OFFSITE DOSE CALCULATION MANUAL

FOR

TEXAS UTILITIES GENERATING COMPANY

COMANCHE PEAK NUCLEAR STATION

OCTOBER 1984

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REFERENCES

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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 calculation methods or parameters will be incorporated into the ODCM in order to assure that the ODCM represents the present methodology in all applicable areas.

Offsite dose calculations utilized to implement the RADIOLOGICAL EFFLUENT TECHNICAL SPECIFICATIONS shall normally be performed with the RM-21 Report Processor. The RM-21 software utilizes NUREG-0133 (October 1978) dose calculation methodology. The methodology described in the ODCM shall be used as a manual backup to the RM-21.

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 Isotopic Concentration of the Waste Tank

Determine the isotopic concentration of the waste tank to be released:

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

$\sum_i C_i$ = Sum of the batch radioactive concentrations (uCi/ml)

$\sum_g C_g$ = Sum of the concentrations of each measured gamma emitter (uCi/ml)

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

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

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

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

1.1.2 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 - 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. XRE-5253 is an in-line process monitor which only allows 46 gpm to flow past it. As a worst case condition, the effluent flow rate (f) will be determined as the capacity of one tank being pumped. This built in safety factor of 2.2 ensures that the effluent flow rate is not being underestimated. This maximum effluent flow rate of 100 gpm will be used in the calculation of dilution factor for <u>all</u> liquid radwaste system batch discharges.

1.1.3 <u>Dilution of Liquid Effluents Due to Circulating Water Flow (F)</u>

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.

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

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

1.1.4 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: $f = 100$ gpm

$F = (275{,}000 \text{ gpm/pump}) \times (\# \text{ of pumps}) \times SF\ (.9)$

1.1.5 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.

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

$$= (\sum_g (C_g/MPC_g) + (C_a/MPC_a + C_s/MPC_s + C_t/MPC_t + C_{Fe}/MPC_{Fe})) \times SF$$

Where: MPC_i = Maximum Permissible Concentration 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 Upper Setpoint Limit for Detector X-RE-5253

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

Where = The gamma concentration corrected for dilution in microcuries/ml.

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.

When considering the mixture of nuclides in the liquid effluent stream in terms of detector sensitivity, the most probable nuclides present would be those referenced in Technical Specifications 3/4.11.1.1. Figure 1.2 is a representative energy spectrum response for the RD-33 type detector used in XRE-5253. This curve illustrates that for any given mixture of the most probable nuclides present, the conversion factor between counts per minute and microcuries per ml remains relatively constant. In fact between

Cs-137 and Co-60, the total change in sensitivity is approximately 7%. Because this is well within the accuracy of measurement, there is no need to change the software sensitivity for given varied effluent concentrations. However, should the concentration of previously unexpected nuclides become significant, further evaluation would be required.

1.2 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 batch releases for the quarter will be calculated using the following equation:

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

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.

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

$A_{i\tau}$ = 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 $A_{i\tau}$ 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, the $D_{i\tau}$ 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	1.42E+01	1.31E+01	7.80E+00	0.00E+00	2.58E+01	0.00E+00	5.36E+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

SITE RELATED INGESTION DOSE COMMITMENT FACTOR. $A_{i\tau}$
(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

1.3 SERVICE WATER EFFLUENT RADIATION MONITORS 1RE-4269/4270

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. To this end, the background multiple will be three (3) [i.e., setpoint will be initially established at three times background until further data can be collected]. If this effluent stream should become contaminated with radioactivity, radionuclide concentrations must be determined and a radiation monitor setpoint determined as follows:

$$C = \left(\sum_g C_g \right) \div DF \text{ (Setpoint upper limit)}$$

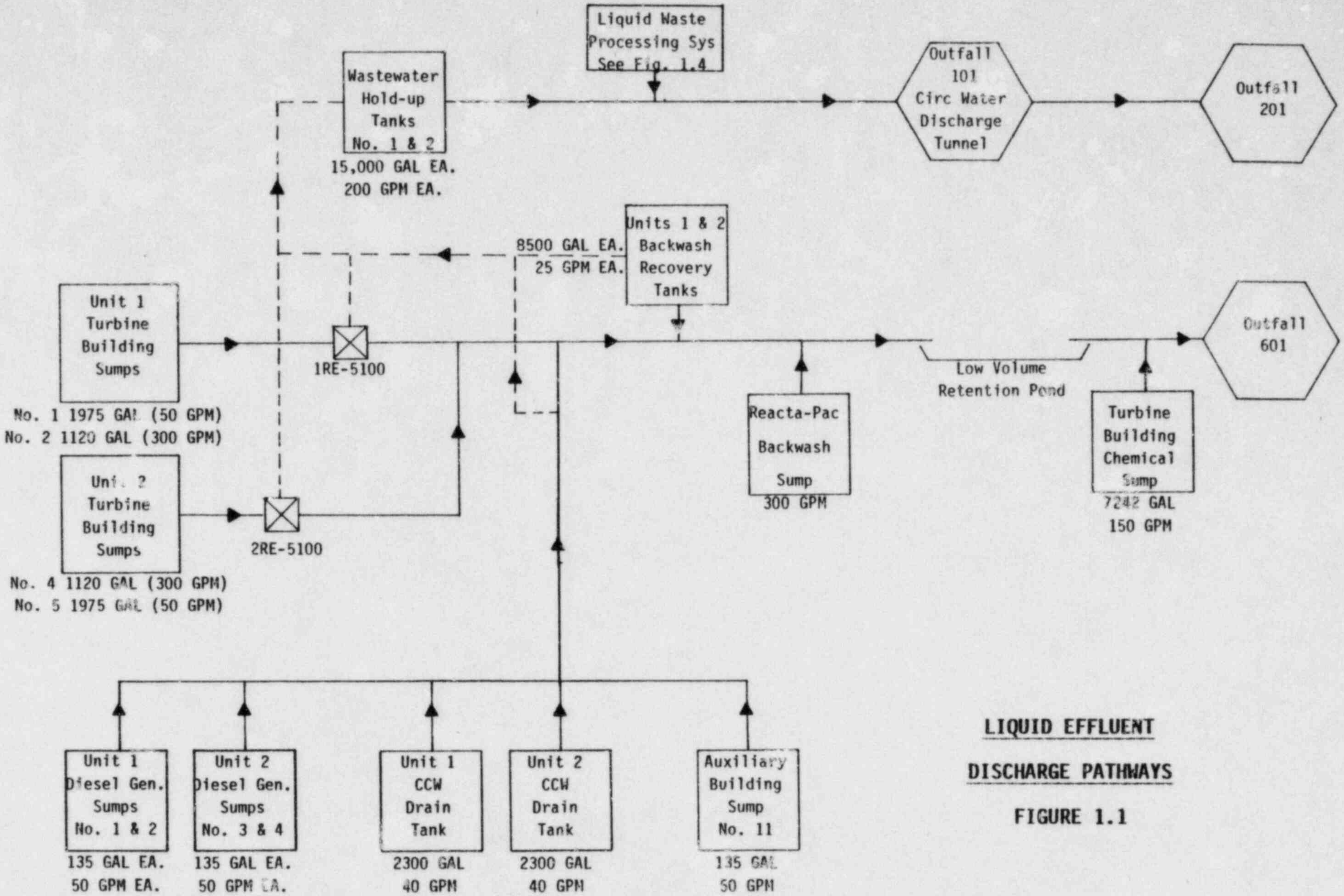
Where $\sum_g C_g$ = Sum of the concentrations of each measured gamma emitter observed in the effluent ($\mu Ci/ml$)

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

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

1.4 Turbine Building Sump Effluent Radiation Monitor 1RE-5100

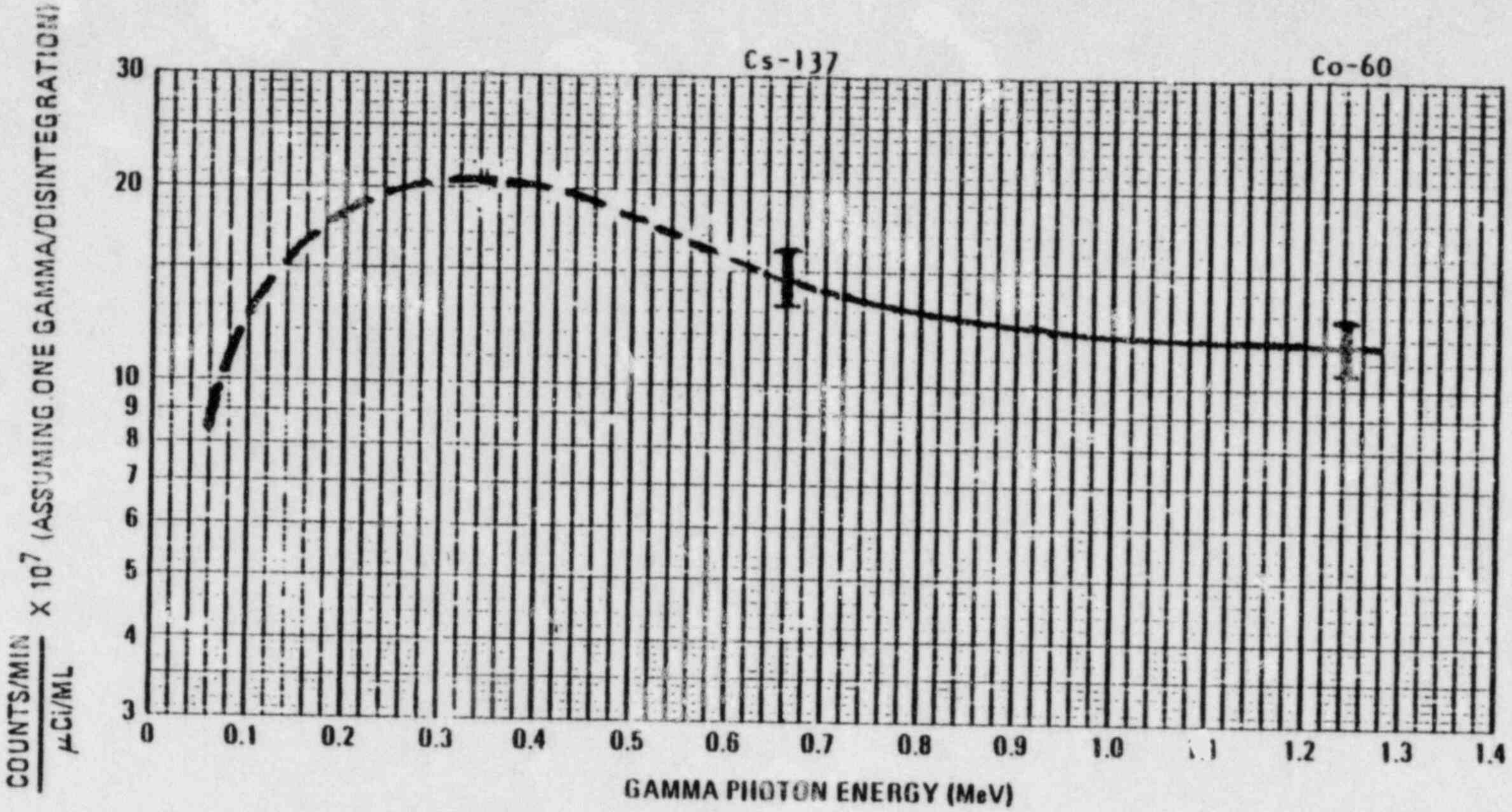
The purpose of the detector for the turbine building sumps is to monitor discharges and divert the turbine building sumps from the Low Volume Waste Pond to the Waste Water Holdup Tanks if they become radioactive. Because the only sources to the sump effluent are from the secondary steam system, activity is expected in the turbine building sump effluent only if a significant primary-to-secondary leak is present. Since only non-radioactive turbine building sump water is allowed to go to the Low Volume Waste Pond, the monitor setpoint should be established as close to background as practical to prevent spurious alarms and yet alarm should an inadvertent radioactive release occur. To this end, the background multiple will be three (3) [i.e., setpoint will be initially established at three times background until further data can be collected]. Then, if this setpoint is exceeded, 1RE-5100 will direct valves 1RV-5100A and B to divert the turbine building sumps to the Waste Water Holdup Tanks where they can then be sampled and released to Squaw Creek Reservoir per 10 CFR 20 limits.



LIQUID EFFLUENT

DISCHARGE PATHWAYS

FIGURE 1.1



EL-3509

NOTE: Shape of curve is taken from earlier data (reference report E-199-558) for photon energies below .662 keV.

