OFFSITE DOSE CALCULATION MANUAL

FOR

SOUTH CAROLINA ELECTRIC AND GAS COMPANY

VIRGIL C. SUMMER NUCLEAR STATION

May 1981

8106080264

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REFERENCES

This Offsite Dose Calculation Manual was prepared for the Virgil C. Summer Nuclear Station by Applied Physical Technology based on information communicated directly to APT by South Carolina Electric and Gas Company personnel and the following reference documents:

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2. "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10CFR 50, Appendix I", U. S. NRC Regulatory Guide 1.109 (March 1976).

3. "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10CFR 50, Appendix I", U. S. NRC Regulatory Guide 1.109, Rev. 1 (October 1977).

4. "Final Safety Analysis Report", South Carolina Electric and Gas Company, Virgil C. Summer Nuclear Station.

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6. Wahlig, B.G., "Estimation of the Radioactivity Release Rate/Equilibrium Concentration Relationship for the Parr Pumped Storage System", Applied Physical Technology, Inc., February 1981.

7. "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light - Water - Cooled Reactors", U.S. NRC Regulatory Guide 1.111 (March 1976).

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9. Slade, D.H., (editor), "Meteorology and Atomic Energy"; U.S. Atomic Energy Commission, AEC TID-24190, 1968.

INTRODUCTION

The OFFSITE DOSE CALCULATION MANUAL is a supporting document of the RADIOLOGICAL EFFLUENT TECHNICAL SPECIFICATIONS. As such the ODCM describes the methodology and parameters to be used in the calculation of offsite doses due to radioactive liquid and gaseous effluents and in the calculation of liquid and gaseous effluent monitoring instrumentation alarm/trip setpoints. The ODCM contains a list and graphical description of the specific sample locations for the radiological environmental monitoring program. Minimum OPERABLE configurations of the liquid and gaseous radwaste treatment systems are also included.

The ODCM will be maintained at the Station for use as a reference guide and training document of accepted methodologies and calculations. Changes in the calculational methods or parameters will be incorporated into the ODCM in order to assure that the ODCM represents the present methodology in all applicable areas. Computer software to perform the described calculations will be maintained current with this ODCM.

1.0 LIQUID EFFLUENTS

The Virgil C. Summer Nuclear Station is located on the Monticello Reservoir which provides supply and discharge for the plant circulating water. This reservoir also provides supply and discharge capacity for the Fairfield Pumped Storage Facility. The Parr Reservoir located below the pumped storage facility is located above the Parr Dam.

There are two basic release pathways and sources of dilution for liquid effluents: the circulating water discharge canal and the liquid effluent line to the penstocks of the pumped storage facility. All liquid effluent pathways discharge to either one or the other release point. Generally speaking, very low concentrations of radioactive waste are discharged to the circulating water discharge while generally higher concentrations of radioactive waste are released to the penstocks of the pumped storage facility during the generation cycle.

1.1 Liquid Effluent Monitor Setpoints

The calculated setpoint values will be regarded as upper bounds for the actual setpoint adjustments. That is, setpoint adjustments are not required to be performed if the existing setpoint level corresponds to a lower count rate than the calculated value. Setpoints may be established at values lower than the calculated values if desired.

1.1.1 Liquid Radwaste Effluent Line Monitors

(RM-L5, RM-L7, RM-L9)

Liquid Radwaste Effluent Line Monitors provide alarm and automatic termination of release functions prior to exceeding the concentration limits specified in 10CFR 20, Appendix B, Table II, Column 2 at the release point to the unrestricted area. To meet

1.1.1 Liquid Radwaste Effluent Line Monitors (Continued)

this specification, the alarm/trip setpoints for liquid effluent monitors and flow measurement devices are set to assure that the following equation is satisfied:

$$\frac{cf}{F+f} \leq C \times RF \qquad (1)$$

where:

C = the effluent concentration limit (Specification 3.11.1.1) implementing 10CFR 20 for the site, corresponding to the specific mix of isotopes in the effluent stream being considered for discharge, in μCi/ml.

RF = the recirculation factor, determined by system equilibrium calculations, used to assure that concentrations of effluents at the outfall do not exceed the effluent concentration limit, C. RF = 0.5. (Reference 6)

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 proportional to the volumetric flow of the effluent line and proportional 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 10CFR 20 in the unrestricted area.

f = the flow setpoint as determined 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 determined prior to the release point, in volume per unit time.

At the Virgil C. Summer Nuclear Station the Liquid Waste Processing System and the Nuclear Blowdown System both discharge to the penstocks of the Fairfield Pumped Storage Facility through a common line. The available dilution water flow (F_{dp}) is assumed to be 90 percent of the flow through the Fairfield Pumped Storage Station penstock(s) to which liquid effluent is being discharged and is dependent upon operational status of the Fairfield Pumped Storage Station. The waste tank flow rates (f_{dm}, f_{db} and f_{dc}) and the monitor setpoints (c_M, c_B and c_C) are set to meet the condition of equation (1) for a given effluent concentration, C. The three monitor setpoints are indicative of the monitor system configuration for this discharge pathway. The LWPS discharges through RM-L5, which has setpoint c_M for alarm/control functions over releases from either Waste Monitor Tanks 1 or 2. The Nuclear Blowdown discharges through RM-L7, which also has setpoint c_B for alarm/control functions over releases from the Nuclear Blowdown Tank. These two release pathways merge into a common line monitored by RM-L9, which has setpoint c_C for control functions over the common effluent line. The method by which this is accomplished is as follows:

1) The isotopic concentration for a waste tank to be released is obtained from the sum of the measured concentrations as determined by the analysis required in the Radiological Effluent Technical Specifications Table 4.11-1:

$$\sum_i C_i = \sum_g C_g + C_a + C_s + C_t \qquad (2)$$

where:

C_i = the concentration of nuclide i as determined by the analysis of the waste sample.

C_g = the sum of the concentrations C_g of each measured gamma emitting nuclide observed by gamma-ray spectroscopy of the waste sample.

C_a* = the measured concentrations C_a of alpha emitting nuclides observed by gross alpha analysis of the monthly composite sample.

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

C_t* = the measured concentration of H-3 in liquid waste as determined by analysis of the monthly composite.

The C_g term will be included in the analysis of each batch; terms for alpha, strontium, and tritium may be included as appropriate.

Isotopic concentrations for both the Waste Monitor Tanks and the Nuclear Blowdown Monitor Tank may be calculated using equation (2).

2) Once isotopic concentrations for either Waste Monitor Tank and/or the Nuclear Blowdown Monitor Tank have been determined, these values are used to calculate a Dilution Factor, DF, which is the ratio of dilution flow rate to tank flow rate(s) required to assure that the limiting concentration of 10CFR, Part 20, Appendix B, Table II, Column 2 are met at the point of discharge.

* Values for these concentrations will be based on previous composite sample analyses as required by Table 4.11-1 of the Radiological Effluent Technical Specifications.

$$DF = \left[\left[\sum_i \frac{C_i}{MPC_i} \right]_M + \left[\sum_i \frac{C_i}{MPC_i} \right]_B \right] \div \left[SF \times RF \right] \quad \text{or} \tag{3}$$

$$DF = \left[\left[\sum_g \frac{C_g}{MPC_g} + \frac{C_a}{MPC_a} + \frac{C_s}{MPC_s} + \frac{C_t}{MPC_t} \right]_M + \left[\sum_g \frac{C_g}{MPC_g} + \frac{C_a}{MPC_a} + \frac{C_s}{MPC_s} + \frac{C_t}{MPC_t} \right]_B \right]$$

$$\div \left[SF \times RF \right] \tag{4}$$

where:

$\left[\sum_i \frac{C_i}{MPC_i} \right]_M$ = the sum of the ratios of the measured concentration of nuclide i to its limiting value MPC; for the waste monitor tank being considered for release.

$\left[\sum_i \frac{C_i}{MPC_i} \right]_B$ = the sum of the ratios of the measured concentration of nuclide i to its limiting value MPC; for the Nuclear Blowdown Monitor Tank.

MPC_i = MPC_g, MPC_a, MPC_s, and MPC_t = limiting concentrations of the appropriate gamma emitting, alpha emitting, and strontium radionuclides, and tritium, respectively, from 10CFR, Part 20, Appendix B, Table II, Column 2.

SF = the safety factor; a conservative factor used to compensate for statistical fluctuations and errors of measurements.
= 0.5, corresponding to a 100 percent variation.

3) The maximum permissible discharge flow rate, f_t, may be calculated for the release of either the WMT or NBMT or for the release of both tanks simultaneously. First the appropriate Dilution Factor is calculated by applying equation (3). If only one tank is being considered for discharge, calculate DF using the appropriate concentration ratio term (i.e. M or B) with the other concentration ratio term set equal to zero. If both tanks are to be discharged simultaneously, calculate DF with both concentration ratio terms included in equation (3).

then

$$f_t = \frac{F_{dp} + f_{dm} + f_{db}}{DF} \simeq \frac{F_{dp}}{DF} \qquad \text{For } F_{dp} >> f_{dm}, f_{db} \tag{5}$$

where:

F_{dp} = dilution flow rate based on Fairfield Pumped Storage Station operational status. The minimum dilution flow alarm setpoint (as described later in Step (4)) is established at 90 percent of expected dilution flow, F_t. Therefore

$$F_{dp} = (0.9)\ F_t \tag{6}$$

where F_t = the flow rate through the Fairfield Pumped Storage Station penstock(s) to which radioactive liquids are being discharged.

f_{db} = flow rate of Nuclear Blowdown Monitor Tank discharge. (This value normally will be either zero, if no release is to be conducted from this system, or the maximum rated capacity of the discharge pump (250 gpm) if a release is to be conducted.)

f_{dm} = flow rate of Waste Monitor Tank discharge. (This value normally will either be zero, if no release is to be conducted from this system, or the maximum rated capacity of the discharge pump (100 gpm) if a release is to be conducted.)

F_{dp} = dilution flow rate from equation (6).

DF = the Dilution Factor from Step 2.

If $f_t > f_{dm} + f_{db}$, the release may be made as planned. Because F_{dp} is normally very large compared to the maximum discharge pump capacities for the Waste Monitor Tank and the Nuclear Blowdown Monitor Tank, it is extremely unlikely that $f_t < f_{dm} + f_{db}$. However, if a situation should arise such that $f_t < f_{dm} + f_{db}$, steps must be taken to assure that equation (1) is satisfied prior to making the release.

These steps may include decreasing $f_{dm} + f_{db}$ by limiting the release to one tank if both had been considered; by decreasing the flow rate of f_{dm} or f_{db} or both; or by increasing F_{dp}.

Note that if DF $\leq$ 1, the waste tank(s) concentration(s) for which the calculation is being performed includes safety factors in Step 2 and meet(s) the limits of 10CFR 20 without further dilution.

4) The dilution flow rate setpoint for minimum flow rate, F, is established at 90 percent of the expected dilution flow rate:

$$F = F_{dp} = (0.9)\ F_t \qquad (7)$$

Flow rate monitor setpoints for effluent streams may be set at the selected discharge pump rate (normally the maximum discharge pump rate or zero) for the case $f_t > f_{dm} + f_{db}$. For the case $f_t < f_{dm} + f_{db}$, the setpoint for the flow rate monitor under consideration must be determined from

$$f_t = \frac{F_{dp}}{DF} \qquad (8)$$

applied for the alternative selected from the possibilities discussed above.

5) The radiation monitor setpoint may now be determined based on the values of $\sum_i C_i$, F and f which were specified to provide compliance with the limits of 10CFR 20, Appendix B, Table II, Column 2. The monitor response is primarily to gamma radiation, therefore, the actual setpoint is based on $\sum_g C_g$. The monitor setpoint in cpm which corresponds to the particular setpoint concentration, c, is taken from the monitor calibration graph. (Example of monitor calibration graph is shown in Figure 1.0-1.)

The setpoint concentration, c, is determined as follows:

$$c = \sum_g C_g \left[\frac{\mu Ci}{ml}\right] \times A \qquad (9)$$

A = Adjustment factor which will allow the setpoint to be established in a practical manner for convenience and to prevent spurious alarms.

$$= \frac{f_t}{f_{dm} + f_{db}} \qquad (10)$$

If $A \geq 1$, Calculate c and determine the maximum value for the actual monitor setpoint (cpm) from the monitor calibration graph.

If $A < 1$, No release may be made. Re-evaluate the alternatives presented in Steps 3 and 4.

NOTE: If calculated setpoint values are near actual concentrations planned for release, it may be impractical to set the monitor alarm at this value. In this case a new setpoint may be calculated following the methodology presented in Steps 3 and 4 for the case $f_t < f_{dm} + f_{db}$.

Within the limits of the conditions stated above, the specific monitor setpoints for the three liquid radiation monitors RM-L5, RM-L7, and RM-L9 are determined as follows:

RM-L5, Waste Monitor Tank Discharge Line Monitor:

$$C_M = \left[\sum_g C_g\right]_M \times A \qquad (11)$$

NOTE: If no discharge is planned for this pathway, the monitor setpoint should be established as close to background as practical to prevent spurious alarms and yet alarm should an inadvertent release occur.

RM-L7, Nuclear Blowdown Monitor Tank Discharge Line Monitor:

$$C_B = \left[\sum_g C_g\right]_B \times A \qquad (12)$$

NOTE: If no discharge is planned for this pathway, the monitor setpoint should be established as close to background as practical to prevent spurious alarms and yet alarm should an inadvertent release occur.

RM-L9, Combined Liquid Waste Processing System and Nuclear Blowdown Waste Effluent Discharge Line Monitor

If a discharge is made from only one system, the monitor setpoint on the common line, c_c, should be the same as the setpoint for the monitor on the individual discharge line (i.e., c_M, or c_B as determined above). If simultaneous discharges are made, c_c is determined as follows:

$$c_c = \left[\frac{f_{dm}\left[\sum_g C_g\right]_M + f_{db}\left[\sum_g C_g\right]_B}{f_{dm} + f_{db}}\right] \times A \qquad (13)$$

NOTE: In all cases, c_M, c_B, and c_c are the setpoint values in μCi/ml. The actual monitor setpoints (cpm) for RM-L5, RM-L7, and RM-L9 are determined from the calibration graph for the particular monitor.

1.1.2 Detergent Waste Discharge Via Sanitary Waste System (RM-L5)

In the Virgil C. Summer Nuclear Station liquid waste effluent system design, there exists a mechanism for discharging detergent wastes via the sanitary waste system. The sample point prior to discha is normally Waste Monitor Tank No. 2. The analysis requirements are the requirements listed in the Radiological Effluent Technical Specifications, Table 4.11-1.

This effluent pathway shall only be used when the following condition is met:

$$\left[\sum_i C_i\right]_D \leq \left[\sum_i C_i\right]_{LLD} \qquad (14)$$

where:

$\left[\sum_i C_i\right]_D$ = the isotopic concentration of the detergent waste contained within the Waste Monitor Tank serving as the holding facility for sampling and analysis prior to discharge.

$\left[\sum_i C_i\right]_{LLD}$ = the Lower Limit of Detection, (LLD), for the isotopic concentrations of the Waste Monitor Tank as determined by the analysis required in the Radiological Effluent Technical Specifications, Table 4.11-1.

When the conditions of equation (14) are met, the detergent waste may be released via the Sanitary Waste System pathway. There is no requirement to perform the Steps 2, 3, 4, or 5 of Section 1.1.1 if the conditions of equation (14) are met.

1.1.3 Steam Generator Blowdown and Turbine Building Sump Effluent Lines (RM-L3, RM-L10, RM-L8)

Concentrations of radionuclides in the liquid effluent discharges made via the Turbine Building Sump and Steam Generator Blowdown are expected to be very low or nondetectable. These releases are expected to be continuous in nature and thus will be sampled in an appropriate manner as specified in Table 4.11-1 of the RETS. The Steam Generator Blowdown Monitors and the Turbine Building Sump Monitor provide alarm and automatic termination of release prior to exceeding the concentration limits specified in 10CFR 20, Appendix B, Table II, Column 2 at the release point to the unrestricted area. Both of these effluent pathways utilize the circulating water as dilution to the effluent stream with the circulating water discharge canal being the point of release into an unrestricted area.

Equation (1) is again used to assure that effluents are in compliance with the aforementioned specification:

$$\frac{cf}{F+f} \leq C \times RF$$

where c, f, F, C, and RF are the same generic terms discussed in Section 1.1.1.

The common usage of the Circulating Water System for dilution of both the Steam Generator Blowdown and the Turbine Building Sump effluents is similar to the release mechanism utilized by the higher activity effluents in Section 1.1.1. The basic difference is that the two pathways do not merge into a single discharge line. Therefore, only individual pathways are monitored.

The available dilution water flow (F_{dc}) is dependent upon the mode of operation of the Circulating Water System. Any change in this value will be accounted for in a recalculation of equation (1). The Steam Generator Blowdown flow rate (f_{ds}), the Turbine Building Sump flow rate (f_{dt}), and the monitor setpoints (c_{Sa}, c_{Sb}, and c_T) are also set to meet the condition of equation (1). The three monitor setpoints correspond to the methodology of the two release pathways. RM-L8, the Turbine Building Sump monitor alarms and terminates release upon exceeding the monitor setpoint (c_T). RM-L3, the first monitor in the Steam Generator Blowdown discharge pathway, alarms and terminates release of the stream. The discharge is then manually diverted to the Nuclear Blowdown Processing System. RM-L10, the last monitor in the Steam Generator Blowdown discharge pathway, alarms and terminates the release. Thus, RM-L10 is basically redundant to RM-L3 and the setpoint (c_{Sb}) will be determined in the same manner as RM-L3 (c_{Sa}). The method by which the monitor setpoints are determined is as follows:

1) The isotopic concentrations for either release source to be or being released are obtained from the sum of the measured concentrations as determined in the Radiological Effluent Technical Specifications Table 4.11-1. Equation (2) is again employed for this calculation:

$$\sum_i C_i = \sum_g C_g + C_a + C_s + C_t$$

where:

$\sum_i C_i$ = the sum of the measured concentrations as determined by the analysis of the waste sample.

$\sum_g C_g$ = the sum of the concentrations C_g of each measured gamma emitting nuclide observed by gamma-ray spectroscopy of the waste sample.

C_a = the measured concentrations C_a of alpha emitting nuclides observed by gross alpha analysis of the monthly composite sample.

C_s = the measured concentrations of Sr-89 ad Sr-90 in liquid waste as determined by analysis of the quarterly composite sample.

C_t = the measured concentration of H-3 in liquid waste as determined by analysis of the monthly composite sample.

Isotopic concentrations for both the Steam Generator Blowdown System effluent and the Turbine Building Sump effluent may be calculated using equation (2).

2) Once isotopic concentrations for either the Steam Generator Blowdown or the Turbine Building Sump have been determined, these values are used to calculate a Dilution Factor, DF, which is the ratio of the total dilution flow rate to effluent stream flow rate(s) required to assure that the limiting concentration of 10CFR, Part 20, Appendix B, Table II, Column 2 are met at the point of discharge.

$$DF = \left[\left[\sum_i \frac{C_i}{MPC_i} \right]_S + \left[\sum_i \frac{C_i}{MPC_i} \right]_T \right] \div \left[SF \times RF \right] \quad \text{or} \qquad (15)$$

$$DF = \left[\left[\sum_g \frac{C_g}{MPC_g} + \frac{C_a}{MPC_a} + \frac{C_s}{MPC_s} + \frac{C_t}{MPC_t} \right]_S + \left[\sum_g \frac{C_g}{MPC_g} + \frac{C_a}{MPC_a} + \frac{C_s}{MPC_s} + \frac{C_t}{MPC_t} \right]_T \right]$$

$$\div \left[SF \times RF \right] \qquad (16)$$

where:

C_i = C_g, C_a C_s, and C_t; measured concentrations as defined in Step 1. Terms C_a, C_s, and C_t will be included in the calculation as appropriate.

$\left[\sum_i \frac{C_i}{MPC_i}\right]_S$ = the sum of the ratios of the measured concentration of nuclide i to its limiting value MPC_i for the Steam Generator Blowdown effluent.

$\left[\sum_i \frac{C_i}{MPC_i}\right]_T$ = the sum of the ratios of the measured concentration of nuclide i to its limiting value MPC_i for the Turbine Building Sump effluent.

MPC_i = MPC_g, MPC_a, MPC_s, and MPC_t are limiting concentrations of the appropriate radionuclide from 10CFR, Part 20, Appendix B, Table II, Column 2 limits.

SF = the same generic term as used in Section 1.1.1, Step 2.

3) The maximum permissible effluent discharge flow rate, f_d, may be calculated for a release from either the Turbine Building Sump or the Steam Generator Blowdown or releases via both pathways simultaneously. First the appropriate Dilution Factor is calculated by applying equation (~~3~~ 15). For discharges via only one pathway, calculate DF using the appropriate concentration ratio term (i.e. T or S) with the other concentration ratio term set equal to zero. For simultaneous discharges, calculate DF with both concentration ratio terms included in equation (~~3~~ 15).

$$f_d = \frac{F_{dc} + f_{dt} + f_{ds}}{DF} \simeq \frac{F_{dc}}{DF} \quad \text{for} \quad F_{dc} >> f_{ds}, f_{dt} \tag{17}$$

where:

F_{dc} = Dilution flow rate based on 90 percent of the expected flow rate of the Circulating Water System during the time of release:
= (0.9) F_d

f_{ds} = Flow rate of the Steam Generator Blowdown discharge. (This value normally will either be zero, if no release is conducted concurrently, or the maximum rated capacity of the discharge pump, if a release is conducted concurrently.)

f_{dt} = Flow rate of the Turbine Building Sump discharge. (This value normally will be either zero, if no release is being conducted concurrently, or the maximum rated capacity of the discharge pump, if a release is being conducted concurrently.)

DF = the Dilution Factor from Step 2.

Note that the equation is valid only for DF > 1; for DF $\leq$ 1, the effluent concentration meets the limits of 10CFR 20 without dilution as well as being in compliance with the conservatism imposed by the Safety Factor in Step 2.

If $f_d > f_{ds} + f_{dt}$, releases may be made as planned. Because F_{dc} is normally very large compared to the maximum discharge pump capacities for the Turbine Building Sump and the Steam Generator Blowdown System, it is extremely unlikely that $f_d < f_{ds} + f_{dt}$. However, if a situation should arise such that $f_d < f_{ds} + f_{dt}$, steps must be taken to assure that equation (1) is satisfied prior to making the release. These steps may include diverting Nuclear Blowdown to the Nuclear Blowdown Processing System, diverting the Turbine Building Sump output to the Excess Waste Holdup Tank or both.

