OFFSITE DOSE CALCULATION MANUAL

FORT CALHOUN STATION UNIT NO. 1

August, 1984

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1. INTRODUCTION

Section 50.36a of 10 CFR Part 50 requires certain specific provisions to assure that releases of radioactive material from the plant to unrestricted areas during normal plant operations, including expected operational occurrences, are kept as low as is reasonably achievable. These provisions have been incorporated in the pertinent sections of the Technical Specifications of the Fort Calhoun Station Unit No. 1 as deemed appropriate and necessary in order to provide conformance with Section 50.36a and Section 50.36, "Technical Specifications," of 10 CFR Part 50.

The Offsite Dose Calculation Manual (ODCM) has been developed to provide guidance for calculating the concentrations of radioactive effluents, the doses to any individual via various exposure pathways, and alarm and trip action setpoints for radiation effluent monitors in order to comply with the provisions of Section 20.106 and 10 CFR Part 20 and Section 50.36a and Appendix I of 10 CFR Part 50. The ODCM is a manual that also describes the methodology and parameters to be used in the calculation of doses to any individual in the unrestricted areas due to radioactive liquid and gaseous effluents.

Section 2 of this manual contains the equations and methodology to be used at the Fort Calhoun Station for each alarm and trip setpoint on each effluent release point according to Specifications 2.9.1(1)d. and 2.9.1(1)e. for liquid effluents and Specifications 2.9.1(2)e. and 2.9.1(2)f. for gaseous effluents. High alarm monitor setpoints will be set based on values as determined by ODCM, but not to exceed the upper scale of the monitor.

Sections 3, 4, and 5 of this manual are applicable to specification on liquid effluents. Sections 3 and 4 contain the equations and methodology to be used according to Specifications 2.9.1(1)a. and 2.9.1(1)b. Section 5 describes the equipment or subsystem(s) of liquid radwaste treatment system to be used for providing compliance with Specification 2.9.1(1)c.

Sections 6, 7, and 8 of this manual are applicable to specification on gaseous effluents. Sections 6 and 7 contain the equations and methodology to be used according to Specifications 2.9.1(2)a. and 2.9.1(2)b. Section 8 describes the equipment or subsystem(s) of the gaseous radwaste treatment system to be used for providing conformance with Specification 2.9.1(2)c.

Section 9 provides the details describing the Radiological Environmental Monitoring Program as required by Specification 3.11. This section also provides a map and table of the sample locations and the analysis schedule.

This manual will be used along with plant administrative and surveillance and dose evaluation procedures for liquid and gaseous effluents and for environmental monitoring program. Any changes to this manual shall be reviewed and approved by the Plant Review Committee and audited by the Safety Audit and Review Committee, as designated by Specifications 5.5.1.69 and 5.5.2.8. Changes to this manual shall be submitted to the Commission pursuant to Specification 5.9.4.a.

2. EFFLUENT MONITOR SETPOINTS

2.1 Liquid Effluent Radiation Monitors

2.1.1 Steam Generator Blowdown Monitors (RM-054A and B)

These process radiation detectors monitor the flow through the steam generator blowdown lines and automatically close the blowdown isolation valves if the monitor high alarm setpoint is reached. The high alarm setpoint calculations are based on controlling the outfall at 10 CFR Part 20 limits of 1.0E-07 µCi/cc for unrestricted areas, for unidentified isotopes.

The maximum allowable concentration in the blowdown line is calculated as follows:

$$A_o = \frac{(1.0E\text{-}07\ \mu Ci/cc)\ (X_o)}{Y_o}$$

where:

X_o = Dilution flow in the discharge tunnel (gpm).

(Normal flow is based on 1 circulating water pump at 120,000 gpm)

Y_o = Blowdown flow rate (gpm). (Normal blowdown flow rate is based on 2 transfer pumps with a design flow of 135 gpm each, 270 gpm total).

A_o = Maximum allowable blowdown line concentration (µCi/cc).

The high alarm setpoint (CPM) =

$$8.5E\text{-}01\ (S_F)\ (A_o) + B$$

where:

8.5E-01 = Correction factor for instrument meter error.

S_F = Detector sensitivity factor (CPM/µCi/cc). (Sensitivity based on CS^{137})

A_o = Maximum allowable blowdown line activity (µCi/cc).

B = Background (CPM).

Setpoints may be recalculated based on adjusted dilution flow and adjusted blowdown flow.

2. EFFLUENT MONITOR SETPOINTS (Continued)

2.1.2 Overboard Discharge Header Monitor (RM-055 or RM-055A)

This process radiation monitor provides surveillance of the waste monitor tank effluent by monitoring the overboard header prior to its discharge into the circulating water discharge tunnel. The concentration of activity at the tunnel outfall is controlled below the 10 CFR Part 20 limit of 1.0E-07 μCi/cc for unrestricted areas for unidentified isotopes by the high alarm setpoint which also closes the overboard flow control valve.

The maximum allowable concentration in the overboard discharge header is:

$$A_o = \frac{(1.0E\text{-}07\ \mu Ci/cc)\ (X_o)}{Y_o}$$

where:

X_o = Dilution flow in the discharge tunnel (gpm).

Y_o = Maximum monitor tank discharge flow rate (gpm).

A_o = Maximum allowable activity in discharge header (μCi/cc).

The high alarm setpoint (CPM) =

$$8.5E\text{-}01\ (S_F)\ (A_o) + B$$

where:

8.5E-01 = Correction factor for instrument meter error.

S_F = Detector sensitivity factor (CPM/μCi/cc). (Sensitivity based on CS^{137})

A_o = Maximum allowable concentration in discharge header (μCi/cc).

B = Background (CPM).

