OFFSITE DOSE CALCULATION MANUAL

FOR

TEXAS UTILITIES GENERATING COMPANY

COMANCHE PEAK NUCLEAR STATION

OCTOBER 1982

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REFERENCES

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2. Calculation of Annual Doses to Man from Routine Release of Reactor Effluents for the Purpose of Evaluating Compliance with 10CFR50, 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 10CFR50, Appendix I, U. S. NRC Regulatory Guide 1.109, Rev. 1 (October 1977).

4. "Environmental Report," Texas Utilities Generating Company, Comanche Peak Steam Electric Station.

5. "Final Safety Analysis Report," Texas Utilities Generating Company, Comanche Peak Steam Electric Station.

6. 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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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 shown in Figures 1.4 and 2.1.

The ODCM will be maintained at the plant 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.

SECTION 1.0

LIQUID EFFLUENTS

The Comanche Peak Steam Electric Station, Units 1 and 2, is located on the Squaw Creek Reservoir which is a point of supply and discharge for the plant circulating water. Liquid releases are made via the Circulating Water Discharge Canal. Discharge pathways for the liquid radwaste sources are shown in the diagram of Figure 1.1. Although no significant releases of radioactivity are expected from the General Service Water System, this effluent pathway is monitored as a precautionary measure.

1.1 GENERAL METHODOLOGY FOR DETERMINING LIQUID EFFLUENT MONITOR SETPOINTS

Normal liquid releases from the radwaste system will originate from the laundry holdup tanks and waste monitor tanks and terminate in Squaw Creek Reservoir. To ensure such discharges do not exceed the limits of 10CFR20, Appendix B, Table II, Column 2 at the release point to the unrestricted area, an in-line radiation detector monitors discharges to the circulating water discharge canal.

X-RV-5253 is the isolation valve controlled by detector X-RE-5253. The isolation valve shuts automatically if the detector alarms or is placed out of service. The methodology for determining the setpoint for detector X-RE-5253 is as follows:

1.1.1 Determine the isotopic concentration of the waste tank to be released.

$$\sum_i C_i = \sum_g C_g + (C_a + C_s + C_t + C_{Fe})$$

$\sum_i C_i$ = batch radioactive concentration (µCi/ml)

$\sum_g C_g$ = concentration of each measured gamma emitter (µCi/ml)

C_a = concentration of alpha emitters as measured in the monthly composite sample. (Sample analyzed for gross alpha only) (μCi/ml)

C_s = concentration of Sr-89 and Sr-90 as measured in the quarterly composite sample (μCi/ml)

C_t = concentration of H-3 as measured in the monthly composite sample (μCi/ml)

C_{Fe} = concentration of Fe-55 as measured in the quarterly composite sample (μCi/ml)

1.1.2 Determine the Maximum Effluent Flow Rate (f)

The effluent discharge rate is determined from the number of pumps running and their capacity. The radwaste system is comprised of the following pumps:

Laundry Holdup and Monitor Tank Pump	- 100 gpm
Waste Monitor Tank Pump #1	- 100 gpm
Waste Monitor Tank Pump #2	- 100 gpm

Normally, only one waste tank will be pumped at a time. If, however, more than one tank is to be pumped, the tanks will be sampled and the maximum isotopic concentrations will be used to determine $\sum_i C_i$. As a worst case condition, the effluent flow rate (f) will be determined as total pumping capacity of the Laundry Holdup and Waste Monitor Pumps (300 gpm). To ensure that under no circumstances the effluent flow rate is under estimated, a safety factor of 1.5 will be applied (300 x 1.5) to yield f = 450 gpm. This maximum effluent flow rate of 450 gpm will be used in the calculation of dilution factor for all liquid radwaste system batch discharges.

1.1.3 Dilution of Liquid Effluents Due to Circulating Water Flow (F)

Since liquid effluent from the radwaste treatment system is mixed with circulating water prior to being returned to Squaw

Creek Reservoir, the setpoint for detector X-RE-5253 is a function of the circulating water flow rate. The total circulating water flow rate per plant is 1.1 million gpm. This is determined from the Ingersoll-Rand pump curves (Fig. 1.3) which indicate a flow rate per pump of 275,000 gpm. At least two operating pumps are required for a discharge to take place. Isolation valve, X-RV-5253, will shut automatically if less than two circulating pumps are in operation.

F(diluting flow) = (275,000 gpm/pump) x (# of pumps) x SF x AF

Where: SF = Safety Factor of (.9). This compensates for flow fluctuations from the rate predicted by the circulating water pump curves (Fig. 1.3).

AF = Allocation Factor of (.5). This compensates for simultaneous turbine building sump discharges with batch radwaste discharges to the environment. Turbine building sumps would only be contaminated upon a significant primary to secondary leak.

1.1.4 Determine the Actual Dilution Factor (ADF)

ADF is the ratio of the effluent flow rate plus the circulating water flow rate divided by the effluent flow rate.

ADF = (f + F)/f

Where: f = 450 gpm

F = (275,000 gpm/pump) x (# of pumps) x SF (.9) x AF (.5)

1.1.5 Determine the Required Dilution Factor (RDF)

The required dilution factor ensures that the isotopic concentrations expressed in 10CFR20, Appendix B, Table II, Column 2 are not exceeded during a discharge.

$$RDF = \left(\sum_i (C_i/MPC_i)\right) \times SF$$
$$= \left(\sum_g (C_g/MPC_g) + (C_a/MPC_a + C_s/MPC_s + C_t/MPC_t + C_{Fe}/MPC_{Fe})\right) \times SF$$

Where: MPC_i = Maximum Permissible Concentrations of Radionuclide i

SF = Safety Factor of 2

NOTE: If RDF is less than 1, the tank effluent meets discharge limits without dilution. Detector, X-RE-5253, would then be set in accordance with Eq. 1 below with RFD set equal to 1.

1.1.6 Determining the Counts/Minute <u>(Upper Setpoint Limit)</u> for Detector X-RE-5253

Eq. 1 $c = (ADF/RDF) \times \Sigma C_g$

Where c = The gamma concentration corrected for dilution in microcuries/ml. From this concentration level, the detector setpoint in counts/minute is determined from the detector calibration curve (Figure 1.2 Example Only).

As a further consideration, the reservoir into which the diluted radwaste flows may build up a concentration of radioactive isotopes. It is therefore necessary to account for recirculation of previously discharged radionuclides. This is accomplished as follows:

Eq. 2 $F' = F\,(1 - \sum_i (C'_i/MPC_i))$

F' = Adjusted Circulating Water Flow Rate

C'_i = Radionuclide Concentration of the Reservoir

MPC_i = Maximum Permissible Concentration of Radionuclide i

F = (275,000 gpm/pump) x (# of pumps) x SF x AF

NOTE: If C_i is less LLD then F' = F and no adjusted flow rate need be considered in the calculation of ADF. LLD is the smallest concentration of radioactive material in a sample that will be detected with a 95% probability.

1.2 Turbine Building Sump Effluent Line Monitor

The Purpose of the detector for the turbine building sumps is to monitor discharges so as to prevent contamination in excess of the 10CFR20 limits from reaching Squaw Creek Reservoir. Because the only sources to the sump effluent are from the secondary steam system, activity is expected in the turbine building sump effluent only if a significant primary-to-secondary leak is present. If a primary-to-secondary leak does exist, the activity in the sump effluent system would be comprised of only those radionuclides found in the secondary system, but with reduced activity due to decay and dilution.

Until activity is measured in the secondary system, it will not be possible to measure all the radionuclides on which the detector should be set. Therefore, the detector will be set administratively as follows:

$C = MPC\ (Co^{60}) \times \text{Actual Dilution Factor (ADF)}$

C in microcuries/ml is then used to determine the count per minute setpoint from the detector curves.

The Actual Dilution Factor is determined in the following manner:

1.2.1 Determine Maximum Effluent Flow Rate (f)

A maximum sump effluent flow rate is determined by summing the combined outputs of the pumps for the turbine building sumps.

Sump No. 2	#1	300 gpm
	#2	300 gpm
Sump No. 2	#1	50 gpm
	#2	50 gpm

Total pumping capacity = 700 gpm x SF (1.5) = 1050 gpm

SF = Safety Factor of 1.5

1.2.2 Determine Minimum Circulating Water Flow (F)

As a worst case, the administrative monitor setpoint will be based upon two operating circulating water pumps out of four. Due to pump cavitation and pump flow vortexing, two pumps is the minimum conceivable circulating water pump lineup.

F = 2 pumps x (275,000 gpm/pump) x SF (.9) x AF (.5) = 247,500 gpm

(SF = Safety Factor of .9), (AF = Allocation Factor of .5)

1.2.3 Determine the Actual Dilution Factor (ADF)

$$ADF = \frac{f + F}{f}$$

$$= \frac{1050 + 247{,}500}{1050} = 236.7$$

The administrative setpoint therefore becomes:

$c = 236.7\ (MPC\ Co^{60})$ (Setpoint Upper Limit)

If the administrative alarm point is exceeded while discharging to the lake, the discharge will be halted or directed to the evaporation ponds as desired.

After a significant primary-to-secondary leak has been confirmed and the isotopic concentration of the secondary has been determined, the monitor alarm point will be redetermined in the following manner:

1.2.4 Determine the Isotopic Concentration of the Secondary Effluent

$$\sum_i C_i = \sum_g C_g + (C_a + C_s + C_t + C_{Fe})$$

ΣC_i = radioactive concentration of the secondary (μC_i/mi)

ΣC_g = concentration of each measured gamma emitter in the effluent

C_a = measured concentration of alpha emitters in the effluent

C_s = measured concentration of Sr89 and SR90 in the effluent

C_t = measured concentration of H-3 in the effluent

C_{Fe} = measured concentration of Fe55 in the effluent

1.2.5 Determine the Required Dilution Factor (RDF)

$RDF = \sum_i (C_i/MPC_i) \times SF$

MPC_i = Maximum Permissible Concentration of Radionuclide i

SF = Safety Factor of 2

C_i = effluent isotopic concentrations

1.2.6 Determine the Actual Dilution Factor (ADF)

$$ADF = \frac{f + F}{f}$$

f = 1050 gpm

F = (275,000 gpm/pump) x (# of pumps) x SF x AF

Note: See Eq. 2 if C_i' is greater than LLD_i

C_i' = radionuclide concentration of the lake water

1.2.7 Utilizing the information provided above, the turbine building sump detector will be set as follows:

$c = (ADF/RDF) \times \sum_g C_g$

c in microcuries/ml is then referenced to the detector curves to determine the proper count per minute setpoint.

If at any time, the administrative or post accident alarm setting is exceeded, effluent flow will be terminated or directed to the evaporation ponds until such time as the effluent meets State and Federal limits for discharge to Squaw Creek Reservoir.

1.3 Dose Calculation for Liquid Effluents

The dose contribution from the release of liquid effluents will be calculated once per 31 days and a cumulative summation of the total body and organ doses will be maintained for each calendar quarter. The dose contribution for all b. tch releases for the quarter will be calculated using the following equation:

$$D_{i\tau} = \sum_{i} [A_{i\tau} \sum_{k=1} t_k C_{ik} F_k]$$

Where: D = the cumulative dose commitment to the total body or any organ from all liquid effluent releases in a 31 day period.

t_k = the time duration of the batch release in hours.

C_{ik} = the isotopic concentration (microcuries/ml) of radionuclide (i) found in the pre-release sample. Concentrations are determined primarily from a gamma isotopic analysis of the liquid effluent sample. For Sr89, Sr90, H3, and Fe55, the last measured value will be used in the dose calculation.

F_k = near field average dilution factor during a liquid effluent release. Defined as the ratio of the average undiluted liquid waste flow during release to the average circulating water flow. For conservatism, the maximum effluent flow rate will be used in the calculation.

$$= \frac{\text{Maximum Effluent Flow Rate}}{\text{Circulating Water Flow Rate}}$$

Max. Eff. Flow Rate = 450 for the Waste Processing System or 1050 for the Turbine Building Sump discharge.

$A_{i\tau}$ = the site related ingestion dose commitment factor to the total body or any organ for each identified principle gamma and beta emitter, mRem/hr per microcurie/ml.

$$A_{i\tau} = ko\ (U_w / D_w + U_F\ BF_i)\ DF_i$$

Where: ko = unit conversion factor, 1.14×10^5

U_w = adult water consumption, 730 liters/year

U_F = adult fish consumption, 21 liters/year

BF_i = Bio accumulation factor, Table A-1, Ref. 3

DF_i = Dose Conversion Factor, Table II, Ref. 2

D_w = near field dilution factor, (1) for CPSES

Calculated values for $A_{i\tau}$ for nuclides with a half life greater than eight days are given in Table 1.1.

NOTE: It may be necessary to consider the recirculation of previously discharged radionuclides should they be detected in the water of Squaw Creek Reservoir. If C'_i (lake) is greater than LLD, then $D_{i\tau}$ must be calculated and added to the 31 day $D_{i\tau}$ (effluent) amount.

$$D_{i\tau}\ (\text{lake}) = A_{i\tau} \times t \times C'_i$$

Where: t ≈ 744 hours (31 days)

C'_i = isotopic concentration for radionuclides in the lake.

TABLE 1.1

SITE RELATED INGESTION DOSE COMMITMENT FACTOR, $A_{i\tau}$
(mREM/HR PER µCi/ML)

ATOM	BONE	LIVER	T-BODY	THYROID	KIDNEY	LUNG	GI-LLI
H3	0.00E+00	8.96E+00	8.96E+00	8.96E+00	8.96E+00	8.96E+00	8.96E+00
C14	3.15E+04	6.30E+03	6.30E+03	6.30E+03	6.30E+03	6.30E+03	6.30E+03
P32	4.62E+07	2.87E+06	1.79E+06	0.00E+00	0.00E+00	0.00E+00	5.20E+06
CR51	0.00E+00	0.00E+00	1.49E+00	8.94E-01	3.29E-01	1.98E+00	3.76E+02
MN54	0.00E+00	4.76E+03	9.08E+02	0.00E+00	1.42E+03	0.00E+00	1.46E+04
FE55	8.87E+02	6.13E+02	1.43E+02	0.00E+00	0.00E+00	3.42E+02	3.52E+02
FE59	1.40E+03	3.29E+03	1.26E+03	0.00E+00	0.00E+00	9.19E+02	1.10E+04
CO58	0.00E+00	1.51E+02	3.39E+02	0.00E+00	0.00E+00	0.00E+00	3.06E+03
CO60	0.00E+00	4.34E+02	9.58E+02	0.00E+00	0.00E+00	0.00E+00	8.16E+03
NI63	4.19E+04	2.91E+03	1.41E+03	0.00E+00	0.00E+00	0.00E+00	6.07E+02
ZN65	2.36E+04	7.50E+04	3.39E+04	0.00E+00	5.02E+04	0.00E+00	4.73E+04
RB86	0.00E+00	1.03E+05	4.79E+04	0.00E+00	0.00E+00	0.00E+00	2.03E+04
SR89	4.78E+04	0.00E+00	1.37E+03	0.00E+00	0.00E+00	0.00E+00	7.66E+03
SR90	1.18E+06	0.00E+00	2.88E+05	0.00E+00	0.00E+00	0.00E+00	3.40E+04
Y91M	1.30E-02	0.00E+00	5.04E-04	0.00E+00	0.00E+00	0.00E+00	3.82E-02
Y91	2.02E+01	0.00E+00	5.39E-01	0.00E+00	0.00E+00	0.00E+00	1.11E+04
ZR95	2.77E+00	8.88E-01	6.01E-01	0.00E+00	1.39E+00	0.00E+00	2.82E+03
NB95	4.47E+02	2.49E+02	1.34E+02	0.00E+00	2.46E+02	0.00E+00	1.51E+06
TC99M	2.94E-02	8.32E-02	1.06E+00	0.00E+00	1.26E+00	4.07E-02	4.92E+01
RU103	1.98E+01	0.00E+00	8.54E+00	0.00E+00	7.57E+01	0.00E+00	2.31E+03
RU106	2.95E+02	0.00E+00	3.73E+01	0.00E+00	5.69E+02	0.00E+00	1.91E+04
AG110M	1.33E+01	1.23E+01	7.32E+00	0.00E+00	2.42E+01	0.00E+00	5.03E+03
TE125M	2.79E+03	1.01E+03	3.74E+02	8.39E+02	1.13E+04	0.00E+00	1.11E+04