Figure 1-2 Detector energy response to gamma radiations for RD-33 offline gamma detector

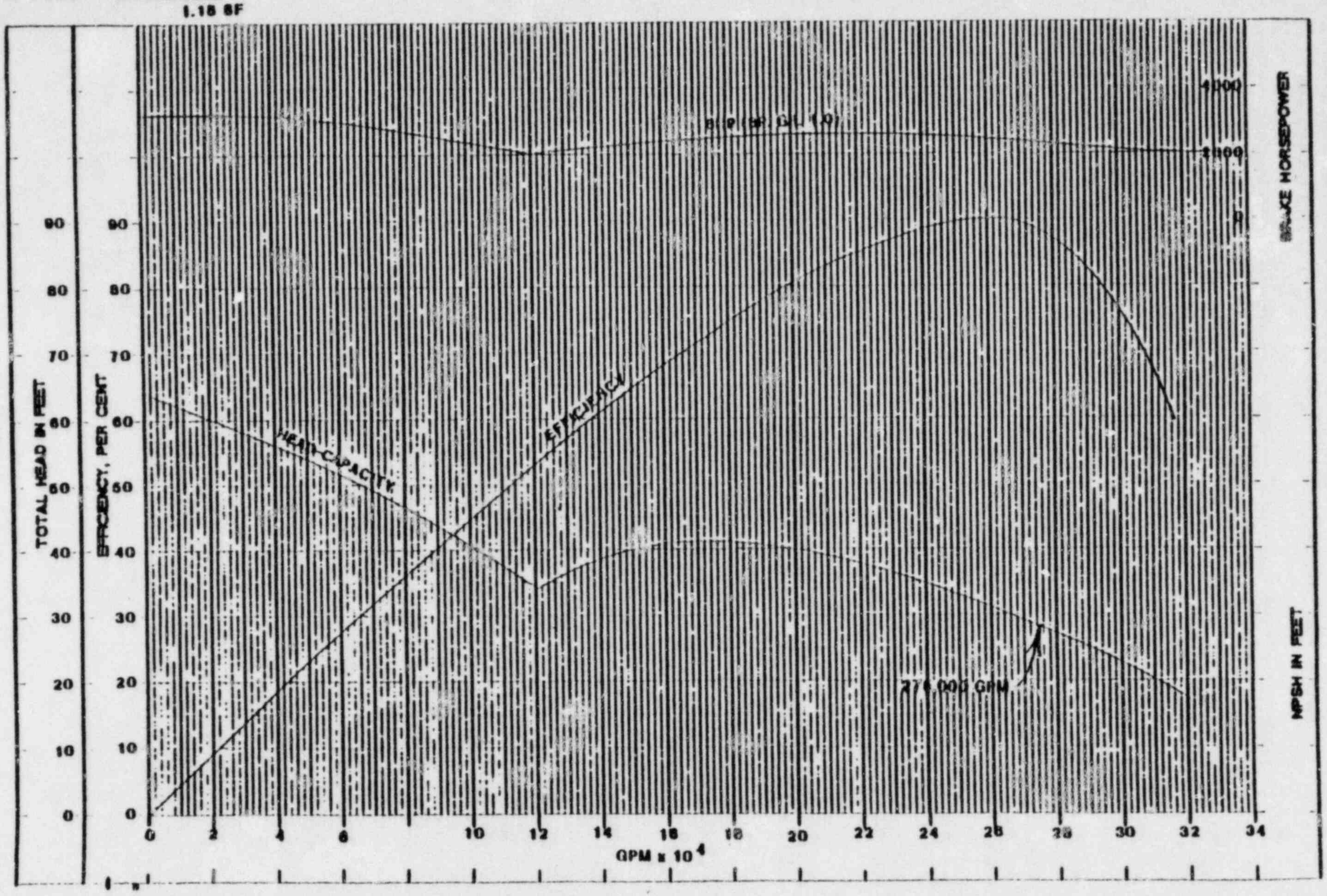
FIGURE 1.3

CIRCULATING WATER PUMP CURVES

DESIGN CONDITIONS

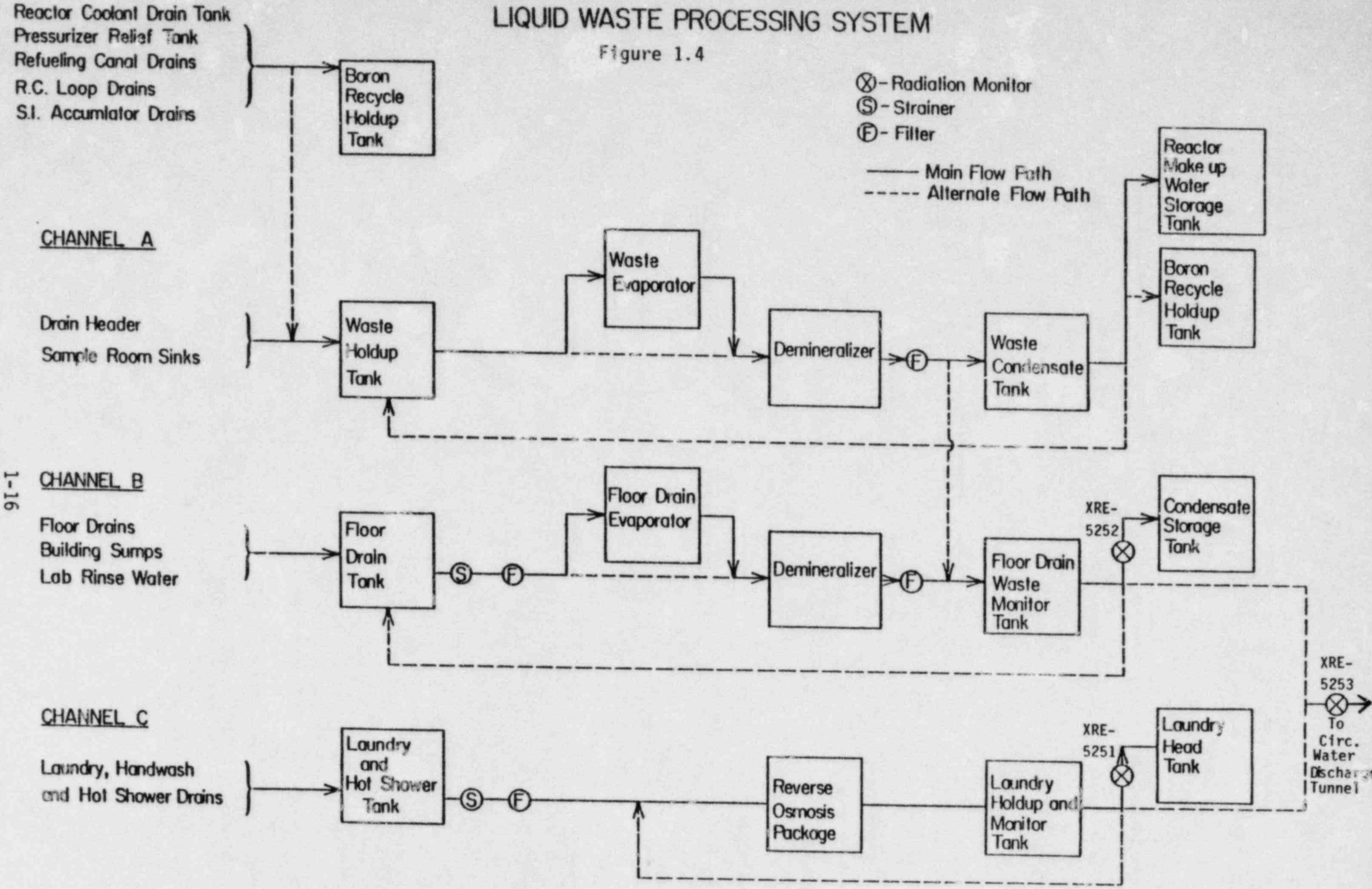
GPM 276,000 EFF 88
TH (FT) 28 BHP 2200 SG. 1.0
RPM 258 DRIVER 2500
1.15 SF

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



LIQUID WASTE PROCESSING SYSTEM

Figure 1.4



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.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)

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

$\overline{X/Q}$ = 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.

$= 3.3 \times 10^{-6}$ sec/m³ in the NNW sector

K_i = total body dose factor due to gamma emissions from noble gas radionuclide i (mrem/hear per microcurie/m³) from Table 2.1.

L_i = skin dose factor due to beta emissions from noble gas radionuclide i (mrem/yr per microcurie/m³) from Table 2.1.

M_i = air dose factor due to gamma emissions from noble gas radionuclide i (mrad/yr per microcurie/m³) 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/cc) as measured at the vent and F_v is the flowrate at the vent (cc/sec).

2.1.1.b <u>PLANT VENT STACK NOBLE GAS MONITORS XRE5570A/B and XRE5567A/B</u>

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.

$$= \text{the lesser of} \quad (SF) \times R_t \times D_{TB} \times AF \quad \text{or} \quad (SF) \times R_s \times D_{ss} \times AF$$

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 reading per mrem/yr to the total body

$$= C \div (X/Q) \sum_i K_i Q_i D_t$$

R_s = monitor reading per mrem/yr to the skin

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

1.1 = mrem skin dose per mrad air dose

C = calculated monitor reading of a noble gas monitor corresponding to the concentration due to the combined sources as calculated from the grab sample radionuclide concentrations taken in accordance with RETS Table 4.11-2.

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 batch 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

$$Q_i = F_v X_{iv}$$
$$= X_{ic} F_c + X_{iB} F_B$$

2.1.1c <u>AUXILIARY BUILDING VENTILATION EXHAUST MONITOR XRE-5701</u>

For implementation of Technical Specification 3.3.3.11, the alarm setpoint for the Auxiliary Building Ventilation Exhaust Monitor will be calculated in the following manner: The alarm setpoint is based on Waste Gas Decay Tank Purge Operations only (i.e., a containment purge or vent is not occurring at the same time.)

$F_v = F_c + F_b$ from section 2.1.1b

$F_{aux} = F_b$

= the flowrate contribution associated with the release of the Waste Gas Decay Tanks (ml/sec).

$Q_i = X_{iv} F_v$ from section 2.1.1b

$X_{iv}F_v = X_{ic}F_c + X_{iaux}F_{aux}$

X_{iaux} = the concentration of noble gas radionuclide i (microcurie/ml) in the Waste Gas Decay Tank release stream as sampled in accordance with RETS Table 4.11.2.

Assuming that X_{iaux} is much greater than X_{ic}, $X_{iv}F_v$ is approximately equal to $X_{iaux}F_{aux}$. Since the setpoint of the monitor is proportional to the concentration of the the release stream,

$C_s F_v = C_{aux}F_{aux}$

$C_{aux} = (C_sF_v) \div F_{aux}$

= monitor reading of the Auxiliary Building Ventilation Exhaust Monitor at the alarm setpoint concentration.

2.1.1d <u>CONTAINMENT ATMOSPHERE GASEOUS MONITOR 1RE-5503</u>

For implementation of Technical Specification 3.3.3.1, the alarm setpoint for the Containment Atmosphere Gaseous Monitor will be calculated in the following manner during containment purge or vent (assume Waste Gas Decay Tank Purge operations are not occurring).

$F_v = F_c + F_b$ from Section 2.1.16

$F_{cont} = F_b$

= the flowrate contribution associated with the release of the containment atmosphere (ml/sec)

$Q_i = X_{iv}F_v$ from section 2.1.16

$X_{iv}F_v = X_{ic}\ F_c + X_{icont}\ F_{cont}$

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

Assuming that X_{icont} is much greater than X_{ic}, $X_{iv}F_v$ is approximately equal to $X_{iaux}\ F_{aux}$. Since the setpoint of the monitor is proportional to the concentration of the release stream,

$C_s\ F_v = C_{cont}\ F_{cont}$

$C_{cont} = (C_sF_v) \div F_{cont}$

= monitor reading of the Containment Atmosphere Gaseous Monitor at the alarm setpoint concentration

2.1.2a <u>DOSE RATES DUE TO RADIOIODINES, TRITIUM, AND PARTICULATES</u>

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.

2.1.2b <u>PLANT VENT STACK IODINE MONITORS XRE-5575A/B</u>

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. However, in an effort to establish a conservative basis to which the alarm can be set, the monitor will be set to provide warning of the Technical Specification limit for the most limiting radionuclide, I-131, as indicated in FSAR 11.5.2.5.6. 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.

$1500 \text{ mrem/yr} = \overline{(X/Q)} \sum_i P_i Q_i$ from Section 2.1.2.a

$Q_i = F_v X_{iI}$ from Section 2.1.1.a

$X_{iI} = [(AF) \times (SF) \times 1500 \text{ mrem/yr}]/[\overline{(X/Q)}\ PiFv]$

$X_{iI} = 6.98/Fv$

where X_{iI} = the monitor reading of Iodine at the alarm setpoint concentration.

(all other variables previously defined)

2.1.2c <u>PLANT VENT STACK PARTICULATE MONITORS XRE-5568A/B</u>

Continuous integrating particulate monitors cannot practically be set to an instantaneous alarm setpoint as indicated in NUEG 0133 Section 5.1.1. However, in an effort to establish a conservative basis to which the alarm can be set, the monitor will be set to provide warning of the Technical Specification limit for the most limiting particulate, Cs-137 as indicated in FSAR 11.5.2.5.6.

$X_{ip} = [(AF)\ (SF) \times 1500 \text{ mrem/yr}] / [\overline{(X/Q)}\ P_i F_v]$

$X_{ip} = 125.4/F_v$

where X_{ip} = the monitor reading of particulate Cs-137 at the alarm setpoint concentration.

(all other variables previously defined)

TABLE 2.1

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

Nuclide	-Body*** (K)	-Skin***(L)	-Air**(M)	-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

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

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

2.2 GASEOUS EFFLUENT DOSE CALCULATIONS

2.2.1 AIR DOSE IN UNRESTRICTED AREAS

For implementation of Technical Specification 3.11.2.1 and 3.11.2.4, the air dose in unrestricted areas shall be determined as follows:

D = 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 2.1.1a

$\overline{X/Q}$ = the relative concentration for the location occupied by the maximum exposed individual. If actual value not available, use X/Q.

$= 3.3 \times 10^{-6}$ sec/m³ in the NNW Sector

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

D = 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/m³) Table 2.1

2.2.2 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 = the dispersion parameter for estimating the dose to an individual at the controlling location

W = $\overline{X/Q}$ for the inhalation pathway in sec/m³

= 3.3×10^{-6} sec/m³ in the NNW sector

W = $\overline{D/Q}$ for the food and groundplane pathway in m^{-2}

= 2.8×10^{-9} m^{-2} in the WNW sector

NOTE: for tritium, the dispersion parameter, W, is always taken as $\overline{X/Q}$.

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)

2.2.3 DOSE CALCULATIONS TO SUPPORT OTHER TECHNICAL SPECIFICATIONS

For the purpose of implementing Technical Specification 6.9.1.11, 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 6.9.1.7, 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.

For the purpose of implementing Technical Specification 3.11.4, the total annual dose to an individual may be determined by combining the annual doses determined for a member of the public in accordance with Technical Specification 3.11.1.2

and/or 3.11.2.3 with the direct radiation dose received by the particular member of the public. This determination is required only in the event calculated doses exceed twice the limits of 3.11.1.2 or 3.11.2.3 as specified in Technical Specification 3.11.4. The dose component due to direct radiation may be determined by thermoluminescent dosimeters or other appropriate methods of determining direct radiation levels.