2. EFFLUENT MONITOR SETPOINTS (Continued)

2.2 Gaseous Effluent Radiation Monitors

2.2.1 Stack Particulate Monitors (RM-061/RM-050)

Either of these monitors may be used to measure airborne particulate activity in the ventilation stack. The detector is located adjacent to a section of moveable filter paper on a capstan drive which is set to move in a continuous mode. The monitor measures airborne particulate activity releases so that the unrestricted areas limits (of 1.0E-10 μCi/cc) for radionuclides with half-lives greater than 8 days are not exceeded at the site boundary. The Ventilation Isolation Actuation Signal (VIAS) is initiated when the high alarm setpoint is reached.

The maximum allowable release rate:

$$\frac{(1.0E\text{-}10\ \mu Ci/cc)}{(1.5E\text{-}05\ sec/m^3)} \times (1.0E\text{+}06\ cc/m^3) = 6.67E00\ \mu Ci/sec$$

where:

1.0E-10 μCi/cc = Limiting activity at site boundary for unidentified isotopes with half lives greater than 8 days.

1.5E-05 sec/m³ = Annual average dispersion factor at the site boundary.

The high alarm setpoint (CPM):

$$8.5E\text{-}01 \frac{(6.67E00)\ (S_F)\ \ (F_s)\ (T)}{(F_v)} + B$$

where:

8.5E-01 = Correction for instrument meter error.

S_F = Detector sensitivity factor (CPM/μCi). (Sensitivity based on CS^{137})

F_s = Monitor sample flow rate (SCFM).

T = Effective monitor response time (sec).

F_v = Vent stack flow rate (SCFM).

B = Background (CPM).

2. EFFLUENT MONITOR SETPOINTS (Continued)

2.2.2 Stack Gaseous Activity Monitors (RM-062/RM-051)

Either of these monitors may be used to measure gaseous activity in the ventilation stack. The gas is monitored after passing through a particulate filter. The monitor controls gaseous activity releases so that the unrestricted area limits of 3.0E-07 μCi/cc for noble gases are not exceeded at the site boundary. The Ventilation Isolation Actuation Signal is initiated when the high alarm setpoint is reached.

The maximum allowable release rate:

$$\frac{3.0\text{E-07 } \mu\text{Ci/cc}}{1.5\text{E-05 sec/m}^3} \times 1.0\text{E+06 cc/m}^3 = 2.0\text{E+04 } \mu\text{Ci/sec}$$

where:

3.0E-07 μCi/cc = Limiting gaseous activity at site boundary for XE-133.

1.5E-05 sec/m^3 = Annual average dispersion factor at the site boundary.

The high alarm setpoint (CPM):

$$8.5\text{E-01} \frac{(2.00\text{E+04})\ (S_F)\ (60)}{(F_v)\ (28316)} + B$$

$$= 8.5\text{E-01} \frac{(4.24\text{E+01})\ (S_F)}{(F_v)} + B$$

where:

8.5E-01 = Correction for instrument meter error.

S_F = Detector sensitivity factor (CPM/μCi/cc). (Sensitivity based on CS^{137})

60 = Conversion (seconds to minutes).

28316 = Conversion factor (ft^3 to cc).

F_v = Vent stack flow rate (ft^3/min).

B = Background (CPM).

2. EFFLUENT MONITOR SETPOINTS (Continued)

2.2.3 Stack Iodine Monitor (RM-060)

RM-060 monitors the gaseous waste discharged from the stack for iodine (I-131) activity by continuously counting a charcoal filter cartridge through which a sample of ventilation stack air is passing at a known rate. The monitor alarm setpoint initiates the Ventilation Isolation Actuation Signal, when reached, and prevents the concentration of iodine activity, at the site boundary, from exceeding 10 CFR Part 20 limits for unrestricted areas.

The maximum allowable release rate:

$$\frac{(1.0E\text{-}10\ \mu Ci/cc)}{(1.5E\text{-}05\ sec/m^3)} \times (1.0E{+}06\ cc/m^3) = 6.67E00\ \mu Ci/sec$$

where:

1.0E-10 μCi/cc = Limiting activity at site boundary for I-131.

The high alarm setpoint (CPM):

$$8.5E\text{-}01\ \frac{(6.67E00)\ (S_F)\ \ (F_s)\ (T)\ (E)}{(F_v)} + B$$

where:

8.5E-01 = Correction factor for instrument meter error.

S_F = Detector sensitivity factor (CPM/μCi). (Sensitivity based on I^{131})

F_s = Monitor sample flow rate (SCFM).

T = Effective monitor response time (sec).

F_v = Vent stack flow rate (SCFM).

E = Charcoal filter collection efficiency.

B = Background (CPM).

2. EFFLUENT MONITOR SETPOINTS (Continued)

2.2.4 Condenser Air Ejector Monitor (RM-057)

This monitor is located in the turbine building and monitors the condenser off-gases. The purpose of this monitor is to monitor gaseous releases so that the 10 CFR Part 20 limits for unrestricted areas are not exceeded.

The maximum allowable release rate:

$$\frac{3.0\text{E-07 } \mu\text{Ci/cc}}{1.5\text{E-05 sec/m}^3} \times 1.0\text{E+06 cc/m}^3 = 2.0\text{E+04 } \mu\text{Ci/sec}$$

where:

3.0E-07 μCi/cc = Limiting gaseous activity at site boundary for XE-133.

1.5E-05 sec/m³ = Annual average dispersion factor at the site boundary.

The high alarm setpoint (CPM):

$$8.5\text{E-01} \frac{(2.0\text{E+04})\ (S_F)\ (60)}{(F_v)\ (28316)} + B$$

$$= 8.5\text{E-01} \frac{(4.24\text{E+01})\ (S_F)}{(F_v)} + B$$

where:

8.5E-01 = Correction for instrument meter error.

S_F = Detector sensitivity factor (CPM/μCi/cc). (Sensitivity based on CS^{137})

60 = Conversion (seconds to minutes).

28316 = Conversion factor (cubic feet to cc).

F_v = Condenser vent system flow rate (ft³/min).