4) The dilution flow rate setpoint for minimum flow rate, F, is established at 90 percent of the expected dilution flow rate:

$$F = F_{dc} = (0.9)\ (F_d) \tag{18}$$

Flow rate monitor setpoints for effluent streams may be set at the selected discharge pump rate (normally the maximum discharge pump rate or zero) for the case $f_d > f_{ds} + f_{dt}$. For the case $f_d < f_{ds} + f_{dt}$, the setpoint for the flow rate monitor under consideration must be determined from:

$$f_d = \frac{F_{dc}}{DF} \qquad (19)$$

applied for the alternative selected to satisfy equation (1).

5) The monitor setpoint may now be specified based on the values of $\sum_i C_i$, F, and f which were specified to provide compliance with the limits of 10CFR 20, Appendix B, Table II, Column 2. The monitor response is primarily to gamma radiation, therefore, the actual setpoint is based on $\sum_g C_g$. The monitor setpoint in cpm which corresponds to the calculated value c is taken from the monitor calibration graph.

where:

$$c = \sum_g C_g \left[\frac{\mu Ci}{ml}\right] \times B \qquad (20)$$

B = Adjustment factor which will allow the setpoint to be established in a practical manner for convenience and to prevent spurious alarms.

$$= \frac{f_d}{f_{ds} + f_{dt}} \qquad (21)$$

If $B \geq 1$ Calculate c and determine the maximum value for the actual monitor setpoint (cpm) from the monitor calibration graph.

If $B < 1$ No release may be made. Re-evaluate the alternatives presented in steps 3 and 4.

NOTE: If calculated setpoint values are near actual concentrations being released or planned for release, it may be impractical to set the monitor alarm at this value. In this case a new setpoint may be calculated following the methodology presented in steps 3 and 4 for the case $f_d < f_{ds} + f_{dt}$.

Within the limits of the conditions stated above, the specific monitor setpoints for the three liquid radiation monitors RM-L3, RM-L10, and RM-L8 are determined as follows:

For RM-L3, Steam Generator Blowdown Discharge initial monitor, and for RM-L10, Steam Generator Blowdown Discharge final monitor:

$$c_{Sa} \text{ or } c_{Sb} = \left[\sum_g C_g \right]_S \times B \qquad (22)$$

Where

$\left[\sum_g C_g \right]_S$ = the isotopic concentration of the Steam Generator Blowdown effluent as obtained from the sum of the measured concentrations determined by the analysis required in the Radiological Effluents Technical Specifications Table 4.11-1.

NOTE: If no discharge is planned for this pathway, the monitor setpoint should be established as close to background as practical to prevent spurious alarms and yet alarm should an inadvertent release occur.

For RM-L8, Turbine Building Sump Discharge Monitor:

$$c_T = \left[\sum_g C_g\right]_T \times B$$

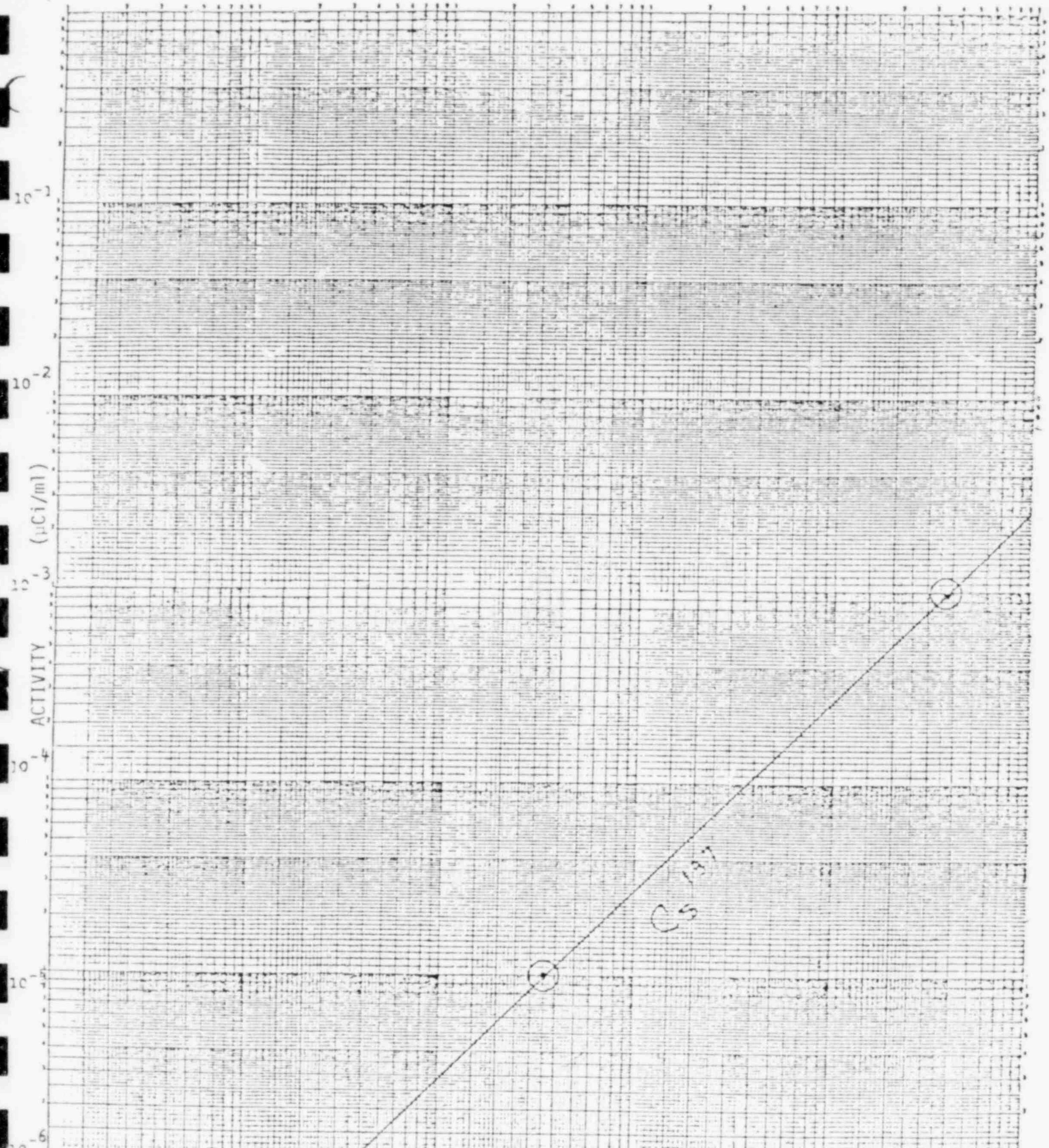
Where

$\left[\sum_g C_g\right]_T$ = The gamma isotopic concentration of the Turbine Building Sump effluent as obtained from the sum of the measured concentrations determined by the analysis required in the Radiological Effluents Technical Specifications Table 4.11-1.

NOTE: If no discharge is planned for this pathway, the monitor setpoint should be established as close to background as practical to prevent spurious alarms and yet alarm should an inadvertent release occur.

Figure 1.0-1

Example Calibration Curve for Liquid Effluent Monitor



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1.2 Dose Calculation For Liquid Effluents

The dose contribution from all radionuclides identified in liquid effluents released to unrestricted areas is calculated using the following expression:

$$D_\tau = \sum_i \left[A_{i\tau} \sum_{\ell=1}^{m} \Delta t_\ell \, C_{i\ell} \, F_\ell \right] \qquad (24)$$

Where:

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

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

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

$A_{i\tau}$ = 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 1.2-3 in mrem-ml per hr-μCi.

$$A_{i\tau} = K_o \left((U_w/D_w) + U_F \, BF_i \right) DF_i \qquad (25)$$

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

$$= \frac{\text{(average undiluted liquid waste flow)}}{\text{(average flow from the discharge structure)} \times (Z)}$$

where:

$Z = 1$ = applicable factor when no additional dilution is to be considered. (Reference 1; Section 4.3)

K_o = units conversion factor 1.14×10^5

= $((10^6 \frac{pCi}{uCi}) \times (10^3 \frac{ml}{Kg}) \div (8760 \frac{hr}{yr}))$

U_F = 21 kg/yr, fish consumption (adult). (Reference 3)

BF_i = Bioaccumulation Factor for nuclide, i, in fish, pCi/Kg per pCi/l, from Table 1.2-1, (taken from reference 3, Table A-1).

DF_i = Dose conversion factor for nuclide, i, for adults in preselected organ, , in mrem/pCi, from Table 1.2-2 (taken from reference 3, Table E-11).

U_w = 730 kg/yr, water consumption (adult). (Reference 3)

D_w = Dilution Factor from the near field area within one-quarter mile of the release points to the potable water intake for adult water consumption; for V. C. Summer, D_w = 1. (Reference 1)

TABLE 1.2-1

BIOACCUMULATION FACTORS

(pCi/kg per pCi/liter)*

ELEMENT	FRESHWATER FISH
H	9.0E 01
C	4.6E 03
NA	1.0E 02
P	1.0E 05
CR	2.0E 02
MN	4.0E 02
FE	1.0E 02
CO	5.0E 01
NI	1.0E 02
CU	5.0E 01
ZN	2.0E 03
BR	4.2E 02
RB	2.0E 03
SR	3.0E 01
Y	2.5E 01
ZR	3.3E 00
NB	3.0E 04
MO	1.0E 01
TC	1.5E 01
RU	1.0E 01
RH	1.0E 01
TE	4.0E 02
I	1.5E 01
CS	2.0E 03
BA	4.0E 00
LA	2.5E 01
CE	1.0E 00
PR	2.5E 01
ND	2.5E 01
W	1.2E 03
NP	1.0E 01

*Values in Table 1.2-1 are taken from Reference 3, Table A-1.

TABLE 1.2-2

Page 1 of 2

ADULT INGESTION DOSE FACTORS*

(mrem/pCi ingested)

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
H 3	NO DATA	1.05E-07	1.05E-07	1.05E-07	1.05E-07	1.05E-07	1.05E-07
C 14	2.84E-06	5.68E-07	5.68E-07	5.68E-07	5.68E-07	5.68E-07	5.68E-07
NA 24	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06	1.70E-06
P 32	1.93E-04	1.20E-05	7.46E-06	NO DATA	NO DATA	NO DATA	2.17E-05
CR 51	NO DATA	NO DATA	2.66E-09	[illegible].59E-09	5.86E-10	3.53E-09	6.69E-07
MN 54	NO DATA	4.57E-06	8.72E-07	NO DATA	1.36E-06	NO DATA	1.[illegible]0E-05
MN 56	NO DATA	1.15E-07	2.04E-08	NO DATA	1.46E-07	NO DATA	3.67E-06
FE 55	2.75E-06	1.90E-06	4.43E-07	NO DATA	NO DATA	1.06E-06	1.09E-06
FE 59	4.34E-06	1.02E-05	3.91E-06	NO DATA	NO DATA	2.85E-06	3.40E-05
CO 58	NO DATA	7.45E-07	1.67E-06	NO DATA	NO DATA	NO DATA	1.51E-05
CO 60	NO DATA	2.14E-06	4.72E-06	NO DATA	NO DATA	NO DATA	4.02E-05
NI 63	1.30E-04	9.01E-06	4.36E-06	NO DATA	NO DATA	NO DATA	1.88E-06
NI 65	5.28E-07	6.86E-08	3.13E-08	NO DATA	NO DATA	NO DATA	1.74E-06
CU 64	NO DATA	8.33E-08	3.91E-08	NO DATA	2.10E-07	NO DATA	7.10E-06
ZN 65	4.84E-06	1.54E-05	6.96E-06	NO DATA	1.03E-05	NO DATA	9.70E-06
ZN 69	1.03E-08	1.97E-08	1.37E-09	NO DATA	1.28E-08	NO DATA	2.96E-09
BR 83	NO DATA	NO DATA	4.02E-08	NO DATA	NO DATA	NO DATA	5.79E-08
BR 84	NO DATA	NO DATA	5.21E-08	NO DATA	NO DATA	NO DATA	4.09E-13
BR 85	NO DATA	NO DATA	2.14E-09	NO DATA	NO DATA	NO DATA	LT E-24
RB 86	NO DATA	2.11E-05	9.83E-06	NO DATA	NO DATA	NO DATA	4.16E-06
RB 88	NO DATA	6.05E-08	3.21E-08	NO DATA	NO DATA	NO DATA	8.36E-19
RB 89	NO DATA	4.01E-08	2.82E-08	NO DATA	NO DATA	NO DATA	2.33E-21
SR 89	3.08E-04	NO DATA	8.84E-06	NO DATA	NO DATA	NO DATA	4.94E-05
SR 90	7.58E-03	NO DATA	1.86E-03	NO DATA	NO DATA	NO DATA	2.19E-04
SR 91	5.67E-06	NO DATA	2.29E-07	NO DATA	NO DATA	NO DATA	2.70E-05
SR 92	2.15E-06	NO DATA	9.30E-08	NO DATA	NO DATA	NO DATA	4.26E-05
Y 90	9.62E-09	NO DATA	2.58E-10	NO DATA	NO DATA	NO DATA	1.02E-04
Y 91M	9.09E-11	NO DATA	3.52E-12	NO DATA	NO DATA	NO DATA	2.67E-10
Y 91	1.41E-07	NO DATA	3.77E-09	NO DATA	NO DATA	NO DATA	7.76E-05
Y 92	8.45E-10	NO DATA	2.47E-11	NO DATA	NO DATA	NO DATA	1.48E-05
Y 93	2.68E-09	NO DATA	7.40E-11	NO DATA	NO DATA	NO DATA	8.50E-05
ZR 95	3.04E-08	9.75E-09	6.60E-09	NO DATA	1.53E-08	NO DATA	3.09E-05
ZR 97	1.68E-09	3.39E-10	1.55E-10	NO DATA	5.12E-10	NO DATA	1.05E-04
NB 95	6.22E-09	3.46E-09	1.86E-09	NO DATA	3.42E-09	NO DATA	2.10E-05
MO 99	NO DATA	4.31E-06	8.20E-07	NO DATA	9.76E-06	NO DATA	9.99E-06
TC 99M	2.47E-10	6.98E-10	8.89E-09	NO DATA	1.06E-08	3.42E-10	4.13E-07
TC101	2.54E-10	3.66E-10	3.59E-09	NO DATA	6.59E-09	1.87E-10	1.10E-21
RU103	1.85E-07	NO DATA	7.97E-08	NO DATA	7.06E-07	NO DATA	2.16E-05
RU105	1.54E-08	NO DATA	6.08E-09	NO DATA	1.99E-07	NO DATA	9.42E-06

*Values in Table 1.2-2 are taken from Reference 3, Table E-11.

TABLE 1.2-2

ADULT INGESTION DOSE FACTORS

(mrem/pCi ingested)

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
RU106	2.75E-06	NO DATA	3.48E-07	NO DATA	5.31E-06	NO DATA	1.78E-04
AG110M	1.60E-07	1.48E-07	8.79E-08	NO DATA	2.91E-07	NO DATA	6.04E-05
TE125M	2.68E-06	9.71E-07	3.59E-07	8.06E-07	1.09E-05	NO DATA	1.07E-05
TE127M	6.77E-06	2.42E-06	8.25E-07	1.73E-06	2.75E-05	NO DATA	2.27E-05
TE127	1.10E-07	3.95E-08	2.38E-08	8.15E-08	4.48E-07	NO DATA	8.68E-06
TE129M	1.15E-05	4.29E-06	1.82E-06	3.95E-06	4.80E-05	NO DATA	5.79E-05
TE129	3.14E-08	1.18E-08	7.65E-09	2.41E-08	1.32E-07	NO DATA	2.37E-08
TE131M	1.73E-06	8.46E-07	7.05E-07	1.34E-06	8.57E-06	NO DATA	8.40E-05
TE131	1.97E-08	8.23E-09	6.22E-09	1.62E-08	8.63E-08	NO DATA	2.79E-09
TE132	2.52E-06	1.63E-06	1.53E-06	1.80E-06	1.57E-05	NO DATA	7.71E-05
I 130	7.56E-07	2.23E-06	8.80E-07	1.89E-04	3.48E-06	NO DATA	1.92E-06
I 131	4.16E-06	5.95E-06	3.41E-06	1.95E-03	1.02E-05	NO DATA	1.57E-06
I 132	2.03E-07	5.43E-07	1.90E-07	1.90E-05	8.65E-07	NO DATA	1.02E-07
I 133	1.42E-06	2.47E-06	7.53E-07	3.63E-04	4.31E-06	NO DATA	2.22E-06
I 134	1.06E-07	2.88E-07	1.03E-07	4.99E-06	4.58E-07	NO DATA	2.51E-10
I 135	4.43E-07	1.16E-06	4.28E-07	7.65E-05	1.86E-06	NO DATA	1.31E-06
CS134	6.22E-05	1.48E-04	1.21E-04	NO DATA	4.79E-05	1.59E-05	2.59E-06
CS136	6.51E-06	2.57E-05	1.85E-05	NO DATA	1.43E-05	1.96E-06	2.92E-06
CS137	7.97E-05	1.09E-04	7.14E-05	NO DATA	3.70E-05	1.23E-05	2.11E-06
CS138	5.52E-08	1.09E-07	5.40E-08	NO DATA	8.01E-08	7.91E-09	4.65E-13
BA139	9.70E-08	6.91E-11	2.84E-09	NO DATA	6.46E-11	3.92E-11	1.72E-07
BA140	2.03E-05	2.55E-08	1.33E-06	NO DATA	8.67E-09	1.46E-08	4.18E-05
BA141	4.71E-08	3.56E-11	1.59E-09	NO DATA	3.31E-11	2.02E-11	2.22E-17
BA142	2.13E-08	2.19E-11	1.34E-09	NO DATA	1.85E-11	1.24E-11	3.00E-26
LA140	2.50E-09	1.26E-09	3.33E-10	NO DATA	NO DATA	NO DATA	9.25E-05
LA142	1.28E-10	5.82E-11	1.45E-11	NO DATA	NO DATA	NO DATA	4.25E-07
CE141	9.36E-09	6.33E-09	7.18E-10	NO DATA	2.94E-09	NO DATA	2.42E-05
CE143	1.65E-09	1.22E-06	1.35E-10	NO DATA	5.37E-10	NO DATA	4.56E-05
CE144	4.88E-07	2.04E-07	2.62E-08	NO DATA	1.21E-07	NO DATA	1.65E-04
PR143	9.20E-09	3.69E-09	4.56E-10	NO DATA	2.13E-09	NO DATA	4.03E-05
PR144	3.01E-11	1.25E-11	1.53E-12	NO DATA	7.05E-12	NO DATA	4.33E-18
ND147	6.29E-09	7.27E-09	4.35E-10	NO DATA	4.25E-09	NO DATA	3.49E-05
W 187	1.03E-07	8.61E-08	3.01E-08	NO DATA	NO DATA	NO DATA	2.82E-05
NP239	1.19E-09	1.17E-10	6.45E-11	NO DATA	3.65E-10	NO DATA	2.40E-05

TABLE 1.2-3

SITE RELATED INGESTION DOSE COMMITMENT FACTOR,*

$A_{i\tau}$, in mrem/hr per μCi/ml.