TABLE 2.2

PATHWAY DOSE FACTOR (P_i)

ATOM	INHALATION*	GROUND PLANE**	FOOD**
H3	1.125E+03	0.000E+00	2.430E+03
P32	2.605E+06	0.000E+00	7.781E+10
CR51	1.702E+04	7.880E+06	5.402E+06
NM54	1.576E+06	1.288E+09	2.097E+07
F[illegible]5	1.110E+05	0.000E+00	1.118E+08
FE59	1.269E+06	4.609E+08	2.031E+08
CO58	1.110E+06	6.225E+08	7.088E+07
CO60	7.067E+06	5.171E+09	2.391E+08
NI63	8.214E+05	0.000E+00	2.965E+10
ZN65	9.953E+05	7.903E+08	1.101E+10
RB86	1.983E+05	1.470E+07	8.780E+09
SR89	2.157E+06	3.579E+04	6.627E+09
SR90	1.010E+08	0.000E+00	1.117E+11
Y91	2.627E+06	1.715E+06	5.209E+06
ZR95	2.231E+06	4.075E+08	8.833E+05

*mrem/yr per uCi/m^3

**m^2 (mrem/yr) per uCi/sec

TABLE 2.2

PATHWAY DOSE FACTOR (P_i)

ATOM	INHALATION*	GROUND PLANE**	FOOD**
NB95	6.142E+05	2.298E+08	2.290E+08
RU103	6.623E+05	1.749E+08	1.118E+05
RU106	1.432E+07	3.593E+08	1.437E+06
AG110	5.476E+06	3.665E+09	1.679E+10
TE125	4.773E+05	3.008E+06	7.380E+07
TE127	1.480E+06	1.395E+05	5.932E+08
TE129	1.761E+06	3.353E+07	8.011E+08
I131	1.628E+07	2.993E+07	4.343E+11
I133	3.848E+06	4.262E+06	3.952E+09
CS134	1.014E+06	3.279E+09	3.715E+10
CS136	1.709E+05	2.414E+08	2.760E+09
CS137	9.065E+05	1.337E+09	3.224E+10
BA140	1.743E+06	3.358E+07	1.173E+08
CE141	5.439E+05	2.198E+07	1.361E+07
CE143	1.273E+05	3.756E+06	1.490E+06

* mrem/yr per uCi/m^3

** m^2 (mrem/yr) per uCi/sec

TABLE 2.2

PATHWAY DOSE FACTOR (P_i)

ATOM	INHALATION*	GROUND PLANE**	FOOD**
CE144	1.195E+07	6.766E+07	1.327E+08
PR143	4.329E+05	0.000E+00	7.752E+05
ND147	3.282E+05	1.450E+07	5.735E+05
NP239	6.401E+04	2.826E+06	9.153E+04

* mrem/yr per uCi/m^3

** m^2 (mrem/yr) per uCi/sec

TABLE 2.3

PATHWAY DOSE FACTOR (R_i)

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
P32	2.030E+06	0.000E+00	1.603E+11	0.000E+00	0.000E+00	1.924E+11
CR51	1.284E+04	5.517E+06	4.692E+06	0.000E+00	0.000E+00	5.631E+05
MN54	9.996E+05	1.629E+09	3.920E+07	0.000E+00	0.000E+00	4.704E+06
FE55	8.694E+04	0.000E+00	1.351E+08	0.000E+00	0.000E+00	1.757E+06
FE59	1.015E+06	3.238E+08	3.930E+08	0.000E+00	0.000E+00	5.109E+06
CO58	7.770E+05	4.490E+08	6.062E+07	0.000E+00	0.000E+00	7.274E+06
CO60	4.508E+06	2.523E+10	2.098E+08	0.000E+00	0.000E+00	2.517E+07
NI63	3.388E+05	0.000E+00	3.493E+10	0.000E+00	0.000E+00	4.192E+09
ZN65	6.538E+05	8.574E+08	1.904E+10	0.000E+00	0.000E+00	2.285E+09
RB86	1.904E+05	1.029E+07	2.228E+10	0.000E+00	0.000E+00	2.673E+09
SR89	2.030E+06	2.523E+04	1.255E+10	0.000E+00	0.000E+00	2.636E+10
SR90	4.088E+07	0.000E+00	1.216E+11	0.000E+00	0.000E+00	2.553E+11
Y91	2.450E+06	1.217E+06	5.261E+06	0.000E+00	0.000E+00	6.313E+05

* mrem/yr per uCi/m^3

** m^2 (mrem/yr) per uCi/sec

TABLE 2.3

PATHWAY DOSE FACTOR (R_i)

INFANT

ATOM	INHAL*	G/P**	COW/MILK**	COW/MEAT**	VEG**	GT/MILK**
ZR95	1.750E+06	2.915E+08	8.302E+05	0.000E+00	0.000E+00	9.962E+04
NB95	4.788E+05	1.610E+08	2.064E+08	0.000E+00	0.000E+00	2.476E+07
RU103	5.516E+05	1.226E+08	1.059E+05	0.000E+00	0.000E+00	1.271E+04
RU106	1.156E+07	5.063E+08	1.445E+06	0.000E+00	0.000E+00	1.734E+05
AG110	3.668E+06	4.062E+09	1.462E+10	0.000E+00	0.000E+00	1.754E+09
TE125	4.480E+05	2.133E+06	1.502E+08	0.000E+00	0.000E+00	1.802E+07
TE127	1.312E+06	1.083E+05	1.037E+09	0.000E+00	0.000E+00	1.244E+08
TE129	1.680E+06	2.348E+07	1.401E+09	0.000E+00	0.000E+00	1.681E+08
I131	1.484E+07	2.095E+07	1.055E+12	0.000E+00	0.000E+00	1.267E+12
I133	3.556E+06	2.983E+06	9.590E+09	0.000E+00	0.000E+00	1.151E+10
CS134	7.028E+05	7.972E+09	6.801E+10	0.000E+00	0.000E+00	2.040E+11
CS136	1.344E+05	1.690E+08	5.768E+09	0.000E+00	0.000E+00	1.730E+10

* mrem/yr per uCi/m^3

** m^2 (mrem/yr) per uCi/sec

TABLE 2.3

PATHWAY DOSE FACTOR (R_i)

INFANT

ATOM	INHAL*	G/P**	COW/MILK**	COW/MEAT**	VEG**	GT/MILK**
CS137	6.118E+05	1.203E+10	6.024E+10	0.000E+00	0.000E+00	1.807E+11
BA140	1.596E+06	2.351E+07	2.413E+08	0.000E+00	0.000E+00	2.896E+07
CE141	5.166E+05	1.539E+07	1.366E+07	0.000E+00	0.000E+00	1.639E+06
CE143	1.162E+05	2.630E+06	1.539E+06	0.000E+00	0.000E+00	1.846E+05
CE144	9.842E+06	8.046E+07	1.334E+08	0.000E+00	0.000E+00	1.601E+07
PR143	4.326E+05	0.000E+00	7.843E+05	0.000E+00	0.000E+00	9.412E+04
ND147	3.220E+05	1.015E+07	5.767E+05	0.000E+00	0.000E+00	6.920E+04
NP239	5.950E+04	1.978E+06	9.416E+04	0.000E+00	0.000E+00	1.130E+04

* mrem/yr per uCi/m^3

** m^2 (mrem/yr) per uCi/sec

TABLE 2.4

PATHWAY DOSE FACTOR (R_i)

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
P32	2.605E+06	0.000E+00	7.781E+10	7.427E+09	3.375E+09	9.337E+10
CR51	1.702E+04	5.517E+06	5.402E+06	4.669E+05	6.232E+06	6.482E+05
MN54	1.576E+06	1.629E+09	2.097E+07	8.013E+06	6.651E+08	2.517E+06
FE55	1.110E+05	0.000E+00	1.118E+08	4.571E+08	8.012E+08	1.453E+06
FE59	1.269E+06	3.238E+08	2.031E+08	6.374E+08	6.766E+08	2.640E+06
CO58	1.110E+06	4.490E+08	7.088E+07	9.616E+07	3.786E+08	8.505E+06
CO60	7.067E+06	2.528E+10	2.391E+08	3.837E+08	2.095E+09	2.870E+07
NI63	8.214E+05	0.000E+00	2.965E+10	2.913E+10	3.949E+10	3.557E+09
ZN65	9.953E+05	8.574E+08	1.101E+10	1.000E+09	2.164E+09	1.322E+09
RB86	1.983E+05	1.029E+07	8.780E+09	5.780E+08	4.539E+08	1.054E+09
SR89	2.157E+06	2.523E+04	6.627E+09	4.828E+08	3.611E+10	1.392E+10
SR90	1.010E+08	0.000E+00	1.117E+11	1.040E+10	1.243E+12	2.346E+11

* mrem/yr per uCi/m^3

** m^2 (mrem/yr) per uCi/sec

TABLE 2.4

PATHWAY DOSE FACTOR (R_i)

CHILD

ATOM	INHAL*	G/P**	COW/MILK**	COW/MEAT**	VEG**	GT/MILK**
Y91	2.627E+06	1.217E+06	5.209E+06	2.409E+08	2.501E+09	6.250E+05
ZR95	2.231E+06	2.915E+08	8.833E+05	6.172E+08	9.025E+08	1.060E+05
NB95	6.142E+05	1.610E+08	2.290E+08	2.232E+09	2.961E+08	2.748E+07
RU103	6.623E+05	1.226E+08	1.118E+05	4.062E+09	4.052E+08	1.341E+04
RU106	1.432E+07	5.063E+08	1.437E+06	6.903E+10	1.160E+10	1.724E+05
AG110	5.476E+06	4.062E+09	1.679E+10	6.749E+08	2.587E+09	2.014E+09
TE125	4.773E+05	2.133E+06	7.380E+07	5.695E+08	3.512E+08	8.857E+06
TE127	1.480E+06	1.083E+05	5.932E+08	5.060E+09	3.769E+09	7.118E+07
TE129	1.761E+06	2.348E+07	8.011E+08	5.315E+09	2.521E+09	9.613E+07
I131	1.628E+07	2.095E+07	4.343E+11	5.540E+09	4.770E+10	5.212E+11
I133	3.848E+06	2.983E+06	3.952E+09	1.320E+02	8.124E+08	4.743E+09
CS134	1.014E+06	7.972E+09	3.715E+10	1.5[illegible]E+09	2.631E+10	1.114E+11

* mrem/yr per uCi/m^3

** m^2 (mrem/yr) per uCi/sec

TABLE 2.4

PATHWAY DOSE FACTOR (R_i)

CHILD

ATOM	INHAL*	G/P**	COW/MILK**	COW/MEAT**	VEG**	GT/MILK**
CS136	1.709E+05	1.690E+08	2.760E+09	4.374E+07	2.216E+08	8.280E+09
CS137	9.065E+05	1.203E+10	3.224E+10	1.334E+09	2.392E+10	9.672E+10
BA140	1.743E+06	2.351E+07	1.173E+08	4.398E+07	2.777E+08	1.407E+07
CE141	5.439E+05	1.539E+07	1.361E+07	1.381E+07	4.078E+08	1.633E+06
CE143	1.273E+05	2.630E+06	1.990E+06	2.538E+02	1.365E+07	1.788E+05
CE144	1.195E+07	8.046E+07	1.327E+08	1.893E+08	1.039E+10	1.592E+07
PR143	4.329E+05	0.000E+00	7.752E+05	3.607E+07	1.574E+08	9.302E+04
ND147	3.282E+05	1.015E+07	5.735E+05	1.521E+07	9.287E+07	6.882E+04
NP239	6.401E+04	1.978E+06	9.153E+04	2.249E+03	1.358E+07	1.098E+04

* mrem/yr per uCi/m^3

** m^2 (mrem/yr) per uCi/sec

TABLE 2.5

PATHWAY DOSE FACTOR (R_i)

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
P32	1.888E+06	0.000E+00	3.155E+10	3.939E+09	1.61[illegible]E+09	3.786E+10
CR51	2.096E+04	5.517E+06	8.393E+06	9.487E+05	1.040E+07	1.007E+06
MN54	1.984E+06	1.629E+09	2.875E+07	1.437E+07	9.324E+08	3.450E+06
FE55	1.240E+05	0.000E+00	4.454E+07	2.382E+08	3.259E+08	5.790E+05
FE59	1.520E+06	3.238E+08	2.869E+08	1.178E+09	1.000E+09	3.729E+06
CO58	1.344E+06	4.490E+08	1.096E+08	1.945E+08	6.057E+08	1.316E+07
CO60	8.800E+06	2.528E+10	3.621E+08	7.600E+08	3.237E+09	4.345E+07
NI63	5.800E+05	0.000E+00	1.182E+10	1.519E+10	1.607E+10	1.419E+09
ZN65	1.240E+06	8.574E+08	7.314E+09	8.687E+08	1.471E+09	8.777E+08
RB86	1.904E+05	1.[illegible]29E+07	4.734E+09	4.076E+08	2.747E+08	5.680E+08
SR89	2.416E+06	2.523E+04	2.677E+09	2.351E+08	1.521E+10	5.623E+09
SR90	1.080E+08	0.000E+00	6.612E+10	8.049E+09	7.507E+11	1.389E+11

* mrem/yr per uCi/m^3
** m^2 (mrem/yr) per uCi/sec

TABLE 2.5

PATHWAY DOSE FACTOR (R_i)

TEENAGER

ATOM	INHAL*	G/P**	COW/MILK**	COW/MEAT**	VEG**	GT/MILK**
Y91	2.960E+06	1.217E+06	6.487E+06	3.923E+08	3.233E+09	7.784E+05
ZR95	2.688E+06	2.915E+08	1.208E+06	1.103E+09	1.278E+09	1.449E+05
NB95	7.512E+05	1.610E+08	3.341E+08	4.260E+09	4.568E+08	4.009E+07
RU103	7.832E+05	1.226E+08	1.519E+05	7.219E+09	5.788E+08	1.823E+04
RU106	1.608E+07	5.063E+08	1.818E+06	1.143E+11	1.500E+10	2.182E+05
AG110	6.752E+06	4.062E+09	2.561E+10	1.347E+09	4.039E+09	3.073E+09
TE125	5.360E+05	2.133E+06	8.868E+07	8.950E+08	4.383E+08	1.064E+07
TE127	1.656E+06	1.083E+05	3.420E+08	3.816E+09	2.236E+09	4.105E+07
TE129	1.976E+06	2.348E+07	4.631E+08	4.019E+09	1.544E+09	5.557E+07
I131	1.464E+07	2.095E+07	2.209E+11	3.685E+09	3.162E+10	2.651E+11
I133	2.920E+06	2.983E+06	1.677E+09	7.324E+01	4.593E+08	2.012E+09
CS134	1.128E+06	7.972E+09	2.310E+10	1.231E+09	1.670E+10	6.930E+10

* mrem/yr per uCi/m^3

** m^2(mrem/yr) per uCi/sec

TABLE 2.5

PATHWAY DOSE FACTOR (R_i)

TEENAGER

ATOM	INHAL*	G/P**	COW/MILK**	COW/MEAT**	VEG**	GT/MILK**
CS136	1.936E+05	1.690E+08	1.761E+09	3.650E+07	1.698E+08	5.282E+09
CS137	8.480E+05	1.203E+10	1.781E+10	9.634E+08	1.348E+10	5.342E+10
BA140	2.032E+06	2.351E+07	7.493E+07	3.675E+07	2.137E+08	8.991E+06
CE141	6.136E+05	1.539E+07	1.696E+07	2.251E+07	5.399E+08	2.035E+06
CE143	2.552E+05	2.630E+06	1.673E+06	3.727E+02	2.042E+07	2.008E+05
CE144	1.336E+07	8.046E+07	1.655E+08	3.089E+08	1.326E+10	1.986E+07
PR143	4.832E+05	0.000E+00	9.551E+05	5.813E+07	2.308E+08	1.146E+05
ND147	3.720E+05	1.015E+07	7.146E+05	2.478E+07	1.436E+08	8.575E+04
NP239	1.320E+05	1.978E+06	1.062E+05	3.413E+03	2.100E+07	1.274E+04