3. CONCENTRATIONS IN LIQUID EFFLUENTS

The concentration of radioactive liquid effluents to the unrestricted area will be limited to the concentration levels of 10 CFR Part 20, Appendix B, Table II.

For batch releases (Monitor and Hotel Waste Tanks) and for continuous releases (Steam Generator Blowdown), the analyses will be performed in accordance with Table 3-11 of the Technical Specifications and the concentration of each radionuclide will be less than or equal to the maximum permissible concentrations of 10 CFR Part 20, Appendix B, Table II.

The following method will be utilized to calculate the concentrations of liquid effluents for each radionuclide at the point of discharge based on certain known parameters:

$$C_i = \frac{a_i f}{F} \leq MPC_i$$

where:

- C_i is the concentration at the point of discharge for nuclide, i, in μCi/ml.
- a_i is the concentration of nuclide, i, in the tank or steam generator, in μCi/ml.
- f is the total undiluted effluents flow rate, in gpm.
- F is the total circulating water flow rate in the discharge canal, in gpm.
- MPC_i is the maximum permissible concentration for nuclide, i, per 10 CFR Part 20, Appendix B, Table II.

NOTE: In addition to the above defined method, NOTES 1 through 4 of 10 CFR Part 20, Appendix B, will also be applicable.

The lower limit of detection (LLD), referenced in Table 3-11 of the Technical Specifications, is defined 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:

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

3. CONCENTRATIONS IN LIQUID EFFLUENTS (Continued)

Where:

LLD is the lower limit of detection as defined above, as microcuries per unit mass or volume,

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

E is the counting efficiency, as counts per disintegration,

V is the sample size in units of mass or volume,

2.22×10^6 is the number of disintegrations per minute per microcurie,

Y is the fractional radiochemical yield, when applicable,

λ is the radioactive decay constant for the particular radionuclide, and

Δt for plant effluents is the elapsed time between the midpoint of sample collection and time of counting.

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

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

4. DOSE CONTRIBUTIONS FROM LIQUID EFFLUENTS

The cumulative dose contributions to the total body and any organ of an individual will be calculated on a quarterly basis based on the total nuclides released from the plant to unrestricted areas during the previous calendar quarter. These dose contributions will be calculated using the following expression:

$$D_\tau = \Sigma_i A_{i\tau} \Sigma(\Delta t \, a_i \cdot \frac{f}{F})$$
$$= \Sigma_i A_{i\tau} \Sigma(\Delta t \, C_i)$$

where:

D_τ is the cumulative dose commitment to the total body or any organ, τ, from the liquid effluents for the total time period, in mrem.

$A_{i\tau}$ is the ingestion dose commitment factor to the total body or any organ, τ, for each identified principal gamma and beta emitter listed in Table 3-11 of the Technical Specifications, in mrem/hr per μCi/ml.

Δt is the length of time period over which C_i, f, and F are averaged for all liquid releases, in hours.

a_i, C_i, f, F are as defined under Section 3. of this manual.

The cumulative dose contributions to the total body and any organ will be reviewed quarterly to verify satisfaction to the design objectives and the actions of Technical Specification 2.9.1 (1) determined.

4.1 Ingestion Dose Commitment Factors

The above equation for calculating the dose contributions requires the use of an ingestion dose commitment factor, $A_{i\tau}$, for each nuclide, i, which embodies the dose factors, and dilution factors for the points of pathway origin (only drinking water and fish consumption are considered the major pathways of exposure due to liquid effluents). The adult total body dose factor and the adult critical organ (liver) dose factor for each radionuclide are obtained from Regulatory Guide 1.109, Revision 1. The ingestion dose commitment factor can be calculated from the following expression:

$$A_{i\tau} = 1.14\text{ E+05} \frac{730}{D_w} e^{-\lambda_i t_p} + 21 \, BF_i \, e^{-\lambda_i t_f} DF_i$$

4. DOSE CONTRIBUTIONS FROM LIQUID EFFLUENTS (Continued)

where:

D_w - Dilution factor from the near field area of the release point to the drinking water facility 19 miles downstream.

λ_i - Radioactive decay constant of nuclide, i, in ($days^{-1}$).

t_p - The average transit time from the point of release to the drinking water facility including the time through the purification plant and the water distribution system, in days.

t_f - The time for radionuclide decay during transit through the aquatic food chain, in days.

BF_i - Bioaccumulation factor for nuclide, i, in fish for fresh water site, in pCi/kg per pCi/l.

DF_i - Dose conversion factor for nuclide, i, for adults, in mrem/pCi.

1.14E+05 - Unit Conversion Factor (1.0E+06 pCi/μCi x 1.0E+03 $\frac{ml}{kg}$ ÷ 8760 hr/yr)

Tabulated below are the appropriate values and other references:

Parameter	Value
D_w	30.8 (dimensionless)
t_p	0.75 day
t_f	1 day
BF_i	Table A-1 of Regulatory Guide 1.109
DF_i	Table E-11 of Regulatory Guide 1.109

Resolution of the units yields:

$$A_{i\tau} = 2.40E+06 \; 1.13 \; e^{-0.75\lambda_i} + BF_i \; e^{-\lambda_i} \; DF_i$$

The values for ingestion dose commitment factor, $A_{i\tau}$, for the adult total body, and critical organ (liver), are presented in Table 1.

