10 CFR Part 50. The specified limits governing the use of appropriate portions of the systems were specified as a suitable fraction of the dose design objectives set forth in Sections II.B and II.C of Appendix I, 10 CFR Part 50, for gaseous effluents.

9.10 TOTAL DOSE

41864 9.10.1 Controls

9.10.1.1 The annual (calendar year) dose or dose commitment to any MEMBER OF THE PUBLIC due to releases of radioactivity and to radiation from uranium fuel cycle sources shall be limited to less than or equal to 25 mrems to the whole body or any organ, except the thyroid, which shall be limited to less than or equal to 75 mrems.

APPLICABILITY: At all times.

ACTION:

a. With the calculated doses from the release of radioactive materials in liquid or gaseous effluents exceeding twice the limits of Section 9.4.1.1a., 9.4.1.1b, 9.7.1.1a., 9.7.1.1b., 9.8.1.1a., or 9.8.1.1b., calculations should be made including direct radiation contributions from the units and from outside storage tanks to determine whether the above limits of Section 9.10.1.1 have been exceeded. If such is the case, prepare and submit to the Commission within 30 days, pursuant to Technical Specification 6.9.2, a Special Report that defines the corrective action to be taken to reduce subsequent releases to prevent recurrence of exceeding the above limits and includes the schedule for achieving conformance with the above limits. This Special Report, as defined in 10 CFR 20.405c, shall include an analysis that estimates the radiation exposure (dose) to a MEMBER OF THE PUBLIC from uranium fuel cycle sources, including all effluent pathways and direct radiation, for the calendar year that includes the release(s) covered by this report. It shall also describe levels of radiation and concentrations of radioactive material involved, and the cause of the exposure levels or concentrations. If the estimated dose(s) exceeds the above limits, and if the release condition resulting in violation of 40 CFR Part 190 has not already been corrected, the Special Report shall include a request for a variance in accordance with the provisions of 40 CFR Part 190. Submittal of the report is considered a timely request, and a variance is granted until staff action on the request is complete.

b. The provisions of Sections 9.0.3 and 9.0.4 are not applicalbe.

41865 9.10.2 Surveillance Requirements

9.10.2.1 Cumulative dose contributions from liquid and gaseous effluents shall be determined in accordance with Sections 9.4.2.1, 9.7.2.1 and 9.8.2.1, and in accordance with the methodology and parameters in the ODCM.

9.10.2.2 Cumulative dose contributions from direct radiation from the units and from radwaste storage tanks shall be determined in accordance with the methodology and parameters in the ODCM. This requirement is applicable only under conditions set forth in ACTION a. of Section 9.10.1.1

9.10.3 Bases

9.10.3.1 This section is provided to meet the dose limitations of 40 CFR Part 190 that have been incorporated into 10 CFR Part 20 by 46 FR 18525. The control requires the preparation and submittal of a Special Report whenever the calculated doses due to releases of radioactivity and the radiation from uranium fuel cycle sources exceed 25 mrems to the whole body or any organ, except the thyroid, which shall be limited to less than or equal to 75 mrems. For sites containing up to four reactors, it is highly unlikely that the resultant dose to a MEMBER OF THE PUBLIC will exceed the dose limits of 40 CFR Part 190 if the individual reactors remain within twice the dose design objectives of Appendix I, and if direct radiation doses from the reactor units and from outside storage tanks are kept small. The Special Report will describe a course of action that should result in the limitation of the annual dose to a MEMBER OF THE PUBLIC to within the 40 CFR Part 190 limits. For the purposes of the Special Report, it may be assumed that the dose commitment to the MEMBER OF THE PUBLIC from other uranium fuel cycle sources is negligible, with the exception that dose contribution from other nuclear fuel cycle facilities at the same site or within a radius of 8 km must be considered. If the dose to any MEMBER OF THE PUBLIC is estimated to exceed the requirements of 40 CFR Part 190, the Special Report with a request for a variance (provided the release conditions resulting in violation of 40 CFR Part 190 have not already been corrected), in accordance with the provisions of 40 CFR 190.11 and 10 CFR 20.405c, is considered to be a timely request and fulfills the requirements of 40 CFR Part 190 until NRC staff action is completed. The variance only relates to the limits of 40 CFR Part 190, and does not apply in any way to the other requirements for dose limitation of 10 CFR Part 20, as addressed in Sections 9.3.1.1 and 9.6.1.1. An individual is not considered a MEMBER OF THE PUBLIC during any period in which he/she is engaged in carrying out any operation that is part of the nuclear fuel cycle.