TABLE 1.1(Cont)

SITE RELATED INGESTION DOSE COMMITMENT FACTOR, A_{iT}
(mREM/hr per uCi/ml)

ATOM	BONE	LIVER	T-BODY	THYROID	KIDNEY	LUNG	GI-LLI
TE127M	7.05E+03	2.52E+03	8.59E+02	1.80E+03	2.86E+04	0.00E+00	2.36E+04
TE127	1.14E+02	4.11E+01	2.48E+01	8.48E+01	4.66E+02	0.00E+00	9.03E+03
TE129M	1.20E+04	4.47E+03	1.89E+03	4.11E+03	5.00E+04	0.00E+00	6.03E+04
TE129	3.27E+01	1.23E+01	7.96E+00	2.51E+01	1.37E+02	0.00E+00	2.47E+01
I131	4.96E+02	7.09E+02	4.06E+02	2.32E+05	1.22E+03	0.00E+00	1.87E+02
CS134	3.03E+05	7.21E+05	5.89E+05	0.00E+00	2.33E+05	7.75E+04	1.26E+04
CS136	3.17E+04	1.25E+05	9.01E+04	0.00E+00	6.97E+04	9.55E+03	1.42E+04
CS137	3.88E+05	5.31E+05	3.48E+05	0.00E+00	1.80E+05	5.99E+04	1.03E+04
BA140	1.88E+03	2.37E+00	1.23E+02	0.00E+00	8.05E-01	1.35E+00	3.88E+03
CE144	4.18E+01	1.75E+01	2.24E+00	0.00E+00	1.04E+01	0.00E+00	1.41E+04
PR143	1.32E+00	5.28E-01	6.52E-02	0.00E+00	3.05E-01	0.00E+00	5.77E+03
ND147	9.00E-01	1.04E+00	6.22E-02	0.00E+00	6.08E-01	0.00E+00	4.99E+03
W187	3.04E+02	2.55E+02	8.90E+01	0.00E+00	0.00E+00	0.00E+00	8.34E+04
NP239	1.28E-01	1.25E-02	6.91E-03	0.00E+00	3.91E-02	0.00E+00	2.57E+03

1.4 SERVICE WATER EFFLUENT RADIATION MONITOR RF 4270

Concentration of radioactivity in this effluent line normally is expected to be insignificant. Therefore, the monitor setpoint should be established as close to background as practical to prevent spurious alarms and yet alarm should an inadvertent release occur.

If this effluent stream should become contaminated with radioactivity, radionuclide concentrations must be determined and a radiation monitor setpoint determined as follows:

$$C = (\Sigma C_g) \div DF \quad \text{(Setpoint upper limit)}$$

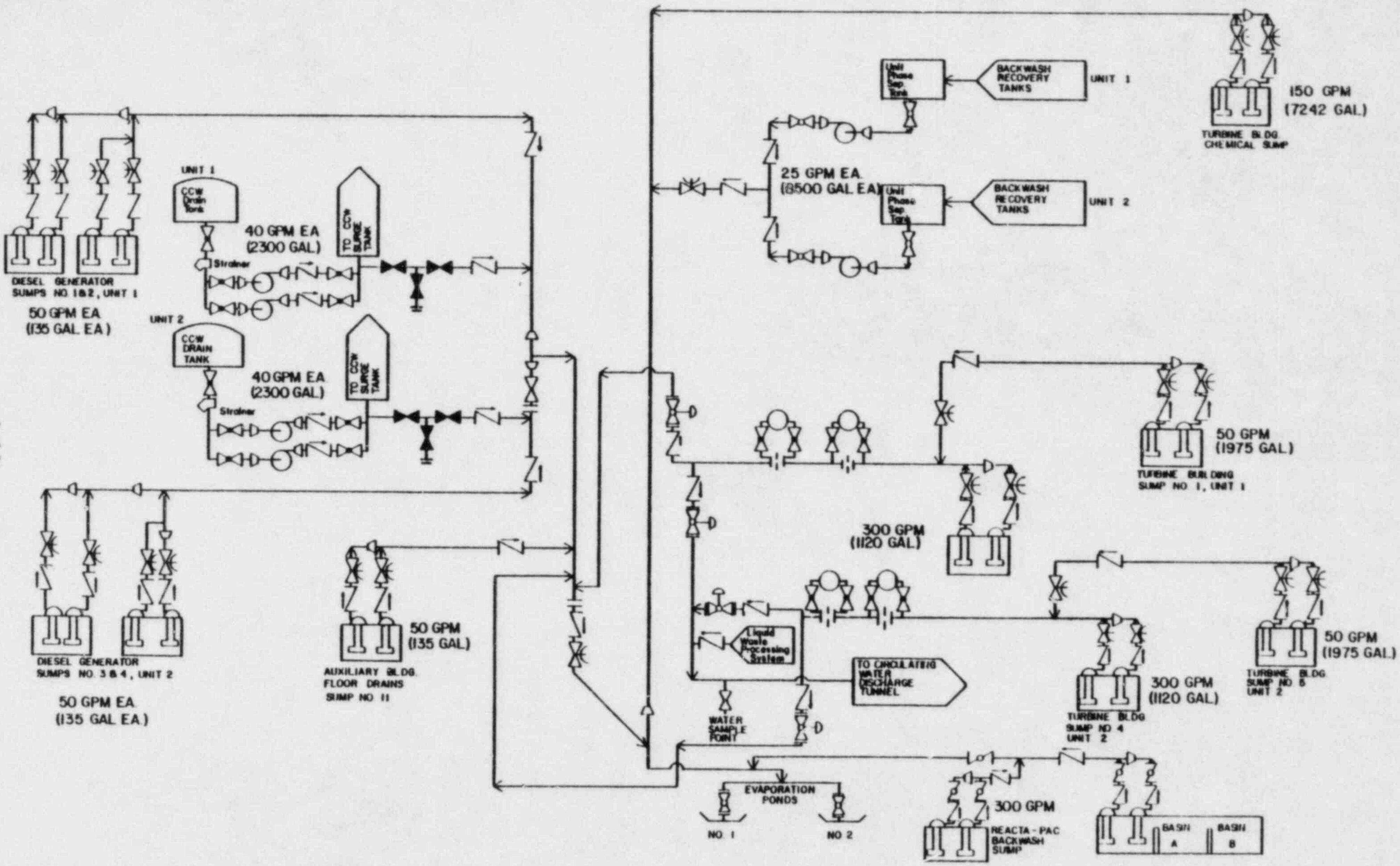
Where ΣC_g = the concentration of each measured gamma emitter observed in the effluent (μCi/ml)

$$DF = \sum_i (C_i/MPC_i)$$

For this release pathway no additional dilution is available. Therefore, o releases are permissible if DF is greater than 1.

FIGURE 1.1

LIQUID EFFLUENT DISCHARGE PATHWAYS



1-13

FIGURE 1.2

EXAMPLE CALIBRATION CURVE FOR LIQUID EFFLUENT MONITOR

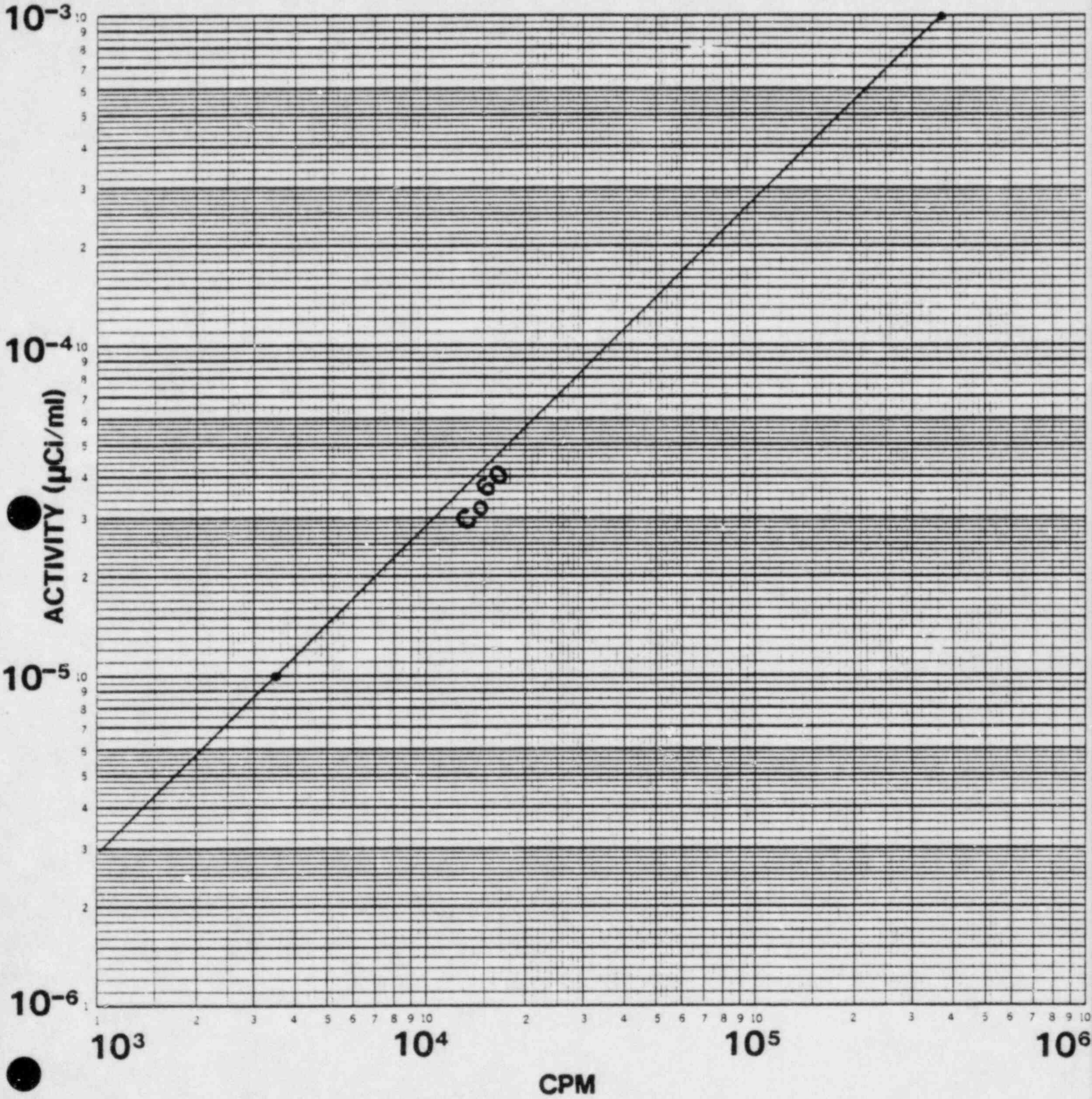


FIGURE 1.3

CIRCULATING WATER PUMP CURVES

DESIGN CONDITIONS

GPM 275,000 EFF 88
TH (FT) 28 BHP 2209 SG. 1.0
RPM 258 DRIVER 2500
1.15 SF

INGERSOLL-RAND CURVE # NY-3552-4
for Pump 83 APMA-1
DATE 8/25/77

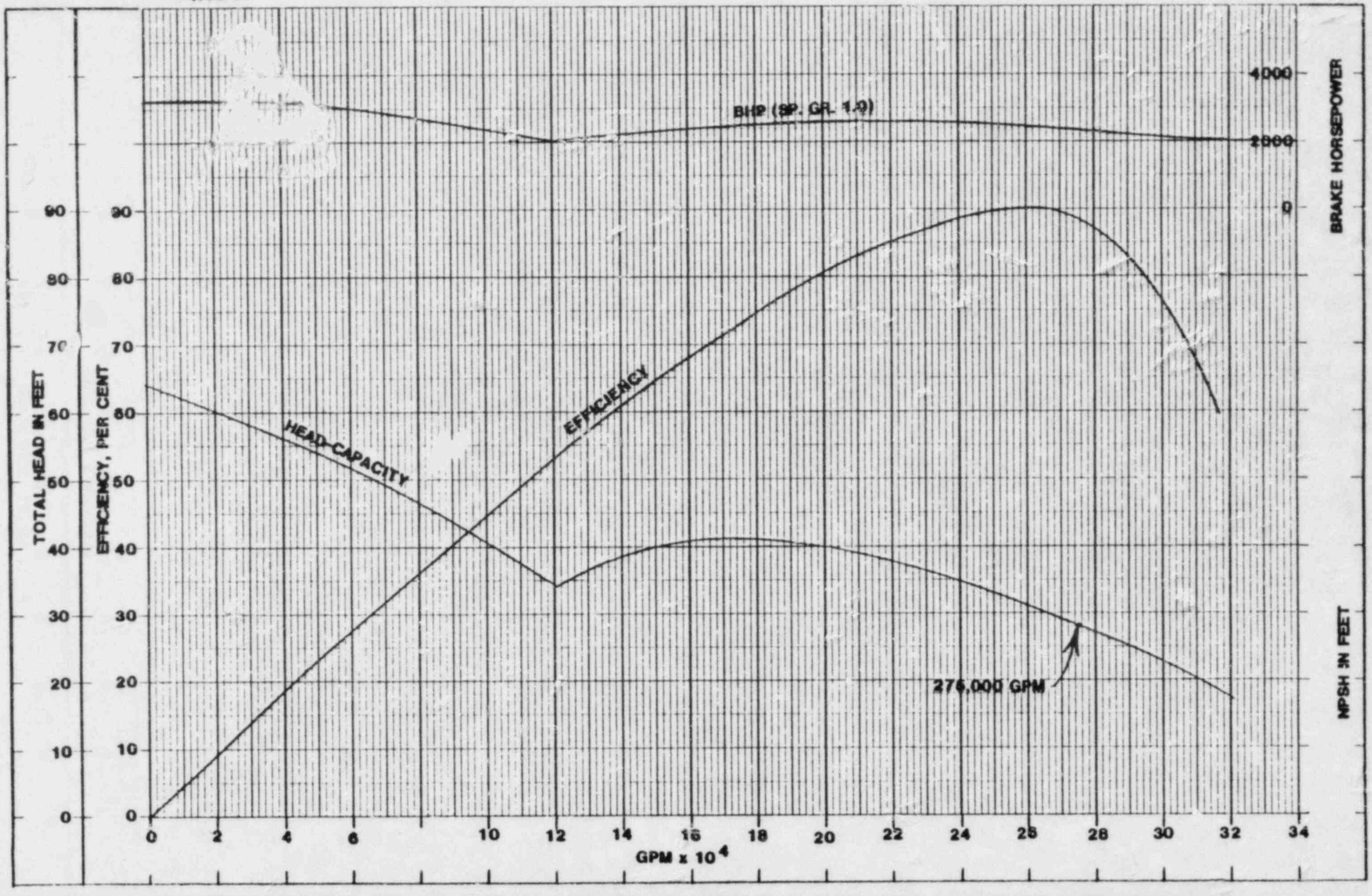
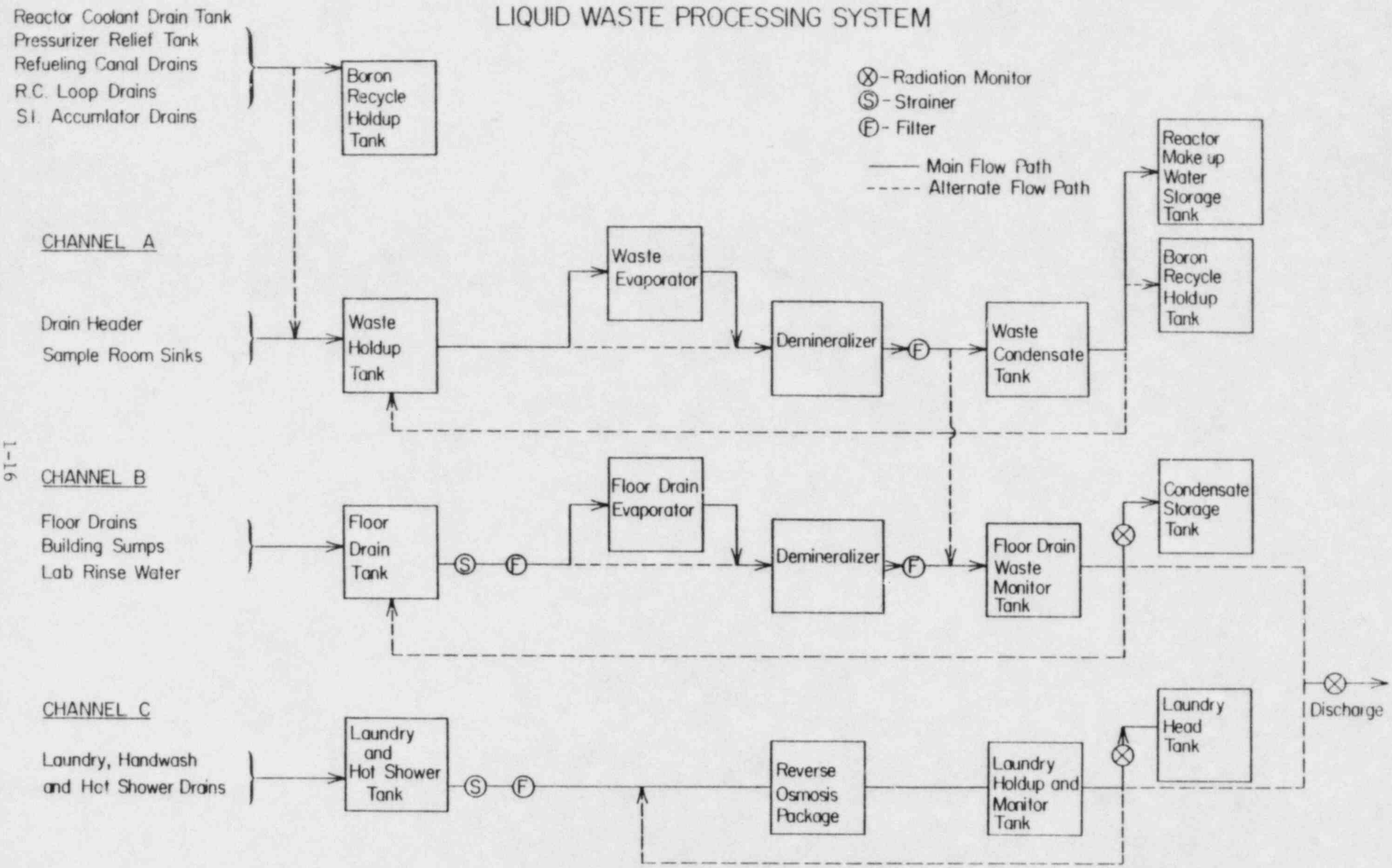