* mrem/yr per uCi/m^3

** m^2(mrem/yr) per uCi/sec

TABLE 2.6

PATHWAY DOSE FACTOR (R_i)

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
P32	1.320E+06	0.000E+00	1.710E+10	4.661E+09	1.406E+09	2.052E+10
CR51	1.440E+04	5.517E+06	7.203E+06	1.778E+06	1.173E+07	8.644E+05
MN54	1.400E+06	1.629E+09	2.578E+07	2.813E+07	9.589E+08	3.094E+06
FE55	7.208E+04	0.000E+00	2.511E+07	2.933E+08	2.096E+08	3.265E+05
FE59	1.016E+06	3.238E+08	2.333E+08	2.091E+09	9.969E+08	3.033E+06
CO58	9.280E+05	4.490E+08	9.575E+07	3.710E+08	6.274E+08	1.149E+07
CO60	5.968E+06	2.528E+10	3.082E+08	1.413E+09	3.139E+09	3.699E+07
NI63	4.320E+05	0.000E+00	6.729E+09	1.888E+10	1.041E+10	8.075E+08
ZN65	8.640E+04	8.574E+08	4.365+09	1.132E+09	1.009E+09	5.238E+08
RB86	1.360E+05	1.029E+07	2.598E+09	4.884E+08	2.201E+08	3.117E+08
SR89	1.400E+06	2.523E+04	1.452E+09	3.023E+08	1.001E+10	3.050E+09
SR90	9.920E+07	0.000E+00	4.680E+10	1.244E+10	6.046E+11	9.828E+10

* mrem/yr per uCi/m^3

** m^2(mrem/yr) per uCi/sec

TABLE 2.6

PATHWAY DOSE FACTOR (R_i)

ADULT

ATOM	INHAL*	G/P**	COW/MILK**	COW/MEAT**	VEG**	GT/MILK**
Y91	1.704E+06	1.217E+06	4.734E+06	6.253E+08	2.831E+09	5.681E+05
ZR95	1.768E+06	2.915E+08	9.639E+05	1.923E+09	1.216E+09	1.157E+05
N395	5.048E+05	1.610E+08	2.788E+08	7.764E+09	4.814E+08	3.346E+07
RU103	5.048E+05	1.226E+08	1.194E+05	1.239E+10	5.649E+08	1.432E+04
RU106	9.360E+06	5.063E+08	1.320E+06	1.811E+11	1.248E+10	1.584E+05
AG110	4.632E+06	4.062E+09	2.200E+10	2.526E+09	3.987E+09	2.640E+09
TE125	3.120E+05	2.133E+06	6.690E+07	1.474E+09	3.970E+08	8.028E+06
TE127	9.600E+05	1.083E+05	1.860E+08	4.531E+09	1.418E+09	2.232E+07
TE129	1.160E+06	2.348E+07	3.047E+08	5.774E+09	1.288E+09	3.656E+07
I131	1.200E+07	2.095E+07	4.080E+11	1.486E+10	1.113E+11	4.896E+11
I133	2.160E+06	2.983E+06	9.910E+08	9.452E+01	5.337E+08	1.189E+09
CS134	8.480E+05	7.972E+09	1.345E+10	1.565E+09	1.110E+10	4.035E+10
CS136	1.464E+05	1.690E+08	1.032E+09	4.668E+07	1.660E+08	3.095E+09

* mrem/yr per uCi/m^3

** m^2(mrem/yr) per uCi/sec

TABLE 2.6

PATHWAY DOSE FACTOR (R_i)

ADULT

ATOM	INHAL*	G/P**	COW/MILK**	COW/MEAT**	VEG**	GT/MILK**
CS137	6.208E+05	1.203E+10	1.010E+10	1.193E+09	8.696E+09	3.029E+10
BA140	1.272E+06	2.351E+07	5.542E+07	5.936E+07	2.652E+08	6.650E+06
CE141	3.616E+05	1.539E+07	1.252E+07	3.630E+07	5.094E+08	1.503E+06
CE143	2.264E+05	2.630E+06	1.150E+06	5.595E+02	2.761E+07	1.380E+05
CE144	7.776E+06	8.046E+07	1.210E+08	4.929E+08	1.112E+10	1.451E+07
PR143	2.808E+05	0.000E+00	6.921E+05	9.198E+07	2.747E+08	8.305E+04
ND147	2.208E+05	1.015E+07	5.252E+05	3.978E+07	1.865E+08	6.302E+04
NP239	1.192E+05	1.978E+06	7.397E+04	5.191E+03	2.876E+07	8.876E+03

* mrem/yr per uCi/m^3

** m^2(mrem/yr) per uCi/sec

TABLE 2.7

ATMOSPHERIC DISPERSION PARAMETERS*

FOR TECHNICAL SPECIFICATION 4.11.2.4.1

Sector	Miles	X/Q	D/Q
N	4.5	2.4E-07	1.0E-09
NNE	2.4	4.7E-07	2.3E-09
NE	2.4	3.2E-07	1.1E-09
ENE	2.6	2.2E-07	4.1E-10
E	3.5	1.5E-07	2.7E-10
ESE	2.3	3.7E-07	9.0E-10
SE	5.0	1.4E-07	3.7E-10
SSE	2.0	5.8E-07	3.2E-09
S	4.8	1.0E-07	3.6E-10
SSW	4.3	9.2E-08	2.9E-10
SW	3.5	1.2E-07	3.3E-10
WSW	1.5	6.9E-07	2.2E-09
W	1.7	6.5E-07	2.2E-09
WNW	3.0	3.7E-07	1.0E-09
NW	5.0	2.2E-07	5.3E-10
NNW	3.4	4.9E-07	1.9E-09

* Reference Comanche Peak SES, Environmental Report, Operating License Stage, Tables 2.3-16 and 2.3-17.

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	4.5	Vegetation	Child
NNE	2.4	Vegetation	Child
NE	2.4	Vegetation	Child
ENE	2.6	Vegetation	Child
E	3.5	Vegetation	Child
ESE	2.3	Vegetation	Child
SE*	5.0	Cow/Milk	Infant
SSE	2.0	Vegetation	Child
S	4.8	Cow/Milk	Infant
SSW	4.3	Vegetation	Child
SW	3.5	Vegetation	Child
WSW	1.5	Vegetation	Child
W	1.7	Vegetation	Child
WNW	3.0	Vegetation	Child
NW*	5.0	Cow/Milk	Infant
NNW	3.4	Vegetation	Child

*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

*Model Reference 8 Chapter 3 and Data Chapter 3 Comanche Peak FSAR.

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 = veritical height of reactor containment structure (79.4 meters).

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) $^{-1}$

2.4 DEFINITIONS OF GASEOUS EFFLUENTS PARAMETERS

Term	Definition	Section of Initial Use
AF	= Allocation Factor (.5); a factor allowing for releases from both stacks simultaneously.	2.1.1.b
b	= maximum height of the adjacent building.	2.3
C	= calculated monitor reading of a gaseous effluent monitor corresponding to associated sample radionuclide concentrations.	2.1.1.b
C_s	= monitor reading of the stack noble gas monitor at the alarm setpoint concentration	2.1.1.b
C_{aux}	= monitor reading of the Auxiliary Building Ventilation Exhaust monitor at the alarm setpoint.	2.1.1.c
C_{cont}	= monitor reading of the Containment Atmosphere Gaseous monitor at the alarm setpoint.	2.1.1.d
D_g	= relative deposition rate for a ground-level release	2.3
D_o	= average organ dose rate in the current year (mrem/yr)	2.1.2.a
D_p	= dose to an individual from radioiodines and radionuclides in particulate from with half-lifes greater than eight days (mrem).	2.2.2
D_s	= calculated skin dose rate (mrem/yr)	2.1.1.a
D_{ss}	= limiting dose rate to the skin = 3000 mrem/yr	2.1.1.b
D_t	= calculated total body dose rate (mrem/yr)	2.1.1.a
D_{TB}	= limiting dose rate to the body = 500 mrem/yr	2.1.1.b
D_β	= air dose due to beta emissions from noble gas	2.2.1
D_γ	= air dose due to gamma emissions from noble gas	2.2.1
D/Q	= the sector averaged annual average relative deposition for any distance in a given sector.	2.2.3
D/Q'	= annual average relative deposition at the location of the maximum exposed individual. = $2.8 \times 10^{-9}\ m^{-2}$ in the WNW sector	2.2.2
δ	= plume depletion factor at distance r for the appropriate stability class (radioiodines and particulates).	2.3

2.4 DEFINITIONS OF GASEOUS EFFLUENTS PARAMETERS

Term	Definition	Section of Initial Use
F_b	= the flow rate contribution associated with the release rate at the batch source (ml/sec).	2.1.1.b
F_c	= the flow rate contribution of the plant ventilation system (ml/sec)	2.1.1.b
F_v	= the flow rate at the vent (cc/sec)	2.1.1.a
F_{aux}	= the flow rate contribution associated with the release of the Waste Gas Decay Tanks (ml/sec)	2.1.1.c
F_{cont}	= the flow rate contribution associated with the release of the Containment Atmosphere (ml/sec)	2.1.1.d
K	= terrain recirculation factor	2.3
K_i	= total body dose factor due to gamma emissions from isotope i (mrem/year per microcurie/m^3)	2.1.1.a
L_i	= skin dose factor due to beta emissions from isotope i (mrem/yr per microcurie/m^3)	2.1.1.a
M_i	= air dose factor due to gamma emissions from isotope i (mrad/yr per microcurie/m^3)	2.1.1.a
N_i	= air dose factor due to beta emissions from noble gas radionuclide i (mrad/yr per microcurie/m	2.2.1
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
N	= total hours of valid meteorological data.	2.3
P_i	= dose parameter for radionuclide i, (mrem/yr per microcurie/m^3)	2.1.2.a
Q_i	= rate of release of noble gas radionuclide i (microcurie/sec)	2.1.1.a
$\tilde{Q}_i$	= cumulative release of noble gas radionuclide i over the period of interest (microcurie).	2.2.1
$\tilde{Q}_i'$	= cumulative release of radionuclide i of iodine or material in particulate form over the period of interest (microcurie).	2.2.2

2.4 DEFINITIONS OF GASEOUS EFFLUENTS PARAMETERS

Term	Definition	Section of Initial Use
R_i	= dose factor for radionuclide i, (mrem/yr per microcurie/m^3) or (m^2-mrem/yr per microcurie/sec)	2.2.2
R_s	= monitor reading per mrem/yr to the skin.	2.1.1.b
R_t	= monitor reading per mrem/yr to the total body.	2.1.1.b
r	= distance from the point of release to the location of interest for dispersion calculations (meters).	2.3
SF	= Safety Factor (.5); a conservative factor applied to each noble gas monitor to compensate for statistical fluctuations and errors of measurement.	2.1.1.b
Σj	= vertical standard deviation of the plume concentration with building wake correction.	2.3
σj	= vertical standard deviation of the plume concentration (in meters), at distance r for ground level releases under the stability category j indicated by T	2.3
u_{jk}	= wind speed (midpoint of windspeed class k) at ground level (m/sec) during atmospheric stability class j.	2.3
W	= the dispersion parameter for estimating the dose to an individual at the controlling location	2.2.2
X/Q	= the Sector-averaged annual average relative concentration at any distance r in a given sector. (sec/m^3)	2.2.1
$\overline{X/Q}$	= 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.a
X_{ib}	= the concentration of noble gas radionuclide i in the batch release stream (microcuries/ml)	2.1.1.b
X_{ic}	= the concentration of noble gas radionuclide i in the continuous release stream (microcuries/ml)	2.1.1.b
X_{iI}	= the monitor reading of Iodine at the alarm setpoint concentration	2.1.2.b
X_{ip}	= the monitor reading of particulate (s-137) at the alarm setpoint concentration	2.1.2.c
X_{iv}	= the concentration of noble gas radionuclide i as measured at the vent (microcuries/ml)	2.1.1.a

2.4 <u>DEFINITIONS OF GASEOUS EFFLUENTS PARAMETERS</u> (cont.)

Term	Definition	Section of Initial Use
X_{iaux}	= the concentration of noble gas radionuclide i in the Waste Gas Decay Tank release stream (microcuries/ml)	2.1.1.c
X_{icont}	= the concentration of noble gas radionuiclide i in the containment release stream (microcuries/ml)	2.1.1.d