9.11 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

41866 9.11.1 Controls

9.11.1.1 The Radiological Environment Monitoring Program shall be conducted as specified in Table 9.11-A.

APPLICABILITY: At all times.

ACTION:

a. With the Radiological Environmental Monitoring Program not being conducted as specified in Table 9.4-A, prepare and submit to the Commission, in the Annual Radiological Environmental Operating Report required by Section 7.1, a description of the reasons for not conducting the program as required and the plans for preventing a recurrence.

b. With the level of radioactivity as the result of plant effluents in an environmental sampling medium at a specified location exceeding the reporting levels of Table 9.11-A when averaged over any calendar quarter, prepare and submit to the Commission within 30 days, pursuant to Technical Specification 6.9.2, a Special Report that identifies the cause(s) for exceeding the limit(s) and defines the corrective actions to be taken to reduce radioactive effluents so that the potential annual dose* to a MEMBER OF THE PUBLIC is less than the calendar year limits of Sections 9.4.1.1, 9.7.1.1, or 9.8.1.1. When more than one of the radionuclides in Table 9.11-B are detected in the sampling medium, this report shall be submitted if:

$$\frac{\text{concentration (1)}}{\text{reporting level (1)}} + \frac{\text{concentration (2)}}{\text{reporting level (2)}} + \ldots \geq 1.0$$

When radionuclides other than those in Table 9.11-B are detected and are the result of plant effluents, this report shall be submitted if the potential annual dose* to A MEMBER OF THE PUBLIC from all radionuclides is equal to or greater than the calendar year limits of Sections 9.4.1.1, 9.7.1.1 or 9.8.1.1. This report is not required if the measured level of radioactivity was not the result of plant effluents; however, in such an event, the condition shall be reported and described in the Annual Radiological Environmental Operating Report, required by Section 7.1.

*The methodology and parameters used to estimate the potential annual dose to a MEMBER OF THE PUBLIC shall be indicated in this report.

c. With milk or fresh leafy vegetable samples unavailable from one or more of the sample locations required by the Table 9.11-A, identify specific locations for obtaining replacement samples and add them within 30 days to the Radiological Environmental Monitoring Program given in the ODCM.** The specific locations from which samples were unavailable may then be deleted from the monitoring program. Pursuant to Technical Specification 6.14, submit as part of, or concurrent with, the next Semiannual Radioactive Effluent Release Report a complete and legible copy of the entire ODCM, including the revised figure(s) and table reflecting the new location(s) with supporting information identifying the cause of the unavailability of samples and justifying the selection of new location(s) for obtaining samples.

d. The provisions of Sections 9.0.3 and 9.0.4 are not applicable.

41867 9.11.2 Surveillance Requirements

9.11.2.1 The radiological environmental monitoring samples shall be collected pursuant to Table 9.11-A from the specific locations given in the table and figure(s) in the ODCM, and shall be analyzed pursuant to the requirements of Table 9.11-A and the detection capabilities required by Table 9.11-c.

9.11.3 Bases

9.11.3.1 The Radiological Enviornmental Monitoring Program required by this section provides representative measurements of radiation and of radioactive materials in those exposure pathways and for those radionuclides that lead to the highest potential radiation exposures of MEMBERS OF THE PUBLIC resulting from the station operation. This monitoring program implements Section IV.B.2 of Appendix I to 10 CFR Part 50 and thereby supplements the Radiological Effluent Monitoring Program by verifying that the measurable concentrations of radioactive materials and levels of radiation are not higher than expected on the basis of the effluent measurements and the

**Excluding short term or temporary unavailability.

modeling of the environmental exposure pathways. Guidance for this monitoring program is provided by the Radiological Assessment Branch Technical Position on Environmental Monitoring, Revision 1, November 1979. The initially specified monitoring program will be effective for at least the first 3 years of commercial operation. Following this period, program changes may be initiated based on operational experience.

The required detection capabilities for environmental sample analyses are tabulated in terms of the lower limits of detection (LLDs). The LLDs required by Table 9.11-C are considered optimum for routine environmental measurements in industrial laboratories. It should be recognized that the LLD is defined as a priori (before the fact) limit representing the capability of a measurement system and not as an a posteriori (after the fact) limit for a particular measurement.

Detailed discussion of the LLD, and other detection limits, can be found in HASL Procedures Manual, HASL-300 (revised annually), Currie, L. A., "Limits for Qualitative Detection and Quantitative Determination - Application to Radiochemistry", Anal. Chem. 40, 586-93 (1986), and Hartwell, J. K., "Atlantic Richfield Hanford Company Report ARH-SA-215 (June 1975).