NUCLIDE	BONE	LIVER	T.BODY	THYROID	KIDNEY	LUNG	GI-LLI
H-3	0.00E+00	8.96E+00	8.96E+00	8.96E+00	8.96E+00	8.96E+00	8.96E+00
C-14	3.15E+04	6.30E+03	6.30E+03	6.30E+03	6.30E+03	6.30E+03	6.30E+03
Na-24	5.48E+02	5.48E+02	5.48E+02	5.48E+02	5.48E+02	5.48E+02	5.48E+02
P-32	4.62E+07	2.87E+06	1.79E+06	0.00E+00	0.00E+00	0.00E+00	5.20E+06
Cr-51	0.00E+00	0.00E+00	1.49E+00	8.94E-01	3.29E-0[illegible]	1.98E+00	3.76E+02
Mn-54	0.00E+00	4.76E+03	9.08E+02	0.00E+00	1.42E+03	0.00E+00	1.46E+04
Mn-56	0.00E+00	1.20E+02	2.[illegible]2E+01	0.00E+00	1.52E+02	0.00E+00	3.82E+03
Fe-55	8.87E+02	6.13E+02	1.43E+02	0.00E+00	0.00E+00	3.42E+02	3.52E+02
Fe-59	1.40E+03	3.29E+03	1.26E+03	0.00E+00	0.00E+00	9.19E+02	1.10E+04
Co-58	0.00E+00	1.51E+02	3.39E+02	0.00E+00	0.00E+00	0.00E+00	3.06E+03
Co-60	0.00E+00	4.34E+02	9.58E+02	0.00E+00	0.00E+00	0.00E+00	8.16E+03
Ni-63	4.19E+04	2.91E+03	1.41E+03	0.00E+00	0.00E+00	0.00E+00	6.07E+02
Ni-65	1.70E+02	2.21E+01	1.01E+01	0.00E+00	0.00E+00	0.00E+00	5.61E+02
Cu-64	0.00E+00	1.69E+01	7.93E+00	0.00E+00	4.26E+01	0.00E+00	1.44E+03
Zn-65	2.36E+04	7.50E+04	3.39E+04	0.00E+00	5.02E+04	0.00E+00	4.73E+04
Zn-69	5.02E+01	9.60E+01	6.67E+00	0.00E+00	6.24E+01	0.00E+00	1.44E+01
Br-83	0.00E+00	0.00E+00	4.57E+01	0.00E+00	0.00E+00	0.00E+00	6.30E+01
Br-84	0.00E+00	0.00E+00	5.67E+01	0.00E+00	0.00E+00	0.00E+00	4.45E-04
Br-85	0.00E+00	0.00E+00	2.33E+00	0.00E+00	0.00E+00	0.00E+00	1.09E-15
Rb-86	0.00E+00	1.03E+05	4.79E+04	0.00E+00	0.00E+00	0.00E+00	2.03E+04
Rb-88	0.00E+00	2.95E+02	1.56E+02	0.00E+00	0.00E+00	0.00E+00	4.07E-09
Rb-89	0.00E+00	1.95E+02	1.37E+02	0.00E+00	0.00E+00	0.00E+00	1.13E-11
Sr-89	4.78E+04	0.00E+00	1.37E+03	0.00E+00	0.00E+00	0.00E+00	7.66E+03
Sr-90	1.18E+06	0.00E+00	2.88E+05	0.00E+00	0.00E+00	0.00E+00	3.40E+04
Sr-91	8.79E+02	0.00E+00	3.55E+01	0.00E+00	0.00E+00	0.00E+00	4.19E+03
Sr-92	3.33E+02	0.00E+00	1.44E+01	0.00E+00	0.00E+00	0.00E+00	6.60E+03
Y-90	1.38E+00	0.00E+00	3.69E-02	0.00E+00	0.00E+00	0.00E+00	1.46E+04
Y-91m	1.30E-02	0.00E+00	5.04E-04	0.00E+00	0.00E+00	0.00E+00	3.82E-02
Y-91	2.02E+01	0.00E+00	5.39E-01	0.00E+00	0.00E+00	0.00E+00	1.11E+04
Y-92	1.21E-01	0.00E+00	3.53E-03	0.00E+00	0.00E+00	0.00E+00	2.12E+03
Y-93	3.83E-01	0.00E+00	1.06E-02	0.00E+00	0.00E+00	0.00E+00	1.22E+04
Zr-95	2.77E+00	8.88E-01	6.01E-01	0.00E+00	1.39E+00	0.00E+00	2.[illegible]2E+03
Zr-97	1.53E-01	3.09E-02	1.41E-02	0.00E+00	4.67E-02	0.00E+00	9.57E+03
Nb-95	4.47E+02	2.49E+02	1.34E+02	0.00E+00	2.46E+02	0.00E+00	1.51E+06
Mo-99	0.00E+00	4.62E+02	8.79E+01	0.00E+00	1.05E+03	0.00E+00	1.07E+03
Tc-99m	2.94E-02	8.32E-02	1.06E+00	0.00E+00	1.26E+00	4.07E-02	4.92E+01
Tc-101	3.03E-02	4.36E-02	4.28E-01	0.00E+00	7.85E-01	2.23E-02	1.31E-13
Ru-103	1.98E+01	0.00E+00	8.54E+00	0.00E+00	7.57E+01	0.00E+00	2.31E+03
Ru-105	1.65E+00	0.00E+00	6.52E-01	0.00E+00	2.13E+01	0.00E+00	1.01E+03
Ru-106	2.95E+02	0.00E+00	3.73E+01	0.00E+00	5.69E+02	0.00E+00	1.91E+04
Ag-110m	8.82E+00	1.23E+01	7.32E+00	0.00E+00	2.42E+01	0.00E+00	5.03E+03
Te-125m	2.79E+03	1.01E+03	3.74E+02	8.39E+02	1.13E+04	0.00E+00	1.11E+04
Te-127m	7.05E+03	2.52E+03	8.59E+02	1.80E+03	2.86E+04	0.00E+00	2.36E+04
Te-127	1.14E+02	4.11E+0[illegible]	2.48E+01	8.48E+01	4.66E+02	0.00E+00	9.03E+03
Te-129m	1.20E+04	4.47E+03	1.89E+03	4.11E+03	5.00E+04	0.00E+00	6.03E+04
Te-129	3.27E+01	1.23E+01	7.96E+00	2.51E+01	1.37E+02	0.00E+00	2.[illegible]7E+01
Te-131m	1.80E+03	8.81E+02	7.34E+02	1.39E+03	8.92E+03	0.00E+00	8.74E+04
Te-131	2.05E+01	8.57E+00	6.47E+00	1.69E+01	8.98E+01	0.00E+00	2.90E+00
Te-132	2.62E+03	1.70E+03	1.59E+03	1.87E+03	1.63E+04	0.00E+00	8.02E+04
I-130	9.01E+01	2.66E+02	1.05E+02	2.2[illegible]E+04	4.15E+02	0.00E+00	2.29E+02
I-131	4.96E+02	7.09E+02	4.06E+02	2.32E+05	1.22E+03	0.00E+00	1.87E+02
I-132	2.42E+01	6.47E+01	2.26E+01	2.26E+03	1.[illegible]3E+02	0.00E+00	1.22E+01
I-133	1.69E+02	2.94E+02	8.[illegible]7E+01	4.32E+04	5.13E+02	0.00E+00	2.64E+02
I-134	1.26E+01	3.43E+01	1.23E+01	5.94E+02	5.46E+01	0.00E+00	2.99E-02
I-135	5.28E+01	1.38E+02	5.10E+01	9.11E+03	2.22E+02	0.00E+00	1.56E+02
Cs-134	3.03E+05	7.21E+05	5.89E+05	0.00E+00	2.33E+05	7.75E+04	1.26E+04
Cs-136	3.1[illegible]E+04	1.25E+05	9.0[illegible]E+04	0.00E+00	6.97E+04	9.55E+03	1.42E+04
Cs-137	3.6[illegible]E+05	5.31E+05	3.48E+05	0.00E+00	1.80E+05	5.99E+04	1.03E+04
Cs-138	2.6[illegible]E+02	5.31E+02	2.63E+02	0.00E+00	3.90E+02	3.85E+01	2.27E-03
Ba-139	9.00E+00	6.41E-03	2.6[illegible]E-01	0.00E+00	5.99E-03	3.64E-03	1.60E+01
Ba-140	1.88E+03	2.37E+00	1.23E+02	0.00E+00	8.05E-01	1.35E+00	3.88E+03
Ba-141	4.37E+00	3.30E-03	1.48E-01	0.00E+00	3.37E-03	1.87E-03	2.06E-09
Ba-142	1.98E+00	2.03E-03	1.[illegible]4E-01	0.00E+00	1.72E-03	1.15E-03	2.78E-18
La-140	3.58E-01	1.80E-01	4.76E-02	0.00E+00	0.00E+00	0.00E+00	1.32E+04
La-142	1.83E-02	8.33E-03	2.07E-03	0.00E+00	0.00E+00	0.00E+00	6.08E+01
Ce-141	8.01E-01	5.42E-01	6.15E-02	0.00E+00	2.52E-01	0.00E+00	2.07E+03
Ce-143	1.41E-01	1.04E+02	1.16E-02	0.0[illegible]E+00	4.60E-02	0.00E+00	3.90E+03
Ce-144	4.18E+01	1.75E+01	2.24E+00	0.0[illegible]E+00	1.04E+01	0.00E+00	1.41E+04
Pr-143	1.32E+00	5.28E-01	6.52E-02	0.00E+00	3.05E-01	0.00E+00	5.77E+03
Pr-144	4.31E-03	1.79E-03	2.19E-04	0.00E+00	1.01E-03	0.00E+00	6.19E-10
Nd-147	9.00E-01	1.04E+00	6.22E-02	0.00E+00	[illegible].08E-01	0.00E+00	4.99E+03
W-187	3.04E+02	2.55E+02	8.90E+01	0.00E+00	[illegible].00E+00	0.00E+00	8.34E+04
Np-239	1.29E-01	1.25E-02	6.91E-03	0.00E+00	3.91E-02	0.00E+00	2.57E+03

*Calculated using equation (25).

1.3 Definitions of Liquid Effluent Parameters

Term		Definition	Section of Initial Use
$A_{i\tau}$	=	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 1.2-3 in mrem-ml per hr-μCi.	1.2
B_{Fi}	=	Bioaccumulation Factor for nuclide i, in fish, pCi/Kg per pCi/l, from Table 1.2-1.	1.2
C	=	the effluent concentration limit (Specification 3.11.1.1) implementing 10CFR 20 for the site, in μCi/ml.	1.1.1
C_a	=	the effluent concentration of alpha emitting nuclides observed by gross alpha analysis of the monthly composite sample.	1.1.1
C_g	=	the effluent concentration of a gamma emitting nuclide, g, observed by gamma-ray spectroscopy of the waste sample.	1.1.1
C_i	=	the concentration of nuclide, i, as determined by the analysis of the waste sample.	1.1.1
$C_{i\ell}$	=	the average concentration of radionuclide, i, in undiluted liquid effluent during time period Δt_ℓ from any liquid release, in μCi/ml.	1.2
C_s	=	the concentration of Sr-89 or Sr-90 in liquid wastes as determined by analysis of the quarterly composite sample.	1.1.1
C_t	=	the measured concentration of H-3 in liquid waste as determined by analysis of the monthly composite.	1.1.1

Term		Definition	Section of Initial Use
c	=	the setpoint, in μCi/ml, of the radioactivity monitor measuring the radioactivity concentration in the effluent line prior to dilution and subsequent release.	1.1.1
c_B	=	the monitor setpoint for RM-L7, the Nuclear Blowdown Monitor Tank discharge line monitor.	1.1.1
c_C	=	the monitor setpoint for RM-L9, the combined Liquid Waste Processing System and Nuclear Blowdown System effluent discharge line monitor.	1.1.1
c_M	=	the monitor setpoint for RM-L5, the Waste Monitor Tank discharge line monitor.	1.1.1
c_{Sa}	=	the monitor setpoint for RM-L3, the initial Steam Generator Blowdown Effluent line monitor.	1.1.3
c_{Sb}	=	the monitor setpoint for RM-L10, the final Steam Generator Blowdown Effluent line monitor.	1.1.3
c_T	=	the monitor setpoint for RM-L8, the Turbine Building Sump Effluent line monitor.	1.1.3
DF_i	=	a dose conversion factor for nuclide, i, for adults in preselected organ, τ, in mrem/pCi found in Table 1.2-2.	1.2
D	=	the cumulative dose commitment to the total body or any organ, τ, from the liquid effluents for the total time period.	1.2
DF	=	the dilution factor, which is the ratio of the total dilution flow rate to the effluent stream flow rate(s) required to assure that the limiting concentration of 10CFR, Part 20, Appendix B, Table II, Column 2 are met at the point of discharge.	1.1.1

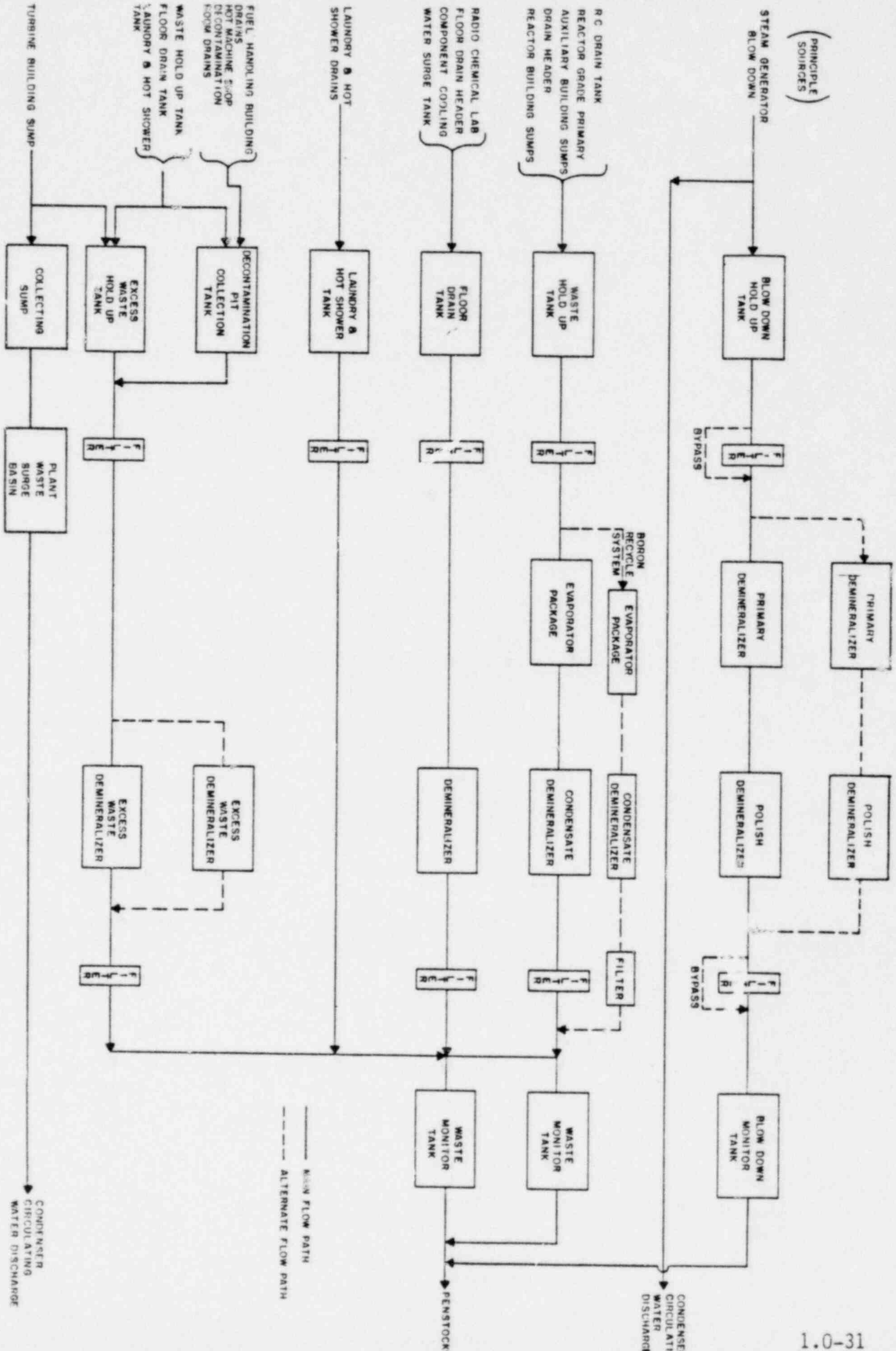
Term		Definition	Section of Initial Use
D_w	=	Dilution Factor from the near field area within one-quarter mile of the release points to the potable water intake for adult water consumption; for V. C. Summer, $D_w = 1$.	1.2
F	=	the dilution water flow setpoint as determined prior to the release point, in volume per unit time.	1.1.1
F_d	=	the flow rate of the Circulating Water System during the time of release of the Turbine Building Sump and/or the Steam Generator Blowdown.	1.1.3
F_{dc}	=	the dilution flow rate of the Circulating Water System upon which the setpoint is based: 90 percent of F_d.	1.1.3
F_t	=	the flow rate of water through the Fairfield Pumped Storage Station penstock(s) to which radioactive liquids are being discharged during the period of effluent release. This flow rate is dependent upon operational status of Fairfield Pumped Storage Station.	1.1.1
f	=	the flow setpoint as determined for the radiation monitor location.	1.1.1
F_{dp}	=	the dilution flow rate (through the penstock(s) receiving the radioactive liquid release) upon which the setpoint is based: 90 percent of F_t.	1.1.1
F_ℓ	=	the near field average dilution factor for $C_{i\ell}$ during any liquid effluent release.	1.2
f_{db}	=	the flow rate of the Nuclear Blowdown Monitor Tank discharge.	1.1.1
f_{dc}	=	the flow rate of the combined Waste Monitor Tank and Nuclear Blowdown Monitor Tank discharge.	1.1.1

Term		Definition	Section of Initial Use
f_{dm}	=	the flow rate of a waste monitor tank discharge	1.1.1
f_{ds}	=	the flow rate of the Steam Generator Blowdown discharge.	1.1.3
f_{dt}	=	the flow rate of the Turbine Building Sump discharge.	1.1.3
k_o	=	1.14×10^5, units conversion factor.	1.2
MPC_i	=	MPC_g, MPC_a, MPC_s, and MPC_t = the limiting concentrations of the appropriate gamma emitting, alpha emitting, and strontium radionuclides and tritium, respectively, from 10CFR, Part 20, Appendix B, Table II, Column 2.	1.1.1
RF	=	the recirculation factor, determined by system equilibrium calculations, used to assure that concentrations of effluents at the outfall do not exceed the effluent concentration limit, C. RF = 0.5.	1.1.1
SF	=	the safety factor, a conservative factor used to compensate for statistical fluctuations and errors of measurements. SF = 0.5, corresponding to a 100 percent variation.	1.1.1
$\left[\sum_i C_i\right]_B$	=	the sum of the measured radionuclide concentrations of the Nuclear Blowdown Monitor Tank.	1.1.1
$\left[\sum_i C_i\right]_D$	=	the sum of the measured radionuclide concentrations of the detergent waste in a Waste Monitor Tank to be discharged via the Sanitary Waste System.	1.1.2
$\left[\sum_i C_i\right]_{LLD}$	=	the sum of the Lower Limits of Detection, LLD, for the isotopic concentrations of the Waste Monitor Tank as determined by the analysis required in the Radiological Effluent Technical Specifications, Table 4.11-1.	1.1.2

Term	Definition	Section of Initial Use
$\left[\sum_i C_i\right]_M$	= the sum of the measured radionuclide concentrations for a Waste Monitor Tank.	1.1.1
$\left[\sum_i C_i\right]_S$	= the sum of the measured radionuclide concentrations for the Steam Generator Blowdown.	1.1.3
$\left[\sum_i C_i\right]_T$	= the sum of the measured radionuclide concentrations for the Turbine Building Sump.	1.1.3
$\left[\sum_i \frac{C_i}{MPC_i}\right]_B$	= the sum of the ratios of the measured concentration of nuclide i to its limiting value MPC_i for the Nuclear Blowdown Monitor Tank.	1.1.1
$\left[\sum_i \frac{C_i}{MPC_i}\right]_M$	= the sum of the ratios of the measured concentration of nuclide i to its limiting value MPC_i for the Waste Monitor Tank being considered for release.	1.1.1
$\left[\sum_i \frac{C_i}{MPC_i}\right]_S$	= the sum of the ratios of the measured concentration of nuclide i to its limiting value MPC_i for the Steam Generator Blowdown Effluent.	1.1.3
$\left[\sum_i \frac{C_i}{MPC_i}\right]_T$	= the sum of the ratios of the measured concentration of nuclide i to its limiting value MPC_i for the Turbine Building Sump Effluent.	1.1.3
U_F	= 21 kg/yr, fish consumption (adult).	1.2
Z	= applicable factor when no additional dilution is to be be considered; Z = 1.	1.2
U_w	= 730 kg/yr, water consumption (adult).	1.2

1.4 Liquid Radwaste Treatment System

Figure 1.4-1 Minimum OPERABLE Liquid Radwaste Treatment System



2.0 GASEOUS EFFLUENTS

2.1 Gaseous Effluent Monitor Setpoints

The calculated setpoint values will be regarded as upper bounds for the actual setpoint adjustments. That is, setpoint adjustments are not required to be performed if the existing setpoint level corresponds to a lower count rate than the calculated value.

2.1.1 Station Vent Noble Gas Monitors

For the purpose of implementation of section 3.3.3.9 of the Technical Specifications, the alarm setpoint level for the station vent noble gas monitors will be calculated as follows:

S_v = count rate of the plant vent noble gas monitor (S_{vp} = RM-A3) or the containment purge noble gas monitor (S_{vc} = RM-A4) at the alarm setpoint level count rate.

$$= \text{the lesser of} \begin{cases} 0.25 \times R_t \times D_{TB} & (1) \\ \text{or} \\ 0.25 \times R_s \times D_{ss} & (2) \end{cases}$$

0.25 = the safety factor applied to each of the two vent noble gas monitors (plant vent and containment purge) to assure that the sum of the releases has a combined safety factor of 0.5 which allows a 100 percent margin for cumulative uncertainties of measurements.

D_{TB} = Dose rate limit to the total body of an individual in an unrestricted area required to limit dose to 500 mrem in one year.

$$= \frac{500 - F\left[(\overline{X/Q}) \sum_i K_i \overline{Q}_i \right]}{(1-F)} \qquad (3)$$

R_t = count rate per mrem/yr to the total body

$$= C \div \left((\overline{X/Q}) \sum_i K_i Q_i \right) \quad (4)$$

C = count rate of a station vent monitor corresponding to grab sample radionuclide concentrations. (For the plant vent the sample is taken concurrently with the release. For the containment purge, the sample is taken prior to the release and the count rate corresponding to the measured concentration is determined from the monitor calibration curve.)

$\overline{X/Q}$ = 5.3×10^{-6} sec/m^3 in the SE sector*

K_i = total body dose factor due to gamma emissions from isotope i (mrem/yr per $\mu Ci/m^3$) from Table 2.1-1.

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

F = fraction of current year elapsed at the time of the calculation.

$\overline{Q}_i$ = average rate of release of noble gas radionuclide i for the elapsed fraction of the year, F, (μCi/sec).

D_{ss} = Dose rate limit to the skin of the body of an individual in an unrestricted area required to limit dose to 3000 mrem in one year.

$$= \frac{3000 - F \left[(\overline{X/Q}) \sum_i (L_i + 1.1\, M_i)\, \overline{Q}_i \right]}{(1-F)} \quad (5)$$

R_s = count rate per mrem/yr to the skin

* Reference 4, Section 11.3.8.

$$= C \div \overline{X/Q} \sum_i (L_i + 1.1\, M_i)\, Q_i \qquad (6)$$

L_i = skin dose factor due to beta emissions from isotope i (mrem/yr per $\mu Ci/m^3$) from Table 2.1-1.

1.1 = mrem skin dose per mrad air dose

M_i = air dose factor due to gamma emissions from isotope i (mrad/yr per $\mu Ci/m^3$) from Table 2.1-1.

2.1.2 Waste Gas Decay System

The setpoint level for discharge through the waste gas decay system monitor (S_d = RM-A10) will be calculated in a corresponding manner:

$$S_d = \text{the lesser of} \begin{cases} 0.25 \times r_t \times D'_{TB} & (7) \\ \text{or} \\ 0.25 \times r_s \times D'_{ss} & (8) \end{cases}$$

$$D'_{TB} = \frac{500 - (F\,(\overline{X/Q}) \sum_i K_i\, \overline{q}_i)}{(1-F)} \qquad (9)$$

$$r_t = c \div (\overline{X/Q} \sum_i K_i\, q_i) \qquad (10)$$

c = count rate of the waste gas decay system monitor for radionuclide concentrations to be discharged.

q_i = rate of release of noble gas radionuclide i ($\mu Ci/sec$) from the waste gas decay system.

$\overline{q}_i$ = average rate of release of noble gas radionuclide i from the waste gas decay system for the elapsed fraction of the year, F, ($\mu Ci/sec$).

$$D'_{ss} = \frac{3000 - F\,[(\overline{X/Q})\,\sum_i (L_i + 1.1\,M_i)\,\bar{q}_i\,]}{(1-F)} \qquad (11)$$

$$r_s = c \div [\,\overline{X/Q}\,\sum_i (L_i + 1.1\,M_i)\,q_i] \qquad (12)$$

NOTE: For planned releases from the waste gas decay system, calculations may first be performed assuming maximum flow from the system. If this calculation results in an unacceptable release rate, q_i must be controlled by limiting the flow rate from the system. Due to the 0.25 safety factor in equations (1) and (2), the release rate also must be controlled such that the ratio of dose rate limit (D'_{TB} or D'_{ss}) to the dose rate which would result from the planned release ($\overline{X/Q}\,\sum_i K_i\,q_i$) or $[\,\overline{X/Q}\,\sum_i (L_i + 1.1\,M_i)\,q_i]$ is greater than four (4).