FIGURE 2.1

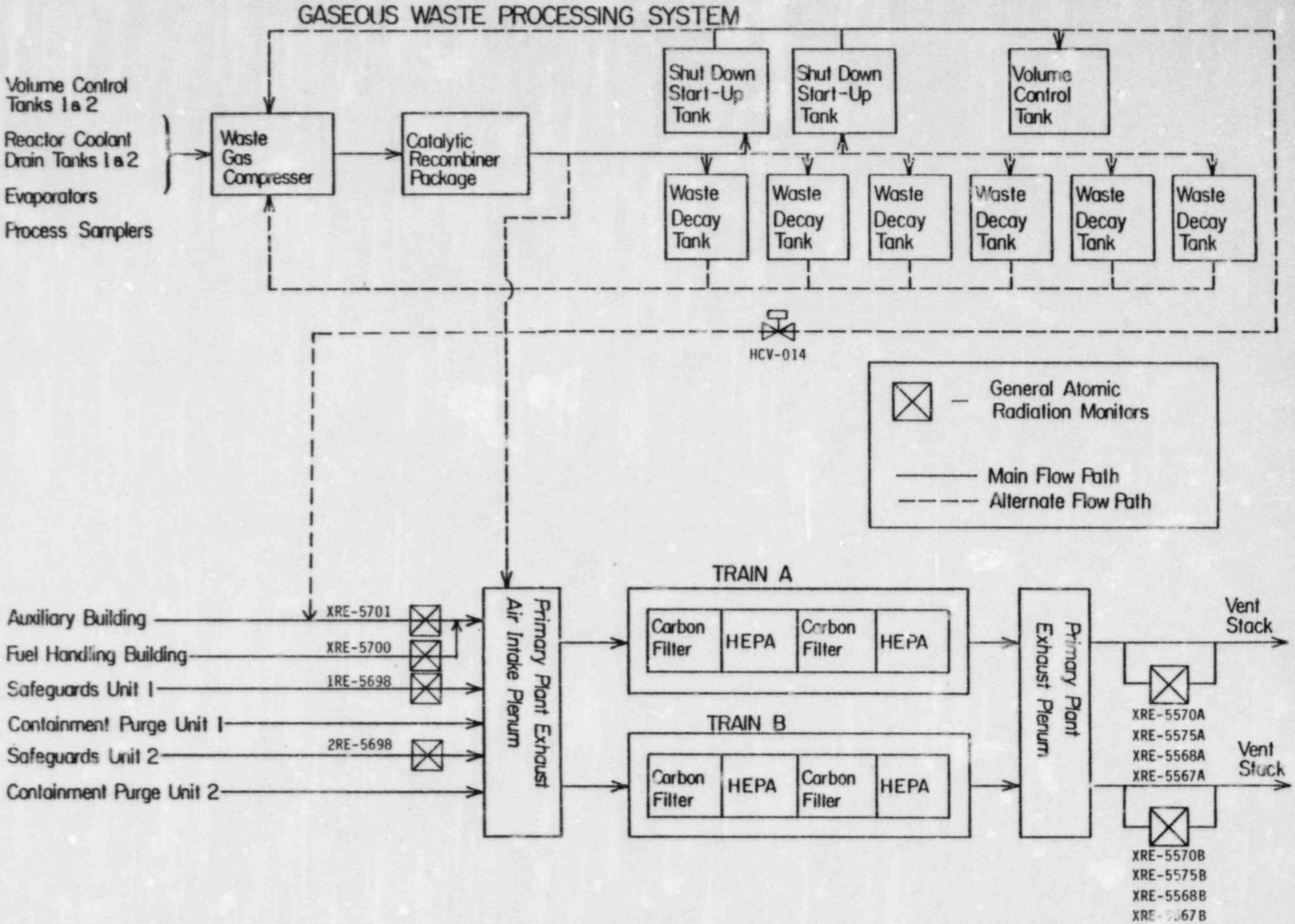

GASEOUS WASTE PROCESSING SYSTEM
Volume Control Tanks 1 & 2
Reactor Coolant Drain Tanks 1 & 2
Evaporators
Process Samplers
Waste Gas Compresser
Catalytic Recombiner Package
Shut Down Start-Up Tank
Shut Down Start-Up Tank
Volume Control Tank
Waste Decay Tank
Waste Decay Tank
Waste Decay Tank
Waste Decay Tank
Waste Decay Tank
Waste Decay Tank
HCV-014
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
XRE-5701
XRE-5700
1RE-5698
2RE-5698
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
XRE-5570A
XRE-5575A
XRE-5568A
XRE-5567A
Vent Stack
XRE-5570B
XRE-5575B
XRE-5568B

Figure 2-2 Plume Depletion Effect for Ground-Level Releases (All Atmospheric Stability Classes)

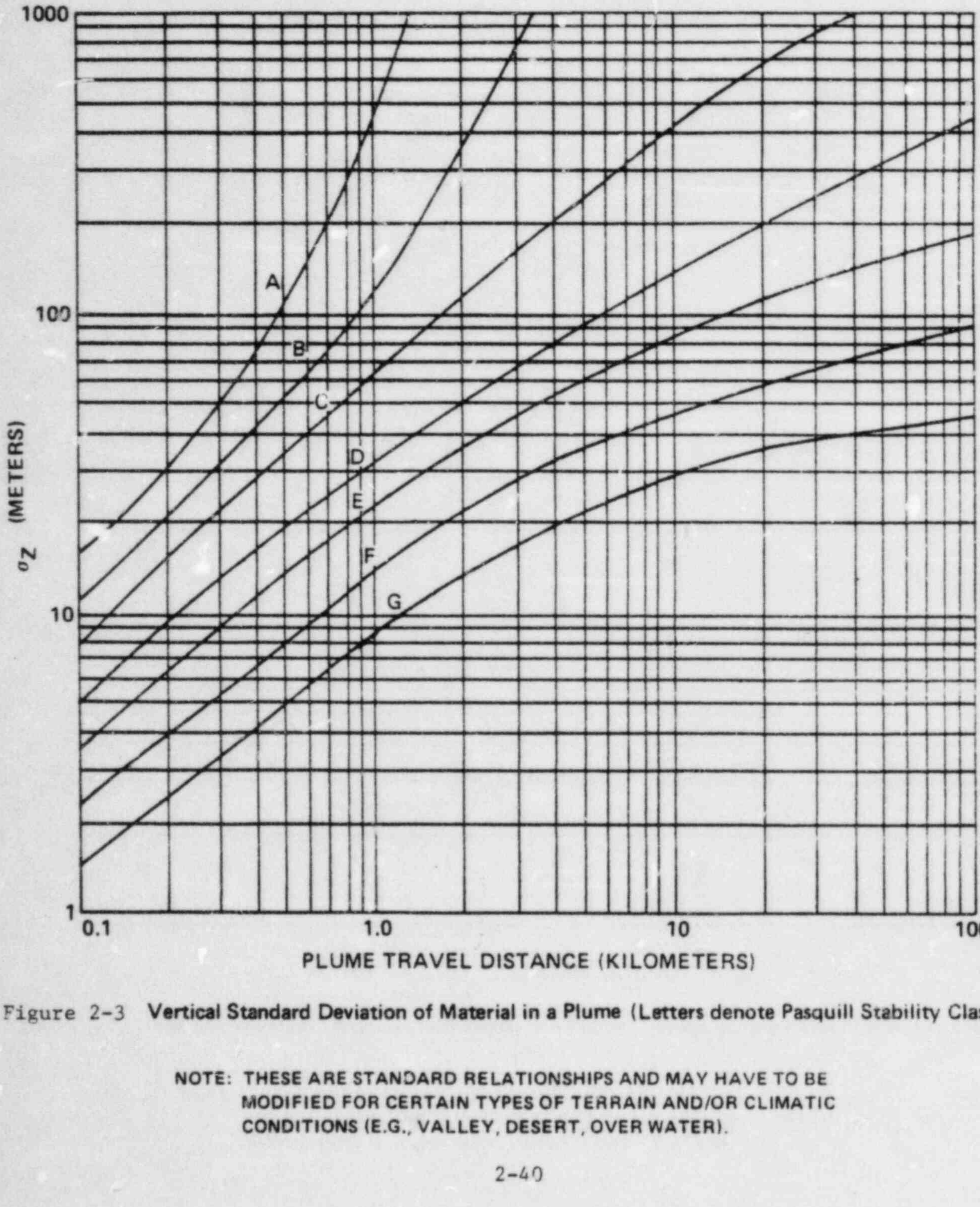


Figure 2-3 **Vertical Standard Deviation of Material in a Plume** (Letters denote Pasquill Stability Class)

NOTE: THESE ARE STANDARD RELATIONSHIPS AND MAY HAVE TO BE MODIFIED FOR CERTAIN TYPES OF TERRAIN AND/OR CLIMATIC CONDITIONS (E.G., VALLEY, DESERT, OVER WATER).

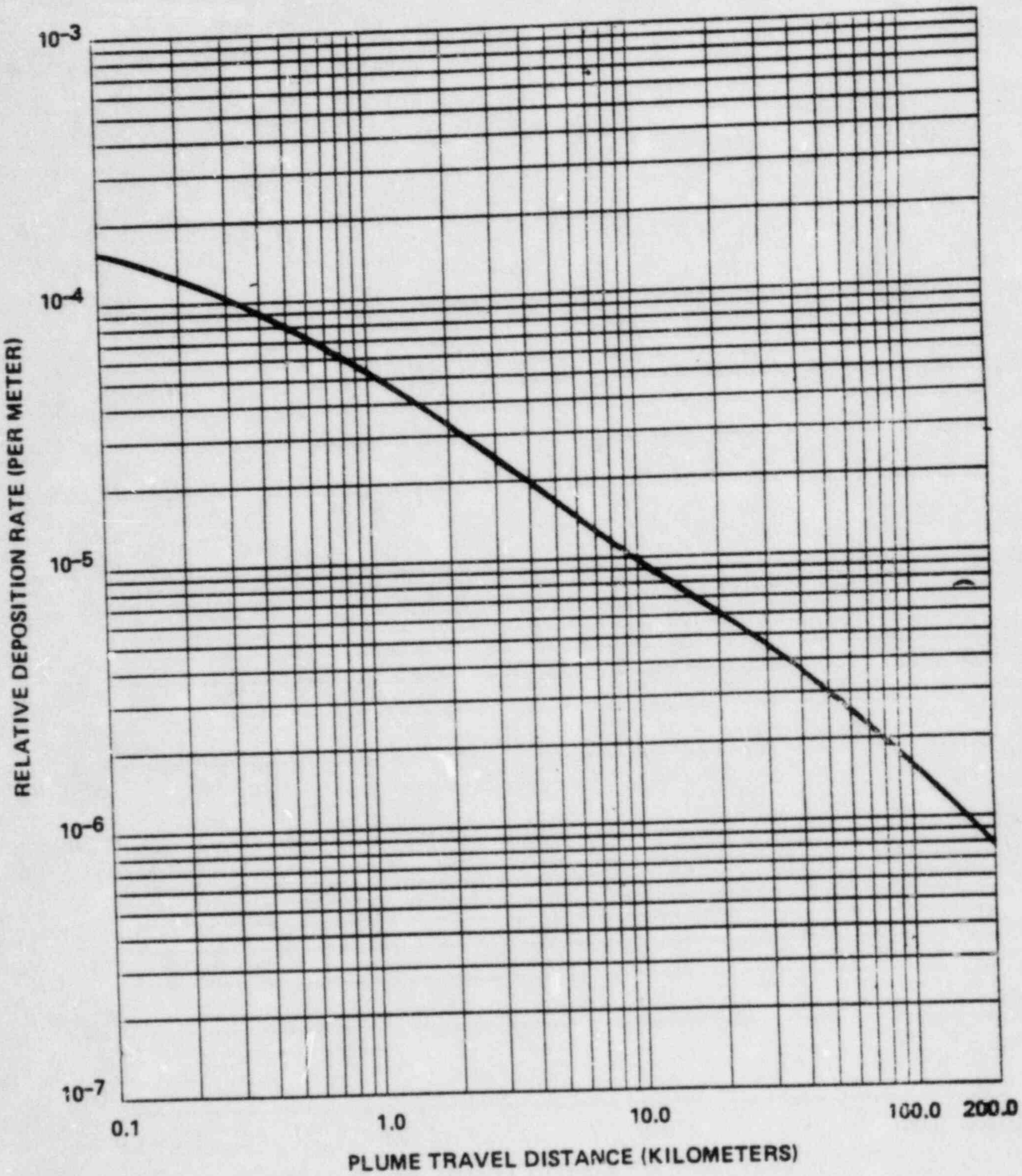


Figure 2-4 **Relative Deposition for Ground-Level Releases (All Atmospheric Stability Classes)**

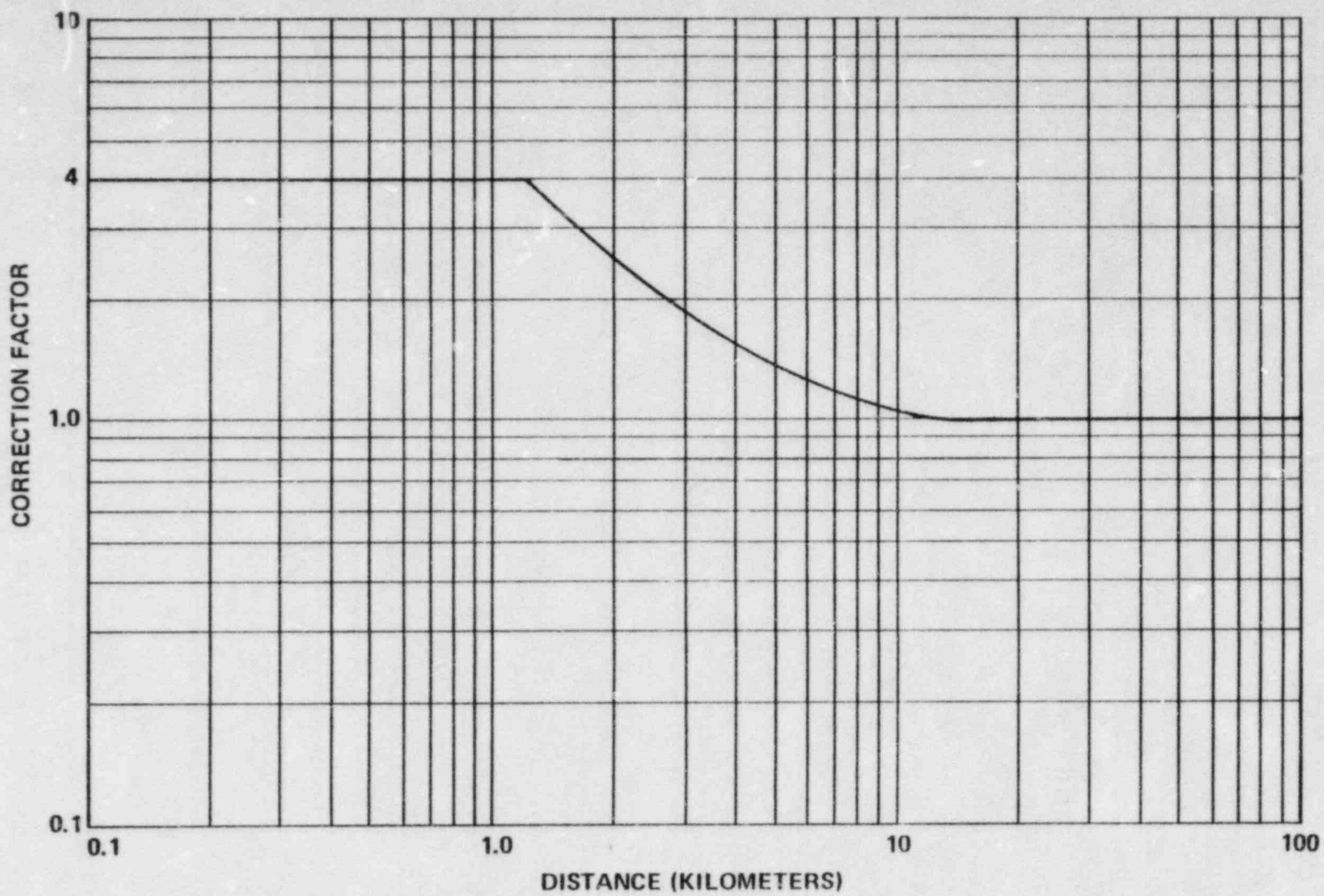


Figure 2-5 Open Terrain Correction Factor

SECTION 3.0

RADIOLOGICAL ENVIRONMENTAL MONITORING

3.1 SAMPLING LOCATIONS

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.