FIGURE 1.4

LIQUID WASTE PROCESSING SYSTEM



SECTION 2.0

GASEOUS EFFLUENTS

2.1 GASEOUS EFFLUENT MONITOR SETPOINTS

The gaseous monitor setpoint values determined in the following sections will be regarded as upper bounds for the actual setpoint adjustments. That is, setpoint adjustments are not required to be made 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.

If a calculated setpoint is less than the monitor reading associated with the particular release pathway, no release may be made. Under such circumstances, contributing source terms may be reduced and the setpoint recalculated.

At CPSES, all gaseous effluents are released to the atmosphere through the two Plant Vent Stacks (Figure 2.1). Setpoint methodology for the noble gas monitors associated with the plant vent is addressed in the following section.

2.1.1 PLANT VENT STACK NOBLE GAS MONITORS XRE5570A and XRE5570B

For implementation of Technical Specification 3.3.3.11, the alarm setpoint level for these noble gas monitors will be calculated as follows:

C_S = Monitor reading of the noble gas monitor at the alarm setpoint concentration.

= the lesser of

$$(SF) \times R_t \times D_{TB} \times AF$$

or

$$(SF) \times R_s \times D_{ss} \times AF$$

SF = Safety Factor (.5); a conservative factor applied to each noble gas monitor to compensate for statistical fluctuations and errors of measurement.

AF = Allocation Factor (.5); a factor allowing for releases from both plant stacks simultaneously.

R_t = monitor reader per mrem/yr to the total body

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

K_i = total body dose factor due to gamma emissions from noble gas radionuclide i (mrem/year per microcurie/m^3) from Table 2.1.

R_s = monitor reading per mrem/yr to the skin

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

L_i = skin dose factor due to beta emissions from noble gas radionuclide i (mrem/yr per microcurie/m^3) from Table 2.1.

1.1 = mrem skin dose per mrad air dose

M_i = air dose factor due to gamma emissions from noble gas radionuclide i (mrad/yr per microcurie/m^3) from Table 2.1)

Q_i = the release rate of noble gas radionuclide i from the Plant Vent Stack (microcurie/sec).

= the product of X_{iv} and F_v, where X_{iv} is the concentration of noble gas radionuclide i (microcurie/ml) as measure at the vent and F_v is the flowrate at the vent (ml/sec).

C = monitor reading of a noble gas monitor corresponding to the grab sample radionuclide concentrations taken in accordance with RETS Table 4.11-2. The count rate corresponding to the measured concentration is determined from the monitor calibration curve supplied by the instrument manufacturer or based on historical data for a particular monitor.

$\overline{X/Q}$ = the highest annual average relative concentration at the site boundary. (If desired, the annual average relative concentration at the site boundary for the particular release point may be used).

= 3.3×10^{-6} sec/m^3 in the NNW sector.

D_{TB} = dose rate limit to the total body of an individual in an unrestricted area.

= 500 mrem/year (Technical Specification 3.11.2.1a).

D_{ss} = Dose rate limit to the skin of the body of an individual in an unrestricted area.

= 3000 mrem/year (Technical Specification 3.11.2.1.a).

With the addition of a batch release (waste gas decay tank or containment purge) into the effluent stream, the Q_i term will be calculated in a similar manner as previously shown. The flow rate at the vent monitor is given by

$$F_v = F_c + F_B$$

where

F_c = the flow rate contribution of the plant ventilation system (ml/sec).

F_B = the flow rate contribution associated with the release rate of the batch source (ml/sec). This value will be very small as compared to the value of F_c.

The resulting concentration due to the combined sources that would be detected by the Plant Vent Stack Monitor is given by:

$$X_{iv} = \frac{X_{ic} F_c + X_{iB} F_B}{F_c + F_B},$$

where:

X_{ic} = the concentration of noble gas radionuclide i (microcurie/ml) in the continuous release stream as sampled in accordance with RETS Table 4.11-2.

X_{iB} = the concentration of noble gas radionuclide i (microcurie/ml) in the continuous release stream as sampled in accordance with RETS Table 4.11-2.

The count rate corresponding to this combined concentration (X_{iv}) at the vent monitor is determined by the monitor calibration curve as previously described. The release rate at the vent for noble gas radionuclide i (microcurie/sec) is given by

$$Q_i = F_v X_{iv}$$

$$= X_{ic} F_c + X_{iB} F_B$$

2.1.2 PLANT VENT STACK IODINE MONITORS

In general it is not practical to establish a setpoint for the Plant Vent Stack Radioiodine Monitors to ensure compliance with Technical Specification 3.11.2.1b. Therefore, dose rate calculations should be performed in accordance with Section 2.2.1 and compared with the Technical Specification dose rate limit of 1500 mrem/year for compliance. An Allocation Factor and Safety Factor should also be utilized for this determination.

TABLE 2-1

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

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 Rates

2.2.1.a Dose Rates Due to Noble Gases

For implementation of Technical Specifications 3.11.2.1.a, the dose rate 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)

$$= (\overline{X/Q}) \sum_i K_i \; Q_i$$

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

$$= (\overline{X/Q}) \sum_i (L_i + 1.1 \; M_i) \; (Q_i)$$

2.2.1.b Dose Rates Due to Radioiodines, Tritium and Particulates

Organ doses due to radioiodines, tritium, and all radioactive materials in particulate form with half-lives greater than eight days, will be calculated to implement the requirements of Technical Specification 3.11.2.1.b as follows:

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

$$= (\overline{X/Q}) \sum_i P_i \; Q_i$$

where: P_i = dose parameter factor for radionuclide i; (mrem/yr per microcurie/m^3), for inhalation. (Table 2.2)

Q_i = the release rate of radionuclide i for (radioiodine, tritium, and particulates) as determined from the concentrations measured in the analysis of the appropriate sample required by Technical Specification 3.11.2.1.b.

2.2.2 Unrestricted Area (Air Dose/Dose to Individual)

2.2.2.a Air Dose in Unrestricted Areas

For implementation of Technical Specification 3.11.2.2 and 3.11.2.4, 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)

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

where: 3.17×10^{-8} = the fraction of a year represented by one second

M_i is defined in section 2.1.1

$\overline{X/Q}$ = the relative concentration for the location occupied by the maximum exposed individual

= 3.3×10^{-6} sec/m^3 in the NNW Sector

$\tilde{Q}_i$ = the cumulative release of noble gas radionuclide i (microcuries) for the type of release under consideration

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

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

where: N_i = the air dose factor due to beta emissions from noble gas radionuclide i (mrad/yr per microcurie/m^3) Table 2.1

2.2.2.b Dose to an Individual

Dose to an individual from radioiodine, tritium, and radioactive materials in particulate form will be calculated to implement Technical Specification 3.11.2.3. and 3.11.2.4 as follows:

D_p = dose to an individual from radioiodine, tritium, and radionuclides in particulate form (mrem)

$= 3.17 \times 10^{-8} \sum_i R_i W' \tilde{Q}_i$

where: W' = relative dispersion parameter

= for inhalation of all tritium pathways

$= 2.8 \times 10^{-9} M^{-2}$ in the WNW Sector

R_i = dose factor for radionuclide i (Table 2.3 - 2.6)

$\tilde{Q}_i$ = cumulative release of radionuclide i as required by Technical Specification 3.11.2.3 in (microcuries)

2.2.2.c DOSE CALCULATIONS TO SUPPORT OTHER TECHNICAL SPECIFICATIONS

For the purpose of implementing Technical Specification 6.9.1.13 dose calculations will be performed using the above equations with the substitution of average meteorological parameters for the period of the report, and the appropriate pathway receptor dose factors (R_i). Values for R_i may be found in Tables 2.3 through 2.6.

For the purpose of implementing Technical Specification 6.9.1.9, dose calculations may be performed using the above equations with the substitution of the dispersion parameters (X/Q, D/Q) which are concurrent with actual releases, and the appropriate pathway receptor dose factors.

For the purpose of implementing Technical Specification 3.12.2, dose calculations may be performed using the above equations substituting the appropriate pathway receptor dose factors and the appropriate dispersion parameters for the location(s) of interest. Annual average dispersion parameters (or grazing period average for D/Q may be used for these calculations).

TABLE 2.2

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

AGE GROUP (CHILD)

ISOTOPE	INHALATION
H-3	1.125E+03
C-14	3.589E+04
NA-24	1.610E+04
P-32	2.605E+06
CR-51	1.698E+04
MN-54	1.576E+06
MN-56	1.232E+05
FE-55	1.110E+05
FE-59	1.269E+06
CO-58	1.106E+06
CO-60	7.067E+06
NI-63	8.214E+05
NI-65	8.399E+04
CU-64	3.670E+04
ZN-65	9.953E+05
ZN-69	1.018E+04
BR-83	4.736E+02
BR-84	5.476E+02

* Values based on Reference 1, Section 5.2.1 assumptions unless otherwise indicated in Reference 5.

1 - mrem/yr per $\mu Ci/m^3$

TABLE 2.2 (Continued)

PATHWAY DOSE FACTORS FOR SECTION 2.2.1.b (P_i)

AGE GROUP (CHILD)

ISOTOPE	INHALATION
BR-85	2.531E+01
RB-86	1.983E+05
RB-88	5.624E+02
RB-89	3.452E+02
SR-89	2.157E+06
SR-90	1.010E+08
SR-91	1.739E+05
SR-92	2.424E+05
Y-90	2.679E+05
Y-91M	2.812E+03
Y-91	2.627E+06
Y-92	2.390E+05
Y-93	3.885E+05
ZR-95	2.231E+06
ZR-97	3.511E+05
NB-95	6.142E+05
MO-99	1.354E+05
TC-99M	4.810E+03
TC-101	5.846E+02
RU-103	6.623E+05
RU-105	9.953E+04

1 - mrem/yr per $\mu Ci/m^3$

TABLE 2.2 (Continued)

PATHWAY DOSE FACTORS FOR SECTION 2.2.1.b (P_i)

AGE GROUP (CHILD)

ISOTOPE	INHALATION
RU-106	1.432E+87
AG-110M	5.476E+06
TE-125M	4.773E+05
TE-127M	1.480E+06
TE-127	5.624E+84
TE-129M	1.761E+06
TE-129	2.549E+04
TE-131M	3.078E+05
TE-131	2.054E+03
TE-132	3.774E+05
I-138	1.046E+06
I-131	1.624E+07
I-132	1.935E+05
I-133	3.848E+86
I-134	5.069E+04
I-135	7.918E+05
CS-134	1.014E+06
CS-136	1.709E+05
CS-137	9.065E+05
CS-138	8.399E+02
BA-139	5.772E+04

1 - mrem/yr per µCi/m^3

TABLE 2.2 (Continued)

PATHWAY DOSE FACTORS FOR SECTION 2.2.1.b (P_i)

AGE GROUP (CHILD)

ISOTOPE	INHALATION
BA-148	1.743E+06
BA-141	2.919E+03
BA-142	1.643E+03
LA-140	2.257E+05
LA-142	7.585E+04
CE-141	5.439E+05
CE-143	1.273E+05
CE-144	1.195E+07
PR-143	4.329E+05
PR-144	1.565E+03
ND-147	3.282E+05
W-187	9.102E+04
NP-239	6.401E+04

1 - mrem/yr per $\mu Ci/m^3$

TABLE 2.3

PATHWAY DOSE FACTOR (R)