TABLE 1

$A_{i\tau}$ for Liquid Pathways (Adult)
(mrem/hr per μCi/ml)

Nuclide	Total Body	Liver
H-3	5.1E-01	5.1E-01
CR-51	1.3E+00	0.0
MN-54	8.4E+02	4.4E+03
FE-59	9.3E+02	2.4E+03
CO-58	2.0E+02	9.0E+01
CO-60	5.8E+02	2.6E+02
ZN-65	3.3E+04	7.4E+04
SR-89	6.5E+02	0.0
SR-90	1.4E+05	0.0
ZR-95	6.9E-02	1.0E-01
NB-95	1.3E+02	2.4E+02
MO-99	1.7E+01	9.0E+01
RU-103	2.1E+00	0.0
I-131	1.2E+02	2.1E+02
I-133	1.3E+01	4.4E+01
I-135	1.5E+00	4.0E+00
CS-134	5.8E+05	7.1E+05
CS-136	8.4E+04	1.2E+05
CS-137	3.4E+05	5.2E+05
BA-140	1.6E+01	3.0E-01

5. LIQUID RADWASTE TREATMENT SYSTEM

The major equipment or subsystem(s) of the liquid radwaste treatment system are comprised of waste filters, and evaporator. This equipment, including associated pumps, valves and piping, is used in different combinations on an as-needed basis in order to process the liquid effluent to provide compliance with the as low as is reasonably achievable philosophy and the applicable sections of 10 CFR Part 20.

Waste filters (WD-17A and WD-17B) are used only on those occasions when considered necessary, otherwise the flows from the low activity fluids may bypass the filters. No credit for decontamination factors (iodines, Cs, Rb, others) was taken for these filters during the Appendix I dose design objective evaluation; therefore, the inoperability of these filters does not affect the dose contributions to any individual in the unrestricted areas via liquid pathways. The inoperability of waste filters will not be considered a reportable event in accordance with Specification 2.9.1(1)c.

Every effort will be made to process all liquid waste, except from the hotel waste tanks, through the evaporator before entering the monitor tanks. If the radioactive liquid waste was discharged without processing through the evaporator a special report shall be submitted to the Commission, pursuant to Specification 2.9.1(1)c.

The quantity of radioactive material contained in each unprotected outdoor liquid holdup tank shall not exceed 10 curies, excluding tritium and dissolved or entrained noble gases.

6. CONCENTRATIONS IN GASEOUS EFFLUENTS

The concentration of radioactive gaseous effluents to the unrestricted areas will be limited to the concentration levels of 10 CFR Part 20, Appendix B, Table II.

For various types of releases (batch and continuous) the analyses will be performed in accordance with the appropriate sampling and analysis-frequencies and type of activities of the Technical Specification, Table 3-12. The concentration of each radionuclide at the unrestricted areas will be less than or equal to the maximum permissible concentrations of 10 CFR Part 20, Appendix B, Table II.

6.1 Noble Gases

The following method is used to estimate the concentrations of gaseous effluents (noble gases) in the unrestricted areas (see Figure 1):

$$C_i = K \cdot Q_i \cdot \frac{X}{Q} \leq MPC_i$$

where:

- C_i is the concentration of radionuclide, i, in the unrestricted area, in μCi/ml.
- Q_i is the release rate of radionuclide, i, from the ventilation stack, in μCi/sec.
- $\frac{X}{Q}$ is the highest calculated annual average dispersion for any area at or beyond the unrestricted area boundary, in sec/m^3 (use value from Table 7).
- K is the unit conversion factor (1.0 E-06 Ci/μCi).

Resolution of units yields:

$$C_i = 1.5\text{ E-11} \cdot Q_i \leq MPC_i$$

NOTE: In addition to the above defined method, NOTES 1 through 4 of 10 CFR Part 20, Appendix B, will also be applicable.

6.2 Radioiodines and Particulates

The concentrations of radioiodines and particulates, with half-lives greater than 8 days, in the unrestricted areas (see Figure 1) will be estimated based on deposition of these radioactive materials on the ground at or near the location of receptors in the worst sector.

6. CONCENTRATIONS IN GASEOUS EFFLUENTS (Continued)

Therefore, the value χ/Q in the above equation will be replaced by 3.8E-06 sec/m³ or:

$$C_i = 3.8E\text{-}12\ Q_i \leq MPC_i$$

The parameters and values are described under section 6.1 above.

NOTE: In addition to the above defined method, NOTES 1 through 4 of 10 CFR Part 20, Appendix B, will also be applicable.

The lower limit of detection (LLD), referenced in Table 3-12 of the Technical Specifications, is defined 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 is the lower limit of detection as defined above, as microcuries per unit mass or volume,