Also, a setpoint calculation should be performed for the plant vent monitor (RM-A3) incorporating the waste gas decay system planned relase rates with the existing plant vent release rates to determine whether the plant vent monitor setpoint should be adjusted.

When no discharges are being made from the Waste Gas Decay System, the monitor setpoint should be established as near background as practical to prevent spurious alarms yet alarm in the event of an inadvertent release.

2.1.3 Alternative Methodologies for Establishing Conservative Setpoints:

Alternate 1:

For ease of implementation, the count rate setpoints may be calculated by applying the methodologies presented in sections 2.1.1 and 2.1.2 with the more restrictive assumption of continuous release at the limiting rate for a year as follows:

$$D_{TB} = D''_{TB} = 500 \text{ mrem/year} \quad (13)$$

$$D_{ss} = D''_{ss} = 3000 \text{ mrem/year} \quad (14)$$

Alternate 2:

A more conservative setpoint may be calculated to minimize requirements for adjustment of the monitor as follows:

$$D_{TB} = D''_{TB} = 500 \text{ mrem/year} \quad (15)$$

$$D_{ss} = D''_{ss} = 3000 \text{ mrem/year} \quad (16)$$

R'_t = conservative count rate per mrem to the total body (Xe-133 detection, Kr-89 dose).

$$= C' \div [\overline{X/Q} \times K_{Kr-89} \times Q''], \text{ where} \quad (17)$$

Q" = Assigned value of, for example, 1.0 μCi/sec, Xe-133; or, if necessary, a more practical value. (See definition of C' below.)

C' = count rate of the vent monitor for an effluent concentration of Xe-133 corresponding to a 1.0 μCi/sec release rate of Xe-133. [Note: Calculate the related concentration based on dilution flow.] If the concentration corresponding to a release rate of 1.0 μCi/sec of Xe-133 is not compatible with the calibration curve for the particular monitor, a compatible release rate may be selected.

K_{Kr-89} = total body dose factor for Kr-89, the most restrictive isotope from Table 2.1-1.

R'_s = conservative count rate per mrem/yr to the skin.

$$= C' \div [\overline{X/Q} \times (L_{Kr-89} + 1.1\ M_{Kr-89}) \times Q''] \qquad (18)$$

where:

L_{Kr-89} = skin dose factor for Kr-89, the most restrictive isotope, from Table 2.1-1.

M_{Kr-89} = air dose factor for Kr-89, the most restrictive isotope, from Table 2.1-1.

Similarly for the waste gas decay system:

r_t' = conservative count rate per mrem/yr to the total body for the waste gas decay system only.

$$= c' \div [\overline{X/Q} \times K_{Kr-89} \times q''], \text{ where} \qquad (19)$$

c' = Count rate of the waste gas decay system monitor corresponding to, for example, a 1.0 μCi/ml concentration of Kr-85. If this concentration is incompatible with the calibration curve for the particular monitor, a compatible concentration may be selected.

q'' = release rate from the waste gas decay system (may be determined for maximum flow from the system and the concentration selected for c' above).

r_s' = conservative count rate per mrem/yr to the skin for waste gas decay system only.

$$= c' \div [\overline{X/Q} \times (L_{Kr-89} + 1.1\ M_{Kr-89}) \times q''] \qquad (20)$$

TABLE 2.1-1

DOSE FACTORS FOR EXPOSURE TO A SEMI-INFINITE CLOUD OF NOBLE GASES,*

Nuclide	γ-Body*** (K)	β-Skin***(L)	γ-Air**(M)	β-Air**(N)
Kr-85m	1.17E+03****	1.46E+03	1.23E+03	1.97E+03
Kr-85	1.61E+01	1.34E+03	1.72E+01	1.95E+03
Kr-87	5.92E+03	9.73E+03	6.17E+03	1.03E+04
Kr-88	1.47E+04	2.37E+03	1.52E+04	2.93E+03
Kr-89	1.66E+04	1.01E+04	1.73E+04	1.06E+04
Kr-90	1.56E+04	7.29E+03	1.63E+04	7.83E+03
Xe-131m	9.15E+01	4.76E+02	1.56E+02	1.11E+03
Xe-133m	2.51E+02	9.94E+02	3.27E+02	1.48E+03
Xe-133	2.94E+02	3.06E+02	3.53E+02	1.05E+03
Xe-135m	3.12E+03	7.11E+02	3.36E+03	7.39E+02
Xe-135	1.81E+03	1.86E+03	1.92E+03	2.46E+03
Xe-137	1.42E+03	1.22E+04	1.51E+03	1.27E+04
Xe-138	8.83E+03	4.13E+03	9.21E+03	4.75E+03
Ar-41	8.84E+03	2.69E+03	9.30E+03	3.28E+03

*Values taken from Reference 3, Table B-1

** $\frac{mrad\text{-}m^3}{\mu Ci\text{-}yr}$

*** $\frac{mrem\text{-}m^3}{\mu Ci\text{-}yr}$

**** 1.17E+03 = 1.17×10^3

2.2 Gaseous Effluent Dose Calculations

2.2.1 Unrestricted Area Boundary Dose

2.2.1.a For the purpose of implementation of section 3.11.2.1.a of the Technical Specifications, the dose at the unrestricted area boundary due to noble gases shall be calculated as follows:

D_t = average total body dose rate in the current year (mrem/yr)

$$= \overline{X/Q} \sum_i K_i \overline{Q}_i \qquad (21)$$

D_s = average skin dose rate in current year (mrem/yr)

$$= \overline{X/Q} \sum_i (L_i + 1.1 M_i) \overline{Q}_i \qquad (22)$$

2.2.1.b Organ doses due to radioiodines and all radioactive materials in particulate form,and radionuclides (other than noble gases) with half-lives greater than eight days, will be calculated for the purpose of implementation of section 3.11.2.1.b as follows:

D_o = average organ dose rate in the current year (mrem/yr)

$$= W \sum_i P_i \overline{Q}_i', \text{ where} \qquad (23)$$

W = controlling sector annual average atmospheric dispersion at the site boundary for the appropriate pathway.

= { $\overline{X/Q}$ for inhalation and all tritium pathways (Section 2.1.1) (24)

$\overline{D/Q}$ = 2.0×10^{-8} * for other pathways in the NE sector (25)

* Value based on Reference 5, Table 6.1-13.

P_i = dose parameter for radionuclide i, (mrem/yr per $\mu Ci/m^3$) for inhalation and (m^2-mrem/yr per μCi/sec) for other pathways, from Table 2.2-1

$\overline{Q}_i'$ = average release rate of radionuclide i (required by Technical Specification 3.11.2.1.b) in the current year (μCi/sec).

2.2.2 Unrestricted Area Dose to Individual

2.2.2.a For the purpose of sections 3.11.2.2 and 3.11.2.4 of the Technical Specifications, the air dose in unrestricted areas shall be determined as follows:

D_γ = air dose due to gamma emissions from noble gas radionuclide i (mrad)

$$= 3.17 \times 10^{-8} \sum_i M_i \overline{X/Q}' \tilde{Q}_i \qquad (26)$$

where,

3.17×10^{-8} = the fraction of one year per one second

$\overline{X/Q}'$ = relative concentration for unrestricted areas for long term releases

= 2.8×10^{-6} sec/m^3*, in the ESE sector

$\tilde{Q}_i$ = cumulative release of noble gas radionuclide i over the period of interest (μCi).

D_β = air dose due to beta emissions from noble gas radionuclide i (mrad).

* Values based on Reference 4, Table 2.3-119; Reference 5, Table 6.1-10.

$$= 3.17 \times 10^{-8} \sum_i N_i \overline{X/Q}' \tilde{Q}_i, \text{ where} \quad (27)$$

N_i = air dose factor due to beta emissions from noble gas radionuclide i (mrad/yr per $\mu Ci/m^3$ from Table 2.1-1.)

2.2.2.b Dose to an individual from radioiodines and radioactive materials in particulate form, and radionuclides (other than noble gases) with half-lives greater than eight (8) days will be calculated for the purpose of implementation of section 3.11.2.3 of the Technical Specifications as follows:

D_p = dose to an individual from radioiodines and radionuclides in particulate form, and radionuclides (other than noble gases) with half-lives greater than eight (8) days (mrem).

$$= 3.17 \times 10^{-8} \sum_i R_i W' \tilde{Q}_i, \text{ where} \quad (28)$$

W' = relative concentration or relative deposition for unrestricted areas.

= { $\overline{X/Q}'$ = (2.8×10^{-6})*sec/m^3 for inhalation and all tritium pathways. (29)

$\overline{D/Q}'$ = (8.8×10^{-9})*m^{-2} for other pathways in the ESE sector. (30)

$\overline{D/Q}'$ = relative deposition for unrestricted areas per unit area $(m^2)^{-1}$, for long term releases.

R_i = dose factor for radionuclide i, (mrem/yr per $\mu Ci/m^3$) or (m^2 - mrem/yr per $\mu Ci/sec$) from Table 2.2-2.

* Values based on Reference 4, Table 2.3-119; Reference 5, Table 6.1-10.

$\tilde{Q}_i'$ = Cumulative release of radionuclide i (required by Technical Specification 3.11.2.3) over the period of interest (μCi).

2.2.2.c For the purpose of implementing section 6.9.1.13 of the Technical Specifications, dose calculations will be performed using the above equations with the substitution of average meteorological parameters for the period of the report. Values for R_i may be found in Tables 2.2-3 through 2.2-6.

TABLE 2.2-1

PATHWAY DOSE FACTORS FOR SECTION 2.2.1.b (P_i)*
(For Dose Calculation Required by TS 3.11.2.1)

AGE GROUP	(INFANT)	(N.A.)	(INFANT)
ISOTOPE	INHALATION(1)	GROUND PLANE(2)	FOOD(2)
H-3	6.468E+02	0.000E+00	2.430E+03
C-14	2.646E+04	0.000E+00	2.340E+09
NA-24	1.056E+04	1.979E+07	1.542E+07
P-32	2.030E+06	0.000E+00	1.602E+11
CR-51	1.284E+04	7.864E+06	4.700E+06
MN-54	9.996E+05	1.287E+09	3.900E+07
MN-56	7.168E+04	1.525E+06	2.862E+00
FE-55	8.694E+04	0.000E+00	1.351E+08
FE-59	1.015E+06	4.562E+08	3.919E+08
CO-58	7.770E+05	6.194E+08	6.055E+07
CO-60	4.508E+06	5.172E+09	2.098E+08
NI-63	3.388E+05	0.000E+00	3.493E+10
NI-65	5.012E+04	4.930E+05	3.020E+01
CU-64	1.498E+04	9.823E+05	3.807E+06
ZN-65	6.468E+05	7.907E+08	1.904E+10
ZN-69	1.322E+04	0.000E+00	3.655E-09
BR-83	3.808E+02	1.011E+04	9.339E-01
BR-84	4.004E+02	3.376E+05	1.256E-22
BR-85	2.044E+01	0.000E+00	0.000E+00
RB-86	1.904E+05	1.478E+07	2.234E+10
RB-88	5.572E+02	5.399E+04	1.874E-44
RB-89	3.206E+02	2.075E+05	4.193E-53
SR-89	2.030E+06	3.560E+04	1.258E+10
SR-90	4.088E+07	0.000E+00	1.216E+11
SR-91	7.336E+04	3.587E+06	3.215E+05

* Values based on Reference 1, Section 5.2.1 assumptions unless otherwise indicated.
(1) - mrem/yr per µCi/m³
(2) - m² · mrem/yr per µCi/sec

TABLE 2.2-1 (Continued)

PATHWAY DOSE FACTORS FOR SECTION 2.2.1.b (P_i)

AGE GROUP	(INFANT)	(N.A.)	(INFANT)
ISOTOPE	INHALATION ①	GROUND PLANE ②	FOOD ②
SR-92	1.400E+05	1.233E+06	5.005E+01
Y-90	2.688E+05	7.583E+03	9.406E+05
Y-91M	2.786E+03	1.658E+05	1.876E-15
Y-91	2.450E+06	1.702E+06	5.251E+06
Y-92	1.266E+05	3.060E+05	1.026E+01
Y-93	1.666E+05	3.620E+05	1.776E+04
ZR-95	1.750E+06	3.975E+08	8.257E+05
ZR-97	1.400E+05	4.921E+06	4.446E+04
NB-95	4.788E+05	2.291E+08	2.062E+08
MO-99	1.348E+05	6.608E+06	3.108E+08
TC-99M	2.030E+03	3.013E+05	1.646E+04
TC-101	8.442E+02	3.253E+04	1.423E-56
RU-103	5.516E+05	1.804E+08	1.055E+05
RU-105	4.844E+04	1.030E+06	3.204E+00
RU-106	1.156E+07	3.590E+08	1.445E+06
AG-110M	3.668E+06	3.649E+09	1.461E+10
TE-125M	4.466E+05	3.001E+06	1.508E+08
TE-127M	1.312E+06	1.395E+05	1.037E+09
TE-127	2.436E+04	4.704E+03	1.359E+05
TE-129M	1.680E+06	3.290E+07	1.392E+09
TE-129	2.632E+04	4.395E+04	1.678E-07
TE-131M	1.988E+05	1.351E+07	2.280E+07
TE-131	8.218E+03	4.929E+07	1.384E-30
TE-132	3.402E+05	7.098E+06	6.513E+07
I-130	1.596E+06	9.560E+06	8.754E+08

① - mrem/yr per $\mu Ci/m^3$

② - m^2 · mrem/yr per $\mu Ci/sec$

TABLE 2.2-1 (Continued)

PATHWAY DOSE FACTORS FOR SECTION 2.2.1.b (P_i)

AGE GROUP	(INFANT)	(N.A.)	(INFANT)
ISOTOPE	INHALATION ①	GROUND PLANE ②	FOOD ②
I-131	1.484E+07	2.985E+07	1.053E+12
I-132	1.694E+05	2.075E+06	1.108E+02
I-133	3.556E+06	4.259E+06	9.601E+09
I-134	4.452E+04	7.578E+05	8.402E-10
I-135	6.958E+05	4.210E+06	2.002E+07
CS-134	7.028E+05	3.282E+09	6.801E+10
CS-136	1.345E+05	2.432E+08	5.795E+09
CS-137	6.118E+05	1.337E+09	6.024E+10
CS-138	8.764E+02	5.860E+05	2.180E-22
BA-139	5.096E+04	1.705E+05	2.874E-05
BA-140	1.596E+06	3.352E+07	2.410E+08
BA-141	4.746E+03	6.762E+04	3.141E-41
BA-142	1.554E+03	7.234E+04	0.000E+00
LA-140	1.680E+05	3.114E+07	1.880E+05
LA-142	5.950E+04	1.269E+06	6.019E-06
CE-141	5.166E+05	2.199E+07	1.366E+07
CE-143	1.162E+05	3.753E+06	1.536E+06
CE-144	9.842E+06	6.761E+07	1.334E+08
PR-143	4.326E+05	0.000E+00	7.845E+05
PR-144	4.284E+03	3.017E+03	1.171E-48
ND-147	3.220E+05	1.441E+07	5.743E+05
W-187	3.962E+04	3.915E+06	2.501E+06
NP-239	5.950E+04	2.823E+06	9.400E+04

① - mrem/yr per $\mu Ci/m^3$

② - m^2 · mrem/yr per $\mu Ci/sec$

Table 2.2-2

PATHWAY DOSE FACTORS FOR SECTION 2.2.2.b (R_i)*

(For Dose Calculations Required by TS 3.11.2.3)

AGE GROUP	(CHILD)	(N.A.)	(CHILD)
ISOTOPE	INHALATION	GROUND PLANE	VEGETATION
H-3	1.125E+03	0.000E+00	4.008E+03
C-14	3.589E+04	0.000E+00	8.894E+08
NA-24	1.610E+04	1.385E+07	3.729E+05
P-32	2.605E+06	0.000E+00	3.366E+09
CR-51	1.698E+04	5.506E+06	6.21[illegible]+06
MN-54	1.576E+06	1.625E+09	6.648E+08
MN-56	1.232E+05	1.068E+06	2.723E+03
FE-55	1.110E+05	0.000E+00	8.012E+08
FE-59	1.269E+06	3.204E+08	6.693E+08
CO-58	1.106E+06	4.464E+08	3.771E+08
CO-60	7.067E+06	2.532E+10	2.095E+09
NI-63	8.214E+05	0.000E+00	3.949E+10
NI-65	8.399E+04	3.451E+05	1.211E+03
CU-64	3.670E+04	6.876E+05	5.159E+05
ZN-65	9.953E+05	8.583E+08	2.164E+09
ZN-69	1.018E+04	0.000E+00	9.893E-04
BR-83	4.736E+02	7.079E+03	5.369E+00
BR-84	5.476E+02	2.363E+05	3.822E-11
BR-85	2.531E+01	0.000E+00	0.000E+00
RB-86	1.983E+05	1.035E+07	4.584E+08
RB-88	5.624E+02	3.779E+04	4.374E-22
RB-89	3.452E+02	1.452E+05	1.642E-26
SR-89	2.157E+06	2.509E+04	3.593E+10
SR-90	1.016E+08	0.000E+00	1.243E+12
SR-91	1.739E+05	2.511E+06	1.157E+06

* Values based on Reference 1, Section 5.3.1 assumptions unless otherwise indicated.

Units: Inhalation - mrem/yr per µCi/m^3
Others - m^2 · mrem/yr per µCi/sec

POOR ORIGINAL

Table 2.2-2 (Continued)

PATHWAY DOSE FACTORS FOR SECTION 2.2.2.b (R_i)

AGE GROUP	(CHILD)	(N.A.)	(CHILD)
ISOTOPE	INHALATION	GROUND PLANE	VEGETATION
SR-92	2.424E+05	8.631E+05	1.378E+04
Y-90	2.679E+05	5.309E+03	6.569E+07
Y-91M	2.812E+03	1.161E+05	1.737E-05
Y-91	2.627E+06	1.207E+06	2.484E+09
Y-92	2.390E+05	2.142E+05	4.576E+04
Y-93	3.885E+05	2.534E+05	4.482E+06
ZR-95	2.231E+06	2.837E+08	8.843E+08
ZR-97	3.511E+05	3.445E+06	1.248E+07
NB-95	6.142E+05	1.605E+08	2.949E+08
MO-99	1.354E+05	4.626E+06	1.647E+07
TC-99M	4.810E+03	2.109E+05	5.255E+03
TC-101	5.846E+02	2.277E+04	4.123E-29
RU-103	6.623E+05	1.265E+08	3.971E+08
RU-105	9.953E+04	7.212E+05	5.981E+04
RU-106	1.432E+07	5.049E+08	1.159E+10
AG-110M	5.476E+06	4.019E+09	2.581E+09
TE-125M	4.[illegible]3E+05	2.128E+06	3.506E+08
TE-127M	1.4[illegible]0E+06	1.083E+05	3.769E+09
TE-127	5.624E+04	3.293E+03	3.903E+05
TE-129M	1.761E+06	2.305E+07	2.460E+09
TE-129	2.549E+04	3.076E+04	7.204E-02
TE-131M	3.078E+05	9.459E+06	2.163E+07
TE-131	2.054E+03	3.450E+07	1.349E-14
TE-132	3.774E+05	4.968E+06	3.111E+07
I-130	1.846E+06	6.692E+06	1.370E+08

Units: Inhalation - mrem/yr per μCi/m^3
Others - m^2 · mrem/yr per μCi/sec

POOR ORIGINAL

Table 2.2-2 (Continued)

PATHWAY DOSE FACTORS FOR SECTION 2.2.2.b (R_i)

Page 3 of 3

AGE GROUP	(CHILD)	(N.A.)	(CHILD)
ISOTOPE	INHALATION	GROUND PLANE	VEGETATION
I-131	1.624E+07	2.089E+07	4.754E+10
I-132	1.935E+05	1.452E+06	7.314E+03
I-133	3.848E+06	2.961E+06	8.113E+08
I-134	5.069E+04	5.305E+05	6.622E-03
I-135	7.918E+05	2.947E+06	9.973E+06
CS-134	1.014E+06	8.007E+09	2.631E+10
CS-136	1.709E+05	1.702E+08	2.247E+08
CS-137	9.065E+05	1.201E+10	2.392E+10
CS-138	8.399E+02	4.102E+05	9.133E-11
BA-139	5.772E+04	1.194E+05	2.950E+00
BA-140	1.743E+06	2.346E+07	2.767E+08
BA-141	2.919E+03	4.734E+04	1.605E-21
BA-142	1.643E+03	5.064E+04	4.105E-39
LA-140	2.257E+05	2.180E+07	3.166E+07
LA-142	7.585E+04	8.886E+05	1.582E+01
CE-141	5.439E+05	1.540E+07	4.082E+08
CE-14[illegible]	[illegible].273E+05	2.627E+06	1.364E+07
CE-144	1.[illegible]95E+07	8.032E+07	1.039E+10
PR-143	4.329E+05	0.000E+00	1.575E+08
PR-144	1.565E+03	2.112E+03	3.829E-23
ND-147	3.282E+05	1.009E+07	9.197E+07
W-187	9.102E+04	2.740E+06	5.360E+06
NP-239	6.401E+04	1.976E+06	1.357E+07

Units: Inhalation - mrem/yr per $\mu Ci/m^3$

Others - $m^2 \cdot$ mrem/yr per $\mu Ci/sec$

POOR ORIGINAL

Table 2.2-3

PATHWAY DOSE FACTORS FOR SECTION 2.2.2.c (R_i)*

AGE GROUP	(INFANT)	(N.A.)	(INFANT)	(INFANT)	(INFANT)
ISOTOPE:	INHALATION	GROUND PLANE	GRS/COW/MILK	GRS/COW/MEAT	VEGETATION
H-3	6.468E+02	0.000E+00	2.430E+03	0.000E+00	0.000E+00
C-14	2.646E+04	0.000E+00	2.340E+09	0.000E+00	0.000E+00
NA-24	1.056E+04	1.385E+07	1.542E+07	0.000E+00	0.000E+00
P-32	2.030E+06	0.000E+00	[illegible].602E+11	0.000E+00	0.000E+00
CR-51	1.284E+04	5.566E+06	4.700E+06	0.000E+00	0.000E+00
MN-54	9.996E+05	1.625E+09	3.900E+07	0.000E+00	0.000E+00
MN-56	7.168E+04	1.068E+06	2.862E+00	0.000E+00	0.000E+00
FE-55	8.694E+04	0.000E+00	1.351E+08	0.000E+00	0.000E+00
FE-59	1.015E+06	3.204E+08	3.919E+08	0.000E+00	0.000E+00
CO-58	7.770E+05	4.464E+08	6.055E+07	0.000E+00	0.000E+00
CO-60	4.508E+06	2.532E+10	2.058E+08	0.000E+00	0.000E+00
NI-63	3.388E+05	0.000E+00	3.493E+10	0.000E+00	0.000E+00
NI-65	5.012E+04	3.451E+05	3.020E+01	0.000E+00	0.000E+00
CU-64	1.498E+04	6.876E+05	3.807E+06	0.000E+00	0.000E+00
ZN-65	6.468E+05	8.583E+08	1.904E+10	0.000E+00	0.000E+00
ZN-69	1.322E+04	0.000E+00	3.855E-09	0.000E+00	0.000E+00
BR-83	3.808E+02	7.079E+03	9.339E-01	0.000E+00	0.000E+00
BR-84	4.004E+02	2.363E+05	1.256E-22	0.000E+00	0.000E+00
BR-85	2.044E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-86	1.904E+05	1.035E+07	2.234E+10	0.000E+00	0.000E+00
RB-88	5.572E+02	3.779E+04	1.874E-44	0.000E+00	0.000E+00
RB-89	3.206E+02	1.452E+05	4.193E-53	0.000E+00	0.000E+00
SR-89	2.030E+06	2.509E+04	1.258E+10	0.000E+00	0.000E+00
SR-90	4.088E+07	0.000E+00	1.216E+11	0.000E+00	0.000E+00
SR-91	7.336E+04	2.511E+06	3.215E+05	0.000E+00	0.000E+00

* Values based on Reference 1, Section 5.3.1 assumptions unless otherwise indicated.