INFANT

ATOM	INHAL	G/P	COW/MILK	COW/MEAT	VEG	GT/MILK
H3	6.468E+02	0.000E+00	2.382E+03	0.000E+00	0.000E+00	4.860E+03
C14	2.646E-04	0.000E+00	1.579E+09	0.000E+00	0.000E+00	1.579E+09
P32	2.030E+06	0.000E+00	8.053E+10	0.000E+00	0.000E+00	9.663E+10
CR51	1.284E+04	5.517E+06	2.439E+06	0.000E+00	0.000E+00	2.927E+05
MN54	9.996E+05	1.629E+09	2.522E+07	0.000E+00	0.000E+00	3.027E+06
FE55	8.594E+04	0.000E+00	8.975E+07	0.000E+00	0.000E+00	1.167E+06
FE59	1.015E+06	3.238E+08	2.137E+08	0.000E+00	0.000E+00	2.778E+06
CO58	7.770E+05	4.490E+08	3.475E+07	0.000E+00	0.000E+00	4.170E+06
CO60	4.508E+06	2.528E+10	1.404E+08	0.000E+00	0.000E+00	1.685E+07
NI63	3.388E+05	0.000E+00	2.357E+10	0.000E+00	0.000E+00	2.828E+09
ZN65	6.538E+05	8.574E+08	1.210E+10	0.000E+00	0.000E+00	1.452E+09
RB86	1.904E+05	1.029E+07	1.128E+10	0.000E+00	0.000E+00	1.353E+09
SR89	2.030E+06	2.523E+04	6.945E+09	0.000E+00	0.000E+00	1.459E+10
SR90	4.088E+07	0.000E+00	8.195E+10	0.000E+00	0.000E+00	1.721E+11
Y91	2.450E+06	1.217E+06	2.950E+06	0.000E+00	0.000E+00	3.540E+05
ZR95	1.750E+06	2.915E+08	4.713E+05	0.000E+00	0.000E+00	5.656E+04
NB95	4.788E+05	1.614E+08	1.094E+08	0.000E+00	0.000E+00	1.313E+07
TC99M	2.030E+03	2.101E+05	8.037E+03	0.000E+00	0.000E+00	9.644E+02
RU103	5.516E+05	1.226E+08	5.682E+04	0.000E+00	0.000E+00	6.819E+03
RU106	1.156E+07	5.063E+08	9.359E+05	0.000E+00	0.000E+00	1.123E+05
AG110M	3.668E+06	4.062E+09	9.306E+09	0.000E+00	0.000E+00	1.117E+09
TE125M	4.466E+05	2.133E+06	9.408E+07	0.000E+00	0.000E+00	1.009E+07
TE127M	1.312E+06	1.083E+05	6.206E+08	0.000E+00	0.000E+00	7.447E+07

TABLE 2.3 (cont)

PATHWAY DOSE FACTOR (R)

INFANT

ATOM	INHAL	G/P	COW/MILK	COW/MEAT	VEG	GT/MILK
TE129M	1.680E+06	2.348E+07	7.396E+08	0.000E+00	0.000E+00	8.876E+07
I131	1.484E+07	2.095E+07	5.278E+11	0.000E+00	0.000E+00	6.334E+11
CS134	7.028E+05	7.972E+09	4.495E+10	0.000E+00	0.000E+00	1.349E+11
CS136	1.345E+05	1.690E+08	2.892E+09	0.000E+00	0.000E+00	3.677E+09
CS137	6.118E+05	1.203E+10	4.060E+10	0.000E+00	0.000E+00	1.218E+11
BA140	1.596E+06	2.351E+07	1.210E+08	0.000E+00	0.000E+00	1.452E+07
CE141	5.166E+05	1.539E+07	7.181E+06	0.000E+00	0.000E+00	8.617E+05
CE144	9.842E+06	8.046E+07	8.547E+07	0.000E+00	0.000E+00	1.026E+07
PR143	4.326E+05	0.000E+00	3.935E+05	0.000E+00	0.000E+00	4.722E+04
ND147	3.220E+05	1.015E+07	2.887E+05	0.000E+00	0.000E+00	3.464E+04
NP239	5.950E+04	1.978E+06	4.708E+04	0.000E+00	0.000E+00	5.649E+03

TABLE 2.4

PATHWAY DOSE FACTOR (R)

CHILD

ATOM	INHAL	G/P	COW/MILK	COW/MEAT	VEG	GT/MILK
H3	1.125E+03	0.000E+00	1.570E+03	2.341E-02	4.008E+03	3.203E+03
C14	3.589E+04	0.000E+00	8.064E+08	2.588E+08	8.894E+08	8.064E+08
P32	2.605E+06	0.000E+00	3.908E+10	3.730E+09	3.375E+09	4.690E+10
CR51	1.702E+04	5.517E+06	2.801E+06	2.421E+05	6.232E+06	3.361E+05
MN54	1.576E+06	1.629E+09	1.349E+07	5.155E+06	6.651E+08	1.619E+06
FE55	1.110E+05	0.000E+00	7.426E+07	3.037E+08	8.012E+08	9.553E+05
FE59	1.269E+06	3.238E+08	1.104E+08	3.466E+08	6.766E+08	1.436E+06
CO58	1.110E+06	4.490E+08	4.063E+07	5.512E+07	3.786E+08	4.875E+06
CO60	7.067E+06	2.528E+10	1.601E+08	2.569E+08	2.095E+09	1.921E+07
NI63	8.214E+05	0.000E+00	2.000E+10	1.965E+10	3.949E+10	2.400E+09
ZN65	9.953E+05	8.574E+08	6.998E+09	6.355E+08	2.164E+09	8.398E+08
RB86	1.983E+05	1.029E+07	4.445E+09	2.926E+08	4.539E+08	5.334E+08
SR89	2.157E+06	2.523E+04	3.653E+09	2.361E+08	3.611E+10	7.670E+09
SR90	1.010E+08	0.000E+00	7.530E+10	7.008E+09	1.243E+12	1.581E+11
Y91	2.627E+06	1.217E+06	2.921E+06	1.351E+08	2.501E+09	3.505E+05
ZR95	2.231E+06	2.915E+08	5.015E+05	3.504E+08	9.025E+08	6.018E+04
NB95	6.142E+05	1.614E+08	1.214E+08	1.184E+09	2.969E+08	1.457E+07
TC99M	4.310E+03	2.101E+05	7.198E+03	2.816E-18	5.185E+03	8.637E+02
RU103	6.623E+05	1.226E+08	5.966E+04	2.168E+09	4.031E+08	7.160E+03
RU106	1.432E+07	5.063E+08	9.308E+05	4.471E+10	1.160E+10	1.117E+05
AG110M	5.476E+06	4.062E+09	1.069E+10	4.298E+08	2.587E+09	1.283E+09
TE125M	4.773E+05	2.133E+06	4.132E+07	3.188E+08	3.512E+08	4.958E+06
TE127M	1.480E+06	1.083E+05	3.551E+08	3.030E+09	3.769E+09	4.262E+07

TABLE 2.4 (cont)

PATHWAY DOSE FACTOR (R)

CHILD

ATOM	INHAL	G/P	COW/MILK	COW/MEAT	VEG	GT/MILK
TE129M	1.761E+06	2.348E+07	4.231E+08	2.807E+09	2.521E+09	5.077E+07
I131	1.624E+07	2.095E+07	2.172E+11	2.771E+09	4.770E+10	2.606E+11
CS134	1.014E+06	7.972E+09	2.456E+10	1.000E+09	2.631E+10	7.367E+10
CS136	1.709E+05	1.690E+08	1.384E+09	2.193E+07	2.216E+08	4.152E+09
CS137	9.065E+05	1.203E+10	2.173E+10	8.989E+08	2.392E+10	6.519E+10
BA140	1.743E+06	2.351E+07	5.380E+07	2.205E+07	2.777E+08	7.056E+06
CE141	5.439E+05	1.539E+07	7.152E+06	7.258E+06	4.078E+08	8.582E+05
CE144	1.195E+07	8.046E+07	8.497E+07	1.212E+08	1.039E+10	1.020E+07
PR143	4.329E+05	0.000E+00	3.889E+05	1.810E+07	1.574E+08	4.667E+04
ND147	3.282E+05	1.015E+07	2.871E+05	7.614E+06	9.287E+07	3.445E+04
NP239	5.401E+04	1.978E+06	4.577E+04	1.125E+03	1.358E+07	5.492E+03

TABLE 2.5
PATHWAY DOSE FACTOR (R)

TEENAGER

ATOM	INHAL	G/P	COW/MILK	COW/MEAT	VEG	GT/MILK
H3	1.272E+03	0.000E+00	9.938E+02	1.938E+02	2.588E+03	2.027E+03
C14	2.600E+04	0.000E+00	3.312E+08	1.390E+08	3.726E+08	3.312E+08
P32	1.888E+06	0.000E+00	1.585E+10	1.978E+09	1.611E+09	1.902E+10
CR51	2.096E+04	5.517E+06	4.352E+06	4.919E+05	1.040E+07	5.222E+05
MN54	1.984E+06	1.629E+09	1.850E+07	9.243E+06	9.324E+08	2.220E+06
FE55	1.240E+05	0.000E+00	2.959E+07	1.582E+08	3.259E+08	3.846E+05
FE59	1.528E+06	3.238E+08	1.560E+08	6.405E+08	1.000E+09	2.028E+06
CO58	1.344E+06	4.490E+08	6.285E+07	1.115E+08	6.057E+08	7.542E+06
CO60	8.800E+06	2.528E+10	2.424E+08	5.087E+08	3.237E+09	2.909E+07
NI63	5.800E+05	0.000E+00	7.975E+09	1.025E+10	1.606E+10	9.570E+08
ZN65	1.240E+06	8.574E+08	4.648E+09	5.520E+08	1.471E+09	5.578E+08
RB86	1.304E+05	1.029E+07	2.396E+09	2.063E+08	2.747E+08	2.876E+08
SR89	2.416E+06	2.523E+04	1.476E+09	1.406E+08	1.521E+10	3.099E+09
SR90	1.080E+08	0.000E+00	4.456E+10	5.425E+09	7.507E+11	9.358E+10
Y91	2.936E+06	1.217E+06	3.637E+06	2.200E+08	3.233E+09	4.365E+05
ZR95	2.688E+06	2.915E+08	6.856E+05	6.265E+08	1.278E+09	8.227E+04
NB95	7.512E+05	1.614E+08	1.771E+08	2.260E+09	4.581E+08	2.125E+07
TC99M	6.128E+03	2.101E+05	5.150E+03	2.636E-18	4.344E+03	6.180E+02
RU103	7.832E+05	1.226E+08	8.150E+04	3.874E+09	5.788E+08	9.780E+03
RU106	1.608E+07	5.063E+08	1.165E+06	7.322E+10	1.484E+10	1.399E+05
AG110M	6.752E+06	4.062E+09	1.631E+10	8.576E+08	4.039E+09	1.957E+09
TE125M	5.360E+05	2.133E+06	4.964E+07	5.010E+08	4.363E+08	5.957E+06
TE127M	1.656E+06	1.083E+05	2.048E+08	2.285E+09	2.236E+09	2.457E+07

TABLE 2.5 (cont)

PATHWAY DOSE FACTOR (R)

TEENAGER

ATOM	INHAL	G/P	COW/MILK	COW/MEAT	VEG	GT/MILK
TE129M	1.976E+06	2.348E+07	2.446E+08	2.123E+09	1.544E+09	2.935E+07
I131	1.464E+07	2.095E+07	1.100E+11	1.835E+09	3.149E+10	1.320E+11
CS134	1.128E+06	7.972E+09	1.527E+10	8.134E+08	1.670E+10	4.581E+10
CS136	1.936E+05	1.690E+08	8.778E+08	1.319E+07	1.688E+08	2.633E+09
CS137	8.480E+05	1.203E+10	1.200E+10	6.493E+08	1.348E+10	3.600E+10
BA140	2.032E+06	2.351E+07	3.756E+07	1.843E+07	2.137E+08	4.508E+06
CE141	6.136E+05	1.539E+07	8.914E+06	1.183E+07	5.399E+08	1.070E+06
CE144	1.336E+07	8.046E+07	1.060E+08	1.979E+08	1.326E+10	1.272E+07
PR143	4.832E+05	0.000E+00	4.792E+05	2.917E+07	2.308E+08	5.751E+04
ND147	3.720E+05	1.015E+07	3.577E+05	1.241E+07	1.436E+08	4.293E+04
NP239	1.320E+05	1.978E+06	5.309E+04	1.706E+03	2.100E+07	6.371E+03

TABLE 2-6

PATHWAY DOSE FACTOR (R)

ADULT

ATOM	INHAL	G/P	COW/MILK	COW/MEAT	VEG	GT/MILK
H3	1.264E+03	0.000E+00	7.629E+02	3.248E-02	2.260E+03	1.556E+03
C14	1.816E+04	0.000E+00	1.778E+08	1.630E+08	2.276E+09	1.778E+08
P32	1.320E+06	0.000E+00	8.588E+09	2.341E+09	1.406E+09	1.031E+10
CR51	1.440E+04	5.517E+06	3.729E+06	9.205E+05	1.171E+07	4.475E+05
MN54	1.400E+06	1.629E+09	1.659E+07	1.810E+07	9.589E+08	1.990E+06
FE55	7.208E+04	0.000E+00	1.568E+07	1.948E+08	2.096E+08	2.169E+05
FE59	1.016E+06	3.238E+08	1.269E+08	1.137E+09	9.969E+08	1.649E+06
CO58	9.280E+05	4.490E+08	5.489E+07	2.127E+08	6.274E+08	6.586E+06
CO60	5.968E+06	2.528E+10	2.063E+08	9.456E+08	3.139E+09	2.476E+07
NI63	4.320E+05	0.000E+00	4.540E+09	1.274E+10	1.040E+10	5.448E+08
ZN65	8.640E+05	8.574E+08	2.774E+09	7.193E+08	1.009E+09	3.329E+08
RB86	1.352E+05	1.029E+07	1.315E+09	2.472E+08	2.201E+08	1.578E+08
SR89	1.400E+06	2.523E+04	8.006E+08	1.666E+08	1.001E+10	1.681E+09
SR90	9.920E+07	0.000E+00	3.154E+10	8.384E+09	6.046E+11	6.624E+10
Y91	1.704E+06	1.217E+06	2.655E+06	3.506E+08	2.831E+09	3.186E+05
ZR95	1.768E+06	2.915E+08	5.473E+05	1.092E+09	1.216E+09	6.567E+04
NB95	5.048E+05	1.614E+08	1.478E+08	4.119E+09	4.826E+08	1.774E+07
TC99M	4.160E+03	2.101E+05	2.711E+03	3.030E-18	5.117E+03	3.253E+02
RU103	5.048E+05	1.226E+08	6.406E+04	6.649E+09	5.649E+08	7.687E+03
RU106	9.360E+06	5.063E+08	8.552E+05	1.173E+11	1.248E+10	1.026E+05
AG110M	4.632E+06	4.062E+09	1.401E+10	1.608E+09	3.987E+09	1.681E+09
TE125M	3.136E+05	2.133E+06	3.711E+07	8.179E+08	3.934E+08	4.453E+06
TE127M	9.600E+05	1.083E+05	1.113E+08	2.713E+09	1.418E+09	1.336E+07

TABLE 2.6 (cont)

PATHWAY DOSE FACTOR (R)

ADULT

ATOM	INHAL	G/P	COW/MILK	COW/MEAT	VEG	GT/MILK
TE129M	1.160E+06	2.348E+07	1.609E+08	3.049E+09	1.288E+09	1.931E+07
I131	1.192E+07	2.095E+07	6.956E+10	2.534E+09	3.795E+10	8.347E+10
CS134	8.480E+05	7.972E+09	8.891E+09	1.034E+09	1.110E+10	2.667E+10
CS136	1.464E+05	1.690E+08	5.172E+08	2.341E+07	1.660E+08	1.552E+09
CS137	6.208E+05	1.203E+10	6.804E+09	8.039E+08	8.696E+09	2.041E+10
BA140	1.272E+06	2.351E+07	2.778E+07	2.976E+07	2.652E+08	3.334E+06
CE141	3.616E+05	1.539E+07	6.582E+06	1.908E+07	5.094E+08	7.899E+05
CE144	7.776E+06	8.046E+07	7.747E+07	3.157E+08	1.112E+10	9.297E+06
PR143	2.808E+05	0.000E+00	3.473E+05	4.615E+07	2.747E+08	4.167E+04
ND147	2.208E+05	1.015E+07	2.629E+05	1.991E+07	1.865E+08	3.155E+04
NP239	1.192E+05	1.978E+06	3.698E+04	2.596E+03	2.876E+07	4.438E+03

