OFFSITE DOSE CALCULATION MANUAL

PALO VERDE NUCLEAR GENERATING STATION

UNIT 1

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1. INTRODUCTION

The purpose of the offsite dose calculation manual (ODCM) is to provide the parameters and methodology to be used in calculating offsite doses and effluent monitor setpoints at the Palo Verde Nuclear Generating Station (PVNGS), Unit 1. Included are methods for determining maximum individual, whole body, and organ doses due to plant effluents to assure compliance with the dose limitations in the Technical Specifications. Methods are included for performing dose projections to assure compliance with the gaseous treatment system operability sections of the Technical Specifications. This manual includes the methods used for determining quarterly individual doses for inclusion in Effluent and Waste Disposal Semi-annual Reports.

1.1 Liquid Effluents

Dose calculation methodology for liquid effluents is not included in this manual because of the desert location of the plant and the hydrology of the area. PVNGS is located in the drainage basin of the Centennial Wash, which flows southeasterly into the Gila River. Surface water flows near the site area are intermittent and of short duration because the flows are caused by storm runoff, usually occurring in August and September and from December to April. Surface water bodies, such as ponds, lakes, and marshes, are not present in the area because of the arid climate, the geological character of surficial materials, and the high potential evaporation rate.

The groundwater in the site area consists of an extensive regional aquifer and a local perched-water zone. The regional aquifer extends to over 400 square miles. The primary recharge source to the regional aquifer is underflow from the Upper

Hassayampa Valley to the north. The general flow direction is north to south. Infiltration of precipitation, surface runoff, and return flow from irrigation constitute a small portion of the total recharge of the aquifer. Discharge of the aquifer occurs as underflow to Arlington Valley to the south and pumpage from irrigation wells (the major use of groundwater in the area).

Contaminated water, if accidentally spilled during plant operation, may seep through the ground surface. For this postulated occurrence, the contaminated water will infiltrate downward through the unsaturated soil and reach the perched water table about 40 feet below the land surface. It will then disperse into the perched groundwater. Further downward movement of water from the base of the perched water zone is restricted due to the presence of the Palo Verde Clay layer about 200 feet below the ground surface. Two aquifer systems have been analyzed for the possible effect of a contaminated water spill: the perched water zone and the underlying regional aquifer. The impact of such postulated accidental seepages on the groundwater system, and in particular on the existing wells located in the 5-mile zone around the site area has been calculated and analyzed in Section 2.4.13.3 of the PVNGS FSAR. It is shown that the resultant concentrations of the refueling water tank source-term radionuclides are well below the MPC_w values listed in 10 CFR 20, Appendix B, Table II. Therefore, no methods for calculating doses due to the liquid have been included.

If geological conditions, surface, or groundwater sources change in the future, or if plant operating conditions become such that the likelihood of a liquid effluent pathway increases, then dose calculation methodology for this pathway will be added to this manual.

1.2 Gaseous Effluents

All gaseous effluents are treated as ground level releases. Airborne releases are further subdivided into two subclasses:

1.2.1 Iodine - 131, Iodine - 133, Tritium and Radionuclides in Particulate Form with Half-lives Greater than Eight Days

In this model, a critical location is identified for assessing the maximum exposure to an individual for the various pathways and to critical organs. Infant exposure occurs through inhala- tion and any actual milk pathway. Child, teenager and adult exposure derives from inhalation, consumed leafy vegetable and produce pathways, and any actual milk and meat pathways. Dose to each of the seven organs listed in Regulatory Guide 1.109 (bone, liver, total body, thyroid, kidney, lung and GI-LLI) are computed from individual nuclide contributions in each sector. The largest of the organ doses in any sector is compared to 10 CFR 50, Appendix I design objectives. This dose calculation is performed monthly for all age groups. As necessary, the release rates of these nuclides will be converted to dose rates for comparison to the limits of 10 CFR 20.

1.2.2 Noble Gases

Exposure to the beta and gamma radiations of the noble gases will result in a whole body and skin dose. The maximum whole body and skin doses for each offsite sector are determined from the individual nuclide contributions and the maximum dose values are compared to the 10 CFR 50, Appendix I design objectives. This calculation is performed monthly. As necessary, the noble gas release rate will be converted to dose rates for comparison to the limits of 10 CFR 20.