TABLE 9.11-A

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

EXPOSURE PATHWAY AND/OR SAMPLE	NUMBER OF REPRESENTATIVE SAMPLES AND SAMPLE LOCATIONS(1)	SAMPLING AND COLLECTION FREQUENCY	TYPE AND FREQUENCY OF ANALYSIS
1. Direct Radiation(2)	Forty routine monitoring stations either with two or more dosimeters or with one instrument for measuring and recording dose rate continuously, placed as follows: An inner ring of sixteen stations, one in each meteorological sector in the general area of the SITE BOUNDARY; An outer ring of stations, one in each meteorological sector in the 6- to 8-km (3 to 5 mile) range from the site; and Eight stations to be placed in special interest areas such as population centers, nearby residences, schools, and in one or two areas to serve as control stations.	Quarterly.	Gamma dose quarterly.

TABLE 9.11-A(Continued)

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

EXPOSURE PATHWAY AND/OR SAMPLE	NUMBER OF REPRESENTATIVE SAMPLES AND SAMPLE LOCATIONS(1)	SAMPLING AND COLLECTION FREQUENCY	TYPE AND FREQUEN OF ANALYSIS
2. Airborne			
Radioiodine and Particulates	Samples from five locations; Three samples from close to the three SITE BOUNDARY locations, in different sectors, of the highest calculated annual average ground level D/Q. One sample from the vicinity of a community having the highest calculated annual average ground level D/Q. One sample from a control location, as for example 15 to 30 km (10 to 20 mile) distant and in the least prevalent wind direction.(3)	Continuous sampler operation with sample collection weekly, or more frequently if required by dust loading.	Radioiodine Cannister: I-131 analysis weekly. Particulate Sampler: Gross beta radioactivity analysis following filter change; (4) and gamma isotopic analysis(5) of composite (by location) quarterly.
3. Waterborne			
a. Surface(6)	One sample upstream. One sample downstream.	Composite sample over 1-month period(7).	Gamma isotopic analysis(5) monthly. Composite for tritium analysis of composite sample (by location) quarterly.
b. Drinking	One sample of each of one to three of the nearest water supplies within 10 miles downstream that could be affected by its discharge. One sample from a control location.	Composite sample over 2-week period(7) when I-131 analysis is performed, monthly composite otherwise.	I-131 analysis on each composite when the dose calculated for the consumption of the water is greater than 1 mrem per year.(8) Composite for gross beta and gamma isotopic analyses(5) monthly. Composite for tritium analysis quarterly.

TABLE 9.11-A(Continued)

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

EXPOSURE PATHWAY AND/OR SAMPLE	NUMBER OF REPRESENTATIVE SAMPLES AND SAMPLE LOCATIONS(1)	SAMPLING AND COLLECTION FREQUENCY	TYPE AND FREQUENCY OF ANALYSIS
3. Waterborne (Continued)			
d. Sediment from shoreline	One sample from downstream area with existing or potential recreational value.	Semiannually.	Gamma isotopic analysis(5) semiannually.
4. Ingestion			
a. Milk	Samples from milking animals in three locations within 5 km (3 mile) distance having the highest dose potential. If there are none, then, one sample from milking animals in each of three areas between 5 to 8 km (3 to 5 mile) distant where doses are calculated to be greater than 1 mrem per yr.(8). One sample from milking animals at a control location, 15 to 30 km (10 to 20 mile) distant and in the least prevalent wind direction.	Semimonthly when animals are on pasture, monthly at other times.	Gamma isotopic(5) and I-131 analysis semimonthly when animals are on pasture; monthly at other times.
b. Fish	One sample of each commercially and recreationally important species in vicinity of plant discharge area. One sample of same species in areas not influenced by plant discharge.	Sample in season, or semiannually if they are not seasonal.	Gamma isotopic analysis(5) on edible portions.
c. Food Products	One sample of each principal class of food products from any area that is irrigated by water in which liquid plant wastes have been discharged.	At time of harvest (9)(10).	Gamma isotopic analyses(5) on edible portion.

TABLE 9.11-A(Continued)

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

EXPOSURE PATHWAY AND/OR SAMPLE	NUMBER OF REPRESENTATIVE SAMPLES AND SAMPLE LOCATIONS(1)	SAMPLING AND COLLECTION FREQUENCY	TYPE AND FREQUENCY OF ANALYSIS
4. Ingestion (Continued)			
c. Food Products (continued)	Samples of three different kinds of broad leaf vegetation if available grown nearest each of two different offsite locations of highest predicted annual average ground-level D/Q if milk sampling is not performed.	Monthly when available.	Gamma isotopic(5) and I-131 analysis.
	One sample of each of the similar broad leaf vegetation grown 15 to 30 km (10 to 20 mile) distant in the least prevalent wind direction if milk sampling is not performed.	Monthly when available.	Gamma isotopic(5) and I-131 analysis.