FIGURE 2.1

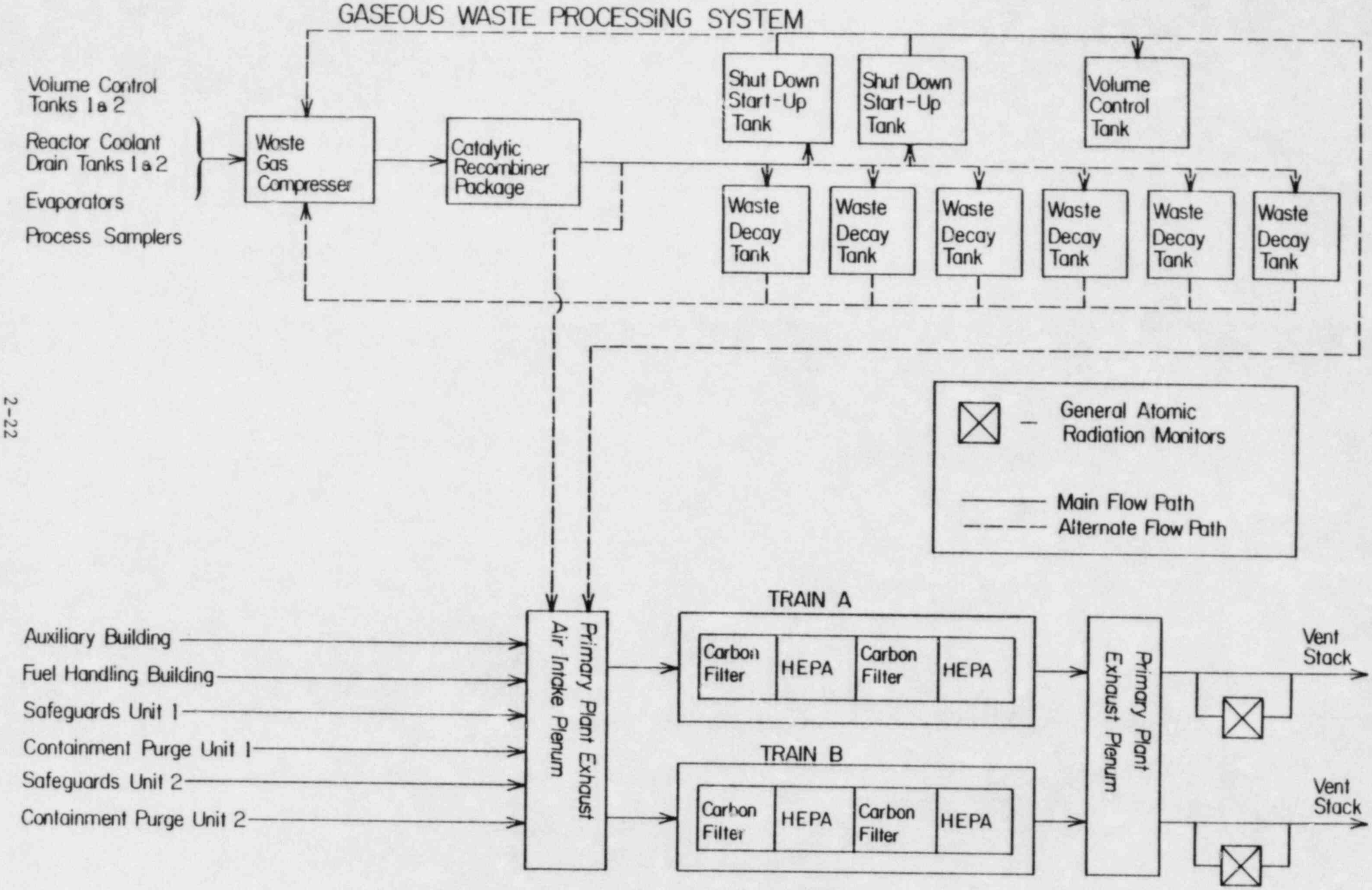

GASEOUS WASTE PROCESSING SYSTEM
Volume Control Tanks 1 & 2
Reactor Coolant Drain Tanks 1 & 2
Evaporators
Process Samplers
Waste Gas Compresser
Catalytic Recombiner Package
Shut Down Start-Up Tank
Shut Down Start-Up Tank
Volume Control Tank
Waste Decay Tank
Waste Decay Tank
Waste Decay Tank
Waste Decay Tank
Waste Decay Tank
Waste Decay Tank
General Atomic Radiation Monitors
Main Flow Path
Alternate Flow Path
Auxiliary Building
Fuel Handling Building
Safeguards Unit 1
Containment Purge Unit 1
Safeguards Unit 2
Containment Purge Unit 2
Primary Plant Exhaust Air Intake Plenum
TRAIN A
Carbon Filter
HEPA
Carbon Filter
HEPA
TRAIN B
Carbon Filter
HEPA
Carbon Filter
HEPA
Primary Plant Exhaust Plenum
Vent Stack
Vent Stack

Table 2.7

ATMOSPHERIC DISPERSION PARAMETERS*

FOR TECHNICAL SPECIFICATION 4.11.2.4.1

Sector	Miles	X/Q	D/Q
N	4.2	2.7E-07	1.2E-09
NNE	3.9	1.9E-07	7.5E-10
NE	3.4	1.7E-07	5.0E-10
ENE	2.6	2.1E-07	5.5E-10
E	3.4	1.6E-07	2.9E-10
ESE	3.8	1.4E-07	2.7E-10
SE	2.8	3.7E-07	1.2E-09
SSE	2.9	2.8E-07	1.3E-09
S	4.2	1.2E-07	4.6E-10
SSW	4.4	9.0E-08	2.6E-10
SW	1.5	6.4E-07	2.5E-09
WSW	1.7	5.2E-07	1.6E-09
W	1.6	7.8E-07	2.5E-09
WNW	1.9	8.2E-07	2.8E-09
NW	5.0	2.4E-07	5.6E-10
NNW	4.9	2.6E-07	8.0E-10

TABLE 2.8

CONTROLLING RECEPTORS, LOCATIONS, AND PATHWAYS

(For Dose Calculations required by Technical Specifications 3.11.2.3, 3.11.2.4 and 6.9.1.13)

SECTOR	DISTANCE (MILES)	PATHWAY	AGE GROUP
N	4.2	Goat/Milk	Infant
NNE	3.9	Cow/Milk	Infant
NE	3.4	Cow/Milk	Infant
ENE	2.6	Vegetation	Child
E	3.4	Goat/Milk	Infant
ESE	3.8	Cow/Milk	Infant
SE	2.8	Vegetation	Child
SSE	2.9	Cow/Milk	Infant
S	4.2	Goat/Milk	Infant
SSW	4.4	Cow/Milk	Infant
SW	1.5	Cow/Milk	Infant
WSW	1.7	Vegetation	Child
W	1.6	Cow/Milk	Infant
WNW	1.9	Cow/Milk	Infant
NW*	5.0	Cow/Milk	Infant
NNW	4.9	Goat/Milk	Infant

*No pathway currently exists in this sector. Cow/Milk pathway to infant is assumed at distance of 5 miles.

2.3 METEOROLOGICAL MODEL

Atmospheric dispersion for releases are calculated using a straight line flow Gaussian model.

X/Q = average atmospheric dispersion (sec/m^3) for a given wind direction (sector) and distance.

$$= 2.032\ \delta K \sum_{j,k} \left(\frac{n_{jk}}{N r\, u_{jk}\, \Sigma_j} \right)$$

2.03 = $(2/\pi)^{1/2}$ divided by the width in radians of a 22.5° sector (0.3927 radians).

$n_{j,k}$ = number of hours meteorological conditions are observed to be in a given wind direction, windspeed class k, and atmospheric stability class j which establishes a joint frequency distribution of grouped meteorological data.

NOTE: If periodic data (hourly) are used instead of the joint frequency data, all variable subscripts are dropped, the $n_{j,k}$ is set equal to 1 and the hourly averaged meteorological variables are entered into the model.

N = total hours of valid meteorological data throughout the period of effluent release.

r = distance from the release point to location of interest (meters)

$u_{j,k}$ = wind speed (midpoint of windspeed class k) measured at the 10 meter level (m/sec) during atmospheric stability class j

Σ_j = building wake corrected vertical standard deviation of the plume concentration.

= the lesser of $(\sigma_j^2 + b^2/2\pi)^{1/2}$ or $(\sqrt{3}\,\sigma_j)$ where:

σ_j = vertical standard deviation of the plume concentration (meters) at distance r for releases (Fig. 2.3)

K = terrain recirculation factor (Fig. 2.5)

δ = plume depletion factor (radioiodines and particulates) at distance r for the applicable stability class. Normally a factor of 1 is assumed when undepleted X/Q values are to be used in dose calculations. (Fig. 2.2)

π = 3.1416

b = vertical height of reactor containment structure (79.4 meters).

ΔT = vertical temperature gradient ($^{\circ}C/100M$).

Relative deposition per unit area is calculated.

D/Q = relative deposition per unit area (m^{-2}), for a given wind direction and at a given distance, r

$$= \frac{2.55K}{r} D_g$$

D_g = relative deposition rate for a ground-level release determined from Figure 2.4.

2.55 = (radians per 22.5° Sector)$^{-1}$

FIGURE 2.2

Plume Depletion Effect for Ground-Level Releases (All Atmospheric Stability Classes)

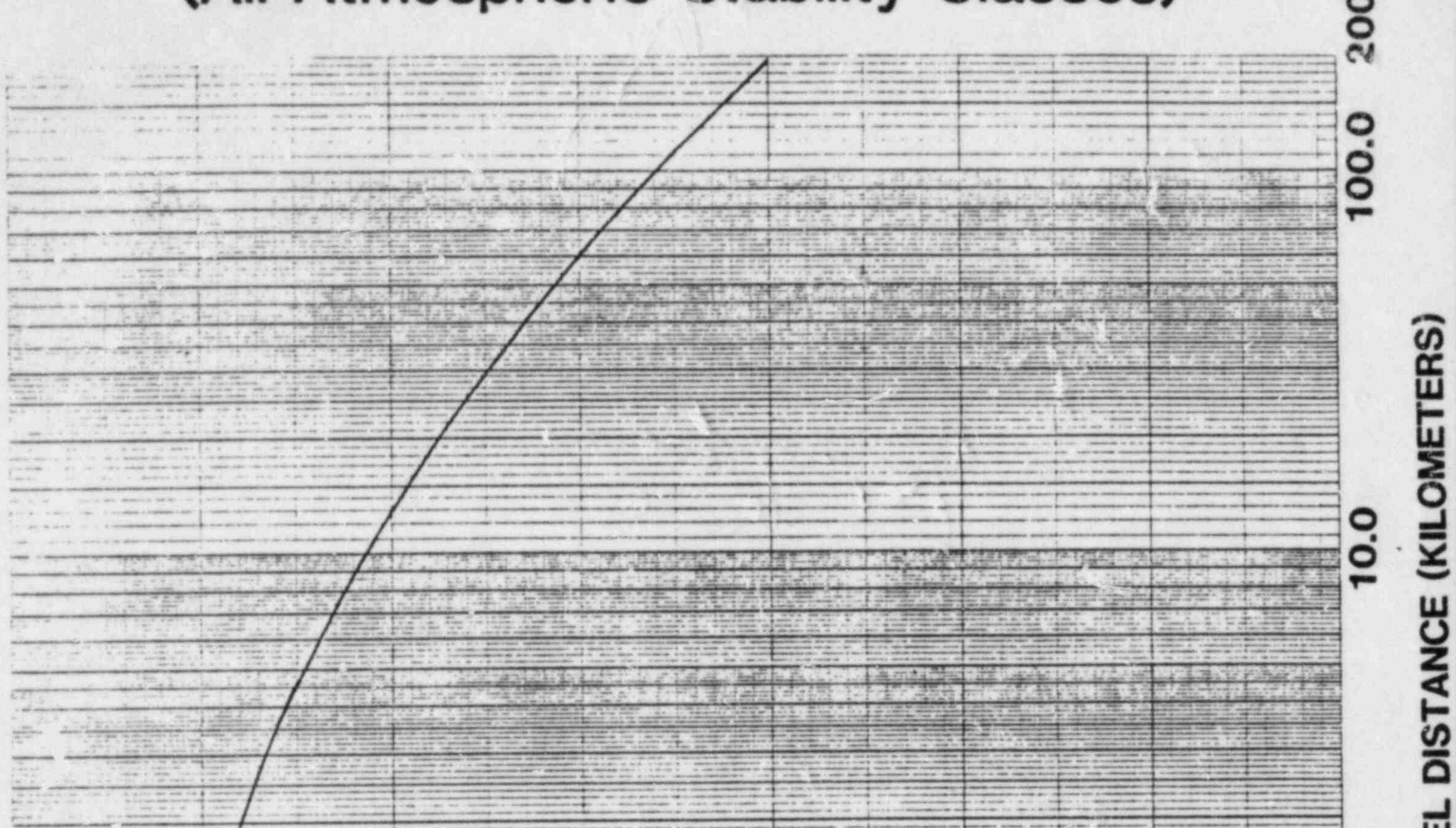


FIGURE 2.3

Vertical Standard Deviation of Material in a Plume
(Letters denote Pasquill Stability Class)