3.2 INTERLABORATORY COMPARISON PROGRAM

For the purpose of implementing technical specificatio . 3.12.3 the Interlaboratory Comparison Program will be conducted to ensure independent checks on the precision and accuracy of the measurements of radioactive material in environmental sample matrices. The requirements will be two-fold: First, to analyse reference-type samples for proiding independent checks on the anaylitical system. These may be available from the EPA as QC samples, from the National Bureau of Standards as standard reference materials, or from commercial sources. If performance limits are not provided, the results should fall within the routine limits of each laboratory for a standard at a level comparable to the specified true value. Second, the program will participate in performance evaluation and method studies as available from the EPA, from the American Society for Testing and Materials, and from other agencies.

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, continued

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	NNW-0.1	SW
54	N-9.9	SW
55	W-1.2	GW
56	WSW-0.1	GW
57	SSE-4.5	GW
58	N-19.3	GW
59	NNE-1.0	SS
60	N-9.9	SS

Table 3.1 (Continued)

Environmental Sampling Locations

Sampling Point	Location (Sector - Miles)	Sample Type*
61	S-4.8	M
62	SW-13.5	M
63	ENE-2.0	F
64	NNE-8.0	F
65	E-4.2	V
66	SW-13.5	V
67	NNW-1.6	V
68	SE-1.3	V
69	SSE-1.3	V

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

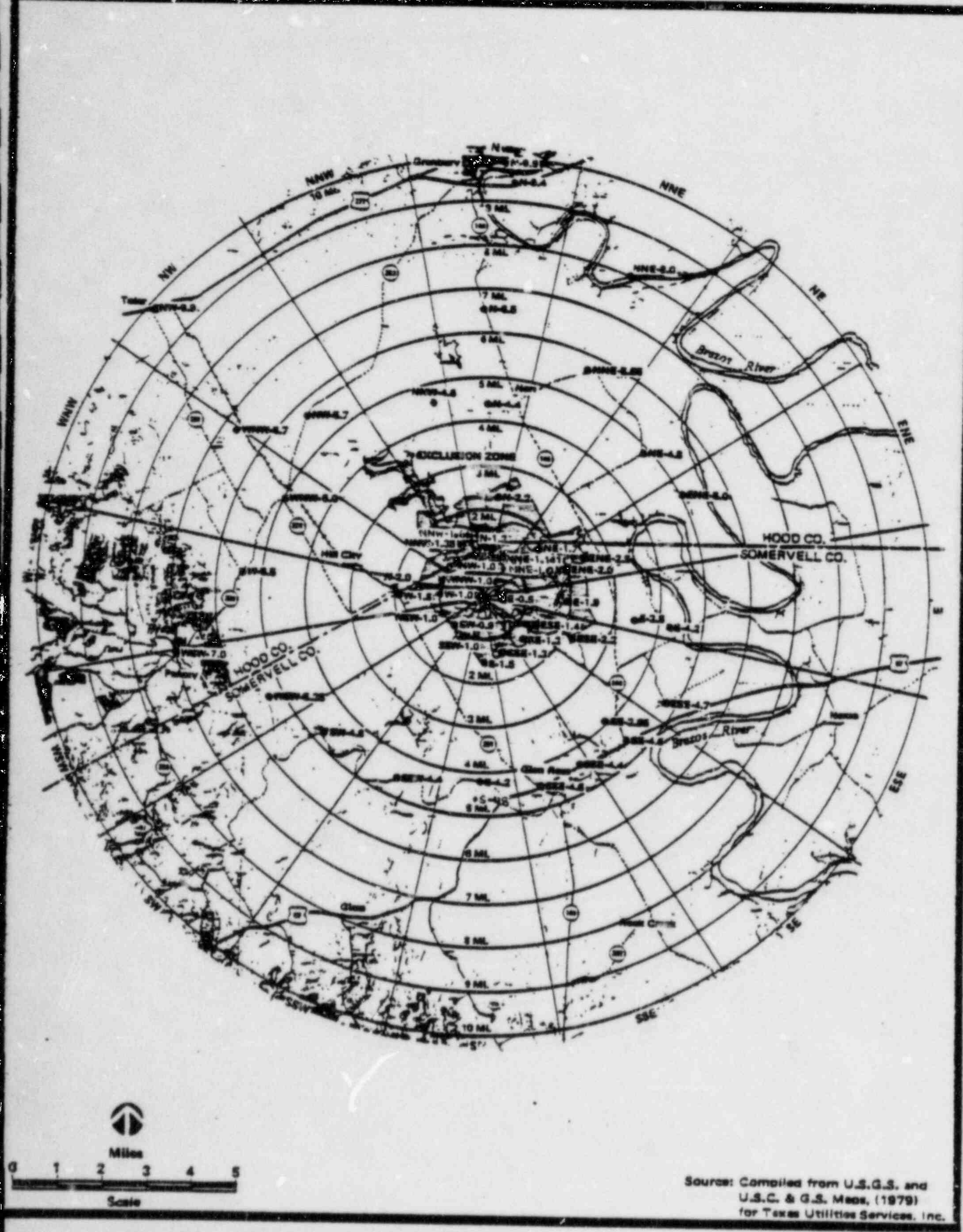
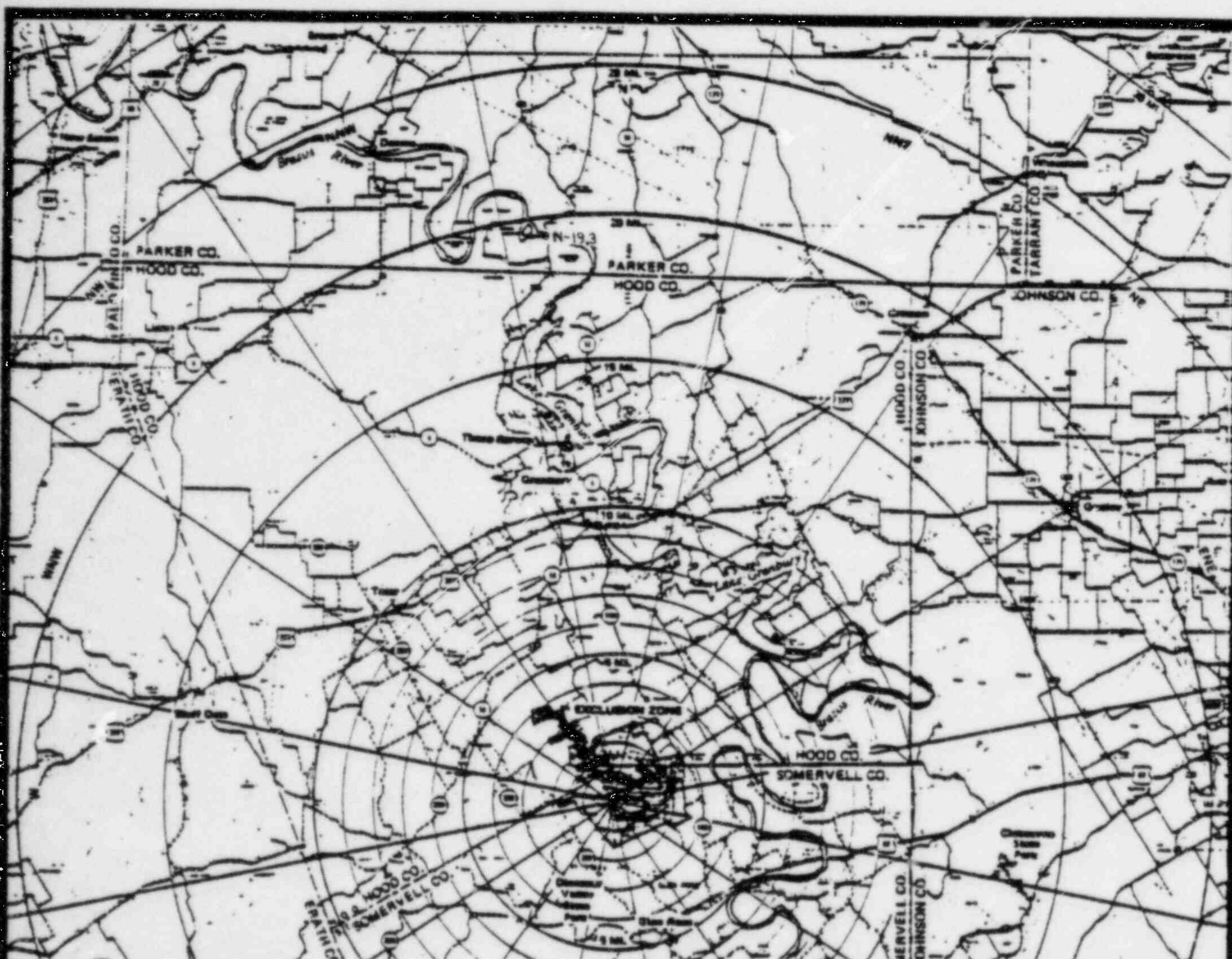


Figure 3.1
Comanche Peak S.E.S.
Radiological Environmental Monitoring Program
Sample Locations Within 10 Miles of the Site



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 Plan Pathway Factor, R_i^G (D/Q)

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

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)

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

where

k'	= conversion factor, 10^6 pC;/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 aduly resp. R.G. 1.109
Yp	= agricultural productivity byunit 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 El 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
λi	= radionuclide decay constant, sec^{-1}
λw	= 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 = 1.0 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:

$$R^C_i (X/Q) = k'k''' \, Fm \, Q_F \, U_{AP} \, DFL_i \, (.75 \, (.5/H))$$

where

k''' = 10[illegible] 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

NOTE: Goat-milk pathway factor, R_i^G (D/Q) will be computed using the cow-milk pathway factor equation. F_m factor for goat-milk will be from table E-2 R.G. 1.109.

APPENDIX E

COW-MEAT PATHWAY FACTOR R_i^M (D/Q)

$$R^M_i \text{ (D/Q)} = k' (Q_F \times U_{AP})/(\lambda i + \lambda w) \times (F_f) \times (r) \times (DFL_i) \times$$
$$((f_p \times f_s)/Y_p + ((1 - f_p f_s) e^{-\lambda_i t_h}))/Ys \times e^{-\lambda_i t_f}$$

where

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

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

U_{AP} = receptor's meat consumption rate for age 0, 41, 65, 110 kg/yr for infant, child, teenager, and adult respectively R.G. 1.109

F_f = the stable element transfer coefficients, days/1lg. Table El R.6. 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

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

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

t_f = 1.73×10^6 sec, the transport time from pasture to receptor NUREG 133

t_h = 7.78×10^6 sec, the transport time from crop field to receptor NUREG 133

APPENDIX E, CONTINUED

COW-MEAT PATHWAY FACTOR R_i^M (D/Q)

Y_p = AGRICULTURAL PRODUCTIVITY by unit area of pasture feed grass, .7 kg/m^2, NUREG 133

Y_s = AGRICULTURAL PRODUCTIVITY by unit area 2.0 Kg/m^2 NUREG 013

f_p = 1.0 the fraction of the year that the cow is on pasture

f_s = 1.0 the fraction of the cow feed that is pasture grass while cow is on pasture

APPENDIX F

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

R_i^V (D/Q) $= k' \times [r/ (Y_v (\lambda_i + \lambda_w))] \times (DFL_i) \times [(U_A^L) f_L e^{-\lambda_i t_L} + U_A^S f_g e^{-\lambda_i t_h}]$