TABLE 9.11-A (Continued)

TABLE NOTATIONS

41868 (1) Specific parameters of distance and direction sector from the centerline of one unit, and additional description where pertinent, shall be provided for each and every sample location in Table 9.11-A in a table and figure(s) in the ODCM. Deviations are permitted from the required sampling schedule if specimens are unobtainable due to hazardous conditions, seasonal unavailability, malfunction of automatic sampling equipment, and other legitimate reasons. If specimens are unobtainable due to sampling equipment malfunction, every effort shall be made to complete corrective action prior to the end of the next sampling period. All deviations from the sampling schedule shall be documented in the Annual Radiological Environmental Operating Report pursuant to Section 7.1. It is recognized that, at times, it may not be possible or practicable to continue to obtain samples of the media of choice at the most desired location or time. In these instances suitable specific alternative media and locations may be chosen for the particular pathway in question and appropriate substitutions made within 30 days in the Radiological Environmental Monitoring Program given in the ODCM. Pursuant to Technical Specification 6.14, submit as part of, or concurrent with, the next Semiannual Radioactive Effluent Release Report a complete and legible copy of the entire ODCM including the revised figure(s) and table reflecting the new location(s) with supporting information identifying the cause of the unavailability of samples for that pathway and justifying the selection of the new location(s) for obtaining samples.

TABLE 9.11-A (Continued)

TABLE NOTATIONS

(2) One or more instruments, such as a pressurized ion chamber, for measuring and recording dose rate continuously may be used in place of, or in addition to, integrating dosimeters. For the purposes of this table, a thermoluminescent dosimeter (TLD) is considered to be one phosphor; two or more phosphors in a packet are considered as two or more dosimeters. Film badges shall not be used as dosimeters for measuring direct radiation. The 40 stations is not an absolute number. The number of direct radiation monitoring stations may be reduced according to geographical limitations; e.g., at an ocean site, some sectors will be over water so that the number of dosimeters may be reduced accordingly. The frequency of analysis or readout for TLD systems will depend upon the characteristics of the specific system used and should be selected to obtain optimum dose information with minimal fading.

(3) The purpose of this sample is to obtain background information. If it is not practical to establish control locations in accordance with the distance and wind direction criteria, other sites that provide valid background data may be substituted.

(4) Airborne particulate sample filters shall be analyzed for gross beta radioactivity 24 hours or more after sampling to allow for radon and thoron daughter decay. If gross beta activity in air particulate samples is greater than 10 times the yearly mean of control samples, gamma isotopic analysis shall be performed on the individual samples.

(5) Gamma isotopic analysis means the identification and quantification of gamma-emitting radionuclides that may be attributable to the effluents from the facility.

(6) The "upstream sample" shall be taken at a distance beyond significant influence of the discharge. The "downstream" sample shall be taken in an area beyond but near the mixing zone.

TABLE 9.11-A (Continued)

TABLE NOTATIONS

(7) In this program composite sample aliquots shall be collected at time intervals that are very short (e.g., hourly) relative to the compositing period (e.g., monthly) in order to assure obtaining a representative sample.

(8) Groundwater samples shall be taken when this source is tapped for drinking or irrigation purposes in areas where the hydraulic gradient or recharge properties are suitable for contamination.

(9) The dose shall be calculated for the maximum organ and age group, using the methodology and parameters in the ODCM.

(10) If harvest occurs more than once a year, sampling shall be performed during each discrete harvest. If harvest occurs continuously, sampling shall be monthly. Attention shall be paid to including samples of tuberous and root food products.

TABLE 9.11-B

REPORTING LEVELS FOR RADIOACTIVITY CONCENTRATIONS IN ENVIRONMENTAL SAMPLES

ANALYSIS	REPORTING LEVELS				
	WATER (pCi/ℓ)	AIRBORNE PARTICULATE OR GASES (pCi/m³)	FISH (pCi/kg, wet)	MILK (pCi/ℓ)	FOOD PRODUCTS (pCi/kg, wet)
H-3	20,000*				
Mn-54	1,000		30,000		
Fe-59	400		10,000		
Co-58	1,000		30,000		
Co-60	300		10,000		
Zr-Nb-95	400**				
I-131	2	0.9		3	100
Cs-134	30	10	1,000	60	1,000
Cs-137	50	20	2,000	70	2,000
Ba-La-140	200**			300**	

* For drinking water samples. This is 40 CFR Part 141 value. For surface water samples, a value of 30,000 pCi/ℓ may be used.