Units: Inhalation – mrem/yr per $\mu Ci/m^3$

Others – $m^2 \cdot$ mrem/yr per $\mu Ci/sec$

POOR ORIGINAL

Table 2.2-3 (Continued)

PATHWAY DOSE FACTORS FOR SECTION 2.2.2.c (R_i)*

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AGE GROUP	(INFANT)	(N.A.)	(INFANT)	(INFANT)	(INFANT)
ISOTOPE	INHALATION	GROUND PLANE	GRS/COW/MILK	GRS/COW/MEAT	VEGETATION
SR-92	1.400E+05	8.631E+05	5.005E+01	0.000E+00	0.000E+00
Y-90	2.688E+05	5.308E+03	9.406E+05	0.000E+00	0.000E+00
Y-91M	2.786E+03	1.161E+05	1.876E-15	0.000E+00	0.000E+00
Y-91	2.450E+06	1.207E+06	5.251E+06	.000E+00	0.000E+00
Y-92	1.266E+05	2.142E+05	1.026E+01	0.000E+00	0.000E+00
Y-93	1.666E+05	2.534E+05	1.776E+04	0.000E+00	0.000E+00
ZR-95	1.750E+06	2.837E+08	8.257E+05	0.000E+00	0.000E+00
ZR-97	1.400E+05	3.445E+06	4.446E+04	0.000E+00	0.000E+00
NB-95	4.788E+05	1.605E+08	2.062E+08	0.000E+00	0.000E+00
MO-99	1.349E+05	4.626E+06	3.108E+08	0.000E+00	0.000E+00
TC-99M	2.030E+03	2.109E+05	1.646E+04	0.000E+00	0.000E+00
TC-101	8.442E+02	2.277E+04	1.423E-56	0.000E+00	0.000E+00
RU-103	5.516E+05	1.265E+08	1.055E+05	0.000E+00	0.000E+00
RU-105	4.844E+04	7.212E+05	3.204E+00	0.000E+00	0.000E+20
RU-106	1.156E+07	5.049E+08	1.445E+06	0.000E+00	0.000E+00
AG-110M	3.668E+06	4.019E+09	1.461E+10	0.000E+00	0.000E+00
TE-125M	4.466E+05	2.128E+06	1.508E+08	0.000E+00	0.000E+00
TE-?27M	1.312E+06	1.083E+05	1.037E+09	0.000E+00	0.000E+00
TE-127	2.436E+04	3.293E+03	1.359E+05	0.000E+00	0.000E+00
TE-129M	1.680E+06	2.305E+07	1.392E+09	0.020E+00	0.000E+00
TE-129	2.632E+04	3.076E+04	1.678E-07	0.000E+00	0.200E+00
TE-131M	1.988E+05	9.459E+06	2.288E+07	0.000E+00	0.000E+00
TE-131	8.218E+03	3.450E+07	1.384E-30	0.000E+00	0.000E+00
TE-132	3.402E+05	4.968E+06	6.513E+07	0.000E+00	0.000E+00
I-130	1.596E+06	6.692E+06	8.754E+08	0.000E+00	0.000E+00

Units: Inhalation - mrem/yr per μCi/m^3

Others - m^2 · mrem/yr per μCi/sec

POOR ORIGINAL

Table 2.2-3 (Continued)

PATHWAY DOSE FACTORS FOR SECTION 2.2.2.c (R_i)*

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AGE GROUP	(INFANT)	(N.A.)	(INFANT)	(INFANT)	(INFANT)
ISOTOPE	INHALATION	GROUND PLANE	GRS/COW/MILK	GRS/COW/MEAT	VEGETATION
I-131	1.484E+07	2.089E+07	1.053E+12	0.000E+00	0.000E+00
I-132	1.694E+05	1.452E+0[illegible]	1.188E+02	0.000E+00	0.000E+00
I-133	3.556E+06	2.981E+06	9.601E+09	0.000E+00	0.000E+00
I-134	4.452E+04	5.305E+05	8.402E-10	0.000E+00	0.000E+00
I-135	6.950E+05	2.947E+06	2.002E+07	0.000E+00	0.000E+00
CS-134	7.028E+05	8.007E+09	6.801E+10	0.000E+00	0.000E+00
CS-136	1.345E+05	1.702E+08	5.795E+09	0.000E+00	0.000E+00
CS-137	6.118E+05	1.201E+10	6.024E+10	0.000E+00	0.000E+00
CS-138	8.764E+02	4.102E+05	2.180E[illegible]2	0.000E+00	0.000E+00
BA-139	5.096E+04	1.194E+05	2.874E-05	0.000E+00	0.000E+00
BA-140	1.596E+06	2.346E+07	2.410E+08	0.000E+00	0.000E+00
BA-141	4.746E+03	4.734E+04	3.141E-44	0.000E+00	0.000E+00
BA-142	1.554E+03	5.064E+04	0.000E+00	0.000E+00	0.000E+00
LA-140	1.680E+05	2.180E+07	1.880E+05	0.000E+00	0.000E+00
LA-142	5.950E+04	8.886E+05	6.019E-06	0.000E+00	0.000E+00
CE-141	5.166E+05	1.540E+07	1.366E+07	0.000E+00	0.000E+00
CE-143	1.162E+05	2.627E+06	1.536E+06	0.000E+00	0.000E+00
CE-144	9.842E+06	8.032E+07	1.334E+09	0.000E+00	0.000E+00
PR-143	4.326E+05	0.000E+00	7.845E+05	0.000E+00	0.000E+00
PR-144	4.284E+03	2.112E+03	1.171E-48	0.000E+00	0.000E+00
ND-147	3.220E+05	1.809E+07	5.743E+05	0.000E+00	0.000E+00
W-187	3.962E+04	2.740E+06	2.501E+06	0.000E+00	0.000E+00
NP-239	5.950E+04	1.976E+06	9.400E+04	0.000E+00	0.000E+00

Units: Inhalation – mrem/yr per $\mu Ci/m^3$

Others – $m^2 \cdot$ mrem/yr per $\mu Ci/sec$

POOR ORIGINAL

Table 2.2-4

PATHWAY DOSE FACTORS FOR SECTION 2.2.2.c (R_i)*

Page 1 of 3

AGE GROUP	(CHILD)	(N.A.)	(CHILD)	(CHILD)	(CHILD)
ISOTOPE	INHALATION	GROUND PLANE	GRS/COW/MILK	GRS/COW/MEAT	VEGETATION
H-3	1.125E+03	0.000E+00	1.601E+03	2.341E+02	4.008E+03
C-14	3.589E+04	0.000E+00	1.195E[illegible]39	3.834[illegible]-08	8.894E+08
NA-24	1.[illegible]10E+04	1.385E+07	8.853E+06	1.725E-03	3.729E+05
P-32	2.605E+06	0.000E+00	7.77[illegible]E+10	7.411E+09	3.[illegible]56E+09
CR-51	1.698E+04	5.506E+06	5.398E+06	4.661E+05	6.213E+06
MN-54	1.576E+06	1.625E+09	2.097E+07	6.011E+06	6.648[illegible]
MN-56	1.232E+05	1.068E+06	1.865E[illegible]	2.4[illegible]7E-51	2.72[illegible]
FE-55	1.110E+05	0.000E+00	1.118E+08	4.571E+08	8.012E+08
FE-59	1.269E+06	3.204E+08	2.025E+08	6.338E+08	6.693E+08
CO-58	1.106E+06	4.464E+08	7.080E+07	9.595E+07	3.771E+08
CO-60	7.067E+06	2.532E+10	2.391E+08	3.838E+08	2.095E+09
NI-63	8.214E+05	0.000E+00	2.964E+10	2.912E+10	3.949E+10
NI-65	8.399E+04	3.451E+05	1.909E+01	4.061E-51	1.211E+03
CU-64	3.670E+04	6.876E+05	3.502E+06	1.393E-05	5.159E+05
ZN-65	9.953E+05	8.583E+08	1.101E+10	1.000E+09	2.[illegible]64E+09
ZN-69	1.018E+04	0.000E+00	1.123E-09	0.000E+00	9.893E-04
BR-83	4.736E+02	7.079E+03	4.399E-01	9.519E-57	5.369E+00
BR-84	5.476E+02	2.363E+05	6.508E-23	0.000E+00	3.822E-11
BR-85	2.531E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-86	1.983E+05	1.035E+07	8.804E-09	5.816E+08	4.584E+08
RB-88	5.624E+02	3.779E+04	7.150E-45	0.000E+00	4.374E-22
RB-89	3.452E+02	1.452E+05	1.715E-53	0.000E+00	1.642E-26
SR-89	2.157E+06	2.509E+04	6.618E+09	4.815E+08	3.593E+10
SR-90	1.010E+08	0.000E+00	1.117E+11	1.040E+10	1.243E+12
SR-91	1.739E+05	2.511E+06	2.878E+05	5.292E-10	1.157E+06

* Values based on Reference 1, Section 5.3.1 assumptions unless otherwise indicated.

Units: Inhalation - mrem/yr per $\mu Ci/m^3$

Others - $m^2 \cdot$ mrem/yr per $\mu Ci/sec$

POOR ORIGINAL

Table 2.2-4 (Continued)

PATHWAY DOSE FACTORS FOR SECTION 2.2.2.c (R_i)*

AGE GROUP	(CHILD)	(N.A.)	(CHILD)	(CHILD)	(CHILD)
ISOTOPE	INHALATION	GROUND PLANE	GRS/COW/MILK	GRS/COW/MEAT	VEGETATION
SR-92	2.424E+05	8.631E+05	4.134E+01	3.492E-48	1.378E+04
Y-90	2.679E+05	5.308E+03	9.171E+05	4.879E+05	6.569E+07
Y-91M	2.812E+03	1.161E+05	5.198E-16	0.000E+00	1.737E-05
Y-91	2.627E+06	1.207E+06	5.199E+06	2.400E+09	2.484E+09
Y-92	2.390E+05	2.142E+05	7.310E+00	6.959E-35	4.576E+04
Y-93	3.885E+05	2.534E+05	1.573E+04	1.547E-07	4.482E+06
ZR-95	2.231E+06	2.837E+08	8.786E+05	6.106E+08	8.843E+06
ZR-97	3.511E+05	3.445E+06	4.199E+04	7.015E-01	1.248E+07
NB-95	6.142E+05	1.605E+08	2.287E+08	2.228E+09	2.949E+08
MO-99	1.354E+05	4.626E+06	1.738E+09	2.456E+05	1.647E+07
TC-99M	4.810E+03	2.199E+05	1.474E+04	6.915E-18	5.255E+03
TC-101	5.846E+02	2.277E+04	5.593E-58	0.000E+00	4.123E-29
RU-103	6.623E+05	1.265E+08	1.108E+05	4.009E+09	3.971E+08
RU-105	9.953E+04	7.212E+05	2.493E+00	5.885E-25	5.981E+04
RU-106	1.432E+07	5.049E+08	1.437E+06	6.902E+10	1.159E+10
AG-110M	5.476E+06	4.019E+09	1.678E+10	6.742E+08	2.581E+09
TE-125M	4.773E+05	2.128E+06	7.377E+07	5.690E+08	3.506E+08
TE-127M	1.480E+06	1.083E+05	5.932E+08	5.060E+09	3.769E+09
TE-127	5.624E+04	3.293E+03	1.151E+05	1.607E-08	3.903E+05
TE-129M	1.761E+06	2.305E+0[illegible]	7.961E+09	5.245E+09	2.460E+09
TE-129	2.549E+04	3.076E+04	6.166E-28	0.000E+00	7.204E-02
TE-131M	3.078E+05	9.459E+06	2.244E+07	9.815E+03	2.163E+07
TE-131	2.054E+03	3.450E+07	9.489E-32	0.000E+00	1.949E-14
TE-132	3.774E+05	4.968E+06	4.551E+07	9.325E+06	3.111E+07
I-130	1.846E+06	6.692E+06	3.845E+08	6.758E-04	1.370E+03

Units: Inhalation – mrem/yr per $\mu Ci/m^3$

Others – $m^2 \cdot$ mrem/yr per μCi/sec

POOR ORIGINAL

Table 2.2-4 (Continued)

PATHWAY DOSE FACTORS FOR SECTION 2.2.2.c (R_i)*

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AGE GROUP	(CHILD)	(N.A.)	(CHILD)	(CHILD)	(CHILD)
ISOTOPE	INHALATION	GROUND PLANE	GRS/COW/MILK	GRS/COW/MEAT	VEGETATION
I-131	1.624E+07	2.089E+07	4.333E+11	5.503E+09	4.754E+10
I-132	1.935E+05	1.452E+06	5.129E+01	2.429E-57	7.314E+03
I-133	3.848E+06	2.981E+06	3.945E+09	1.304E+02	8.113E+08
I-134	5.069E+04	5.305E+05	3.624E-10	0.000E+00	6.622E-03
I-135	7.918E+05	2.947E+06	8.607E+06	1.039E-14	9.973E+05
CS-134	1.014E+06	8.007E+03	3.715E+10	1.513E+09	2.631E+10
CS-136	1.709E+05	1.702E+08	2.773E+09	4.426E+07	2.247E+08
CS-137	9.065E+05	1.201E+10	3.224E+10	1.334E+09	2.392E+10
CS-138	8.399E+02	4.102E+05	5.528E-23	0.000E+00	9.133E-11
BA-139	5.772E+04	1.194E+05	1.231E-05	0.000E+00	2.950E+00
BA-140	1.743E+06	2.346E+07	1.171E+08	4.384E+07	2.767E+08
BA-141	2.919E+03	4.734E+04	1.210E-45	0.000E+00	1.605E-21
BA-142	1.643E+03	5.064E+04	0.000E+00	0.000E+00	4.105E-39
LA-140	2.257E+05	2.180E+07	1.894E+05	5.492E+02	3.166E+07
LA-142	7.585E+04	8.886E+05	2.904E-06	0.000E+00	1.582E+01
CE-141	5.439E+05	1.540E+07	1.361E+07	1.382E+07	4.082E+08
CE-143	1.273E+05	2.627E+06	1.488E+06	2.516E+02	1.364E+07
CE-144	1.195E+07	8.832E+07	1.326E+08	1.893E+08	1.039E+10
PR-143	4.329E+05	0.000E+00	7.754E+05	3.609E+07	1.575E+08
PR-144	1.565E+03	2.112E+03	2.040E-50	0.000E+00	3.829E-23
ND-147	3.282E+05	1.009E+07	5.712E+05	1.505E+07	9.197E+07
W-187	9.102E+04	2.740E+06	2.420E+06	2.790E+00	5.380E+06
NP-239	6.401E+04	1.976E+06	9.138E+04	2.232E+03	1.357E+07

Units: Inhalation – mrem/yr per $\mu Ci/m^3$

Others – $m^2 \cdot$ mrem/yr per $\mu Ci/sec$

POOR ORIGINAL

Table 2.2-5

PATHWAY DOSE FACTORS FOR SECTION 2.2.2.c (R_i)*

Page 1 of 3

AGE GROUP	(TEENAGER)	(N.A.)	(TEENAGER)	(TEENAGER)	(TEENAGER)
ISOTOPE	INHALATION	GROUND PLANE	GRS/COW/MILK	GRS/COW/MEAT	VEGETATION
H-3	1.272E+03	0.000E+00	1.014E+03	1.938E+02	2.588E+03
C-14	2.600E+04	0.000E+00	4.859E+08	2.040E+08	3.690E+08
NA-24	1.376E+04	1.385E+07	4.255E+06	1.084E-03	2.389E+05
P-32	1.888E+06	0.000E+00	3.153E+10	3.931E+09	1.608E+09
CR-51	2.096E+04	5.506E+06	8.387E+06	9.471E+05	1.037E+07
MN-54	1.984E+06	1.625E+09	2.875E+07	1.436E+07	9.320E+08
MN-56	5.744E+04	1.068E+06	4.856E-01	8.302E-52	9.451E+02
FE-55	1.240E+05	0.000E+00	4.454E+07	2.382E+08	3.259E+08
FE-59	1.528E+06	3.204E+08	2.861E+08	1.171E+09	9.895E+08
CO-58	1.344E+06	4.464E+08	1.095E+08	1.942E+08	6.034E+08
CO-60	8.720E+06	2.532E+10	3.621E+08	7.602E+08	3.239E+09
NI-63	5.800E+05	0.000E+00	1.182E+10	1.519E+10	1.606E+10
NI-65	3.672E+04	3.451E+05	4.692E+00	1.305E-51	3.966E+02
CU-64	6.144E+04	6.876E+05	3.293E+06	1.713E-05	6.465E+05
ZN-65	1.240E+06	8.583E+08	7.315E+09	8.688E+08	1.471E+09
ZN-69	1.584E+03	0.000E+00	1.760E-11	0.000E+00	2.067E-05
BR-83	3.440E+02	7.079E+03	1.790E-01	5.066E-57	2.911E+00
BR-84	4.328E+02	2.363E+05	2.877E-23	0.000E+00	2.251E-11
BR-85	1.832E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-86	1.904E+05	1.035E+07	4.746E+09	4.101E+08	2.772E+08
RB-88	5.456E+02	3.779E+04	3.886E-45	0.000E+00	3.168E-22
RB-89	3.520E+02	1.452E+05	9.774E-54	0.000E+00	1.247E-26
SR-89	2.416E+06	2.509E+04	2.674E+09	2.545E+08	1.513E+10
SR-90	1.080E+08	0.000E+00	6.612E+10	8.049E+09	7.507E+11
SR-91	2.592E+05	2.511E+06	2.409E+05	5.794E-10	1.291E+06

* Values based on Reference 1, Section 5.3.1 assumptions unless otherwise indicated.