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

E is the counting efficiency, as counts per disintegration,

V is the sample size in units of mass or volume,

2.22×10^6 is the number of disintegrations per minute per microcurie,

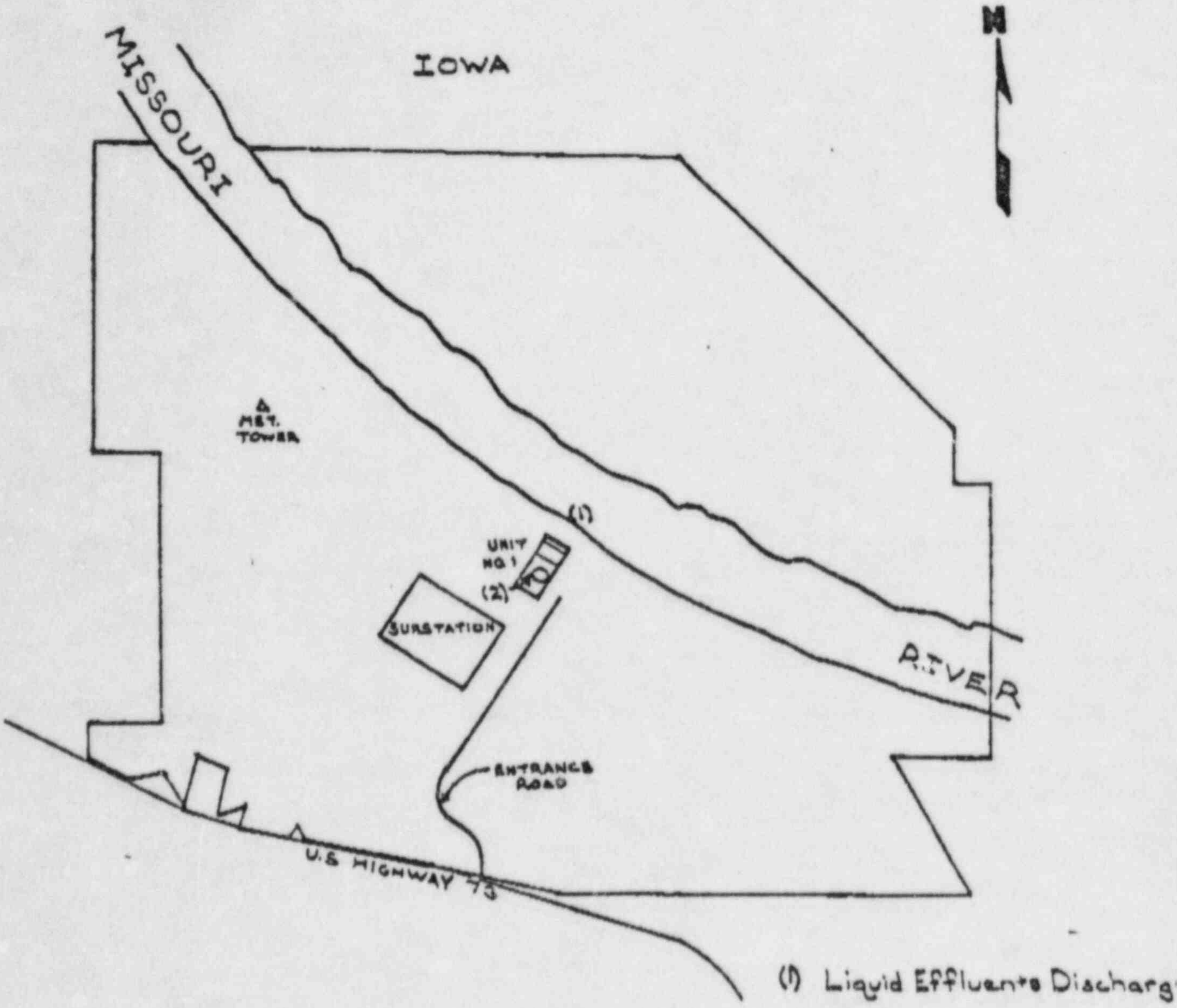
Y is the fractional radiochemical yield, when applicable,

λ is the radioactive decay constant for the particular radionuclide, and

Δt for plant effluents is the elapsed time between the midpoint of sample collection and time of counting.

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

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



Omaha Public Power District Fort Calhoun Station Unit No. 1	Exclusion and Site Boundary Map	Fig. 1

7. DOSE CONTRIBUTIONS FROM GASEOUS EFFLUENTS

The cumulative dose contributions, to each of the 16 cardinal sectors, from radioactive materials in gaseous effluents will be determined on a quarterly basis. The dose contributions are divided into two categories; namely, air doses due to noble gases and dose to an individual (child or infant) from I-131, tritium and radioactive material in particulate form.

7.1 Air Dose Due to Noble Gases

The air dose in unrestricted area (see Figure 1) due to noble gases released in gaseous effluents is determined by the following expressions:

a. During any calendar quarter, for gamma radiation:

$$D_\gamma = \Sigma_i \; DF_i^\gamma \cdot Q_i \cdot \frac{\chi}{Q}$$

b. During any calendar quarter, for beta radiation:

$$D_\beta = \Sigma_i \; DF_i^\beta \cdot Q_i \cdot \frac{\chi}{Q}$$

where:

DF_i^γ is the air dose factor due to gamma emissions for each identified noble gas radionuclide, i, in mrad/sec per $\mu Ci/m^3$ (Table 2).

DF_i^β is the air dose factor due to beta emissions for each identified noble gas radionuclide, i, in mrad/sec per $\mu Ci/m^3$ (Table 2).

Q_i is the release, cumulative over the calendar quarter, of noble gas radionuclides in gaseous effluents, i, in μCi.

$\frac{\chi}{Q}$ is the highest calculated annual average dispersion factor for area at or beyond the unrestricted area boundary, in sec/m^3 (Table 7).

D_γ, D_β are the total gamma air dose and beta air dose from gaseous effluent, in mrad.

7.2 Dose Due to Radioiodines and Particulates

The total body dose and dose to the critical organ (thyroid) of an individual (child or infant), for any calendar quarter from I-131, tritium, and radioactive materials in particulate form with half-lives greater than 8 days in gaseous effluents released to unrestricted areas (see Figure 1) is determined by the following expression:

$$D_I = 3.17E\text{-}08 \cdot \frac{D}{Q} \text{ or } \frac{\chi}{Q} \cdot \Sigma_i \; R_i \cdot Q_i$$

7. DOSE CONTRIBUTIONS FROM GASEOUS EFFLUENTS (Continued)

where:

R_i is the dose factor for each identified radionuclide, i, in mrem/yr per $\mu Ci/m^3$ or m^2 (mrem/yr) per $\mu Ci/sec$ (Tables 3, 4, 5, and 6).

Q_i is the release, cumulative over the calendar quarter, of I-131, tritium and radioactive materials in particulate form in gaseous effluents, i, with half-lives greater than 8 days, in μCi.

$\frac{D}{Q}$ is the annual average deposition factor for estimating the dose to an individual at the controlling location, in $meters^{-2}$ (Table 7).

$\frac{\chi}{Q}$ is the annual average dispersion factor for estimating the dose to an individual at the controlling location, in sec/m^3 (Table 7).

D_I is the quarterly cumulative dose from I-131, tritium, and radioactive materials in particulate form with half-lives greater than 8 days in gaseous effluents, in mrem.

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

The cumulative dose contributions from radioactive materials in gaseous effluents will be reviewed quarterly to verify satisfaction to the design objectives and the actions of Technical Specification 2.9.1.(2)b determined.