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

f_g = 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

Y_v = 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

APPENDIX G

```
1      ! PROGRAM: ODCM_1
2      !
3     DATA H3,1.58E-7,1.59E-7,3.04E-7,4.62E-7,1.05E-7,1.06E-7,2.03E-7,3.08E-7,0,
1E-2,1.2E-2,1.78E-9
4      !
5    ! DATA C14,2.27E-6,3.25E-6,9.7E-6,1.89E-5,2.84E-6,4.1E-6,1.21E-5,2.4E-5,0,1.
2E-2,3.1E-2
6    ! DATA 3.84E-12
7    ! DATA NA24,1.28E-6,1.72E-6,4.35E-6,7.54E-6,1.7E-6,2.3E-6,5.8E-6,1.01E-5,2.9
E-8,4E-2,3E-2
8    ! DATA 1.283E-5
9     DATA P32,1.65E-4,2.36E-4,7.04E-4,1.45E-3,1.93E-4,2.76E-4,8.25E-4,1.7E-3,0,
2.5E-2,4.6E-2
10    DATA 5.61E-7
11 DATA CR51,1.8E-6,2.62E-6,4.6E-6,9.17E-6,6.7E-7,6.05E-7,4.72E-7,4.1E-7,2.6E-10
,2.2E-3,2.4E-3
12    DATA 2.89E-7
13  DATA MN54,1.75E-4,2.48E-4,4.26E-4,7.14E-4,1.4E-5,1.21E-5,1.07E-5,2E-5,3.8E-9
,2.5E-4,8E-4
14    DATA 2.56E-8
15 ! DATA MN56,2.53E-6,7.2E-6,3.33E-5,5.1E-5,3.67E-6,1.04E-5,4.84E-5,7.43E-5,1.3
E-8,2.5E-4,8E-4
16  ! DATA 7.46E-5
17    DATA FE55,9.01E-6,1.55E-5,3E-5,6.71E-5,2.75E-6,3.78E-6,1.15E-5,1.39E-5,0,1
.2E-3,4E-2
18    DATA 8.14E-9
19 DATA FE59,1.27E-4,1.9E-4,3.43E-4,7.25E-4,3.4E-5,3.24E-5,2.78E-5,5.38E-5,9.4E-
9,1.2E-3,4E-2
20    DATA 1.78E-7
21 !DATA CO58,1.16E-4,1.68E-4,3E-4,5.55E-4,1.51E-5,1.34E-5,1.05E-5,8.98E-6,8.2E-
9,1E-3,1.3E-2
22  ! DATA 2.12E-5
23  DATA CO58,1.16E-4,1.68E-4,3E-4,5.55E-4,1.51E-5,1.34E-5,1.05E-5,8.98E-6,8.2E-
9,1E-3,1.3E-2
24    DATA 1.12E-7
26     !
27 DATA CO60,7.46E-4,1.1E-3,1.91E-3,3.22E-3,4.02E-5,3.66E-5,2.93E-5,2.57E-5,2E-8
,1E-3,1.3E-2
28    DATA 4.18E-9
29  DATA NI63,5.4E-5,7.25E-5,2.22E-4,2.42E-4,1.30E-4,1.77E-4,5.38E-4,6.34E-4,0,6
.7E-3,5.3E-2
30    DATA 2.0E-10
31 ! DATA NI65,1.54E-6,4.6E-6,2.3E-5,3.6E-5,1.74E-6,5.2E-6,2.6E-5,4.05E-5,4.3E-9
,6.7E-3,5.3E-2
32 !  DATA 7.55E-5
33 !  DATA CU64,6.12E-6,7.68E-6,9.9E-6,1.07E-5,7.1E-6,8.9E-6,1.15E-5,1.25E-5,1.7
E-9,1.4E-2,8E-3
34  !  DATA 1.51E-5
35 DATA ZN65,1.08E-5,1.55E-4,2.69E-4,4.67E-4,1.54E-5,2E-5,3.65E-5,6.31E-5,4.6E-9
,3.9E-2,3E-2
36    DATA 3.29E-8
37 ! DATA ZN69,1.15E-7,2E-7,2.75E-6,9.44E-6,1.97E-8,5.16E-8,4E-6,1.37E-5,0,3.9E-
2,3E-2,1.41E-5
38     !
40     !
41   ! DATA BR83,3.01E-8,4.3E-8,1.28E-7,2.72E-7,5.79E-8,5.74E-8,1.71E-7,3.63E-7,9
.3E-11,0,0
42  ! DATA 8.02E-5
44     !
46     !
48     !
50     !
51 DATA RB86,1.7E-5,2.38E-5,5.36E-5,1.36E-4,2.11E-5,2.98E-5,6.7E-5,1.7E-4,7.2E-1
```

```
0,3E-2,3.1E-2
52 DATA 4.29E-7
54 !
56 !
57 DATA SR89,1.75E-4,3.02E-4,5.83E-4,1.45E-3,3.08E-4,4.4E-4,1.32E-3,2.5E-3,6.5E-
13,8E-4,6E-4
58 DATA 1.58E-7
59 DATA SR90,1.24E-2,1.35E-2,2.73E-2,2.92E-2,7.58E-3,8.3E-3,1.7E-2,1.85E-2,0,8E-
4,6E-4,7.6E-10
60 !
61 ! DATA SR91,2.3E-5,3.24E-5,4.7E-5,5.24E-5,2.7E-5,3.66E-5,5.3E-5,5.92E-5,8.3E-
9,8E-4,6E-4
62 ! DATA 1.99E-5
63 ! DATA SR92,5.38E-6,1.249E-5,6.55E-5,1E-4,4.26E-5,7.77E-5,1.71E-4,2.07E-4,1E-
8,8E-4,6E-4
64 ! DATA 7.16E-5
65 ! DATA Y90,6.32E-5,7E-5,7.24E-5,1.92E-4,1.02E-4,1.13E-4,1.17E-4,1.2E-4,2.6E-1
2,1E-5,4.6E-3
66 ! DATA 6.03E-5
67 ! DATA Y90,6.32E-5,7E-5,7.24E-5,1.92E-4,1.02E-4,1.13E-4,1.17E-4,1.20E-4,2.6E-
12,1E-5,4.6E-3
68 ! DATA 3.01E-6
70 !
71 DATA Y91,2.13E-4,3.7E-4,7.1E-4,1.75E-3,7.76E-5,8.24E-5,8.02E-5,8.1E-5,2.7E-11
,1E-5,4.6E-3
72  DATA 1.36E-7
73 ! DATA Y92,9.2E-6,2.06E-5,6.46E-5,9.04E-5,1.48E-5,3.32E-5,1.04E-4,1.46E-4,1.9
E-9,1E-5,4.6E-3
74  ! DATA 5.45E-5
75 ! DATA Y93,5.27E-5,7.24E-5,1.05E-4,1.19E-4,8.5E-5,1.17E-4,1.7E-4,1.92E-4,7.8E
-10,1E-5,4.6E-3
76 ! DATA 1.89E-5
77 DATA ZR95,2.21E-4,3.36E-4,6.03E-4,1.25E-3,3.09E-5,3E-5,2.66E-5,2.5E-5,5.8E-9,
5E-6,3.4E-2
78 DATA 1.22E-7
79 ! DATA ZR97,6.54E-5,7.88E-5,9.49E-5,1E-4,1.05E-4,1.27E-4,1.53E-4,1.62E-4,6.4E
-9,5E-6,3.4E-2
80 ! DATA 1.15E-5
81 !DATA NB95,1.3E-5,9.39E-5,1.66E-4,3.42E-4,2.1E-5,1.95E-5,1.62E-5,1.46E-5,6E-9
,2.5E-3,2.8E-1
82 ! DATA 2.21E-6
93 DATA NB95,6.31E-5,9.39E-5,1.66E-4,3.42E-4,2.1E-5,1.95E-5,1.62E-5,1.46E-5,6E-9
,2.5E-3,2.8E-1
84 DATA 2.285E-7
85 ! DATA MO99,3.1E-5,3.36E-5,3.66E-5,9.63E-5,10E-6,1.38E-5,2.84E-5,5.08E-5,2.2E
-9,7.5E-3,8E-3
86 ! DATA 2.89E-6
87 ! DATA TC99,5.2E-7,7.66E-7,1.3E-6,1.45E-6,4.13E-7,6.08E-7,1.03E-6,1.15E-6,1.1
E-7,2.5E-2,4E-1
88 ! DATA 3.21E-5
89    !
93 DATA RU103,6.31E-5,9.79E-5,1.79E-4,3.94E-4,2.16E-5,2.13E-5,1.9E-5,1.8E-5,4.02
E-9,1E-6,4E-1
94 DATA 2.01E-7
95 ! DATA RU105,6.02E-6,1.13E-5,2.7E-5,3.46E-5,9.42E-6,1.76E-5,4.21E-5,5.41E-5,5
.1E-9,1E-6,4E-1
96 ! DATA 4.34E-5
97 DATA RU106,1.17E-3,2.01E-3,3.87E-3,8.26E-3,1.78E-4,1.9E-4,1.82E-4,1.83E-4,1.8
E-9,1E-6,4E-1
98 DATA 2.18E-8
99 DATA AG110,5.79E-4,8.44E-4,1.48E-3,2.62E-3,6.04E-5,5.45E-5,4.33E-5,3.77E-5,2.
1E-8,5E-2,1.7E-2
100 DATA 3.17E-8
```



```
111 !
121 DATA TE125,3.9E-5,6.7E-5,1.29E-4,3.2E-4,1.1E-5,1.13E-5,1.14E-5,2.32E-5,4.8E-
11,1E-3,7.7E-2
```

```
131 DATA 1.38E-7
141!DATA TE127,7.17E-6,1E-5,1.52E-5,1.74E-5,8.68E-6,1.22E-5,1.84E-5,2.1E-5,1E-11
,1E-3,7.7E-2,7.36E-8
151 !
161 DATA TE127,1.2E-4,2.07E-4,4E-4,9.37E-4,2.75E-5,3.92E-5,8.24E-5,1.44E-4,1.3E-
12,1E-3,7.7E-2
171 DATA 7.36E-8
181 DATA TE129,1.45E-4,2.47E-4,4.76E-4,1.2E-3,5.79E-5,6.82E-5,1.43E-4,2.50E-4,9E
-10,1E-3,7.7E-2
191 DATA 2.35E-7
221 ! DATA TE131,1.74E-7,2.9E-7,5.55E-7,5.9E-6,8.63E-8,1.2E-7,4.36E-7,7.1E-6,2.6
E-6,1E-3,7.7E-2
231 ! DATA 6.42E-6
261 !DATA TE132,6.37E-5,5.61E-5,1.02E-4,2.43E-4,7.71E-5,7E-5,4.5E-5,6.44E-5,2E-9
,1E-3,7.7E-2,2.47E-6
271 !
291 !
301 ! DATA I130,1.42E-4,1.86E-4,5E-4,1.14E-3,1.89E-4,2.43E-4,6.5E-4,1.48E-3,1.7E
-8,6E-3,2.9E-3
311 ! DATA 1.55E-5
321 DATA I131,1.5E-3,1.83E-3,4.4E-3,1.06E-2,5.72E-3,2.4E-3,5.72E-3,1.39E-2,3.4E-
9,6E-3,2.9E-3
331 DATA 9.95E-7
341   DATA I133,2.7E-4,3.65E-4,1.04E-3,2.54E-3,3.63E-4,4.76E-4,1.36E-3,3.3E-3,4.
5E-9,6E-3,2.9E-3
351   DATA 9.25E-6
381 ! DATA I135,5.6E-5,7.76E-5,2.14E-4,4.97E-4,7.65E-5,1E-4,2.79E-4,6.49E-4,1.4E
-8,6E-3,2.9E-3
391 ! DATA 2.87E-5
401!DATA CS134,1.06E-4,1.4E-4,2.74E-4,5.02E-4,1.48E-4,2E-4,3.84E-4,7.03E-4,1.4E-
8,1.2E-2,4E-3
411!DATA 6.64E-5
421 DATA CS134,1.06E-4,1.41E-4,2.74E-4,5.02E-4,1.48E-4,1.97E-4,3.84E-4,7.03E-4,1
.4E-8,1.2E-2,4E-3
431 DATA 1.07E-8
441 DATA CS136,1.83E-5,2.42E-5,4.62E-5,9.6E-5,2.57E-5,3.4E-5,6.46E-5,1.35E-4,1.7
E-8,1.2E-2,4E-3
442 DATA 6.17E-7
443 DATA CS137,7.76E-5,1.06E-4,2.45E-4,4.37E-4,1.09E-4,1.49E-4,3.27E-4,6.11E-4,4
.9E-9,1.2E-2,4E-3
444 DATA 7.27E-10
449 DATA BA140,1.59E-4,2.54E-4,4.71E-4,1.14E-3,4.18E-5,4.38E-5,8.31E-5,1.71E-4,2
.4E-9,4E-4,3.2E-3
450 DATA 6.26E-7
455 ! DATA LA140,5.73E-5,6.09E-5,6.1E-5,1.2E-4,9.25E-5,9.82E-5,9.84E-5,9.77E-5,1
.7E-8,5E-6,2E-4
456 ! DATA 4.78E-6
459 DATA CE141,4.52E-5,7.67E-5,1.47E-4,3.69E-4,2.42E-5,2.54E-5,2.47E-5,2.48E-5,6
.2E-10,1E-4,1.2E-3
460 DATA 2.47E-7
461 DATA CE143,2.83E-5,3.19E-5,3.44E-5,8.3E-5,4.56E-5,5.14E-5,5.55E-5,5.73E-5,2.
5E-9,1E-4,1.2E-3
462 DATA 5.83E-6
463 DATA CE144,9.72E-4,1.67E-3,3.23E-3,7.03E-3,1.65E-4,1.75E-4,1.7E-4,1.71E-4,3.
7E-10,1E-4,1.2E-3
464 DATA 2.82E-8
465 DATA PR143,3.51E-5,6.04E-5,1.17E-4,3.09E-4,4.03E-5,4.31E-5,4.24E-5,4.29E-5,0
,5E-6,4.7E-3,5.91E-7
466 !
471 DATA ND147,2.76E-5,4.65E-5,8.87E-5,2.3E-4,3.49E-5,3.68E-5,3.58E-5,3.6E-5,1.2
E-9,5E-6,3.3E-3
472 DATA 7.25E-7
473 ! DATA W187,1.94E-5,2.21E-5,2.46E-5,2.83E-5,2.82E-5,3.22E-5,3.57E-5,3.69E-5,
3.6E-9,5E-4,1.3E-3
474 ! DATA 8.05E-6
475 DATA NP239,1.49E-5,1.65E-5,1.73E-5,4.25E-5,2.4E-5,2.67E-5,2.79E-5,2.87E-5,1.
```

```
1E-9,5E-6,2E-4
476 DATA 3.41E-6
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  !
481  !NOTE:SOME ISOTOPES WITH HALF LIVES LESS THAN 8 DAYS HAVE BEEN DELETED IAW
 RG1.109.
482  !
483  !C-14 HAS BEEN DELETED FROM THE GASEOUS RELEASE CALCULATIONS.
485  !
486  ! DEFINITION OF TERMS
487  !
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, VALUE MAY CHANGE ANNUALLY.
871  !
880  ! FS=FRACTION OF THE COW FEED THAT IS PASTURE GRASS WHILE COW ON PASTURE.
 FS=1.0
890  ! FS CAN POTENTIALLY CHANGE ANNUALLY. TO UP-DATE THIS VALUE, SIMPLY CHANGE
 THE FS ASSIGNMENT
891  !
900  ! KKK=CONSTANT 1.0E3, NUREG 133
910  !
```

```
920   ! H=HUMIDITY, 8, NUREG 133
930   !
940   ! LAMDAW=DECAY CONSTANT FOR REMOVAL OF ACTIVITY FROM PLANTS BY WEATHERING,
 5.73E-7, NUREG 133
950   !
960   ! UAP2=RECEPTOR'S MEAT CONSUMPTION, 0, 41, 65, 110  FOR INFANT,CHILD,TEENA
GER, AND ADULT
971   !
980   ! UAL=CONSUMPTION RATE OF FRESH LEAFY VEGETABLES 0, 26, 42, 64,FOR INFANT,
CHILD,TEENAGER,ADULT
991   !
1000  ! UAS=CONSUMPTION RATE OF STORED VEGETABLES 0, 520, 630, 520,INFANT,CHILD,
TEENAGER,ADULT
1011  !
1020  ! FL=FRACTION FRESH VEGETABLES GROWN LOCALLY
1030  !
1040  ! FG=FRACTION STORED VEGETABLES GROWN LOCALLY
1050  !
1060  ! TL=AVG. TIME BETWEEN HARVEST OF VEGETABLES AND CONSUMPTION, 8.6 E4 SEC.
 NUREG 133
1070  !
1080  ! THH=AVERAGE TIME BETWEEN HARVEST OF STORED VEGETABLES AND CONSUMPTION 5.
18E6 SEC.  NUREG 133
1090  !
1100  !
1110  K=1.0E+6 ! UNITS CONVERSION FACTOR
1120  Kk=8760  ! UNITS CONVERSION FACTOR
1130  Sf=.7    ! SHIELDING FACTOR
1140  T=4.73E+8 ! DECAY TIME FOR DECAY AS ONLY REMOVAL MECHANISM
1150  Qf=50 ! COW CONSUMPTION RATE
1160  R=.2  ! FRACTION OF DEPOSITED ACTIVITY RETAINED ON COW'S FEED GRASS.
1170  Yp=.7 ! AGRICULTURAL PRODUCTIVITY
1180  Ys=2.0 ! AGRICULTURAL PRODUCTIVITY FOR STORED FEED
1190  Tf=1.73E+5 !TRANSPORT TIME FROM PASTURE TO RECEPTOR.
1200 Yv=2 !
1201 Tff=1.73E+6
1210  Th=7.78E+6  ! TRANSPORT TIME FROM PASTURE TO HARVEST TO RECEPTOR.
1220  Fp=1.0  ! FRACTION OF THE YEAR COW IS ON PASTURE.
1230  Fs=1.0  ! FRACTION OF THE COW'S FEED THAT IS STORED FEED WHILE COW ON PAST
URE.
1240  Kkk=1.0E+3  ! UNITS CONVERSION FACTOR.
1250  H=8  !  ABSOLUTE HUMIDITY-DEFAULT VALUE
1260  Lamdaw=5.73E-7  !DECAY CONSTANT FOR                              WEATHER
ING.
1270  Fl=1 ! FRACTION OF FRESH VEG. GROWN LOCALLY
1280  Fg=.76  !  FRACTION OF STORED VEG. GROWN LOCALLY
1290  Tl=8.6E+4  ! AVG. TIME BETWEEN HARVEST OF VEG. AND CONSUMPTION.
1300  Thh=5.18E+6 ! AVG. TIME BETWEEN HARVEST OF STORED VEG. AND CONSUMPTION.
1301  ! BY ENTERING THE AGE GROUP OF CONCERN, THE COMPUTOR WILL GENERATE A TABLE
 OF DOSE FACTORS.
1302  !
1303  !
1310  INPUT "PLEASE INDICATE INFANT,CHILD,TEENAGER, OR ADULT",Age$
1311  !
1312  !
1314  INPUT "PLEASE INDICATE PATHWAY DOSE FACTOR R OR P",A$
1315  !
1317  IF A$<>"P" THEN 1397
1318  READ Atom$,Dfa1,Dfa2,Dfa3,Dfa4,Dfl1,Dfl2,Dfl3,Dfl4,Dfg,Fm,Ff,Lamda
1319  IF Age$="INFANT" THEN 1404
1320  IF Age$="CHILD" THEN 1480
1321  IF Age$="TEENAGER" THEN 1570
1322  IF Age$="ADULT" THEN 1660
1323  PRINT USING "26X,26A","PATHWAY DOSE FACTOR (P)"
1324  PRINT "  "
1325  PRINT "    "
```

```
1326 IMAGE 13X,4A,4X,10A,5X,12A,8X,4A,//
1327 PRINT USING 1326,"ATOM","INHALATION","GROUND PLANE","FOOD"
1328 IF Atom$="I130" THEN R=1 !R=1 FOR ALL ISOTOPES OF RADIOIODINE.
1329 IF Atom$="I131" THEN R=1
1330 IF Atom$="I132" THEN R=1
1331 IF Atom$="I133" THEN R=1
1332 IF Atom$="I134" THEN R=1
1333 IF Atom$="I135" THEN R=1
1334 IF Lamda*3.15E+7<700 THEN 1337 ! AVOID REAL        UNDERFLOW.
1335 Expo10=1.0E-300 ! DEFAULT VALUE FOR EXPONENTIALS TOO LARGE TO BE COMPUTED.
1336 GOTO 1338
1337 Expo10=EXP(-Lamda*3.15E+7)
1338 P2=K*Kk*Dfg*(1-Expo10)/Lamda
1339 IF Lamda*Tf<700 THEN 1342 !AVOID REAL UNDERFLOW
1340 Expo12=1.0E-300 ! DEFAULT VALUE FOR EXPONENTIALS TOO LARGE TO BE COMPUTED.
1341 GOTO 1343
1342 Expo12=EXP(-Lamda*Tf)
1343 P3=(K*R*Wf*Uap1)/(Yp*(Lamda+Lamdaw))*Fm*Dfl*Expo12
1344 IF Atom$="H3" THEN P3=2.43E+3  ! SEE NUREG 133 PAGE 28
1345 P1=K*Br*Dfa
1346 IF Atom$<>"NB95" THEN 1352
1347 PAUSE
1348 PRINT USING "26X,26A,/,/,","PATHWAY DOSE FACTOR (P)"
1349 IMAGE 13X,4A,4X,10A,5X,12A,8X,4A,//
1350 PRINT USING 1349,"ATOM","INHALATION","GROUND PLANE","FOOD"
1352 IMAGE 13X,5A,4X,D.3DE,5X,D.3DE,11X,D.3DE,//
1353 PRINT USING 1352;Atom$,P1,P2,P3
1354 R=.2
1355 IF Atom$="NP239" THEN 1394 ! CHECK FOR END OF DATA
1356 READ Atom$,Dfa1,Dfa2,Dfa3,Dfa4,Dfl1,Dfl2,Dfl3,Dfl4,Dfg,Fm,Ff,Lamda ! THIS
STATEMENT READS THE
1357 ! DATA ASSOCIATED WITH THE PATHWAY DOSE FACTOR (R) CALCULATIONS.
1358 IF Age$<>"INFANT" THEN 1367 !ASSIGNS AGE GROUP SPECIFIC DATA
1359 Dfa=Dfa4
1360 Dfl=Dfl4
1361 Br=1400
1362 Uap1=330
1363 Uap2=0
1364 Ual=0
1365 Uas=0
1366 GOTO 1328
1367 IF Age$<>"CHILD" THEN 1376 !ASSIGNS AGE GROUP SPECIFIC DATA.
1368 Dfa=Dfa3
1369 Dfl=Dfl3
1370 Br=3700
1371 Uap1=330
1372 Uap2=41
1373 Ual=26
1374 Uas=520
1375 GOTO 1328
1376 IF Age$<>"TEENAGER" THEN 1385 ! ASSIGNS AGE GROUP SPECIFIC DATA.
1377 Dfa=Dfa2
1378 Dfl=Dfl2
1379 Br=8000
1380 Uap1=400
1381 Uap2=65
1382 Ual=42
1383 Uas=630
1384 GOTO 1328
1385 IF Age$<>"ADULT" THEN 1393 ! ASSIGNS AGE     GROUP SPECIFIC DATA.
1386 Dfa=Dfa1
1387 Dfl=Dfl1
1388 Br=8000
1389 Uap1=310
1390 Uap2=110
1391 Ual=63
```

```
1392  Uas=520
1393  GOTO 1328
1394  GOTO 2370
1395  ! THE FOLLOWING CODE PRINTS THE PAGE TITLE  AND THE COLUMN HEADS.
1396  !
1397  PRINT USING "28X,26A,/,/,";"PATHWAY DOSE FACTOR  (R) ";Age$
1398   IMAGE  3X,4A,4X,5A,6X,3A,8X,8A,4X,8A,6X,3A,8X,7A,/
1399  PRINT USING 1398;"ATOM","INHAL","G/P","COW/MILK","COW/MEAT","VEG","GT/MILK
"
1400 ! THIS READ STATEMENT READS THE NUCLIDE OF CONCERN PLUS THE DFA AND DFL VAL
UES FOR THAT NUCLIDE
1401 ! NOTE DFA1 IS THE DFA VALUE FOR AN ADULT, DFA2 IS THE VALUE FOR A TEEN, DF
A3 AND DFA4 ARE THE
1402 ! VALUES FOR CHILDREN AND INFANTS RESPECTIVELY
1403  READ  Atom$,Dfa1,Dfa2,Dfa3,Dfa4,Dfl1,Dfl2,Dfl3,Dfl4,Dfg,Fm,Ff,Lamda
1404  IF Age$<>"INFANT" THEN 1480
1405  Dfa=Dfa4 ! ASSIGN INFANT RELATED VALUES
1410  Dfl=Dfl4
1420  Br=1400
1430  Uap1=330
1440  Uap2=0
1450  Ual=0
1460  Uas=0
1461  IF A$="P" THEN 1323
1470  GOTO 1740
1480  IF Age$<>"CHILD" THEN 1570
1490  Dfa=Dfa3 ! ASSIGN CHILD RELATED VALUES
1500  Dfl=Dfl3
1510  Br=3700
1520  Uap1=330
1530  Uap2=41
1540  Ual=26
1550  Uas=520
1551  IF A$="P" THEN 1323
1560  GOTO 1740
1570  IF Age$<>"TEENAGER" THEN 1660
1580  Dfa=Dfa2 ! ASSIGN TEENAGER RELATED VALUES
1590  Dfl=Dfl2
1600  Br=8000
1610  Uap1=400
1620  Uap2=65
1630  Ual=42
1640  Uas=630
1641  IF A$="P" THEN 1323
1650  GOTO 1740
1660  IF Age$<>"ADULT" THEN 1740
1670  Dfa=Dfa1 ! ASSIGN ADULT RELATED VALUES
1680  Dfl=Dfl1
1690  Br=8000
1700  Uap1=310
1710  Uap2=110
1720  Ual=64
1730  Uas=520
1731  IF A$="P" THEN 1323
1740  IF Atom$="I131" THEN R=1 !SEE NUREG 133 P.34 FOR EXPLANATION.
1750  IF Atom$="I132" THEN R=1
1760  IF Atom$="I130" THEN R=1
1770  IF Atom$="I133" THEN R=1
1780  IF Atom$="I134" THEN R=1
1790  IF Atom$="I135" THEN R=1
1791  ! THE FOLLOWING CODE CALCULATES FOUR EXPONENTIAL VALUES.  A DEFAULT VALUE
OF 1.0E-300 IS USED
1792  ! TO AVOID THE ERROR "REAL UNDERFLOW".
1793  IF Lamda*Tff<700 THEN 1796
1794  Expo7=1.0E-300
1795  GOTO 1800
```