** Total activity, parent plus daughter activity.

TABLE 9.11-C

DETECTION CAPABILITIES FOR ENVIRONMENTAL SAMPLE ANALYSIS(1)

LOWER LIMIT OF DETECTION (LLD) (2), (3)

ANALYSIS	WATER (pCi/ℓ)	AIRBORNE PARTICULATE OR GASES (pCi/m³)	FISH (pCi/kg, wet)	MILK (pCi/ℓ)	FOOD PRODUCTS (pCi/kg, wet)	SEDIMENT (pCi/kg, dry)
Gross Beta	4	0.01				
H-3	2000*					
Mn-54	15		130			
Fe-59	30		260			
Co-58,60	15		130			
Zr-Nb-95	15**					
I-131	1(4)	0.07		1	60	
Cs-134	15	0.05	130	15	60	150
Cs-137	18	0.06	150	18	80	180
Ba-La-140	15**			15**		

* For surface water samples, a value of 3000 pCi/ℓ may be used.

** Total activity, parent plus daughter activity.

TABLE 9.11-C (Continued)

TABLE NOTATIONS

41869

(1) This list does not mean that only these nuclides are to be considered. Other peaks that are identifiable, together with those of the above nuclides, shall also be analyzed and reported in the Annual Radiological Environmental Operating Report pursuant to Section 7.1.

(2) Required detection capabilities for thermoluminescent dosimeters used for environmental measurements shall be in accordance with the recommendations of Regulatory Guide 4.13, Revision 1, July 1977.

TABLE 9.11-C (Continued)

TABLE NOTATIONS

(3) The LLD is defined, for purposes of these controls, as the smallest concentration of radioactive material in a sample that will yield a net count, above system background, that will be detected with 95% probability with only 5% probability of falsely concluding that a blank observation represents a "real" signal.

For a particular measurement system, which may include radiochemical separation:

$$LLD = \frac{4.66\ s_b}{E \cdot V \cdot 2.22 \cdot Y \cdot \exp(-\lambda \Delta t)}$$

Where:

LLD = the "a priori" lower limit of detection (microCuries per unit mass or volume),

s_b = the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (counts per minute),

E = the counting efficiency (counts per disintegration),

V = the sample size (units of mass or volume),

2.22 = the number of disintegrations per minute per picoCurie,

Y = the fractional radiochemical yield, when applicable,

λ = the radioactive decay constant for the particular radionuclide (s^{-1}), and

Δt = the elapsed time between the sample collection, or end of the sample collection period, and the time of counting (s).

Typical values of E, V, Y, and Δt should be used in the calculation.

TABLE 9.11-C (Continued)

TABLE NOTATIONS

It should be recognized that the LLD is defined as a a priori (before the fact) limit representing the capability of a measurement system and not as an a posteriori (after the fact) limit for a particular measurement. Analyses shall be performed in such a manner that the stated LLDs will be achieved under routine conditions. Occasionally background fluctuations, unavoidable small sample sizes, the presence of interfering nuclides, or other uncontrollable circumstances may render these LLDs unachievable. In such cases, the contributing factors shall be identified and described in the Annual Radiological Environmental Operating Report pursuant to Section 7.1.

(4) LLD for drinking water samples. For surface water samples, the LLD of gamma isotopic analysis may be used.

9.12 RADIOLOGICAL ENVIRONMENTAL MONITORING LAND USE CENSUS

41870 9.12.1 Controls

9.12.1.1 A Land Use Census shall be conducted and shall identify within a distance of 8 km (5 miles) the location in each of the 16 meteorological sectors of the nearest milk animal, the nearest residence and the nearest garden* of greater than 50 m^2 (500 ft^2) producing broad leaf vegetation.

APPLICABILITY: At all times.

ACTION:

a. With a Land Use Census identifying a location(s) that yields a calculated dose or dose commitment greater than the values currently being calculated in Section 9.8.2.1, identify the new location(s) in the next Semiannual Radioactive Effluent Release Report, pursuant to Section 7.2.

*Broad leaf vegetation sampling of at least three different kinds of vegetation may be performed at the SITE BOUNDARY in each of two different direction sectors with the highest predicted D/Qs in lieu of the garden census. Specifications for broad leaf vegetation sampling in Table 9.11-A, Part 4.c. shall be followed, including analysis of control samples.

b. With a Land Use Census identifying a location(s) that yields a calculated dose or dose commitment (via the same exposure pathway) 20% greater than at a location from which samples are currently being obtained in accordance with Section 9.11.1.1, add the new location(s) within 30 days to the Radiological Environmental Monitoring Program given in the ODCM. The sampling location(s), excluding the control station location, having the lowest calculated dose or dose commitment(s), via the same exposure pathway, may be deleted from this monitoring program after October 31 of the year in which this Land Use Census was conducted. Pursuant to Technical Specification 6.14, submit as part of, or concurrent with, the next Semiannual Radioactive Effluent Release Report a complete and legible copy of the entire ODCM, including the revised figure(s) and table(s) reflecting the new location(s) with information supporting the change in sampling locations.

c. The provisions of Sections 9.0.3 and 9.0.4 are not applicable.