Units: Inhalation – mrem/yr per μCi/m^3

Others – m^2 · mrem/yr per μCi/sec

POOR ORIGINAL

Table 2.2-5 (Continued)

PATHWAY DOSE FACTORS FOR SECTION 2.2.2.c (R_i)*

Page 2 of 3

AGE GROUP	(TEENAGER)	(N.A.)	(TEENAGER)	(TEENAGER)	(TEENAGER)
ISOTOPE:	INHALATION	GROUND PLANE	GRS/COW/MILK	GRS/COW/MEAT	VEGETATION
SR-92	1.192E+05	8.631E+05	2.277E+01	2.516E-48	1.012E+04
Y-90	5.592E+05	5.308E+03	1.074E+06	7.470E+05	1.025E+08
Y-91M	3.200E+03	1.161E+05	5.129E-18	0.000E+00	2.285E-07
Y-91	2.936E+06	1.207E+06	6.475E+26	3.910E+00	3.212E+09
Y-92	1.648E+05	2.142E+05	2.828E+20	3.522E-35	2.360E+04
Y-93	5.792E+05	2.534E+05	1.312E+04	1.688E-07	4.983E+06
ZR-95	2.688E+06	2.837E+08	1.201E+06	1.092E+09	1.253E+09
ZR-97	6.304E+05	3.445E+06	4.225E+04	9.231E-01	1.673E+07
NB-95	7.512E+05	1.605E+08	3.338E+08	4.251E+09	4.551E+08
MO-99	2.688E+05	4.626E+06	1.023E+08	1.892E+05	1.293E+07
TC-99M	6.128E+03	2.109E+05	1.055E+04	6.471E-18	5.011E+03
TC-101	6.672E+02	2.277E+04	3.287E-58	0.000E+00	3.229E-29
RU-103	7.832E+05	1.265E+08	1.513E+05	7.162E+09	5.706E+08
RU-105	9.040E+04	7.212E+05	1.263E+00	3.900E-25	4.039E+04
RU-106	1.608E+07	5.049E+08	1.799E+06	1.130E+11	1.484E+10
AG-110M	6.752E+06	4.019E+09	2.559E+10	1.345E+09	4.031E+09
TE-125M	5.360E+05	2.128E+06	8.863E+07	8.941E+08	4.375E+08
TE-127M	1.656E+06	1.083E+05	3.420E+08	3.816E+09	2.236E+09
TE-127	8.080E+04	3.293E+03	9.572E+04	1.689E-08	4.180E+05
TE-129M	1.976E+06	2.305E+07	4.602E+08	3.966E+09	1.508E+09
TE-129	3.296E+03	3.076E+04	2.196E-09	0.000E+00	3.418E-03
TE-131M	6.208E+05	9.459E+06	2.529E+07	1.447E+04	3.248E+07
TE-131	2.336E+03	3.450E+07	2.879E-32	0.000E+00	6.099E-15
TE-132	4.632E+05	4.960E+06	8.581E+07	2.300E+07	7.818E+07
I-130	1.488E+06	6.692E+06	1.742E+09	4.003E-04	8.276E+07

Units: Inhalation - mrem/yr per μCi/m^3
Others - m^2 · mrem/yr per μCi/sec

POOR ORIGINAL

PATHWAY DOSE FACTORS FOR SECTION 2.2.2.c (R_i)

AGE GROUP	(TEENAGER)	(N.A.)	(TEENAGER)	(TEENAGER)	(TEENAGER)
ISOTOPE	INHALATION	GROUND PLANE	GRS/COW/MILK	GRS/COW/MEAT	VEGETATION
I-131	1.464E+07	2.089E+07	2.195E+11	3.645E+09	3.140E+10
I-132	1.512E+05	1.452E+06	2.242E+01	1.389E-57	4.262E+03
I-133	2.920E+06	2.981E+06	1.674E+09	7.234E+01	4.587E+08
I-134	3.952E+04	5.305E+05	1.583E-10	0.000E+00	3.854E-03
I-135	6.208E+05	2.947E+06	3.777E+06	5.963E-15	5.832E+06
CS-134	1.128E+06	8.007E+09	2.310E+10	1.231E+09	1.671E+10
CS-136	1.936E+05	1.702E+08	1.759E+09	3.671E+07	1.708E+09
CS-137	8.480E+05	1.201E+10	1.781E+10	9.634E+09	1.348E+10
CS-138	8.560E+02	4.102E+05	3.149E-23	0.000E+00	6.935E-11
BA-139	6.464E+03	1.194E+05	7.741E-07	0.000E+00	2.472E-01
BA-140	2.032E+06	2.346E+07	7.483E+07	3.663E+07	2.130E+09
BA-141	3.288E+03	4.734E+04	4.922E-46	0.000E+00	8.699E-22
BA-142	1.912E+03	5.064E+04	0.000E+00	0.000E+00	2.269E-39
LA-140	4.872E+05	2.180E+07	2.291E+05	6.689E+02	5.104E+07
LA-142	1.200E+04	8.886E+05	2.574E-07	0.000E+00	1.868E+00
CE-141	6.136E+05	1.540E+07	1.696E+07	2.252E+07	5.404E+08
CE-143	2.552E+05	2.627E+06	1.671E+06	3.695E+02	2.040E+07
CE-144	1.336E+07	8.032E+07	1.655E+08	3.089E+08	1.326E+10
PR-143	4.832E+05	0.000E+00	9.553E+05	5.817E+07	2.310E+08
PR-144	1.752E+03	2.112E+03	1.238E-53	0.000E+00	3.097E-26
ND-147	3.720E+05	1.009E+07	7.116E+05	2.452E+07	1.424E+08
W-187	1.768E+05	2.740E+06	2.646E+06	3.989E+00	7.839E+06
NP-239	1.320E+05	1.976E+06	1.060E+05	3.387E+03	2.097E+07

Units: Inhalation - mrem/yr per µCi/m^3
Others - m^2 · mrem/yr per µCi/sec

POOR ORIGINAL

Table 2.2-6

PATHWAY DOSE FACTORS FOR SECTION 2.2.2.c (R_i)*

Page 1 of 3

AGE GROUP	(ADULT)	(N.A.)	(ADULT)	(ADULT)	(ADULT)
ISOTOPE	INHALATION	GROUND PLANE	GRS/COW/MILK	GRS/COW/MEAT	VEGETATION
H-3	1.264E+03	0.000E+00	7.781E+02	3.248E+02	2.260E+03
C-14	1.816E+04	0.000E+00	2.634E+08	2.414E+08	2.276E+08
NA-24	1.024E+04	1.385E+07	2.438E+06	1.356E-03	2.690E+05
P-32	1.320E+06	0.000E+00	1.709E+10	4.651E+09	1.403E+09
CR-51	1.440E+04	5.506E+06	7.187E+06	1.772E+06	1.168E+07
MN-54	1.400E+06	1.625E+09	2.578E+07	2.812E+07	9.585E+08
MN-56	2.024E+04	1.068E+06	1.328E-01	4.958E-52	5.082E+02
FE-55	7.208E+04	0.000E+00	2.511E+07	2.933E+09	2.096E+08
FE-59	1.016E+06	3.204E+08	2.326E+08	2.089E+09	9.875E+08
CO-58	9.280E+05	4.464E+08	9.565E+07	3.703E+08	6.252E+08
CO-60	5.968E+06	2.532E+10	3.082E+08	1.413E+09	3.139E+09
NI-63	4.320E+05	0.000E+00	6.729E+09	1.888E+10	1.040E+10
NI-65	1.232E+04	3.451E+05	1.219E+00	7.405E-52	2.026E+02
CU-64	4.896E+04	6.876E+05	6.008E+04	6.825E-07	2.319E+04
ZN-65	8.640E+05	8.583E+08	4.365E+09	1.132E+09	1.009E+09
ZN-69	9.200E+02	0.000E+00	5.207E-12	0.000E+00	1.202E-05
BR-83	2.408E+02	7.079E+03	9.716E-02	6.004E-57	3.107E+00
BR-84	3.128E+02	2.363E+05	1.609E-23	0.000E+00	2.475E-11
BR-85	1.280E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00
RB-86	1.352E+05	1.035E+07	2.604E+09	4.914E+08	2.217E+08
RB-88	3.872E+02	3.779E+04	2.139E-45	0.000E+00	3.428E-22
RB-89	2.560E+02	1.452E+05	5.523E-54	0.000E+00	1.385E-26
SR-89	1.400E+06	2.509E+04	1.451E+09	3.014E+08	9.961E+09
SR-90	9.920E+07	0.000E+00	4.680E+10	1.244E+10	6.046E+11
SR-91	1.912E+05	2.511E+06	1.377E+05	7.233E-10	1.451E+06

* Values based on Reference 1, Section 5.3.1 assumptions unless otherwise indicated.

Units: Inhalation – mrem/yr per μCi/m^3

Others – m^2 · mrem/yr per μCi/sec

POOR ORIGINAL

Table 2.2-6 (Continued)

PATHWAY DOSE FACTORS FOR SECTION 2.2.2.c (R_i)*

Page 2 of 3

AGE GROUP	(ADULT)	(N.A.)	(ADULT)	(ADULT)	(ADULT)
ISOTOPE:	INHALATION	GROUND PLANE	GRS/COW/MILK	GRS/COW/MEAT	VEGETATION
SR-92	4.304E+04	8.631E+05	9.675E+00	2.334E-48	8.452E+03
Y-90	5.056E+05	5.308E+03	7.511E+05	1.141E+06	1.410E+08
Y-91M	1.920E+03	1.161E+05	1.743E-19	0.000E+00	1.527E-08
Y-91	1.704E+06	1.207E+06	4.726E+06	6.231E+08	2.814E+09
Y-92	7.352E+04	2.142E+05	9.772E-01	2.657E-35	1.603E+04
Y-93	4.216E+05	2.534E+05	7.388E+03	2.075E-07	5.517E+06
ZR-95	1.768E+06	2.837E+08	9.587E+05	1.903E+09	1.194E+09
ZR-97	5.232E+05	3.445E+06	2.707E+04	1.292E+00	2.108E+07
NB-95	5.048E+05	1.605E+08	2.786E+08	7.748E+09	4.798E+08
MO-99	2.490E+05	4.626E+06	5.741E+07	2.318E+05	1.426E+07
TC-99M	4.162E+03	2.109E+05	5.553E+03	7.439E-18	5.187E+03
TC-101	3.992E+02	2.277E+04	1.813E-58	0.000E+00	3.502E-29
RU-103	5.048E+05	1.265E+08	1.169E+05	1.229E+10	5.577E+08
RU-105	4.816E+04	7.212E+05	5.240E-01	3.533E-25	3.294E+04
RU-106	9.360E+06	5.049E+08	1.320E+06	1.811E+11	1.247E+10
AG-110M	4.632E+06	4.019E+09	2.198E+10	2.523E+09	3.979E+09
TE-125M	3.136E+05	2.128E+06	6.626E+07	1.460E+09	3.927E+08
TE-127M	9.600E+05	1.083E+05	1.860E+08	4.531E+09	1.418E+09
TE-127	5.736E+04	3.293E+03	5.278E+04	2.034E-08	4.532E+05
TE-129M	1.160E+06	2.305E+07	3.028E+08	5.698E+09	1.261E+09
TE-129	1.936E+03	3.076E+04	9.167E-10	0.000E+00	2.806E-03
TE-131M	5.560E+05	9.459E+06	1.753E+07	2.190E+04	4.429E+07
TE-131	1.392E+03	3.450E+07	1.578E-32	0.000E+00	6.575E-15
TE-132	5.096E+05	4.968E+06	7.324E+07	4.287E+07	1.312E+08
I-130	1.136E+06	6.692E+06	1.050E+08	5.272E-04	9.809E+07

Units: Inhalation – mrem/yr per µCi/m^3

Others – m^2 · mrem/yr per µCi/sec

POOR ORIGINAL

Table 2.2-6 (Continued)

PATHWAY DOSE FACTORS FOR SECTION 2.2.2.c (R_i)*

Page 3 of 3

AGE GROUP	(ADULT)	(N.A.)	(ADULT)	(ADULT)	(ADULT)
ISOTOPE	INHALATION	GROUND PLANE	GRS/COW/MILK	GRS/COW/MEAT	VEGETATION
I-131	1.192E+07	2.089E+07	1.388E+11	5.034E+09	3.785E+10
I-132	1.144E+05	1.452E+06	1.342E+01	1.816E-57	5.016E+03
I-133	2.152E+06	2.981E+06	9.891E+08	9.336E+01	5.331E+08
I-134	2.984E+04	5.305E+05	9.491E-11	0.000E+00	4.544E-03
I-135	4.480E+05	2.947E+06	2.217E+06	7.644E-15	6.731E+06
CS-134	8.480E+05	8.007E+09	1.345E+10	1.565E+09	1.110E+10
CS-136	1.464E+05	1.702E+08	1.036E+09	4.724E+07	1.675E+09
CS-137	6.208E+05	1.201E+10	1.010E+10	1.193E+09	8.696E+09
CS-138	6.208E+02	4.102E+05	1.786E-23	0.000E+00	7.730E-11
BA-139	3.760E+03	1.194E+05	8.322E-08	0.000E+00	5.225E-02
BA-140	1.272E+06	2.346E+07	5.535E+07	5.917E+07	2.646E+08
BA-141	1.936E+03	4.734E+04	2.677E-46	0.000E+00	9.305E-22
BA-142	1.192E+03	5.064E+04	0.000E+00	0.000E+00	2.463E-39
LA-140	4.584E+05	2.180E+07	1.672E+05	1.385E+03	7.327E+07
LA-142	6.328E+03	8.886E+05	3.503E-08	0.000E+00	4.999E-01
CE-141	3.616E+05	1.540E+07	1.253E+07	3.632E+07	5.097E+08
CE-143	2.264E+05	2.627E+06	1.149E+06	5.547E+02	2.758E+08
CE-144	7.776E+05	8.032E+07	1.209E+08	4.928E+09	1.112E+10
PR-143	2.808E+05	0.000E+00	6.923E+05	9.204E+07	2.748E+08
PR-144	1.016E+03	2.112E+03	6.716E-54	0.000E+00	3.303E-26
ND-147	2.208E+05	1.009E+07	5.231E+05	3.935E+07	1.853E+08
W-187	1.552E+05	2.740E+06	1.796E+06	5.912E+00	1.046E+07
NP-239	1.192E+05	1.976E+05	7.385E+04	5.152E+03	2.872E+07

Units: Inhalation – mrem/yr per $\mu Ci/m^3$

Others – $m^2 \cdot$ mrem/yr per $\mu Ci/sec$

POOR ORIGINAL

Table 2.2-7

CONTROLLING RECEPTORS, LOCATIONS, AND PATHWAYS*

SECTOR	DISTANCE (METERS)	PATHWAY	AGE GROUP	ORIGIN (FOR INFORMATION ONLY)
N	6,196	Vegetation	Child	-Vegetable Garden
NNE	4,748	Vegetation	Child	-Vegetable Garden
NE	2,414	Vegetation	Child	-Vegetable Garden
ENE	2,237	Vegetation	Child	-Vegetable Garden
E	2,446	Vegetation	Child	-Vegetable Garden
ESE	1,770	Vegetation	Child	-Vegetable Garden
SE	2,173	Vegetation	Child	-Vegetable Garden
SSE	2,494	Grass/Cow/Meat	Child	-Nearest Cow
S	6,360	Vegetation	Child	-Vegetable Garden
SSW	5,472	Vegetation	Child	-Vegetable Garden
SW	4,909	Vegetation	Child	-Vegetable Garden
WSW	2,446	Grass/Cow/Meat	Child	-Nearest Cow
W	4,458	Vegetation	Child	-Vegetable Garden
WNW	4,023	Grass/Cow/Meat	Child	-Nearest Cow
NW	6,437	Grass/Cow/Milk	Infant	-Nearest Milk Cow
NNW	4,506	Vegetation	Child	-Vegetable Garden

* Table based on Reference 5, Table 2.1-7; and Reference 1, Section 5.3

Table 2.2-8

ATMOSPHERIC DISPERSION PARAMETERS FOR CONTROLLING RECEPTOR LOCATIONS*

SECTOR	X/Q	D/Q	DISTANCE (MILES)
N	2.35E-7	6.80E-10	3.85
NNE	4.40E-7	1.55E-9	2.95
NE	1.90E-6	7.50E-9	1.50
ENE	1.90E-6	7.90E-9	1.39
E	1.40E-6	5.40E-9	1.52
ESE	2.80E-6	8.80E-9	1.10
SE	2.50E-6	6.80E-9	1.35
SSE	1.30E-6	4.20E-9	1.55
S	2.40E-7	3.60E-10	3.95
SSW	3.00E-7	6.50E-10	3.40
SW	4.40E-7	1.25E-9	3.05
WSW	1.30E-6	5.50E-9	1.52
W	3.00E-7	8.50E-10	2.77
WNW	3.00E-7	9.10E-10	2.50
NW	1.60E-7	4.20E-10	4.00
NNW	3.10E-7	1.15E-9	2.80

* Table based on Reference 4, Table 2.3-119; and Reference 5, Tables 6.1-10 through 6.1-14.

2.3 Meteorological Model

2.3.1 Atmospheric dispersion for all releases is calculated using a ground-level, wake-split form of the straight line flow model.

X/Q = atmospheric dispersion (sec/m^3)

$\overline{X/Q}$ = average atmospheric dispersion (sec/m^3) for a given wind direction (sector).

$$= 2.032\delta T \sum_{ij} \frac{n_{ij}}{Nr\bar{u}_i \Sigma_{zj}} \quad (31)$$

2.032 = $(2/\pi)^{1/2}$ divided by the width in radians of a 22.5° sector (0.3927 radians).

δ = plume depletion factor at distance r for the appropriate stability class from Figure 2.3-1; (radioiodines and particulates).

n_{ij} = number of hours meteorological conditions are observed to be in a given wind direction, windspeed class i, and atmospheric stability class j.

N = total hours of valid meteorological data.

r = distance from the containment building to location of interest (m)

$\bar{u}_i$ = wind speed (midpoint of windspeed class i) at ground level (m/sec).

Σ_z = the lesser of $\begin{cases} (\sigma_z^2 + b^2/2\pi)^{1/2} & (32) \\ \text{or} & \\ \sqrt{3}\ \sigma_z) \quad \text{where,} & (33) \end{cases}$

σ_z = vertical standard deviation of the plume (in m) at distance r for ground level releases under the stability category indicated by $\dot{T}$, from Figure 2.3-2.

T = terrain recirculation factor, from Figure 2.3-4

π = 3.1416

b = height of the containment building (50.9M)

$\dot{T}$ = temperature differential with vertical separation (°k/100M).

2.3.2 Relative deposition per unit area for all releases is calculated for a ground-level release.

D/Q = relative deposition per unit area (m^{-2})

$\overline{D/Q}$ = relative deposition per unit area (m^{-2}), for a given wind direction.

$$= \frac{2.55\ D_g\ n}{r\ N} \quad \text{where,} \qquad (34)$$

D_g = deposition rate for ground-level releases relative to distance (r) from the containment building (from Figure 2.3-3).

2.55 = the inverse of the number of radians in a 22.5° sector $\left(\frac{1}{(22.5^\circ)(0.0175\ \text{Radians}/^\circ)}\right)$

n = number of hours wind is in given direction (sector).

N = total hours of valid meteorological data.

Figure 2.3-1 Plume Depletion Effect for Ground Level Releases (6)
(All Atmospheric Stability Classes)

Graph taken from Reference 8, Figure 2

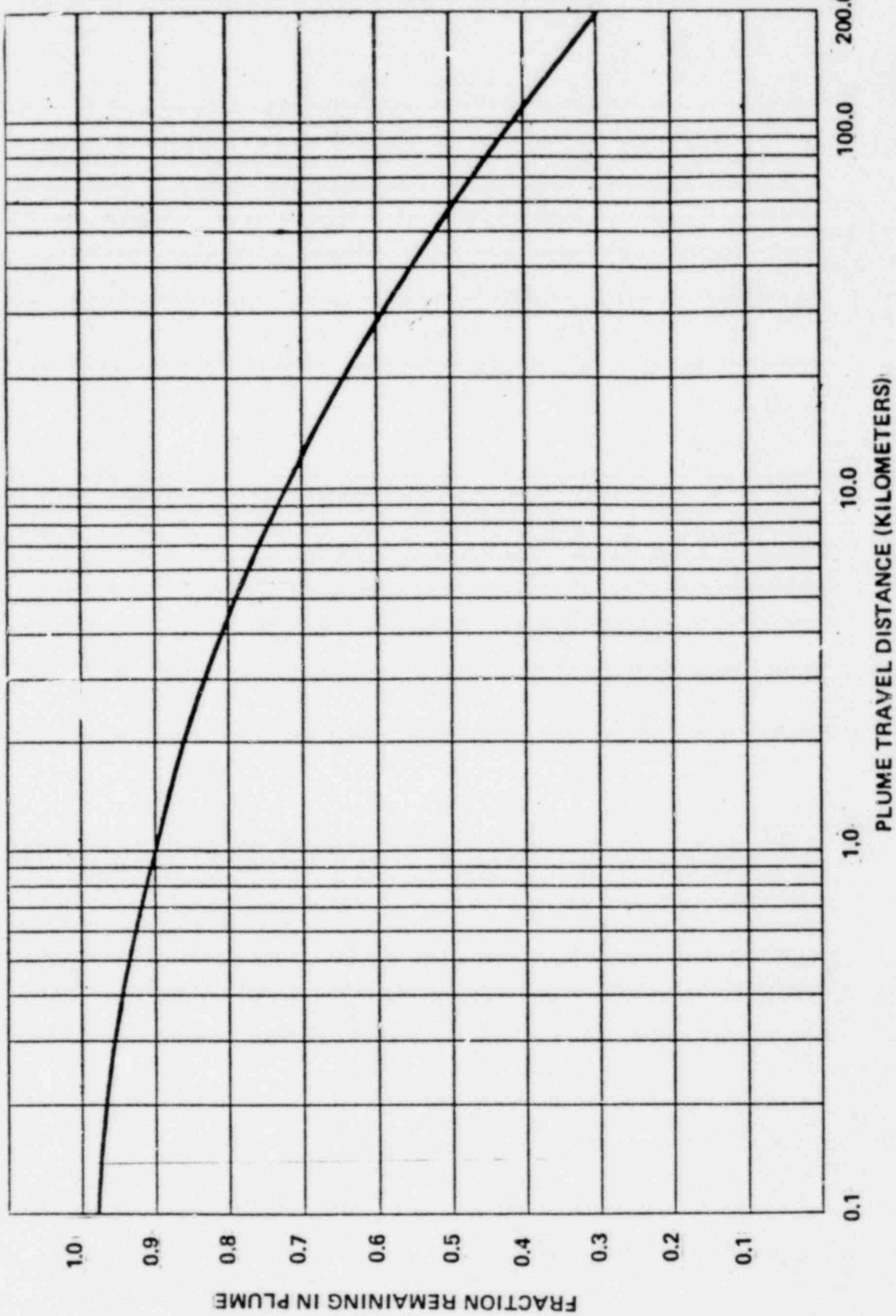
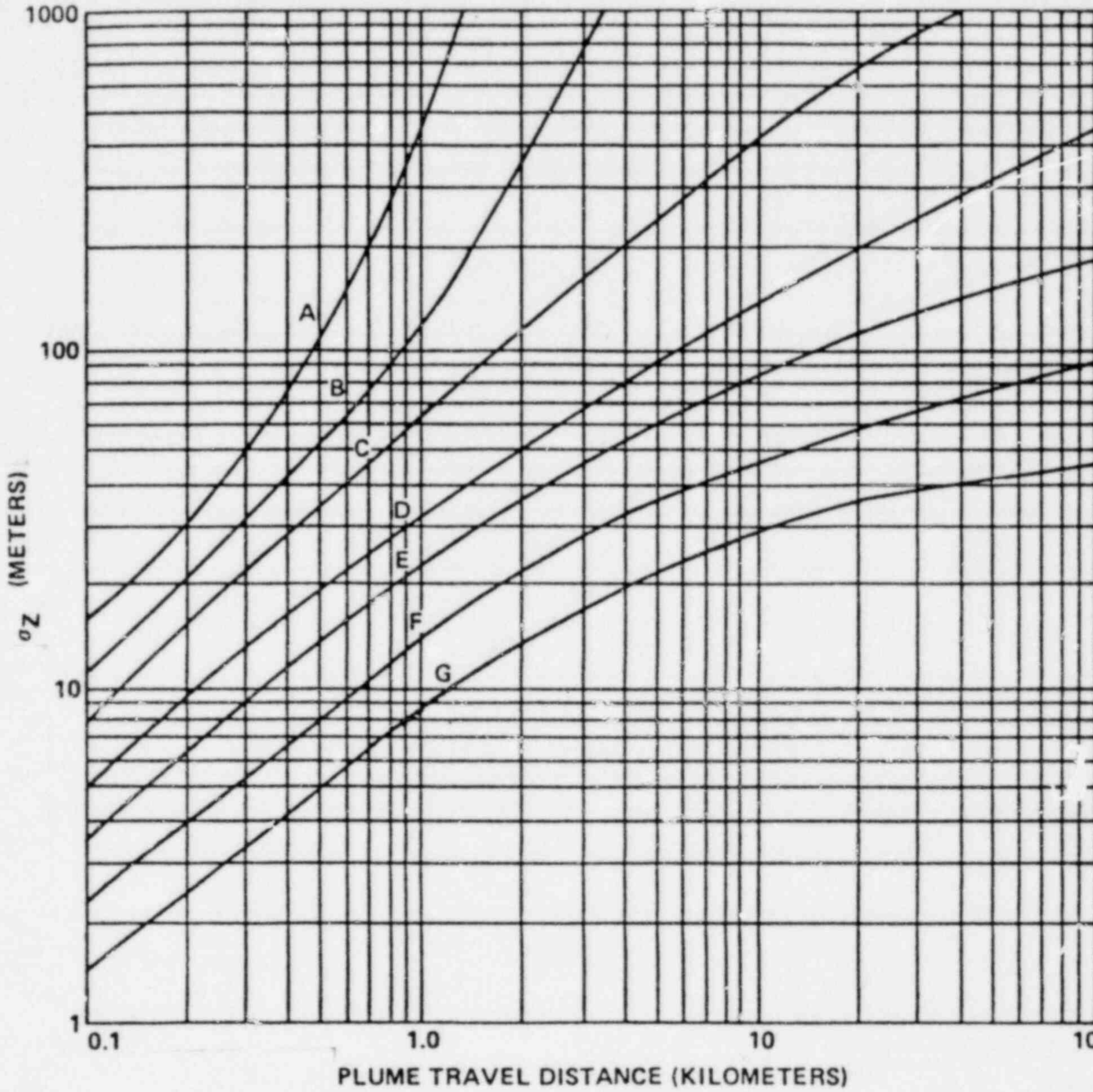