APPENDIX G

```
1796  Expo7=EXP(-Lamda*Iff)
1800  IF Lamda*Ih<700 THEN 1830
1810  Expo1=1.0E-300
1820  GOTO 1840
1830  Expo1=EXP(-Lamda*Ih)
1840  IF Lamda*If<700 THEN 1870
1850  Expo2=1.0E-300
1860  GOTO 1880
1870  Expo2=EXP(-Lamda*If)
1880  IF Lamda*Il<700 THEN 1910
1890  Expo3=1.0E-300
1900  GOTO 1920
1910  Expo3=EXP(-Lamda*Il)
1920  IF Lamda*Ihh<700 THEN 1950
1930  Expo4=1.0E-300
1940  GOTO 1960
1950  Expo4=EXP(-Lamda*Ihh)
1951  ! EXPOA IS A FACTOR UTILIZED IN THE CALCULATION OF THE COW/MILK AND COW/ME
AT DOSE PATHWAYS.
1960  Expoa=((Fp*Fs)/Yp+((1-Fp*Fs)*Expo1)/Ys)*Expo2
1961  ! EXPOB IS USED IN THE CALCULATION OF VEGETABLE DOSE PATHWAY.
1970  Expob=Ual*Fl*Expo3+Uas*Fg*Expo4
1971  Expoc=((Fp*Fs)/Yp+((1-Fp*Fs)*Expo1)/Ys)*Expo7
1980  IF Atom$<>"H3" THEN 2030
1990  R3=K*Kkk*Fm*Qf*Uap1*Dfl*((.75*.5/H)) ! H3 COW/MILK PATHWAY
2000  R4=K*Kkk*Ff*Qf*Uap2*Dfl*((.75*.5/H))  !H3 COW/MEAT PATHWAY
2010  R5=K*Kkk*(Ual*Fl+Fg*Uas)*Dfl*((.75*.5/H)) !H3 VEGETABLE PATHWAY
2020  R6=K*Kkk*.17*Uap1*6*Dfl*((.75*.5/H))  !H3 GT/MILK PATHWAY
2030  R1=K*Br*Dfa  !INHALATION DOSE FACTOR
2040  IF Lamda*T<700 THEN 2070
2050  Expo5=1.0E-300  !DEFAULT VALUE TO AVOID "REAL UNDERFLOW"
2060  GOTO 2080
2070  Expo5=EXP(-Lamda*T)
2080  R2=K*Kk*Sf*Dfg*((1-Expo5)/Lamda) !GROUND PLANE DOSE FACTOR
2090 IF Atom$="H3" THEN 2340 !H3 VALUES WERE CALCULATED ABOVE
2100  R3=K*(Qf*Uap1)/(Lamda+Lamdaw)*Fm*R*Dfl*Expoa!COW/MILK PATHWAY
2110  R4=K*(Qf*Uap2)/(Lamda+Lamdaw)*Ff*R*Dfl*Expoc!COW/MEAT PATHWAY
2111 !
2120  R5=K*R/(Yv*(Lamda+Lamdaw))*Dfl*Expob
2121  !THE FOLLOWING CODE ITEMS ASSIGN FM VALUES FOR THE GOAT/MILK CALCULATION.
2130  IF Atom$="H3" THEN Fm=.17
2150  IF Atom$="P32" THEN Fm=.25
2160  IF Atom$="FE55" THEN Fm=1.3E-4
2170  IF Atom$="FE59" THEN Fm=1.3E-4
2180  IF Atom$="CU64" THEN Fm=.013
2190  IF Atom$="SR89" THEN Fm=.014
2200  IF Atom$="SR90" THEN Fm=.014
2210  IF Atom$="I130" THEN Fm=.06
2220  IF Atom$="I131" THEN Fm=.06
2230  IF Atom$="I132" THEN Fm=.06
2240  IF Atom$="I133" THEN Fm=.06
2250  IF Atom$="I134" THEN Fm=.06
2260  IF Atom$="I135" THEN Fm=.06
2270  IF Atom$="CS134" THEN Fm=.3
2280  IF Atom$="CS136" THEN Fm=.3
2290  IF Atom$="CS137" THEN Fm=.3
2300  IF Atom$="CS138" THEN Fm=.3
2310  Qf=6
2311  ! R6 CALCULATES THE GOAT/MILK PATHWAY.
2320  R6=K*(Qf*Uap1)/(Lamda+Lamdaw)*Fm*R*Dfl*Expoa
2330  Qf=50
2331  R=.2 !REASSIGN FOR NON-IODINE
2340  IMAGE 3X,5A,3X,D.3DE,2X,D.3DE,2X,D.3DE,3X,D.3DE,5X,D.3DE,2X,D.3DE,//
2350   PRINT USING 2340;Atom$,R1,R2,R3,R4,R5,R6
2351 ! PAUSE
2353   IF Atom$<>"NB95" THEN 2361
```

```
2354   PAUSE
2356 ! PRINT USING "@,#"
2357 ! PRINT USING "2X,#"
2358   PRINT USING "28X,26A,/,/,";"PATHWAY DOSE FACTOR (R)",Age$
2359   IMAGE 3X,4A,4X,5A,8X,3A,7X,8A,4X,8A,6X,3A,8X,7A,/
2360   PRINT USING 2359;"ATOM","INHAL","G/P","COW/MILK","COW/MEAT","VEG","GT/MIL
K"
2361 IF Atom$()"NP239" THEN 1403
2370   END
```