41871 9.12.2 Surveillance Requirements

9.12.2.1 The Land Use Census shall be conducted during the growing season at least once per 12 months using that information that will provide the best results, such as by a door-to-door survey, aerial survey, or by consulting local agriculture authorities. The results of the Land Use Census shall be included in the Annual Radiological Environmental Operating Report pursuant to Section 7.1.

41872 9.12.3 Bases

9.12.3.1 This section is provided to ensure that changes in the use of areas at and beyond the SITE BOUNDARY are identified and that modifications to the Radiological Environmental Monitoring Program given in the ODCM are made if required by the results of this census. Information that will provide the best results, such as door-to-door survey, aerial survey, or consulting with local agricultural authorities, shall be used. This census satisfies the requirements of Section IV.B.3 of Appendix I to 10 CFR Part 50. Restricting the census to gardens of greater than 50 m^2 provides assurance that significant exposure pathways via leafy vegetables will be identified and monitored since a garden of this size is the minimum required to produce the quantity (26 kg/year) of leafy vegetables assumed in Regulatory Guide 1.109 for consumption by a child. To determine this minimum garden size, the following assumptions were made: (1) 20% of the garden was used for growing broad leaf vegetation (i.e., similar to lettuce and cabbage), and (2) a vegetation yield of 2 kg/m^2.

9.13 RADIOLOGICAL ENVIRONMENTAL MONITORING INTERLABORATORY COMPARISON PROGRAM

41873 9.13.1 Controls

9.13.1.1 Analyses shall be performed on radioactive materials supplied as part of an Interlaboratory Comparison Program that has been approved by the Commission.

APPLICABILITY: At all times.

ACTION:

a. With analyses not being performed as required above, report the corrective actions taken to prevent a recurrence to the Commission in the Annual Radiological Environmental Operating Report pursuant to Section 7.1.

b. The provisions of Sections 9.0.3 and 9.0.4 are not applicable.

41874 9.13.2 Surveillance Requirements

9.13.2.1 The Interlaboratory Comparison Program shall be described in this procedure. A summary of the results obtained as part of the above required Interlaboratory Comparison Program shall be included in the Annual Radiological Environmental Operating Report pursuant to Section 7.1.

9.13.3 Bases

9.13.3.1 The requirement for participation in an approved Interlaboratory Comparison Program is provided to ensure that independent checks on the precision and accuracy of the measurements of radioactive material in environmental sample matrices are performed as part of the quality assurance program for environmental monitoring in order to demonstrate that the results are valid for the purposes of Section IV.B.2 of Appendix I to 10 CFR Part 50.

10.0 ADMINISTRATIVE CONTROLS

10.1 MAJOR CHANGES TO LIQUID AND GASEOUS RADWASTE TREATMENT SYSTEMS*

10.1.1 Licensee-initiated major changes to the Radwaste Treatment Systems (liquid and gaseous):

a. Shall be reported to the Commission in the Semiannual Radioactive Effluent Release Report for the period in which the evaluation was reviewed by the On-Site Review Committee (ORC). The discussion of each change shall contain:

1) A summary of the evaluation that led to the determination that the change could be made in accordance with 10 CFR 50.59;

2) Sufficient detailed information to totally support the reason for the change without benefit of additional or supplemental information;

3) A detailed description of the equipment, components and processes involved and the interfaces with other plant systems;

4) An evaluation of the change, which shows the predicted releases of radioactive materials in liquid and gaseous effluents and/or quantity of solid waste that differ from those previously predicted in the License application and amendments thereto;

5) An evaluation of the change, which shows the expected maximum exposures to a MEMBER OF THE PUBLIC in the UNRESTRICTED AREA and to the general population that differ from those previously estimated in the License application and amendments thereto;

6) A comparison of the predicted releases of radioactive materials, in liquid and gaseous effluents and in solid waste, to the actual releases for the period prior to when the changes are to be made;

*Union Electric Co. may choose to submit the information called for in this specification as part of the annual FSAR update.