Figure 2.3-2 Vertical Standard Deviation of Material in a Plume (σ_Z)
(Letters denote Pasquill Stability Class)
Graph taken from Reference 8, Figure 1



Temperature Change with Height ($\dot{T}$)(^oK/100m)	Pasquill Categories	Stability Classification
<-1.9	A	Extremely unstable
-1.9 to -1.7	B	Moderately unstable
-1.7 to -1.5	C	Slightly unstable
-1.5 to -0.5	D	Neutral
-0.5 to 1.5	E	Slightly stable
1.5 to 4.0	F	Moderately stable
> 4.0	G	Extremely stable

Figure 2.3-3 Relative Deposition for Ground-Level Releases (D_g)
(All Atmospheric Stability Classes)

Graph taken from Reference 8, Figure 6

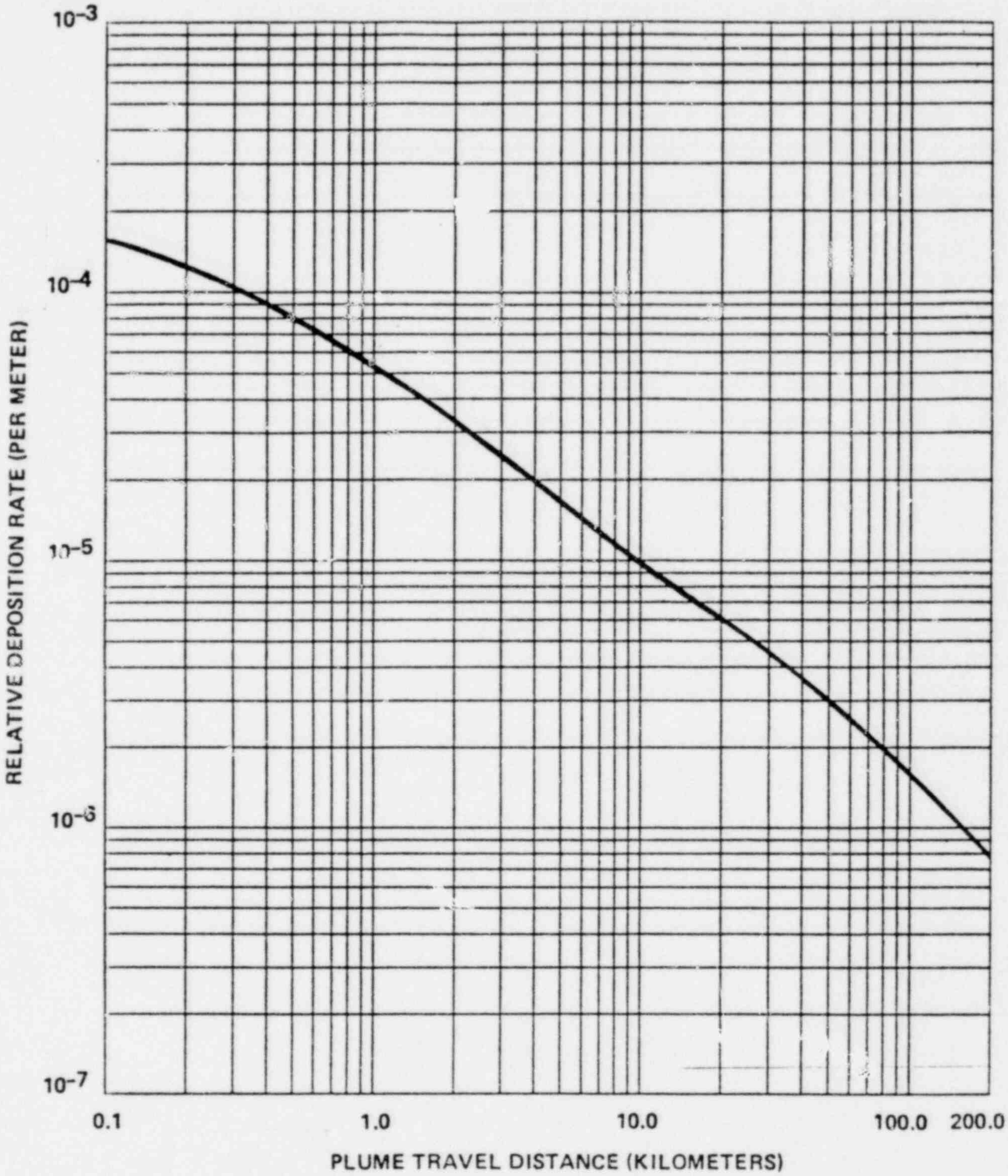
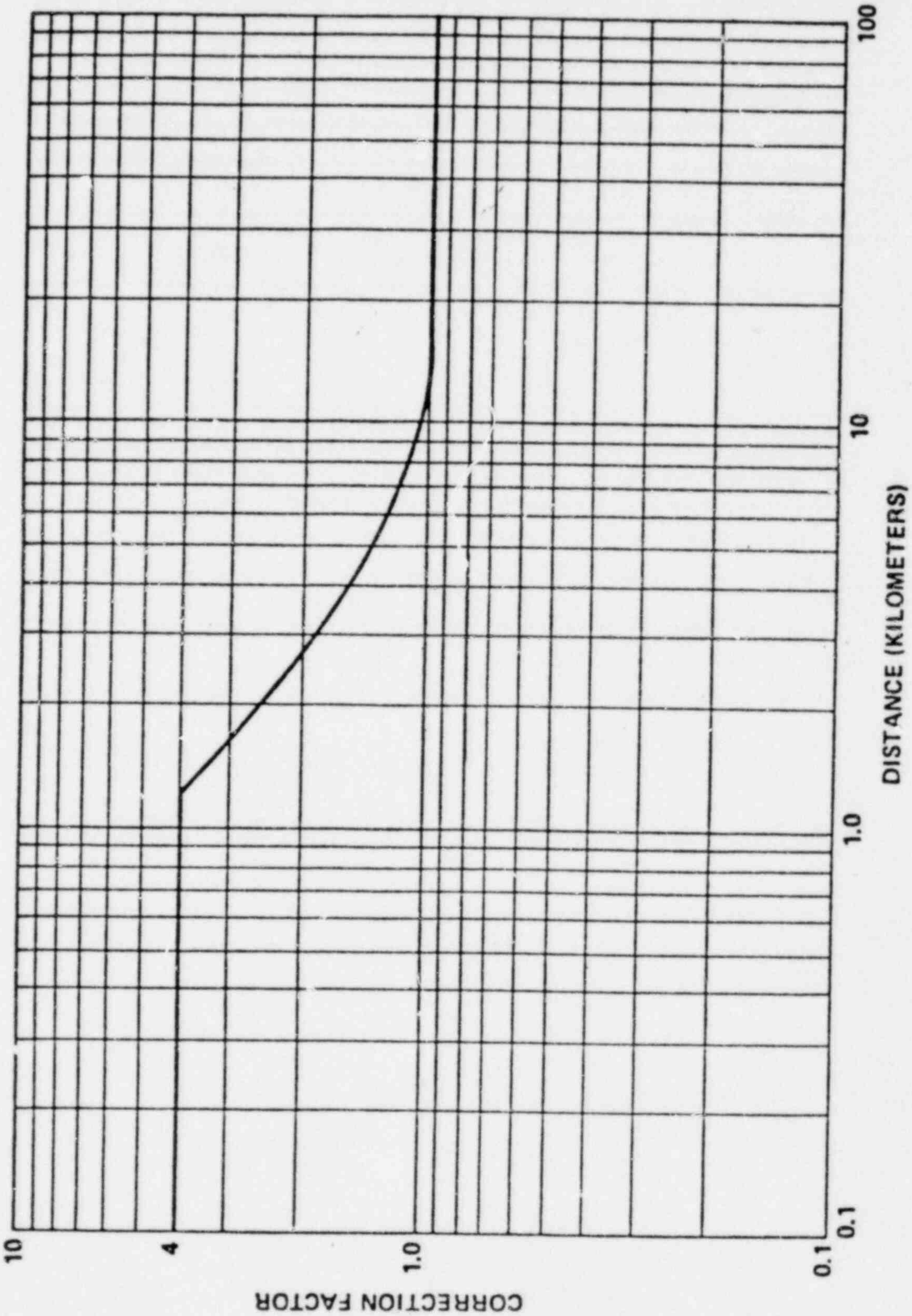


Figure 2.3-4

Open Terrain Recirculation Factor

Graph taken from Reference 7, Figure 2



2.4 Definitions of Gaseous Effluents Parameters

Term		Definition	Section of Initial Use
b	=	height of the containment building.	(2.3.1)
C	=	count rate of a station vent monitor corresponding to grab sample radionuclide concentrations.	(2.1.1)
c	=	count rate of the gas decay system monitor for radionuclide concentrations to be discharged.	(2.1.2)
D_g	=	deposition rate for ground-level releases relative to the distance from the containment building (from Figure 2.3-3).	(2.3.2)
D_o	=	average organ dose rate in the current year (mrem/yr)	(2.2.1.b)
D_p	=	dose to an individual from radioiodines and radionuclides in particulate form, and radio nuclides (other than noble gases) with half-lives greater than eight days (mrem).	(2.2.2.b)
D_s	=	average skin dose rate in current year (mrem/yr)	(2.2.1.a)
D_t	=	average total body dose rate in the current year (mrem/yr)	(2.2.1.a)
D_β	=	air dose due to beta emissions from noble gas radionuclide i (mrad)	(2.2.2.a)
D_γ	=	air dose due to gamma emissions from noble gas radionuclide i (mrad)	(2.2.2.a)
D/Q	=	relative deposition per unit area (m^{-2})	(2.3.2)

2.4 Definitions of Gaseous Effluents Parameters (Continued)

Term		Definition	Section of Initial Use
$\overline{D/Q}$	=	sector annual average relative deposition $(m^2)^{-1}$, based on X/Q.	(2.3.2)
	=	specific value at unrestricted area boundary.	(2.2.1.b)
$\overline{D/Q'}$	=	relative deposition for unrestricted areas per unit area $(m^2)^{-1}$ for long term releases.	(2.2.2.b)
δ	=	plume depletion factor at distance r for the appropriate stability class from Figure 2.3-1; (radioiodines and particulates).	(2.3.1)
F	=	Fraction of current year elapsed at the time of calculation.	(2.1.1)
K_i	=	total body dose factor due to gamma emissions from isotope i (mrem/year per $\mu Ci/m^3$) from Table 2.1-1.	(2.1.1)
K_{Kr-89}	=	total body dose factor for Kr-89, the most restrictive isotope from Table 2.1-1.	(2.1.2)
L_i	=	Skin dose factor due to beta emissions from isotope i (mrem/yr per $\mu Ci/m^3$) from Table 2.1-1	(2.1.1)
L_{Kr-89}	=	Skin dose factor for Kr-89, the most restrictive isotope, from Table 2.1-1	(2.1.2)
M_i	=	air dose factor due to gamma emissions from isotope i (mrad/yr per $\mu Ci/m^3$) from Table 2.1-1.	(2.1.1)
M_{Kr-89}	=	air dose factor for Kr-89, the most restrictive isotope, from Table 2.1-1	(2.1.2)

2.4 Definitions of Gaseous Effluents Parameters (Continued)

Term		Definition	Section of Initial Use
N_i	=	air dose factor due to beta emissions from noble gas radionuclide i (mrad per $\mu Ci/m^3$) from Table 2.1-1.	(2.2.2.a)
n_{ij}	=	number of hours meteorological conditions are observed to be in a given wind direction, wind-speed class i, and atmospheric stability class j.	(2.3.1)
N	=	total hours of valid meteorological data.	(2.3.1)
P_i	=	dose parameter for radionuclide i, (mrem/yr per $\mu Ci/m^3$) for inhalation and all tritium pathways; and (m^2-mrem/yr per $\mu Ci/sec$) for other pathways, from Table 2.2-1.	(2.2.1.b)
Q_i	=	rate of release of noble gas radionuclide i ($\mu Ci/sec$)	(2.1.1)
$\overline{Q_i}$	=	average rate of release of noble gas radionuclide i for the elapsed fraction of the year, F, ($\mu Ci/sec$).	(2.1.1)
$\overline{Q_i}'$	=	average release rate of isotope i of radioiodine or other radionuclides in particulate form and radionuclides (other than noble gases), with a half-life greater than eight (8) days, in the current year ($\mu Ci/sec$)	(2.2.1.b)
$\widetilde{Q}_i$	=	cumulative release of noble gas radionuclide i over the period of interest (μCi).	(2.2.2.a)
$\widetilde{Q}_i'$	=	cumulative release of radionuclide i of iodine or material in particulate form over the period of interest (μCi).	(2.2.2.b)

2.4 Definitions of Gaseous Effluents Parameters (Continued)

Term		Definition	Section of Initial Use
q_i	=	rate of release of noble gas radionuclide i (μCi/sec) from the waste gas decay system.	(2.1.2)
$\overline{q}_i$	=	average rate of release of noble gas radionuclide i from the waste gas decay system for the elapsed fraction of the year, F, (μCi/sec)	(2.1.2)
R_i	=	dose factor for radionuclide i, (mrem/yr per $\mu Ci/m^3$) or (m^2-mrem/yr per μCi/sec) from Tables 2.2-2 throught 2.2-6.	(2.2.2.b)
R_s	=	count rate per mrem/yr to the skin.	(2.1.1)
R_t	=	count rate per mrem/yr to the total body.	(2.1.1)
D_{TB}	=	limiting dose rate to the total body based on the limit of 500 mrem in one year.	(2.1.1)
D_{ss}	=	limiting dose rate to the skin based on the limit of 3000 mrem in one year.	(2.1.1)
r	=	distance from the containment building to the location of interest for dispersion calculations (m).	(2.3.1)
r_s	=	count rate per mrem/yr to the skin for the waste gas decay system monitor only.	(2.1.2)
r_t	=	count rate per mrem/yr to the total body for the waste gas decay system monitor only.	(2.1.2)
D'_{TB}	=	limiting dose rate to the total body based on the limit of 500 mrem in one year (waste gas decay system).	(2.1.2)

2.4 Definitions of Gaseous Effluents Parameters (Continued)

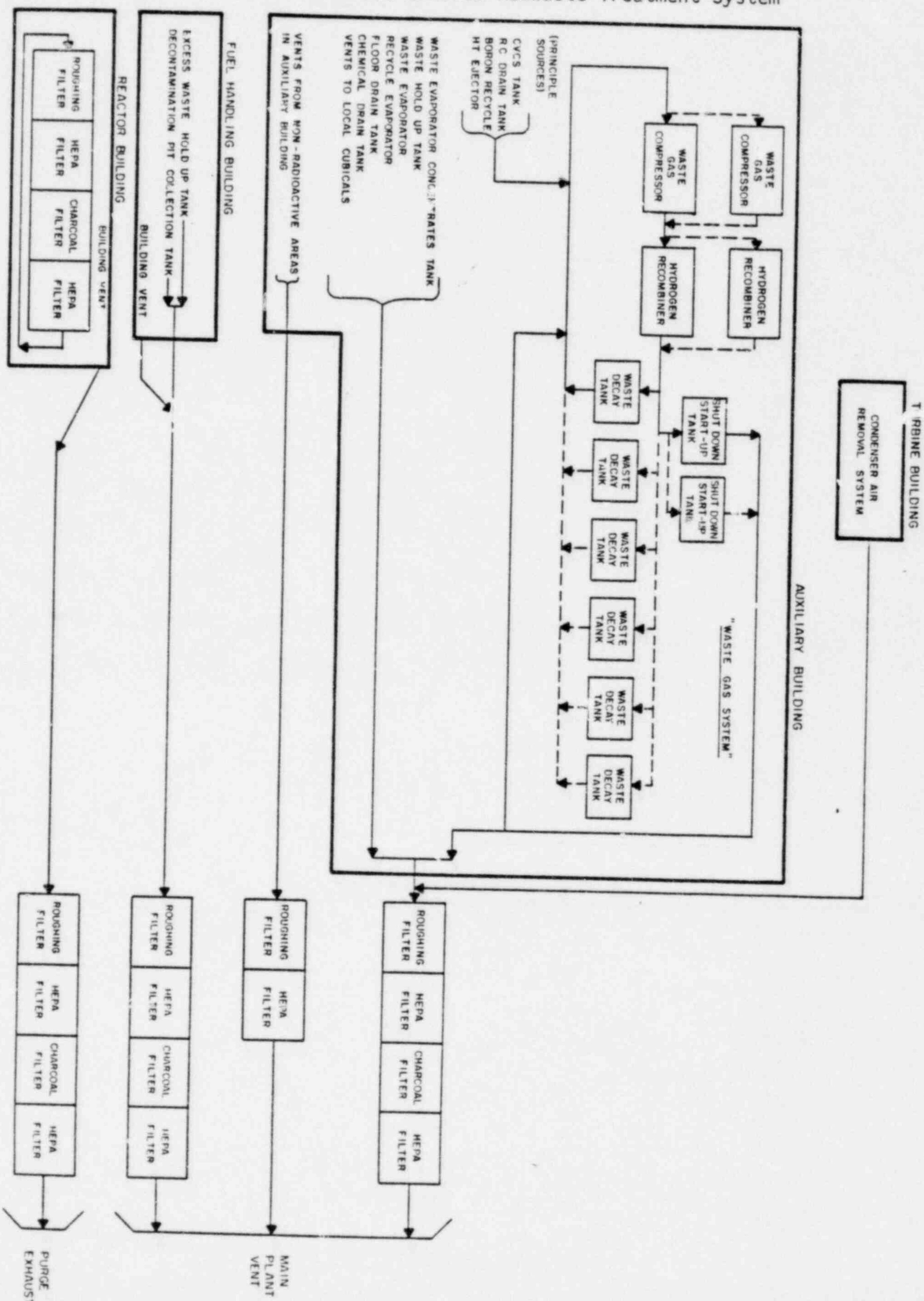
Term	Definition	Section of Initial Use
D'_{ss}	= limiting dose rate to the skin based on the limit of 3000 mrem in one year (waste gas decay system).	(2.1.2)
R_s'	= conservative count rate per mrem to the skin (Xe-133 detection, Kr-89 dose).	(2.1.3)
R_t'	= conservative count rate per mrem to the total body (Xe-133 detection, Kr-89 dose).	(2.1.3)
r_s'	= conservative count rate per mrem to the skin for the waste gas decay system only.	(2.1.3)
r_t'	= conservative count rate per mrem to the total body for the waste gas decay system only.	(2.1.3)
D''_{TB}	= limiting dose rate to the total body based on the conservative dose rate of 500 mrem/year.	(2.1.3)
D''_{ss}	= limiting dose rate to the skin based on the conservative dose rate of 3000 mrem/year.	(2.1.3)
S_d	= count rate of the waste gas decay system noble gas monitor at the alarm setpoint.	(2.1.2)
S_v	= count rate of a station vent noble gas monitor at the alarm setpoint.	(2.1.1)
S_{vc}	= count rate of the containment purge noble gas monitor at the alarm setpoint.	(2.1.1)
S_{vp}	= count rate of the plant vent noble gas monitor at the alarm setpoint.	(2.1.1)

2.4 Definitions of Gaseous Effluents Parameters (Continued)

Term		Definition	Section of Initial Use
Σ_z	=	vertical standard deviation of the plume with building wake correction.	(2.3.1)
σ_z	=	vertical standard deviation of the plume (in m), at distance r for ground level releases under the stability category indicated by $\dot{T}$, from Figure 2.3-2.	(2.3.1)
$\dot{T}$	=	temperature differential with vertical separation (°K/100m).	(2.3.1)
T	=	terrain recirculation factor, Figure 2.3-4.	(2.3.1)
$\bar{u}_i$	=	wind speed (midpoint of windspeed class i) at ground level (m/sec).	(2.3.1)
W	=	controlling sector annual atmospheric dispersion at the site boundary for the appropriate pathway.	(2.2.1.b)
W'	=	relative dispersion for unrestricted areas.	(2.2.2.b)
X/Q	=	atmospheric dispersion (sec/m^3).	(2.3.1)
$\overline{X/Q}$	=	sector annual average atmospheric dispersion (sec/m^3).	(2.3.1)
	=	specific value at unrestricted area boundary	(2.1.1)
$\overline{X/Q}'$	=	relative concentration for unrestricted areas (sec/m^3) for long term releases.	(2.2.2.a)

2.5 Gaseous Radwaste Treatment System

Figure 2.5-1 Minimum OPERABLE Gaseous Radwaste Treatment System



3.0 RADIOLOGICAL ENVIRONMENTAL MONITORING

Sampling locations as required in section 3/4.12.1 of the Radiological Effluent Technical Specifications are described in Table 3.0-1 and shown on the maps in Figures 3.0-1 and 3.0-2.