TABLE 2

Dose Factors for Noble Gases

Nuclide	Gamma Air Dose Factor DF_i^{γ} (mrad/sec per $\mu Ci/m^3$)	Beta Air Dose Factor DF_i^{β} (mrad/sec per $\mu Ci/m^3$)
AR-41	2.95E-04	2.80E-04
KR-85M	3.90E-05	3.71E-05
KR-85	5.45E-07	5.11E-07
KR-87	1.96E-04	1.88E-04
KR-88	4.82E-04	4.66E-04
XE-131M	4.95E-06	2.90E-06
XE-133M	1.04E-05	7.96E-06
XE-133	1.12E-05	9.32E-06
XE-135M	1.07E-04	9.89E-05
XE-135	6.09E-05	5.74E-05
XE-138	2.92E-04	2.80E-04

TABLE 3

Dose Factors for I-131, H-3 and Radioactive Particulates Via Inhalation Pathway

(mrem/yr per μCi/m³) R_i (Child)

Nuclide	Total Body	Thyroid
H-3	1.1E+03	1.1E+03
CR-51	1.5E+02	8.5E+01
MN-54	9.5E+03	0.0
FE-59	1.7E+04	0.0
CO-58	3.2E+03	0.0
CO-60	2.3E+04	0.0
ZN-65	7.0E+04	0.0
SR-89	1.7E+04	0.0
SR-90	6.4E+06	0.0
ZR-95	3.7E+04	0.0
I-131	2.7E+04	1.6E+07
CS-134	2.2E+05	0.0
CS-136	1.2E+05	0.0
CS-137	1.3E+05	0.0
BA-140	4.3E+03	0.0

TABLE 4

Dose Factors for I-131, H-3 and Radioactive Particulates Via Inhalation Pathway

(mrem/yr per μCi/m³) R_i (Infant)

Nuclide	Total Body	Thyroid
H-3	6.5E+02	6.5E+02
CR-51	8.9E+01	5.8E+01
MN-54	5.0E+03	0.0
FE-59	9.5E+03	0.0
CO-58	1.8E+03	0.0
CO-60	1.2E+04	0.0
ZN-65	3.1E+04	0.0
SR-89	1.1E+04	0.0
SR-90	2.6E+06	0.0
ZR-95	2.0E+04	0.0
I-131	2.0E+04	1.5E+07
CS-134	7.4E+04	0.0
CS-136	5.3E+04	0.0
CS-137	4.6E+04	0.0
BA-140	2.9E+03	0.0

TABLE 5

Dose Factors for I-131, H-3 and Radioactive Particulates Via Ground and Food Pathways

(m²-mrem/yr per μCi/sec) R_i (Child)

Nuclide	Total Body	Thyroid
H-3	5.8E+03*	5.8E+03*
CR-51	4.8E+06	3.8E+04
MN-54	1.5E+09	0.0
FE-59	8.2E+08	0.0
CO-58	6.3E+08	0.0
CO-60	2.3E+10	0.0
ZN-65	6.8E+09	0.0
SR-89	1.2E+09	0.0
SR-90	3.4E+11	0.0
ZR-95	2.5E+08	0.0
I-131	4.8E+08	2.7E+11
CS-134	1.8E+10	0.0
CS-136	1.2E+09	0.0
CS-137	1.7E+10	0.0
BA-140	4.2E+07	0.0

*Units for H-3 are mrem/yr per μCi/m³.

TABLE 6

Dose Factors for I-131, H-3 and Radioactive Particulates
Via Ground and Food Pathways
(m^2-mrem/yr per μCi/sec) R_i (Infant)

Nuclide	Total Body	Thyroid
H-3	2.4E+03*	2.4E+03*
CR-51	4.8E+06	5.5E+04
MN-54	1.3E+09	0.0
FE-59	3.6E+08	0.0
CO-58	4.2E+08	0.0
CO-60	2.2E+10	0.0
ZN-65	6.3E+09	0.0
SR-89	2.0E+08	0.0
SR-90	2.1E+10	0.0
ZR-95	2.5E+08	0.0
I-131	7.3E+08	5.3E+11
CS-134	1.1E+10	0.0
CS-136	1.2E+09	0.0
CS-137	1.3E+10	0.0
BA-140	2.7E+07	0.0

*Units for H-3 are mrem/yr per μCi/m^3.

TABLE 7

Annual Average Dispersion and Relative Deposition Factors

$\frac{X}{Q}$ or $\frac{D}{Q}$	Units	Dose to Air: Gamma	Dose to Air: Beta	Dose Via Tritium	Dose to Individual: Total Body	Dose to Individual: Any Organ
$\frac{X}{Q}$	sec/m^3	1.5E-05 (1)	1.5E-05 (1)	3.5E-06 (2)	3.8E-06 (3)	3.8E-06 (3)
$\frac{D}{Q}$	m^{-2}	---	---	---	1.2E-08 (4)	1.2E-08 (4)

(1) The highest calculated annual average dispersion factor for any area at or beyond the unrestricted area boundary for long term releases.

(2) For the nearest residence at or close to real milk animal.

(3) The calculated annual average dispersion factor for the controlling location in the SSE sector.

(4) The calculated annual average deposition factor for the nearest milk source or residence in the SSW sector.

8. GASEOUS RADWASTE TREATMENT SYSTEM

The waste gases at Fort Calhoun Station are collected in the vent header where the gas compressor(s) takes suction, compresses the gas and then delivers it to one of the four gas decay tanks. The waste gases are primarily treated in these gas decay tanks by holding the gases for radioactive decay prior to final controlled release to the environs. In order to provide conformance with the dose design objectives, gas decay tanks are normally stored for approximately 17 days with earlier release allowed to support plant operation only and thus achieve decay of short half-life radioactive materials, e.g., I-131, XE-133. If the radioactive gaseous wastes from the gas decay tank(s) were discharged without processing in accordance with the above conditions, a special report shall be submitted to the Commission pursuant to Specification 2.9.1(2)c.