7) An estimate of the exposure to plant operating personnel as a result of the change; and

8) Documentation of the fact that the change was reviewed and found acceptable by the ORC.

b. Shall become effective upon review and approval by the ORC an in accordance with Technical Specification 6.5.3.1.

10.2 CHANGES TO THE OFFSITE DOSE CALCULATION MANUAL (ODCM)

2815 10.2.1 All changes in the ODCM shall be completed pursuant to Technical Specification 6.14.2 and approved as per APA-ZZ-00101, Preparation, Review, Approval And Control Of Procedures.

2815 10.2.1.1 All changes shall be approved by the ORC PRIOR to implementation.

10.2.2 Cross Disciplinary Review for each revision of the ODCM must include, as a minimum, Health Physics, Quality Assurance, and Radiological Engineering.

2815 10.2.3 A complete and legible copy of each revision of the ODCM that became effective during the last semiannual period shall be submitted as a part of, or concurrent with that periods Semiannual Radioactive Effluent Release Report pursuant to Technical Specification 6.14.2.

11.0 REFERENCES

11.1 Title 10, "Energy", Chapter 1, Code of Federal Regulations, Part 20; U.S. Government Printing Office, Washington, D.C. 20402.

11.2 Title 10, "Energy", Chapter 1, Code of Federal Regulations, Part 50, Appendix I; U.S. Government Printing Office, Washington, D.C. 20402.

11.3 Title 40, "Protection of Environment", Chapter 1, Code of Federal Regulations, Part 190; U.S. Government Printing Office, Washington, D.C. 20402.

11.4 U.S. Nuclear Regulatory Commission, "Technical Specifications Callaway Plant, Unit NO. 1", NUREG-1058 (Rev. 1), October 1984.

11.4.1 Section 6.8.1 (2791)

11.4.2 Section 6.8.4f (41834)

11.5 Communications

11.5.1 Letter NEO-54, D.W. Capone to S.E. Miltenberger, dated January 5, 1983; Union Electric Company correspondence.

11.5.2 Letter BLUE 1285, "Callaway Annual Average X/Q and D/Q Values", J. H. Smith (Bechtel Power Corporation), to D. W. Capone (Union Electric Co.), dated February 27, 1984.

11.5.3 Letter BLUE 1232, "Callaway Annual Average X/Q Values and "S" Values", J. H. Smith (Bechtel Power Corporation) to D. W. Capone (Union Elecctric Co.), dated February 9, 1984.

11.5.4 Letter BLUE 1358, "Comparison of Callaway Plant Offsite Dose Calculations for Routine Effluents", J.H. Smith (Bechtel Power Corporation) to D.W. Capone (Union Electric Company), dated March 22, 1984.

11.5.5 Private Communication, H.C. Lindeman & B.F. Holderness, August 6, 1986

11.5.6 Calculation ZZ-67, "Annual Average Atmospheric Dispersion Parameters", April 1989.

11.6	Union Electric Company Callaway Plant, Unit 1, Final Safety Analysis Report.
11.6.1	Section 11.5.2.2.3.1
11.6.2	Section 11.5.2.2.3.4
11.6.3	Section 11.5.2.1.2
11.6.4	Section 11.5.2.2.3.2
11.6.5	Section 11.5.2.2.3.3
11.6.6	Section 11.2.3.3.4
11.6.7	Section 11.2.3.4.3
11.6.8	Section 11.5.2.3.3.1
11.6.9	Section 11.5.2.3.3.2
11.6.10	Section 11.5.2.3.2.3
11.6.11	Section 11.5.2.3.2.2
11.6.12	Section 2.3.5
11.6.13	Section 2.3.5.2.1.2
11.6.14	Section 9.2.6
11.6.15	Section 9.2.7.2.1
11.6.16	Section 6.3.2.2
11.6.17	Table 11.1-6
11.6.18	Table 9.4-6
11.6.19	Table 9.4-8
11.6.20	Table 9.4-11
11.6.21	Table 9.4-12
11.6.22	Table 2.3-68

11.7	Union Electric Company Callaway Plant Environmental Report, Operating License Stage.
11.7.1	Table 2.1-19
11.7.2	Section 2.1.2.3
11.7.3	Section 2.1.3.3.4
11.7.4	Section 5.2.4.1
11.7.5	Table 2.1-19
11.8	U.S. Nuclear Regulatory Commission, "Preparation of Radiological Effluent Technical Specification For Nuclear Power Plants", USNRC NUREG-0133, Washington, D.C. 20555, October 1978.
11.8.1	Pages AA-1 through AA-3
11.8.2	Section 5.3.1.3
11.8.3	Section 4.3
11.8.4	Section 5.3.1.5
11.8.5	Section 5.1.1
11.8.6	Section 5.1.2
11.8.7	Section 5.2.1
11.8.8	Section 5.2.1.1
11.8.9	Section 5.3.1
11.8.10	Section 3.8
11.8.11	Section 3.3
11.9	U.S. Nuclear Regulatory Commission, "XOQDOQ, Program For the Meterological Evaluation Of Routine Effluent Releases At Nuclear Power Stations", USNRC NUREG-0324, Washington, D.C. 20555.
11.9.1	Pages 19-20 Subroutine PURGE