TABLE 3.0-1 1

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
VIRGIL C. SUMMER NUCLEAR STATION

Exposure Pathway and/or Sample	Criteria for Selection of Sample Number and Location	Sampling and Collection Frequency	Sample Locations: Location(1)	Sample Locations: Mi/Dir	Type and Frequency of Analysis
AIRBORNE					
I. Particulates	A 3 Indicator samples to be taken at locations (in different sectors) beyond but as close to the exclusion boundary as practicable where the highest offsite sectoral ground level concentrations are anticipated.(2)	Continuous sampler operation with weekly collection.	2 5 10	1.1 SW 1.3 SE 2.4 NNE	Gross beta following filter change; Monthly composite (by location) for gamma isotopic.
	B 1 Indicator sample to be taken in the sector beyond but as close to the exclusion boundary as practicable corresponding to the residence having the highest anticipated offsite ground level concentration or dose.(2)		6	1.1 ESE	
	C 1 Indicator sample to be taken at the location of one of the dairies most likely to be affected.(2) (4)		14(4)	5.2 W	1 4

Exposure Pathway and/or Sample	Criteria for Selection of Sample Number and Location	Sampling and Collection Frequency	Sample Locations: Location(1)	Sample Locations: Mi/Dir	Type and Frequency of Analysis	
AIRBORNE, (continued)	D 2 Control samples to be taken at locations at least 10 air miles from the site and not in the most prevalent wind directions.(2)		17 16	24.7 SE 28.0 W		1
II. Radioiodine	A 3 Indicator samples to be taken at two locations as given in I.A above.	Continuous sampler operation with weekly cannister collection.	2 5 10	1.1 SW 1.3 SE 2.4 NNE	Gamma isotopic screening of all five indicators with conjunctive screening of the two controls. If screening is positive, each sample will be subjected to isotopic analysis for iodine.	
	B 1 Indicator sample to be taken at the location as given in I.B above.		6	1.1 ESE		
	C 1 Indicator sample to be taken at the location as given in I.C above.		14	5.2 W		4 1
	D 2 Control samples to be taken at locations similar in nature to A-C above.		17 16	24.7 SE 28.0 W		1

Exposure Pathway and/or Sample	Criteria for Selection of Sample Number and Location	Sampling and Collection Frequency	Sample Locations Location	Mi/Dir	Type and Frequency of Analysis
AIRBORNE, (continued)					
III. Direct	A. 5 Indicator samples to be taken at the locations as given in I.A through D above.	Monthly exchange.(5) Two or more dosimeters at each location.	#'s 2, 5, 6, 10, and 14		Gamma dose monthly(5)
	B. 3 Additional indicator samples to be taken in sectors different from III.A above, beyond but as close to the exclusion boundary as practicable.		1 4 8	1.3 S 1.2 NW 1.3 ENE	
	C. Control samples to be taken at the locations as given at I.D above.		16 17	28.0 W 24.7 SE	
	D. 1 Additional control sample to be taken at a location as set forth in I.D above		18	16.5 S	
	E. Additional Sites		3 7 9 11 12 13 15 19 20	.8 WSW 1.7 E 2.6 NE 3.6 NNE 4.3 N 2.9 NNW 2.3 SSW 17.9 ESE 22.0 NW	
	F. Accident Evaluation Quarterly Exchange (7) Program	Quarterly exchange.(5) Two or more dosimeters at each location.	41 42 43 44 45 46 47	3.7 S 3.6 SSW 4.7 SW 2.3 WSW 5.4 WSW 3.7 WNW 1.0 NW	Gamma dose quarterly.

Exposure Pathway and/or Sample	Criteria for Selection of Sample Number and Location	Sampling and Collection Frequency	Sample Locations Location Mi/Dir	Type and Frequency of Analysis
AIRBORNE, (Continued) III. Direct	F. (Continued)		48 2.4 NW 49 4.6 NNW 50 5.6 N 51 5.6 N 52 4.3 NNE 53 3.6 NE 54 2.2 ENE 55 3.2 E 56 2.0 ESE 57 2.7 SE 58 2.4 SSE 59 2.1 SSE 60 5.7 WSW	
WATERBORNE				
IV. Surface Water	A. 1 Indicator sample to be taken at a location which allows for mixing and dilution in the ultimate receiving river.	Time composite samples with collection every month (corresponds to USG continuous sampling site).(5)	21(3)(6) 2.7 SSE	Gamma isotopic with quarterly composite (by location) to be analyzed for tritium.(7)

Exposure Pathway and/or Sample	Criteria for Selection of Sample Number and Location	Sampling and Collection Frequency	Sample Locations: Location(1)	Sample Locations: Mi/Dir	Type and Frequency of Analysis	
WATERBORNE, (continued)	B 1 Control sample to be taken at a location on the receiving river, sufficiently far upstream such that no effects of pumped storage operation are anticipated.		22(3)	12-15 NNW		1
	C 1 Indicator sample from location immediately upstream of the nearest downstream municipal water supply		17	24.7 S		5
	D 1 Indicator sample to be taken in the upper reservoir of the pumped storage facility.	Grab sampling monthly (5)	23(3)	<1 E	As in V above.	1 4
	E 1 Indicator sample to be taken in the upper reservoir's non-fluctuating recreational area.		24(3)	4.7 N		1
	F 1 Control sample to be taken at a location on a separated unaffected watershed reservoir.		18(3)	16.5 S		1
V. Ground Water	A 2 Indicator samples to be taken within the exclusion boundary and in the direction of potentially affected ground water supplies.	Quarterly grab sampling(7)	26 27	Onsite Onsite	Gamma isotopic and tritium analyses quarterly.(7)	1 4

Exposure Pathway and/or Sample	Criteria for Selection of Sample Number and Location	Sampling and Collection Frequency	Sample Locations: Location[1]	Sample Locations: Mi/Dir	Type and Frequency of Analysis	
WATERBORNE, (continued)	B 1 Control sample from an unaffected location.		16	28.0 W		1
VI. Drinking Water	A 1 Indicator sample from nearby public ground water supply source.	Monthly grab sampling[5]	28	1.3 ESE	Monthly[5] gamma isotopic and gross Beta analyses and quarterly[7] tritium analyses	1 4
	B 1 Indicator (finished water) sample from the nearest downstream water supply.	Monthly grab sampling[5]	17	24.7 S		5
INGESTION						
VII. Milk[5]	A 1 Indicator sample to be taken at the location of one of the dairies most likely to be affected.[2] [5]	Semi-monthly when animals are on pasture,[8] monthly other times.[5]	14[4]	5.2 W	Gamma isotopic and I-131 analysis semi-monthly[8] when animals are on pasture; monthly[5] at other times	1 4
	B 1 Control sample to be taken at the location of a dairy 10-20 miles distant and not in the most prevalent wind direction.[2]		16	28.0 W		1
	C 1 Indicator grass (forage) sample to be taken at one of the locations beyond but as close to the exclusion boundary as practicable where the highest offsite sectoral ground level concentrations are anticipated.[2]	Monthly when available[5]	6	1.1 ESE	Gamma Isotopic	1 4

Exposure Pathway and/or Sample	Criteria for Selection of Sample Number and Location	Sampling and Collection Frequency	Sample Locations: Location(1)	Sample Locations: Mi/Dir	Type and Frequency of Analysis	
INGESTION, (continued)	D 1 Indicator grass (forage) sample to be taken at the location of VIII.A above when animals are on pasture.		14(4)	5.2 W		4
	E 1 Control grass (forage) sample to be taken at the location of VIII.B above.		16	28.0 W		
VIII. Food Products	A 1 Indicator sample to be taken at a nearby garden likely to be affected.	Annually at the approximate median harvest time for the area. Samples, if available, will include: green leafy, fruit, and grain.	6	1.1 ESE	Gamma isotopic on edible portion. Radioiodine on green leafy vegetables.	1, 4
	B 1 Control sample for the same foods taken at a location at least 10 miles distant and not in the most prevalent wind direction.		18(3)	16.5 S		
IX. Fish	A 1 Indicator sample to be taken at a location in the upper reservoir.	Semi-annual(9) collection of the following specie types if available: bass, bream, crappie; catfish, carp; forage fish (shad).	23(3)	0.3-5	Gamma isotopic on edible portions semi-annually	1, 4

TABLE 3.0-1 (Continued)

Exposure Pathway and/or Sample	Criteria for Selection of Sample Number and Location	Sampling and Collection Frequency	Sample Locations: Location[1]	Sample Locations: Mi/Dir	Type and Frequency of Analysis	
INGESTION, (continued)	B 1 Indicator sample to be taken at a location in the lower reservoir		21[3]	1-3		1
	C 1 Indicator sample to be taken at a location in the upper reservoir's non-fluctuating recreational area.		24[3]	4-5 N		1
						1 4
	D 1 Control sample to be taken at a location on the receiving river, sufficiently far up-stream such that no effects of pumped storage operation are anticipated.		22[3]	12-15 NNW		1
AQUATIC						
X. Sediment	A 1 Indicator sample to be taken at a location in the upper reservoir.	Semi-annual grab sample[9]	23[3]	0.3-4	Gamma isotopic[3]	1 4

Exposure Pathway and/or Sample	Criteria for Selection of Sample Number and Location	Sampling and Collection Frequency	Sample Locations		Type and Frequency of Analysis	
			Location[1]	Mi/Dir		
AQUATIC (continued)	B 1 Indicator sample to be taken in the upper reservoir's non-fluctuatin recreational area.		24[3]	4-5 N		1
	C 1 Indicator sample to be taken on the shoreline of the lowe- reservoir.		21[3]	1-3		1
	D 1 Control sample to be taken in receiving river, sufficiently far upstream such that no effects of pumped storage operation are anticipated.		22[3]	12-15		1
						1 4

(1) Location numbers refer to Figures 3.0-1 and 3.0-2

(2) Sample site locations are based on the meteorological analysis for the period of record as presented in Chapters 5 and 6.(Reference 5)

(3) Though generalized areas are noted for simplicity of sample site enumeration, airborne, water and sediment sampling is done at the same location whereas biological sampling sites are generalized areas in order to reasonably assure availability of samples. 1

(4) Milking animal and garden survey results will be analyzed annually. Should the survey indicate new dairying activity of a significant nature (5 or more cows milking) in a quadrant(s) other than W or NW and closer than 4
5-7 miles, the owners shall be contacted with regard to a contract for supplying sufficient samples. If contractural arrangements can be made, the site(s) will be added for additional milk sampling.

(5) Not to exceed 35 days.

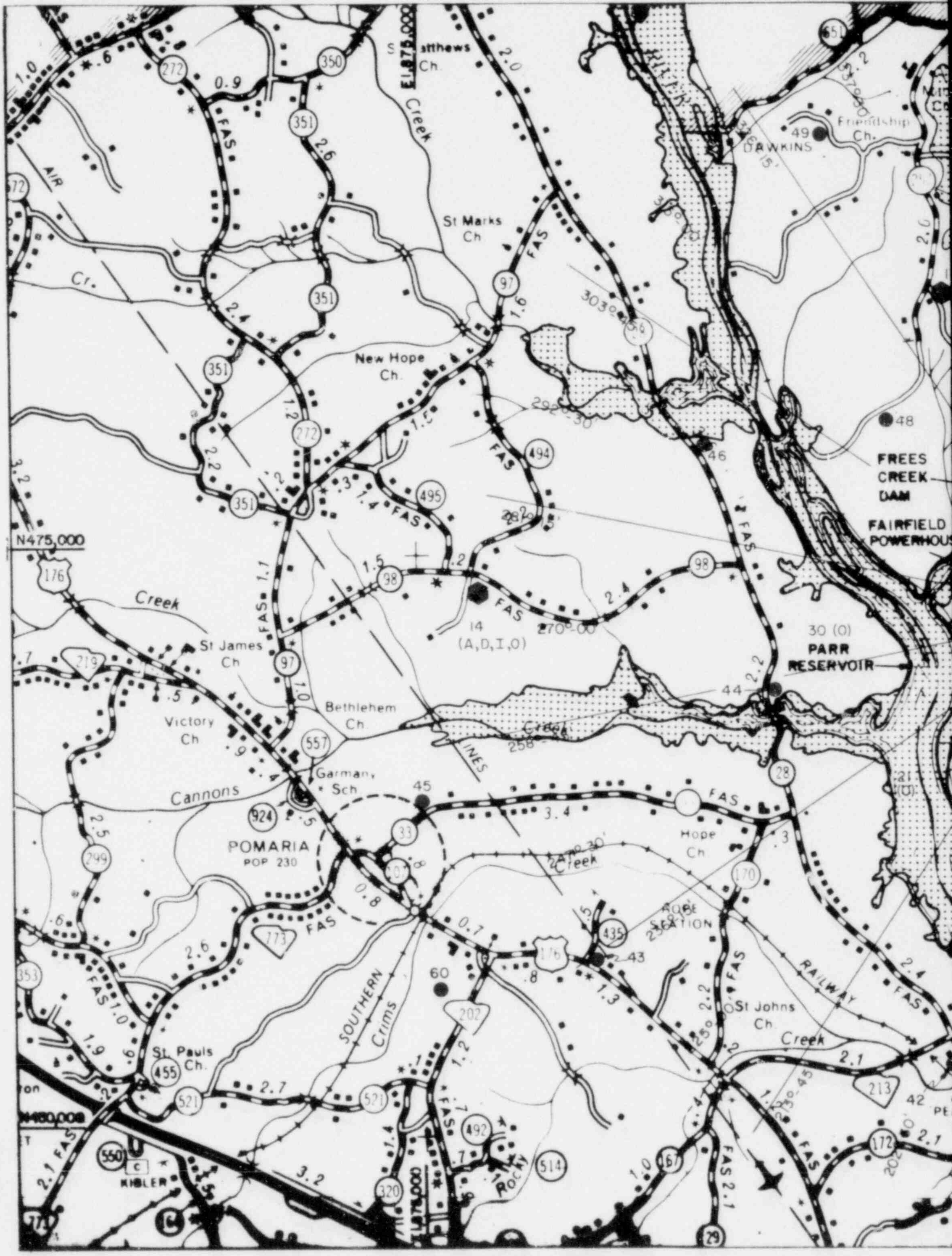
(6) Time composite samples are samples which are collected with equipment capable of collecting an aliquot at time intervals which are short (e.g. hourly) relative to the compositing period.

(7) At least once per 100 days.

(8) At least once per 18 days.

(9) At least once per 200 days.

NOTE: Deviations from this sampling schedule may occasionally be necessary if sample media are unobtainable 4
due to hazardous conditions, seasonal unavailability, insufficient sample size, malfunctions of automatic sampling or analysis 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. Deviations from sampling-analyses schedule will be described in the annual report.



St Matthews Ch.
E1,875,000
Creek
St Marks Ch.
New Hope Ch.
DAWKINS
Friendship Ch.
FREES CREEK DAM
FAIRFIELD POWERHOUS
N475,000
Creek
St James Ch
Victory Ch
Bethlehem Ch.
Garmany Sch.
PARR RESERVOIR
Cannons
POMARIA
POP 230
Hope Ch.
Creek
St Johns Ch.
Creek
RAILWAY
SOUTHERN
Crims
St. Pauls Ch.
KIBLER
Rocky
FAS
AIR
Cr.

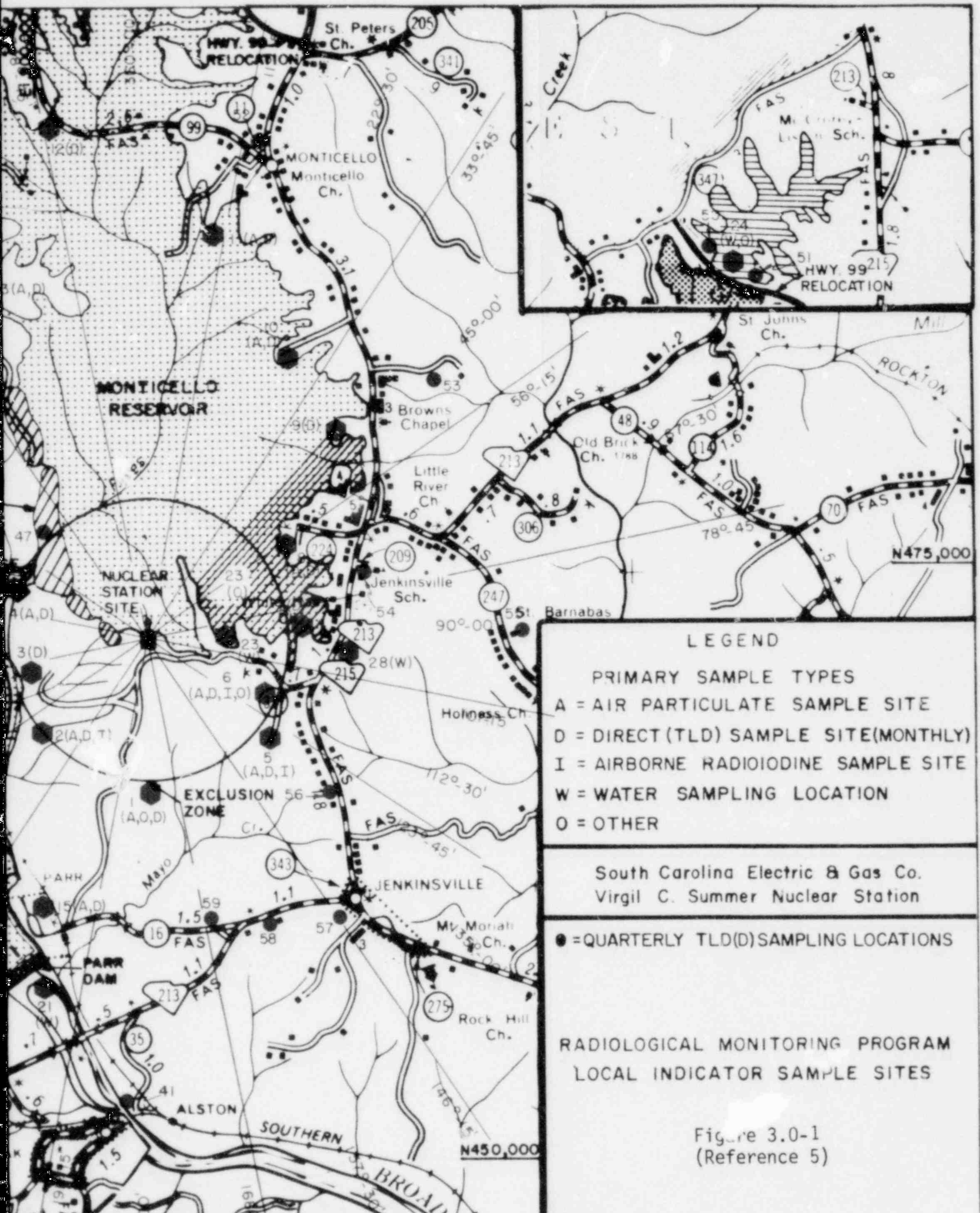
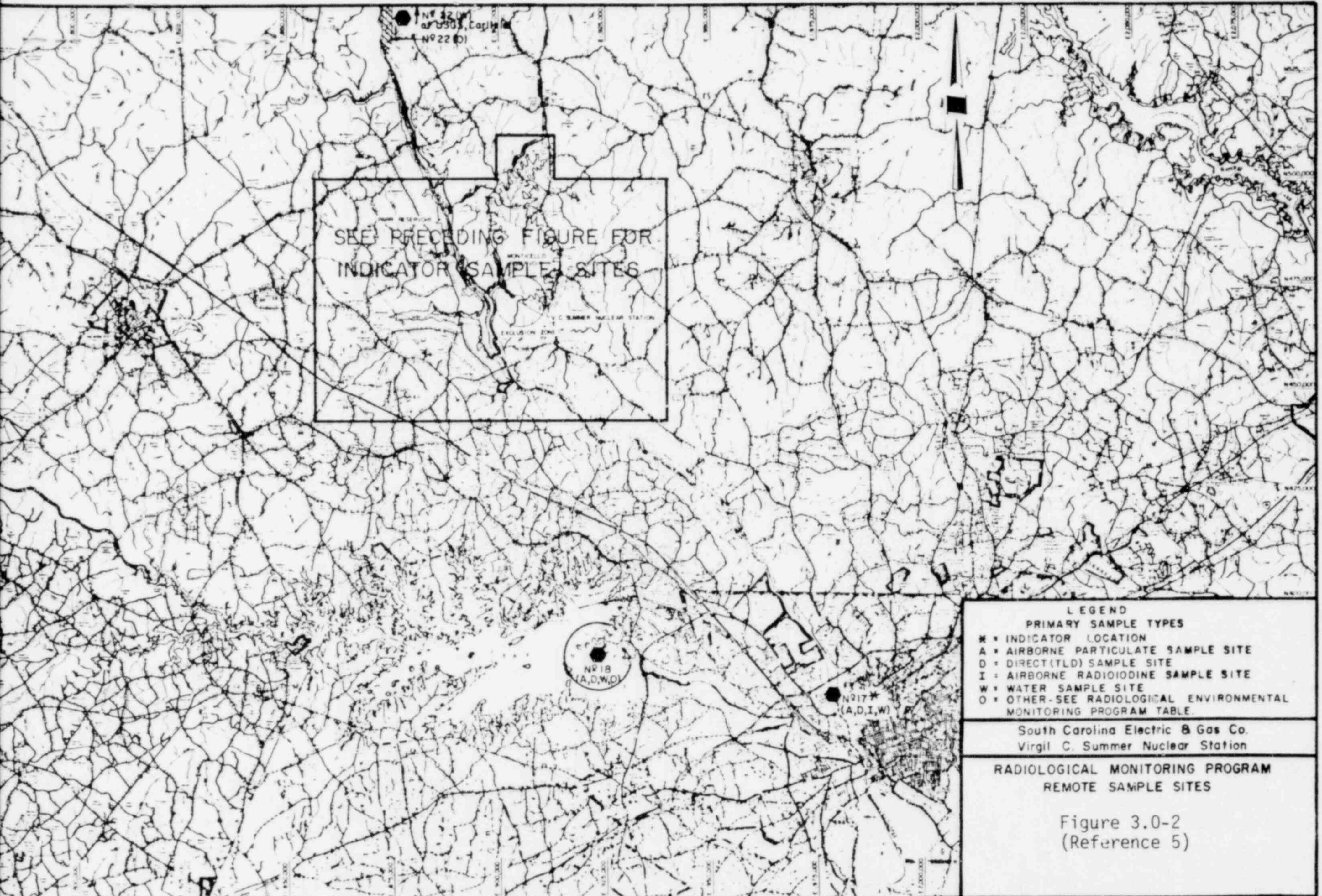


Figure 3.0-1
(Reference 5)



LEGEND

PRIMARY SAMPLE TYPES

- ✱ = INDICATOR LOCATION
- A = AIRBORNE PARTICULATE SAMPLE SITE
- D = DIRECT (TLD) SAMPLE SITE
- I = AIRBORNE RADIOIODINE SAMPLE SITE
- W = WATER SAMPLE SITE
- O = OTHER-SEE RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM TABLE.

South Carolina Electric & Gas Co.
Virgil C. Summer Nuclear Station

RADIOLOGICAL MONITORING PROGRAM
REMOTE SAMPLE SITES

Figure 3.0-2
(Reference 5)