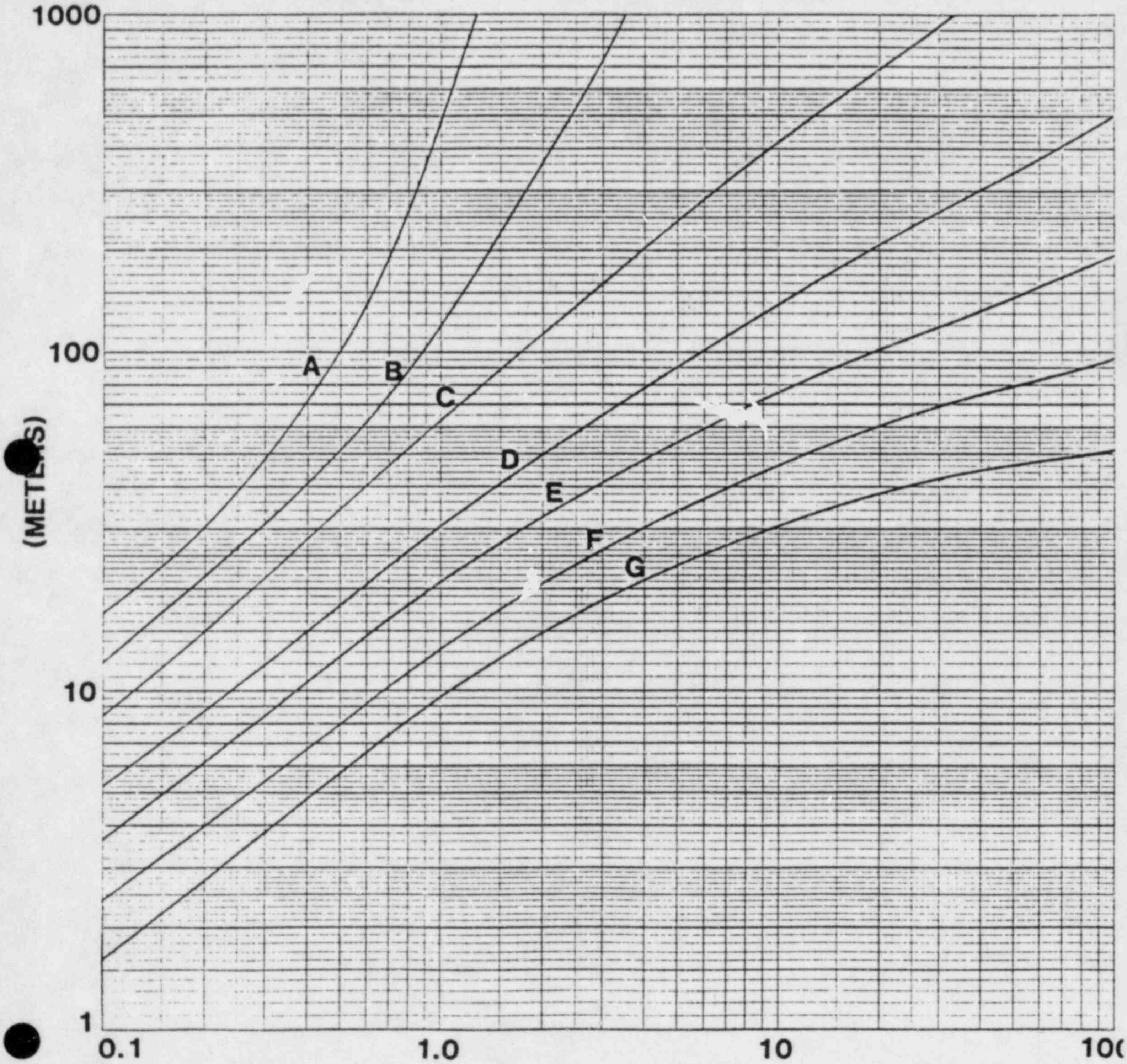
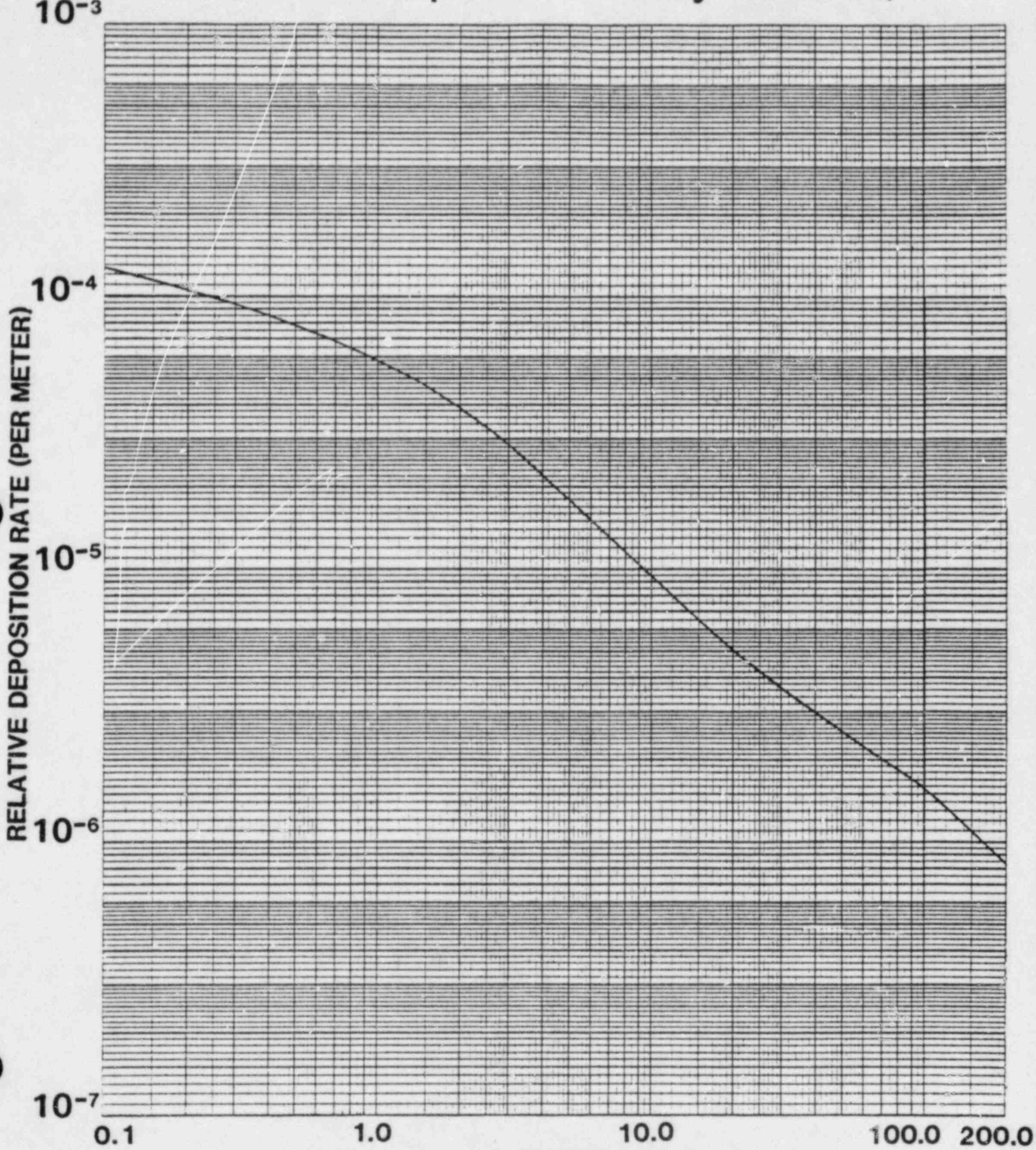


FIGURE 2.4

Relative Deposition for Ground-Level Releases (All Atmospheric Stability Classes)



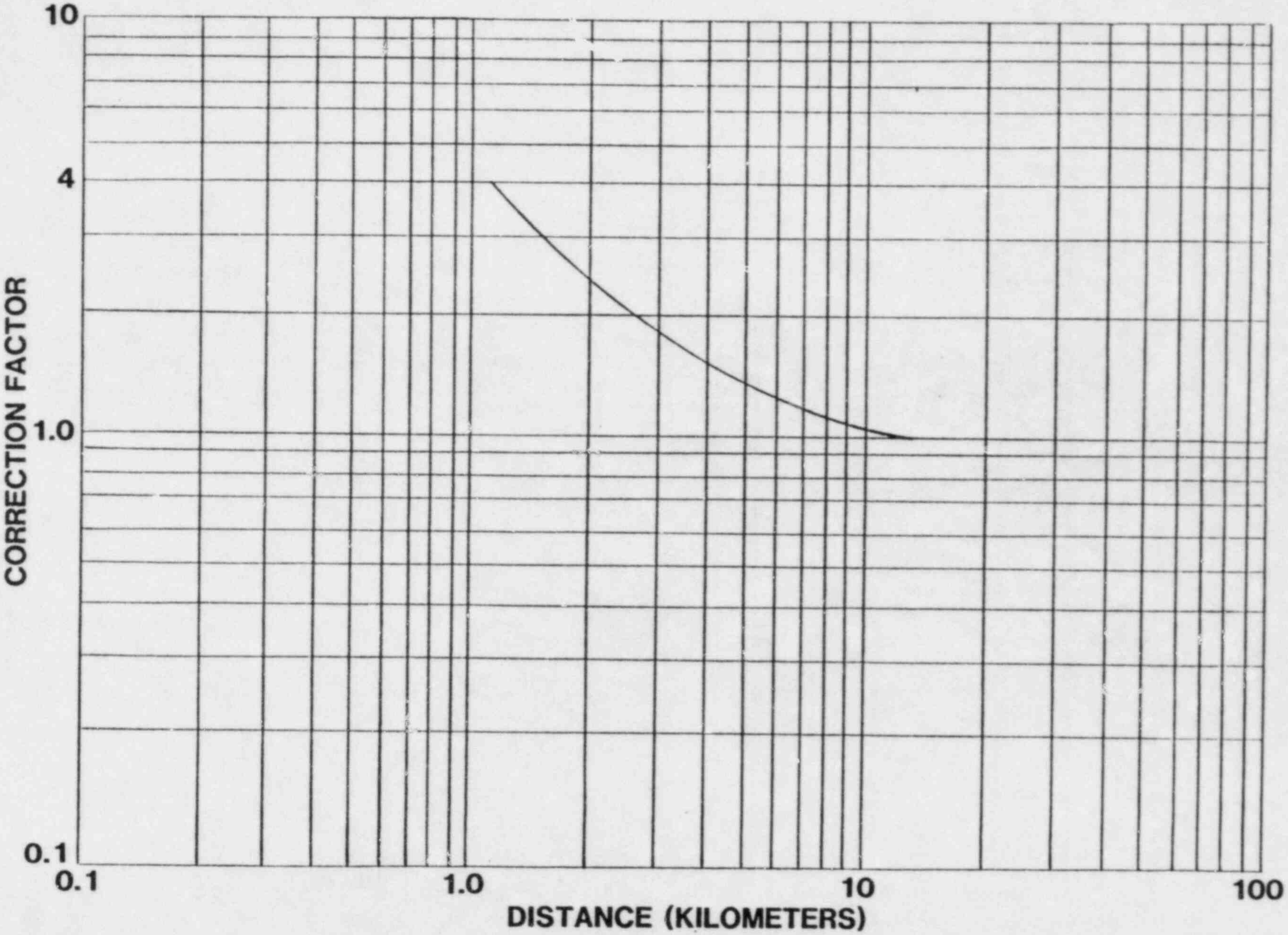


FIGURE 2.5

Open Terrain Recirculation Factor

2.4 DEFINITIONS OF GASEOUS EFFLUENTS PARAMETERS

Term	Definition	Section of Initial Use
B	= administrative allocation factor for gaseous effluent pathways	2.1.1
b	= maximum height of the adjacent building.	2.3.1
C	= monitor reading of a gaseous effluent monitor corresponding to associated sample radionuclide concentrations.	2.1.1
D_o	= average organ duse rate in the current year (mrem/yr)	2.2.1.b
D_p	= d^ e to an individual from radioiodines and radionuclides in particulate form with half-lives greater than eight days (mrem).	2.2.2.b
D_s	= calculated skin dose rate (mrem/yr)	2.2.1.a
D_{ss}	= limiting dose rate to the skin = 3000 mrem/yr	2.1.1
D_t	= calculated total body dose rate (mrem/yr)	2.2.1.a
D_{TB}	= limiting dose rate to the body = 500 mrem/yr	2.1.1
D_β	= air dose due to beta emissions from noble gas	2.2.2.a
D_γ	= air dose due to gamma emissions from noble gas	2.2.2.a
D/Q	= the sector averaged annual average relative deposition for any distance in a given sector.	

2.4 DEFINITIONS OF GASEOUS EFFLUENTS PARAMETERS (CONTINUED)

Term	Definition	Section of Initial Use
$\overline{D/Q'}$	= annual average relative deposition at the location of the maximum exposed individual.	2.2.2.b
	= $2.8 \times 10^{-9}\ m^{-2}$ in the WNW sector	
δ	= plume depletion factor at distance r for the appropriate stability class (radioiodines and particulates).	2.3.1
K_i	= total body dose factor due to gamma emissions from isotope i (mrem/year per microcurie/m^3)	2.1.1
L_i	= skin dose factor due to beta emissions from isotope i (mrem/yr per microcurie/m^3)	2.1.1
M_i	= air dose factor due to gamma emissions from isotope i (mrad/yr per microcurie/m^3)	2.1.1
N_i	= air dose factor due to beta emissions from noble gas radionuclide i (mrad/yr per microcurie/m^3)	2.2.2.a
n_{jk}	= number of hours meteorological conditions are observed to be in a given wind direction, wind-speed class k, 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 microcurie/m^3)	2.2.1.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 (microcurie/sec)	2.1.1
Q_i'	= rate of release of isotope i for radioiodine, tritium, and radionuclides in particulate form. (microcurie/sec)	2.1.3
$\tilde{Q}_i$	= cumulative release of noble gas radionuclide i over the period of interest (microcurie).	2.2.2.a
$\tilde{Q}_i'$	= cumulative release of radionuclide i of iodine or material in particulate form over the period of interest (microcurie).	2.2.2.b
R_i	= dose factor for radionuclide i, (mrem/yr per microcurie/m^3) or (m^2-mrem/yr per microcurie/sec)	2.2.2.b
R_s	= monitor reading per mrem/yr to the skin.	2.1.1
R_t	= monitor reading per mrem/yr to the total body.	2.1.1
r	= distance from the point of release to the location of interest for dispersion calculations (meters).	2.3.1
C_S	= monitor reading of the noble gas monitor at the alarm setpoint for the release pathway under consideration.	2.1.1
Σ_j	= vertical standard deviation of the plume concentration with building wake correction.	2.3.1

2.4 DEFINITIONS OF GASEOUS EFFLUENTS PARAMETERS (CONTINUED)

Term	Definition	Section of Initial Use
σ_j	= vertical standard deviation of the plume concentration (in meters), at distance r for ground level releases under the stability category j indicated by ΔT	2.3.1
ΔT	= vertical temperature gradient ($^{o}C/100m$).	2.3.1
K	= terrain recirculation factor.	2.3.1
u_{jk}	= wind speed (midpoint of windspeed class k) at ground level (m/sec) during atmospheric stability class j.	2.3.1 2.3.1
W'	= relative dispersion for unrestricted areas at the controlling receptor.	2.2.2.b
X/Q	= the sector-averaged annual average relative concentration at any distance r in a given sector. (sec/m^3)	2.3.1 2.3.1
$\overline{X/Q}$	= the highest annual average relative concentration in any sector, at the site boundary. (sec/m^3) = 3.3×10^{-6} sec/m^3 in the NNW sector	2.1.1
$\overline{X/Q'}$	= relative concentration for the location occupied by the maximum exposed individual = 8.2×10^{-7} sec/m^3 in the WNW sector	2.2.2.b

SECTION 3.0

RADIOLOGICAL ENVIRONMENTAL MONITORING

Sampling locations as required in Technical Specification 3/4.12.1 are described in Table 3.1 and shown on the map in Figure 3.1.

NOTE: For the purpose of implementing Technical Specification 3.12.2, sampling locations will be modified as required to reflect the findings of the Land Use Census.

Table 3.1

Environmental Sampling Locations

Sampling Point	Location (Sector - Miles)	Sample Type*
1	E-0.5	A
2	N-2.2	A
3	W-2.0	A
4	NNW-4.6	A
5	E-3.5	A
6	SE-3.85	A
7	SSE-4.5	A
8	N-9.4	A
9	SW-12.3	A
10	N-1.2	R
11	N-4.4	R
12	N-6.5	R
13	N-9.4	R
14	NNE-1.1	R
15	NNE-5.65	R
16	NE-1.7	R
17	NE-4.8	R
18	ENE-2.5	R
19	ENE-5.0	R
20	E-0.5	R

Table 3.1 (Continued)

Environmental Sampling Locations

Sampling Point	Location (Sector - Miles)	Sample Type*
21	E-1.9	R
22	E-3.5	R
23	E-4.2	R
24	ESE-1.4	R
25	ESE-4.7	R
26	SE-1.3	R
27	SE-3.85	R
28	SE-4.6	R
29	SSE-1.3	R
30	SSE-4.4	R
31	SSE-4.5	R
32	S-1.5	R
33	S-4.2	R
34	SSW-1.0	R
35	SSW-4.4	R
36	SW-0.9	R
37	SW-4.8	R
38	SW-12.3	R
39	WSW-1.0	R
40	WSW-5.35	R

Table 3.1 (Continued)

Environmental Sampling Locations

Sampling Point	Location (Sector - Miles)	Sample Type*
41	WSW-7.0	R
42	W-1.0	R
43	W-2.0	R
44	W-5.5	R
45	WNW-1.0	R
46	WNW-5.0	R
47	WNW-6.7	R
48	NW-1.0	R
49	NW-5.7	R
50	NW-9.9	R
51	NNW-1.35	R
52	NNW-4.6	R
53	ESE-0.5	SW
54	ESE-2.2	SW
55	N-9.9	SW
56	E-0.5	GW
57	SSE-4.5	GW
58	NNE-1.0	SS
59	N-9.9	SS
60	**	M

Table 3.1 (Continued)

Environmental Sampling Locations

Sampling Point	Location (Sector - Miles)	Sample Type*
61	**	M
62	**	M
63	SW-13.5	M
64	ENE-2.0	F
65	NNE-8.0	F
66	E-4.2	V
67	SW-13.5	V
68	W-1.8	V
69	SE-1.3	V
70	SSE-1.3	V
71	SW-13.5	V

*Types: A - Air Sample, R - Direct Radiation, SW - Surface Water, GW - Ground Water, SS - Shoreline Sediment, M - Milk, F - Fish; V - Vegetation.