11.10 Regulatory Guide 1.111, "Methods For Estimating Atmospheric Transport And Dispersion of Gaseous Effluents In Routine Releases From Light-Water-Cooled Reactors", Revision 1, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, July, 1977.

11.10.1 Section c.1.b

11.10.2 Figures 7 through 10

11.10.3 Section c.4

11.11 Regulatory Guide 1.109, "Calculation of Annual Doses to Man From Routine Releases Of Reactor Effluents For the Purpose Of Evaluating Compliance With 10 CFR Part 50, Appendix I", Revision 1, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, October 1977.

11.11.1 Appendix C, Section 3.a

11.11.2 Appendix E, Table E-15

11.11.3 Appendix C, Section 1

11.11.4 Appendix E, Table E-11

11.11.5 Appendix E, Table E-9

11.12 U.S. Nuclear Regulatory Commission, "Methods for Demonstrating LWR Compliance with the EPA Uranium Fuel Cycle Standard (40 CFR Part 190)", USNRC NUREG-0543, Washington, D.C. 20555, January 1980.

11.12.1 Section I, Page 2

11.12.2 Section IV, Page 8

11.12.3 Section IV, Page 9

11.12.4 Section III, Page 6

11.12.5 Section III, Page 8

11.13 Management Agreement for the Public Use of Lands, Union Electric Company and the State of Missouri Department of Conservation, December 21, 1982.

11.13.1 Exhibit A

11.14 Miscellaneous References

11.14.1 Drawing Number M-109-0007-06, Revision 5.

11.14.2 Callaway Plant Annual Environmental Operating Report (updated annually).

11.14.3 UE Safety Analysis Calculation 87-001-00.

11.14.4 Calculation ZZ-48, "Calculation of Inhalation and Ingestion Dose Commitment Factors for the Adult and Child", January, 1988.

11.14.5 HPCI 89-02, "Calculation of ODCM Dose Commitment Factors", March, 1989.

11.14.6 HPCI 87-04, "Calculation of the Limiting Setpoint for the Containment Purge Exhaust Monitors, GT-RE-22 and GT-RE-33", March, 1987.

11.14.7 HPCI 88-10, "Methodology for Calculating the Response of Gross NaI(Tl) Monitors to Liquid Effluent Streams", June, 1988.

11.14.8 Calculation ZZ-57, "Dose Factors for Eu-154", January, 1989.

11.15 U.S. Nuclear Regulatory Commission, "XOQDOQ: Computer Program for the Meterological Evaluation of Routine Effluent Releases at Nuclear Power Stations", USNRC NUREG/CR-2929, September, 1982, Washington, D.C. 20555.

11.15.1 Section 4, "Subroutine PURGE", pages 27 and 28.

11.16 Regulatory Guide 4.13, "Performance, Testing, and procedural specifications for Thermoluminiscence Dosimetry: Environmental Applications "(Revision 1), July 1977; USNRC, Washington, D.C. 20555

11.17 TID-7004, "Reactor Shielding Design Manual", Rockwell, Theodore, ed; March 1956.

11.18 BNWL-236, "ISOSHLD - A computer code for General Purpose Isotope Shielding Analysis", Engel, R.C., Greenberg, J., Hendrichson, M.M.; June 1966.

11.19 BNWL-236, Supplement 1, "ISOSHLD-II: Code Revision to include calculation of Dose Rate from Shielded Bremsotrahlung Sources", Simmons, G.L., et al; March 1967.

11.20 BNWL-236, Supplement 2, "A Revised Photon Probability Library for use with ISOSHLD-III", Mansius, C.A.; April 1969.

11.21 ANSI N13.10-1974, "Specification & Performance of On-Site Instrumentation for Continuously Monitoring Radioactivity in Effluents"; September, 1974.

11.22 Nuclear Regulatory Commission Generic Letter 89-01, "Guidance for the Implementation of Programmatic Controls for RETS in the Administrative Controls Section of Technical Specifications and the Relocation of Procedural Details of Current RETS to the Offsite Dose Calculation Manual or Process Control Program", January 1989.

11.23 ODP-ZZ-00002, Equipment Status Control.