The radioactive effluents from the controlled access area of the auxiliary building are filtered by the HEPA filters in the auxiliary building ventilation system. If the radioactive gaseous wastes were discharged without the HEPA filters, a special report shall be submitted to the NRC pursuant to specification 2.9.1(2)c.

The discharge from the gas decay tanks is routed through charcoal and HEPA filter unit VA-82. No credit was taken for the operation of hydrogen purge filters during the Appendix I dose design evaluation and doses through the gaseous pathways were well below the design objectives. The unavailability of hydrogen purge filters will not be considered a reportable event as per Specification 2.9.1(2)c.

The containment air is processed through at least one of the redundant containment HEPA and charcoal filters in the Containment Air Cooling and Filtering Units prior to purging. If the containment purges were made without processing through one of the Containment Air Cooling and Filtering Units, a special report shall be submitted to the Commission pursuant to Specification 2.9.1(2)c.

9. RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

The radiological environmental monitoring program will be conducted, to measure changes in the levels of environmental radioactivity due to plant effluents, in accordance with Specification 3.11. The reporting levels for radioactivity concentrations in the environmental samples are provided in Table 8. Analytical techniques for the sampling program will provide assurance that the detection capabilities specified in Table 9 are achieved.

The specific details of the radiological environmental monitoring program are also presented here with additional detail provided in an Environmental Radiological Monitoring Procedure Manual. Table 10 provides the details regarding the sampling station numbers, collection sites, and distance and location of each station from the centerline of the containment. The sample stations, specifically in the vicinity of the plant, are shown on Figure 2.

Deviations from the monitoring program, presented in Specification 3.11 and detailed in Table 10, are permitted if specimens are unobtainable due to hazardous conditions, seasonal unavailability, malfunction of equipment, or if a person discontinues participation in the program and other legitimate reasons. If the equipment malfunctions, corrective actions will be completed as soon as practicable. If a person no longer supplies samples, a replacement will be made. All deviations from the sampling schedule will be described in the Annual Radiological Environmental Operating Report, pursuant to Specification 3.11.1.

This program is the responsibility of Nuclear Environmental Monitoring Services.

TABLE 8

REPORTING LEVELS FOR RADIOACTIVITY CONCENTRATIONS IN ENVIRONMENTAL SAMPLES*

Sample	Units	H-3	Mn-54	Fe-59	Co-58	Co-60	Zn-65	Zy-Nb-95	I-131	CS-134	CS-137	Ba-140
Water	pCi/l	2E+04	1E+03	4E+02	1E+03	3E+02	3E+02	4E+02	2E+00	3E+01	5E+01	2E+02
Fish	pCi/kg (wet)	--	3E+04	1E+04	3E+04	1E+04	2E+04	--	--	1E+03	2E+03	--
Milk	pCi/l	--	--	--	--	--	--	--	3E+00	6E+01	7E+01	3E+02
Air Particulate or Gases	pCi/m³	--	--	--	--	--	--	--	9E-01	--	--	--
Broad Leaf Vegetation	pCi/kg (wet)	--	--	--	--	--	--	--	1.0E+02	1.0E+03	2.0E+03	--

*When more than one of the radionuclides are detected in the sampling medium, a non-routine report shall be submitted, per Specification 5.9.4.b. if:

$$\frac{\text{Concentration (1)}}{\text{Reporting Level (1)}} + \frac{\text{Concentration (2)}}{\text{Reporting Level (2)}} + - - - - - \geq 1.0$$

When radionuclides other than those listed above are detected and are the result of plant effluents, this report shall be submitted if the potential annual dose to a member of the general public is equal to or greater than the dose objectives of limiting condition of operation 2.9.1.A and 2.9.1.B. 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.

TABLE 9

DETECTION CAPABILITIES FOR ENVIRONMENTAL SAMPLE ANALYSIS
LOWER LIMIT OF DETECTION (LLD)*

Sample	Units	Gross Beta	H-3	Mn-54	Fe-59	Co-58,60	Zn-65	Zr-Nb-95	I-131	CS-134	CS-137	Ba-140
Water	pCi/l	-	2.0E+04	1.5E+01	3.0E+01	1.5E+01	3.0E+01	1.5E+01	1.0E+00	1.5E+01	1.8E+01	1.5E+01
Fish	pCi/kg (wet)	-	-	1.3E+02	2.6E+02	1.3E+02	2.6E+02	-	-	1.3E+02	1.5E+02	-
Milk	pCi/l	-	-	-	-	-	-	-	1.0E+00	1.5E+01	1.8E+01	1.5E+01
Air Partic-ulate or Gas	pCi/m³	1.0E-02	-	-	-	-	-	-	7.0E-02	-	-	-
Sediment	pCi/kg (dry)	-	-	-	-	-	-	-	-	1.5E+02	1.8E+02	-
Broad Leaf Vegetation	pCi/kg (wet)	-	-	-	-	-	-	-	6.0E+01	6.0E+01	8.0E+01	-

*The LLD is defined, for purposes of these specifications, 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:

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

TABLE 9 (Continued)

Where:

LLD is the lower limit of detection as defined above, as microcuries per unit mass or volume,

s_b is the standard deviation of the background counting rate of of the counting rate of a blank sample as appropriate, as counts per minute,

E is the counting efficiency, as counts per disintegration,

V is the sample size in units of mass or volume,

2.22×10^6 is the number of disintegrations per minutes per microcurie,

Y is the fractional radiochemical yield, when applicable,

λ is the radioactive decay constant for the particular radionuclide, and

Δt for plant effluents is the elapsed time between the midpoint of sample collection and time of counting.