**As determined from yearly milk animal census.

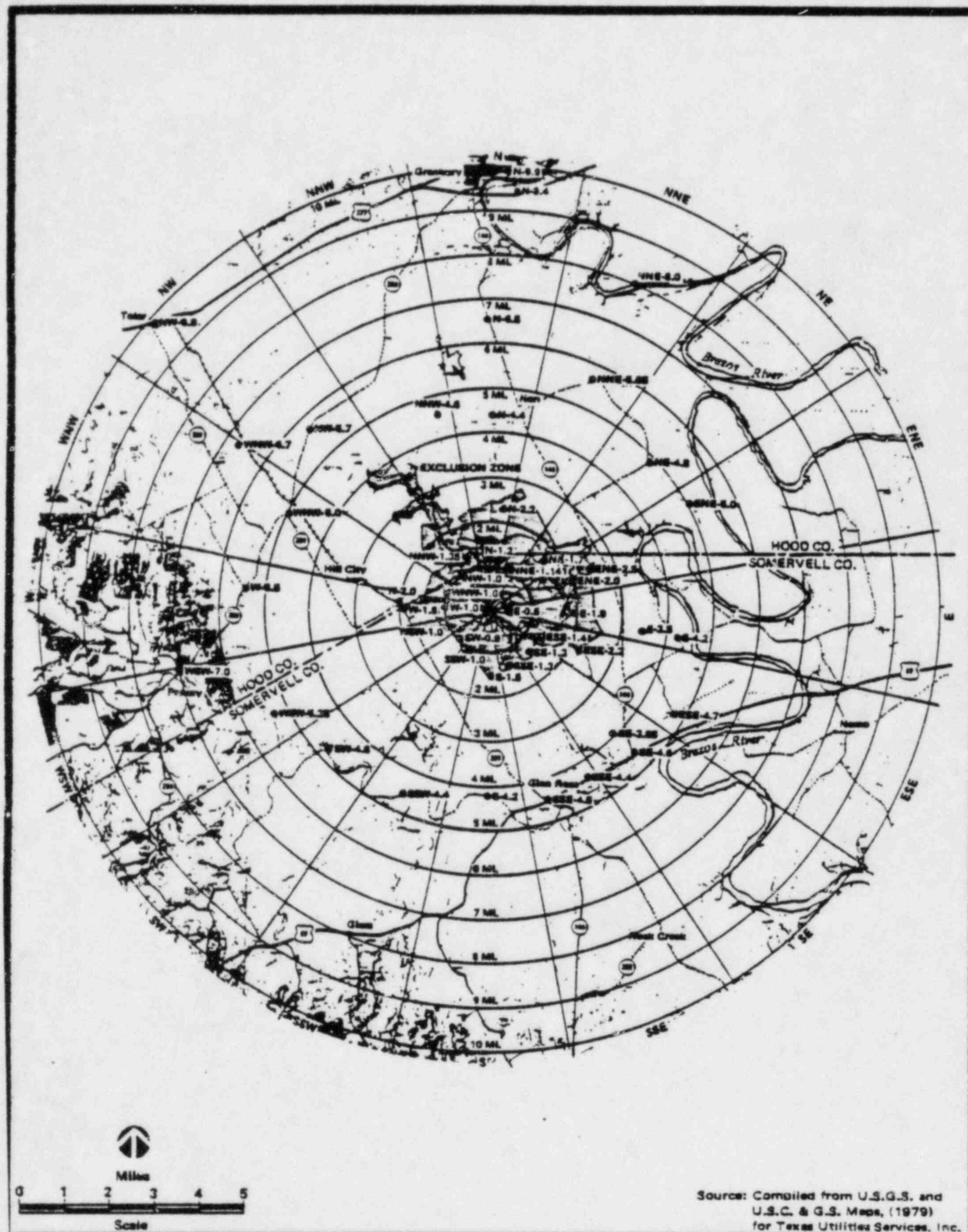
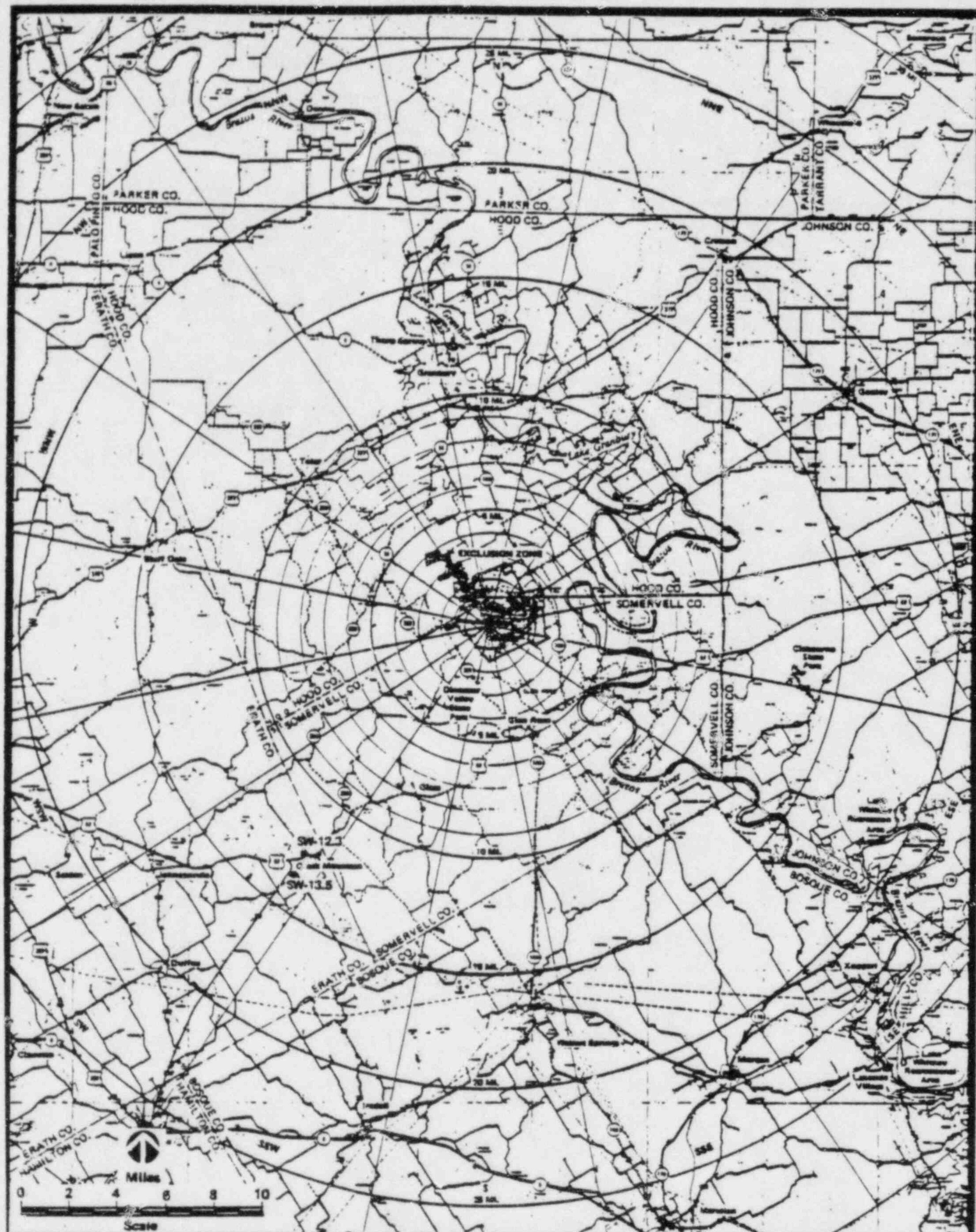


Figure 3.1

Comanche Peak S.E.S.

Radiological Environmental Monitoring Program

Sample Locations Within 10 Miles of the Site



Source: Compiled from Texas Highway Dept.
"General Highway Maps, (1979)"
for Texas Utilities Services, Inc.

Figure 3.1 (Cont.)

Comanche Peak S.E.S.

Radiological Environmental Monitoring Program

Sample Locations Greater than 10 Miles from the Site

APPENDIX A

Calculation of P_i (Inhalation)

P_i = k' (BR) DFA_i

where

P_i = the dose parameter for radionuclides other than noble gases for the inhalation pathway, in mrem/yr per microcurie/m^3. The dose factors are based on the critical individual organ for the child age group.

k' = conversion factor, 10^6 pCi/microcurie

BR = 3700 m^3/yr, breathing rate for child, Ref. 3

DFA_i = the maximum organ inhalation dose factor for the child age group

Resolution of the units yields:

P_i (Inhalation) = 3.7×10^9 DFA_i

The latest NRC guidance has deleted the requirement to determine P_i (ground plane) and P_i (food). In addition, the critical age group has been changed from infant to child.

APPENDIX B

Inhalation Pathway Factor, R_i^I (X/Q)

R_i^I (X/Q) = k' (BR) (DFA_i) (mrem/yr per microcurie/m^3)

where

k' = conversion factor, 10^6 pCi/microcurie

BR = breathing rate, 1400, 3700, 8000, 8000 m^3/yr for infant, child, teenager, and adult respectively

DFA_i = the maximum organ inhalation dose factor for the receptor of given age group for the ith radionuclide, in mrem/pCi. The total body is considered as an organ in the selection of (DFA_i).

APPENDIX C

Ground Plane Pathway Factor, R_i^G (D/Q)

$$R_i^G \text{ (D/Q)} = k' k'' \text{ (SF) } DFG_i \left((1-e^{-\lambda t}) / \lambda \right)$$

where

k' = conversion factor, 10^6 pCi/microcurie

k'' = conversion factor, 8760 hr/yr

λ = radionuclide decay constant, sec^{-1}

t = the decay time, assuming that decay is the only operating removal mechanism, 4.73×10^8 sec.

DFG_i = the ground plane dose conversion factor for the ith radionuclide (mrem/hr per pCi/m^2).

SF = .7, shielding factor, from Table E15 Reg. Guide 1.109

APPENDIX D

Grass-Cow-Milk Pathway Factor, R_i^C (D/Q)

$$R_i^C (D/Q) = k' (Q_F \times U_{AP}) / (\lambda_i + \lambda_w) \times Fm \times r \times DFL_i \times ((fp \times fs)/ Yp + ((1-fp \times fs) e^{-\lambda_i t_h}) Ys)) e^{-\lambda_i t_f}$$

where

k' = conversion factor, 10^6 pCi/microcurie

Q_F = cow consumption rate, 50 kg/day, R.G.1.109

U_{AP} = receptor's milk consumption rate; 330,330,400,310 for infant, child, teenager, and adult resp. R.G. 1.109

Yp = agricultural productivity by unit area of pasture feed grass, .7 kg/m^2, NUREG 133

Ys = agricultural productivity by unit area of stored feed, 2.0 kg/m^2, NUREG 133

Fm = stable element transfer coefficient, Table E1 R.G. 1.109

r = fraction of deposited activity retained on cow's feed grass, .2 for particulates, 1.0 for radioiodine.

DFL_i = the maximum organ ingestion dose factor for the ith radionuclide for each respective age group tables E-11 to E-14 R. G. 1.109

λ_i = decay constant

λ_w = decay constant for weathering, 5.73×10^{-7} sec^{-1}, NUREG 133

t_f = 1.73×10^5 sec, the transport time from pasture to cow, to milk to receptor, in seconds

t_h = 7.78×10^6 sec, the transport time from pasture, to harvest, to cow to milk, to receptor

fp = 1.0, the fraction of the year that the cow is on pasture. Land Census Report 1982

fs = .5, the fraction of the cow feed that is stored feed while the cow is on pasture. Land Census 1982

The concentration of tritium in milk is based on the airborne concentration rather than the deposition. Therefore R_i^c (X/Q) becomes:

$$R_i^c\ (X/Q) = k'k''' \ FM\ Q_F\ U_{AP}\ DFL_i\ \ (.75\ (.5/H))$$

where

k''' = 10^3 grams/kg

H = 8 grams/m^3, absolute humidity of the atmosphere

.75 = fraction of total feed grass mass that is water

.5 = ratio of the specific activity of the feed grass water to the atmospheric water. NUREG 133

APPENDIX E

Vegetation Pathway Factor, R_i^v (D/Q)

R_i^v (D/Q) = $k' \times r/(Yv(\lambda_i + \lambda_w)) \times DFL_i \times U_A^L f_L e^{-\lambda_i t_L} + U_A^S fg e^{-\lambda_i t_h}$

where

k' = 10^6 pCi/microcurie

U_A^L = the consumption rate of fresh leafy vegetation, 0,26,42,64 for infant, child, teen, or adult respectively

U_A^S = the consumption rate of stored vegetation, 0,520,630,520 for infant, child, teen, or adult respectively

f_L = the fraction of the annual intake of fresh leafy vegetation grown locally, 1.0 NUREG 133

fg = the fraction of the stored vegetation grown locally .76 NUREG 133

t_L = the average time between harvest of leafy vegetation and its consumption, 8.6×10^4 seconds Table E-15 R.G. 1.109

t_h = the average time between harvest of stored vegetation and its consumption, 5.18×10^6 seconds Table E-15 R.G.1.109

Yv = 2.0 kg/m^2 Table E-15 R.G.1.109

The concentration of tritium in vegetation is based on the airborne concentration rather than the deposition. Therefore, R_i^v is based on (X/Q)

R_i^v = $k'k''' \; U_A^L f_L + U_A^S fg \; (DFL_i) \; (.75 \, (.5/H))$

k''' = 10^3 grams/kg

H = 8 grams/m^3

.75 = the fraction of total feed grass mass that is water

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

```
478   ! THIS PROGRAM COMPUTES (R), PATHWAY DOSE FACTORS FOR ADULTS, TEENAGERS, C
HILDREN, AND INFANTS
479   ! TO USE THE PROGRAM, PRESS RUN AND THEN RESPOND TO THE QUESTIONS ASKED.
480   !
482   ! DEFINITION OF TERMS
483   !
490   ! DFA=MAX ORGAN INHALATION DOSE FACTOR.     TABLE E-6 THROUGH E-10 R.G. 1.
109
500   !
510   ! DFG=GROUND PLANE DOSE CONVERSION FACTOR.  TABLE E-6 R.G. 1.109
520   !
530   ! DFL=MAX ORGAN INGESTION DOSE FACTOR. TABLE E-11 THROUGH E-14. R.G. 1.109
540   !
550   ! FM=STABLE ELEMENT TRANSFER COEFFICIENT    MILK. TABLE E1 R.G. 1.109
551   !
560   ! FF=STABLE ELEMENT TRANSFER COEFFICIENT    MEAT. TABLE E1 R.G. 1.109
570   !
580   ! K=CONSTANT. 1.0E6, NUREG 133
590   !
600   ! BR=BREATHING RATE. 1400. 3700. 8000  8000 FOR INFANT. CHILD. TEEN. ADULT
 RESP.
610   !
620   ! Kk=CONSTANT, 8760. NUREG 133
630   !
640   ! SF=SHIELDING FACTOR. .7. TABLE E15 R.G. 1.109
650   !
660   ! LAMDA=NUCLIDE DECAY CONSTANT
670   !
680   ! T=DECAY TIME, ASSUMING THAT DECAY IS THE ONLY REMOVAL MECHANISM. 4.73E8.
 NUREG 133
690   !
700   ! QF=COW'S CONSUMPTION RATE, 50. TABLE E3.   R.G. 1.109
710   !
720   ! R=FRACTION OF DEPOSITED ACTIVITY RETAINED ON COW'S FEED GRASS. 1.0 FOR I
ODINE. .2   FOR
721   !  PARTICULATE.
740   !
750   ! UAP1=RECEPTOR'S MILK CONSUMPTION RATE. 330. 330. 400. 310 FOR INFANT.CHI
LD. TEENAGER AND
760   ! ADULT RESPECTFULLY.
770   !
780   ! Yp=AGRICULTURAL PRODUCTIVITY. .7. NUREG 133
790   !
800   ! Ys=AGRICULTURAL PRODUCTIVITY (STORED FEED). 2.0. NUREG 133.
810   !
820   ! Tf=TRANSPORT TIME FROM PASTURE TO RECEPTOR. 1.73E5. NUREG 133.
830   !
840   ! Th=TRANSPORT TIME FROM PASTURE TO HARVEST TO RECEPTOR. 7.78E6. NUREG 133
.
850   !
860   ! FP=FRACTION OF YEAR COW IS ON PASTURE. 1.0. LAND CENSUS.  NOTE. THIS FAC
TOR CAN POTENTIALLY
870   ! CHANGE ANNUALLY.
871   !
880   ! FS=FRACTION OF THE COW FEED THAT IS STORED FEED WHILE THE COW IS ON PAST
URE. .5. LAND CENSUS
890   ! FS CAN POTENTIALLY CHANGE ANNUALLY. TO UP-DATE THIS VALUE, SIMPLY CHANGE
 THE FS ASSIGNMENT
891   ! INSTRUCTION IN THE FIRST PART OF THE       PROGRAM.
900   ! KKK=CONSTANT 1.0E3. NUREG 133
```

```
:0    !
20    ! H=HUMIDITY, 8, NUREG 133
30    !
40    ! LAMDAW=DECAY CONSTANT FOR REMOVAL OF ACTIVITY FROM PLANTS BY WEATHERING.
5.73E-7, NUREG 133
50    !
60    ! UAP2=RECEPTOR'S MEAT CONSUMPTION, 0, 41, 65, 110  FOR INFANT,CHILD,TEENA
ER, AND ADULT
70    ! RESPECTFULLY, NUREG 133
71    !
80    ! UAL=CONSUMPTION RATE OF FRESH LEAFY VEGETABLES 0, 26, 42, 64, FOR INFANT
CHILD, TEENAGER,
90    ! AND ADULT RESPECTFULLY, NUREG 133
91    !
000   ! UAS=CONSUMPTION RATE OF STORED VEGETABLES 0, 520, 630, 520, NUREG 133
010   ! FOR INFANT, CHILD, TEENAGER, AND ADULT.              RESPECTIVELY
011   !
020   ! FL=FRACTION FRESH VEGETABLES GROWN LOCALLY
030   !
040   ! FG=FRACTION STORED VEGETABLES GROWN LOCALLY
050   !
060   ! TL=AVG. TIME BETWEEN HARVEST OF VEGETABLES AND CONSUMPTION, 8.6 E4 SEC.
NUREG 133
070   !
080   ! THH=AVERAGE TIME BETWEEN HARVEST OF STORED VEGETABLES AND CONSUMPTION 5.
8E6 SEC.  NUREG 133
090   !
100   !
110   K=1.0E+6 ! UNITS CONVERSION FACTOR
120   Kk=8760  ! UNITS CONVERSION FACTOR
130   Sf=.7    ! SHIELDING FACTOR
140   T=4.73E+8 ! DECAY TIME FOR DECAY AS ONLY REMOVAL MECHANISM.
150   Qf=50 ! COW CONSUMPTION RATE
160   R=.2  ! FRACTION OF DEPOSITED ACTIVITY RETAINED ON THE COW'S FEED GRASS.
170   Yp=.7 ! AGRICULTURAL PRODUCTIVITY
180   Ys=2.0 ! AGRICULTURAL PRODUCTIVITY FOR STORED FEED.
190   Tf=1.73E+5 !TRANSPORT TIME FROM PASTURE TO RECEPTOR.
200 Yv=2 !
201 Tff=1.73E+6
210   Th=7.78E+6  ! TRANSPORT TIME FROM PASTURE TOHARVEST TO RECEPTOR.
220   Fp=.67  ! FRACTION OF THE YEAR COW IS ON PASTURE.
230   Fs=1.0  ! FRACTION OF THE COW'S FEED THAT IS STORED FEED WHILE COW ON PAST
RE.
240   Kkk=1.0E+3  ! UNITS CONVERSION FACTOR.
250   H=8  !  ABSOLUTE HUMIDITY-DEFAULT VALUE
260   Lamdaw=5.73E-7  !DECAY CONSTANT FOR WEATHERING.
270   Fl=1 ! FRACTION OF FRESH VEG. GROWN LOCALLY
280   Fg=.76  !  FRACTION OF STORED VEG. GROWN  LOCALLY.
290   Tl=8.6E+4  ! AVG. TIME BETWEEN HARVEST OF VEG. AND CONSUMPTION.
300   Thh=5.18E+6 ! AVG. TIME BETWEEN HARVEST OF STORED VEG. AND CONSUMPTION.
301   ! BY ENTERING THE AGE GROUP OF CONCERN, THE COMPUTOR WILL GENERATE A TABLE
OF PATHWAY DOSE
302   ! FACTORS (R).
310   INPUT "PLEASE INDICATE INFANT,CHILD,TEENAGER, OR ADULT",Age$
312   INPUT "PLEASE INDICATE PATHWAY DOSE FACTOR R OR P",A$
314   IF A$<>"P" THEN 1394
315   PRINT USING "28X,26A,//,":"PATHWAY DOSE FACTOR  (P)";Age$
316   PRINT " "
317   IMAGE 6X,7A,5X,22A,/
318   PRINT USING 1317:"NUCLIDE","INHALATION DOSE FACTOR"
```

```
319  IMAGE 6X.6A.9X.D.3DE
321  READ Atom$.Dfa1.Dfa2.Dfa3.Dfa4.Df11.Df12.Df13.Df14.Dfg.Fm.Ff.Lamda
322  P1=K*1400*Dfa4
323  PRINT USING 1319:Atom$.P1
324  PRINT "    "
326  IF Atom$<>"TE125M" THEN 1321
327  IF Atom$="NP239" THEN 1391
328  PRINT USING "$,#"
329  PRINT USING "28X.26A./././":"PATHWAY DOSE FACTOR (P)":Age$
330  PRINT "    "
331  IMAGE  6X.7A.5X.22A./
332  PRINT USING 1331;"NUCLIDE"."INHALATION DOSE FACTOR"
333  GOTO 1321
352  IF Atom$="NP239" THEN 1391 ! CHECK FOR END OF DATA.
353  READ Atom$.Dfa1.Dfa2.Dfa3.Dfa4.Df11.Df12.Df13.Df14.Dfg.Fm.Ff.Lamda ! THIS
TATEMENT READS THE
354  ! DATA ASSOCIATED WITH THE PATHWAY DOSE FACTOR (R) CALCULATIONS.
355  IF Age$<>"INFANT" THEN 1364 !ASSIGNS AGE GROUP SPECIFIC DATA.
356  Dfa=Dfa4
357  Dfl=Df14
358  Br=1400
359  Uap1=330
360  Uap2=0
361  Ual=0
362  Uas=0
363  GOTO 1333
364  IF Age$<>"CHILD" THEN 1373 !ASSIGNS AGE GROUP SPECIFIC DATA.
365  Dfa=Dfa3
366  Dfl=Df13
367  Br=3700
368  Uap1=330
369  Uap2=41
370  Ual=26
371  Uas=520
372  GOTO 1333
373  IF Age$<>"TEENAGER" THEN 1382 ! ASSIGNS AGE GROUP SPECIFIC DATA.
374  Dfa=Dfa2
375  Dfl=Df12
376  Br=8000
377  Uap1=400
378  Uap2=65
379  Ual=42
380  Uas=630
381  GOTO 1333
382  IF Age$<>"ADULT" THEN 1390 ! ASSIGNS AGE    GROUP SPECIFIC DATA.
383  Dfa=Dfa1
384  Dfl=Df11
385  Br=8000
386  Uap1=310
387  Uap2=110
388  Ual=63
389  Uas=520
390  GOTO 1333
391  GOTO 2370
392  ! THE FOLLOWING CODE PRINTS THE PAGE TITLE  AND THE COLUMN HEADS.
393  !
394  PRINT USING "28X.26A./././":"PATHWAY DOSE FACTOR  (R) ":Age$
395   IMAGE  6X.4A.4X.5A.6X.3A.8X.8A.3X.8A.6X.3A.6X.7A./
396  PRINT USING 1395:"ATOM"."INHAL"."G/P"."COW/MILK"."COW/MEAT"."VEG"."GT/MILK
```

```
397 ! THIS READ STATEMENT READS THE NUCLIDE OF CONCERN PLUS THE DFA AND DFL VAL
ES FOR THAT NUCLIDE
398 ! NOTE DFA1 IS THE DFA VALUE FOR AN ADULT. DFA2 IS THE VALUE FOR A TEEN. DF
3 AND DFA4 ARE THE
399 ! VALUES FOR CHILDREN AND INFANTS RESPECTIVELY.
400  READ Atom$.Dfa1.Dfa2.Dfa3.Dfa4.Dfl1.Dfl2.Dfl3.Dfl4.Dfg.Fm,Ff,Lamda
401  IF Age$<>"INFANT" THEN 1480
402  Dfa=Dfa4 ! ASSIGN INFANT RELATED VALUES
410  Dfl=Dfl4
420  Br=1400
430  Uap1=330
440  Uap2=0
450  Ual=0
460  Uas=0
461  IF A$="P" THEN 1329
470  GOTO 1740
480  IF Age$<>"CHILD" THEN 1570
490  Dfa=Dfa3 ! ASSIGN CHILD RELATED VALUES
500  Dfl=Dfl3
510  Br=3700
520  Uap1=330
530  Uap2=41
540  Ual=26
550  Uas=520
551  IF A$="P" THEN 1329
560  GOTO 1740
570  IF Age$<>"TEENAGER" THEN 1660
580  Dfa=Dfa2 ! ASSIGN TEENAGER RELATED VALUES
590  Dfl=Dfl2
600  Br=8000
610  Uap1=400
620  Uap2=65
630  Ual=42
640  Uas=630
641  IF A$="P" THEN 1329
650  GOTO 1740
660  IF Age$<>"ADULT" THEN 1740
670  Dfa=Dfa1 ! ASSIGN ADULT RELATED VALUES
680  Dfl=Dfl1
690  Br=8000
700  Uap1=310
710  Uap2=110
720  Ual=64
730  Uas=520
731  IF A$="P" THEN 1329
740  IF Atom$="I131" THEN R=1 !SEE NUREG 133 P.34 FOR EXPLANATION.
750  IF Atom$="I132" THEN R=1
760  IF Atom$="I130" THEN R=1
770  IF Atom$="I133" THEN R=1
780  IF Atom$="I134" THEN R=1
790  IF Atom$="I135" THEN R=1
791  ! THE FOLLOWING CODE CALCULATES FOUR EXPONENTIAL VALUES.  A DEFAULT VALUE
F 1.0E-300 IS USED
792  ! TO AVOID THE ERROR "REAL UNDERFLOW".
793  IF Lamda*Tff<700 THEN 1796
794  Expo7=1.0E-300
795  GOTO 1800
796  Expo7=EXP(-Lamda*Tff)
800  IF Lamda*Th<700 THEN 1830
810  Expo1=1.0E-300
```

```
820  GOTO 1840
830  Expo1=EXP(-Lamda*Th)
840  IF Lamda*Tf<700 THEN 1870
850  Expo2=1.0E-300
860  GOTO 1880
870  Expo2=EXP(-Lamda*Tf)
880  IF Lamda*Tl<700 THEN 1910
890  Expo3=1.0E-300
900  GOTO 1920
910  Expo3=EXP(-Lamda*Tl)
920  IF Lamda*Thh<700 THEN 1950
930  Expo4=1.0E-300
940  GOTO 1960
950  Expo4=EXP(-Lamda*Thh)
951  ! EXPOA IS A FACTOR UTILIZED IN THE CALCULATION OF THE COW/MILK AND COW/ME
T DOSE PATHWAYS.
960  Expoa=((Fp*Fs)/Yp+((1-Fp*Fs)*Expo1)/Ys)*Expo2
961  ! EXPOB IS USED IN THE CALCULATION OF VEGETABLE DOSE PATHWAY.
970  Expob=Ual*Fl*Expo3+Uas*Fg*Expo4
971  Expoc=((Fp*Fs)/Yp+((1-Fp*Fs)*Expo1)/Ys)*Expo7
980  IF Atom$<>"H3" THEN 2030
990  R3=K*Kkk*Fm*Qf*Uap1*Dfl*((.75*.5/H)) ! H3 COW/MILK PATHWAY
000  R4=K*Kkk*Ff*Qf*Uap2*Dfl*((.75*.5/H))  !H3 COW/MEAT PATHWAY
010  R5=K*Kkk*(Ual*Fl+Fg*Uas)*Dfl*((.75*.5/H)) !H3 VEGETABLE PATHWAY
020  R6=K*Kkk*.17*Uap1*6*Dfl*((.75*.5/H))  !H3 GT/MILK PATHWAY
030  RI=K*Br*Dfa  !INHALATION DOSE FACTOR
040  IF Lamda*T<700 THEN 2070
050  Expo5=1.0E-300  !DEFAULT VALUE TO AVOID "REAL UNDERFLOW"
060  GOTO 2080
070  Expo5=EXP(-Lamda*T)
080  R2=K*Kk*Sf*Dfg*((1-Expo5)/Lamda) !GROUND PLANE DOSE FACTOR
090 IF Atom$="H3" THEN 2340 !H3 VALUES WERE CALCULATED ABOVE
100  R3=K*(Qf*Uap1)/(Lamda+Lamdaw)*Fm*R*Dfl*Expoa!COW/MILK PATHWAY
110  R4=K*(Qf*Uap2)/(Lamda+Lamdaw)*Ff*R*Dfl*Expoc!COW/MEAT PATHWAY
111 !
120  R5=K*R/(Yv*(Lamda+Lamdaw))*Dfl*Expob
121  !THE FOLLOWING CODE ITEMS ASSIGN FM VALUES FOR THE GOAT/MILK CALCULATION.
130  IF Atom$="H3" THEN Fm=.17
140  IF Atom$="C14" THEN Fm=.1
150  IF Atom$="P32" THEN Fm=.25
160  IF Atom$="FE55" THEN Fm=1.3E-4
170  IF Atom$="FE59" THEN Fm=1.3E-4
180  IF Atom$="CU64" THEN Fm=.013
190  IF Atom$="SR89" THEN Fm=.014
200  IF Atom$="SR90" THEN Fm=.014
210  IF Atom$="I130" THEN Fm=.06
220  IF Atom$="I131" THEN Fm=.06
230  IF Atom$="I132" THEN Fm=.06
240  IF Atom$="I133" THEN Fm=.06
250  IF Atom$="I134" THEN Fm=.06
260  IF Atom$="I135" THEN Fm=.06
270  IF Atom$="CS134" THEN Fm=.3
280  IF Atom$="CS136" THEN Fm=.3
290  IF Atom$="CS137" THEN Fm=.3
300  IF Atom$="CS138" THEN Fm=.3
310  Qf=6
311  ! R6 CALCULATES THE GOAT/MILK PATHWAY.
320  R6=K*(Qf*Uap1)/(Lamda+Lamdaw)*Fm*R*Dfl*Expoa
330  Qf=50
331  R=.2 !REASSIGN FOR NON-IODINE
```

```
340  IMAGE 6X.6A.2X.D.3DE.2X.D.3DE.2X.D.3DE.2X.D.3DE.3X.D.3DE.2X.D.3DE./
350   PRINT USING 2340:Atom$.R1.R2.R3.R4.R5.R6
351   IF Atom$<>"TE127M" THEN 2361
355   PRINT USING "@,#"
356   PRINT USING "28X.26A./,/,":"PATHWAY DOSE FACTOR (R)".Age$
357   IMAGE 6X.4A.4X.5A.6X.3A.8X.8A.3X.8A.6X.3A.6X.7A./
358   PRINT USING 2357:"ATOM"."INHAL"."G/P"."COW/MILK"."COW/MEAT"."VEG"."GT/MIL

361 IF Atom$<>"NP239" THEN !400
370    END
```