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

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

TABLE 10

Radiological Environmental Monitoring Program

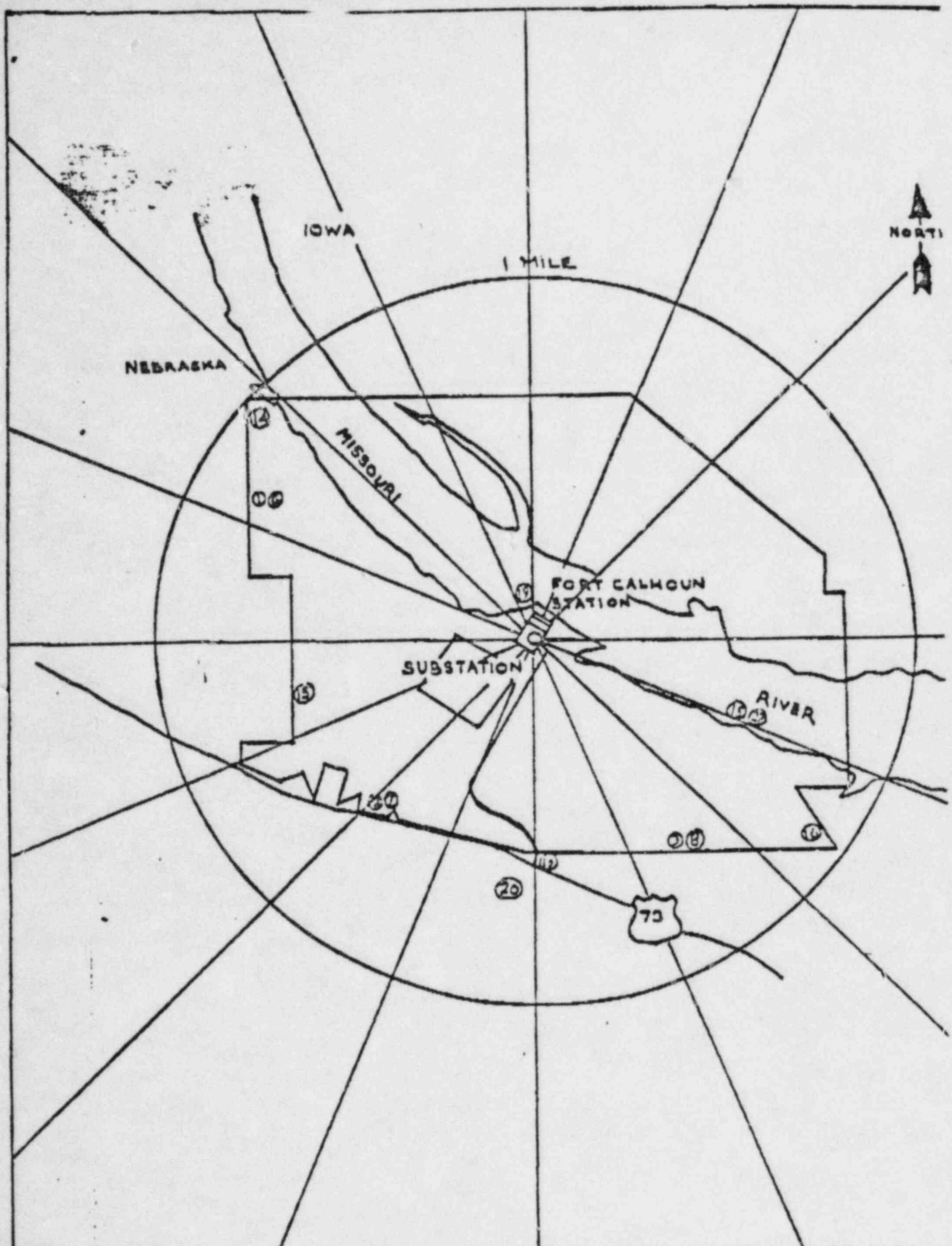
Exposure Pathway and/or Sample	Sampling Station No.	Collection Site	Distance from the Containment (Miles)	Radial (Degrees)
A. Air Monitoring	1	Onsite Station #1	0.7	293
	2	Onsite Station #2	0.6	225
	3	Onsite Station #3	0.6	155
	4	City of Blair	3.1	286
	5	EOF (Background)	17.5	157
B. TLD	6	Onsite Station #1	0.7	293
	7	Onsite Station #2	0.6	225
	8	Onsite Station #3	0.6	155
	9	City of Blair	3.1	286
	10	EOF (Background)	17.5	157
	11	Fort Calhoun City Hall	4.8	149
	12	Fence around Intake Gate at Desoto Refuge	2	101
	13	Entrance to Plant from Hwy 73 (onsite)	0.6	180
	14	Northwest of Plant (onsite)	1.0	310
	15	West-Southwest of Plant (onsite)	0.7	250
	16	Southeast of Plant (onsite)	0.9	130
C. Water	17	Missouri River @ MUD	17	156
	18	West Bank of Missouri River	0.5	106
	19	Missouri River Upstream from Intake (Background)	0.1	345

TABLE 10 (Continued)

Radiological Environmental Monitoring Program

Exposure Pathway and/or Sample	Sampling Station No.	Collection Site	Distance from the Containment (Miles)	Radial (Degrees)
D. Milk	20	Miller Farm[1]	0.7	193
	21	Japp Dairy (Background)	6.3	219
E. Fish	22-25	4 Samples within Vicinity of Plant Discharge	-- R.M.645 --	
	26	West of Mondamin, Iowa (Background)	-- R.M.666 --	
F. Sediment	27	West Bank of River	0.5	106

(1) When a milk sample is unavailable a milk sample will be collected from the Flynn Dairy. If both milk samples are unavailable, a broad leaf vegetation sample will be collected at the location.



Omaha Public Power District
Fort Calhoun Station
Unit No. 1

Radiological Environmental
Monitoring Program
(Sample Sites)

Figure 2