This manual discusses the methodology to be used in determining effluent monitor alarm/trip setpoints to be used to assure compliance with the instantaneous release rate limits in the Technical Specifications. Methods are described for determining the annual cumulative dose to a real individual from gaseous effluents and direct radiation for critical organs to assure compliance with 40 CFR 190 limits. The calculational methodology for doses is based on models and data that make it unlikely to substantially underestimate the actual exposure of an individual through any of the appropriate pathways. The annual dose design objectives of 10 CFR 50, Appendix I and dose standards of 40 CFR 190 are summarized in Table 1-1.

The Radiological Environmental Monitoring Program is described in this manual; also included is the Annual Land Use Census Survey.

The ODCM will be maintained at the station for use as a document of acceptable methodologies and calculations to be used in implementing the Technical Specification. Changes in the calculational methods or parameters will be incorporated into the ODCM in order to assure that the ODCM represents the present methodology.

TABLE 1-1

ANNUAL RADIOLOGICAL EFFLUENT OBJECTIVES AND STANDARDS

	10 CFR 50 APPENDIX I DESIGN OBJECTIVES (PER REACTOR UNIT, ABOVE BACKGROUND)	40 CFR 190 STANDARDS (ALL REACTOR UNITS COMBINED)
NOBLE GAS EFFLUENTS		
Gamma Dose in Air	10 MRAD	
Beta Dose in Air	20 MRAD	
Dose to whole Body of an Individual	5 MREM	
Dose to Skin of an Individual	15 MREM	
RADIOIODINES AND PARTICULATES		
Dose to Any Organ from All Pathways	15 MREM	
TOTAL URANIUM FUEL CYCLE		
Dose to Whole Body from All Fuel Cycle Operations		25 MREM
Dose to Thyroid from All Fuel Cycle Operations		75 MREM
Dose to Any Other Organ from All Fuel Cycle Operations		25 MREM

2.0 GASEOUS EFFLUENT MONITOR SETPOINTS

Technical Specification 3.3.3.9 - The radioactive gaseous effluent monitoring instrumentation channels shown in Table 3.3-13 [of the Technical Specifications] shall be OPERABLE with their alarm/trip setpoints set to ensure that the limits of Specification 3.11.2.1 are not exceeded. The alarm/trip setpoints of these channels shall be determined and adjusted in accordance with the methodology and parameters in the ODCM.

Setpoints are conservatively established for each effluent monitor so that the instantaneous dose rates corresponding to 10 CFR 20 annual dose limits in unrestricted areas will not be exceeded. Conservatism is to be incorporated into the determination of each setpoint to account for:

- All exposure pathways of significance at the critical receptor locations;
- Dose contributions to critical receptors from multiple release points; and
- Dose contributions from major radioisotopes expected to be present in gaseous effluents.

The general methodology for establishing gaseous effluent monitor setpoints as based upon a site release rate limit in μCi/sec derived from site specific meteorological dispersion conditions, radioisotopic distribution, and whole body and skin dose factors. A fraction of the site release rate limit (the administrative value) is then allotted to each release point and its monitor setpoint (μCi/cc) is derived using actual or design maximum flow rates.

Administrative values are used to reduce each setpoint to account for the potential activity in other releases. These administrative

values shall be periodically reviewed based on actual release data and revised in accordance with the Technical Specifications.

2.1 Gaseous Effluent Monitor Setpoint Methodology

For the purpose of implementation of Technical Specification 3.3.3.9, the alarm setpoint level for effluent noble gas monitors shall be established to ensure that the noble gas releases do not exceed the total body dose rate of 500 mrem/yr and 3000 mrem/yr skin dose (Technical Specification 3.11.2.1). The equations in Section 3.0 provide the methodology for calculating the effluent dose rate.

The following methodology will be implemented through plant procedures to provide a value which represents a safe margin of assurance that the instantaneous gaseous release limit of Technical Specification 3.11.2.1 will not be exceeded. Examples of these calculations appear in Appendix A.

2.2 Equivalent Dose Factors

The evaluation of doses due to releases of radioactive material to the atmosphere can be simplified by the use of equivalent dose factors instead of using dose factors which are radionuclide specific. The equivalent dose factors are used only for setpoint determinations. Maintaining the setpoints using this approach provides a reasonable estimate of the actual dose while eliminating the need for a detailed calculational technique.

2.2.1 Equivalent Dose Factor Determination

The equivalent whole body dose factor is calculated as follows:

$$K_{eq} = \Sigma_i [(K_i)(f_i)] \qquad (2\text{-}1)$$

Where:

K_{eq} = the equivalent total body dose factor weighted by historical radionuclide distribution in releases.

K_i = the whole body dose factor due to gamma emissions for each identified noble gas radionuclide, i, in mrem/yr per $\mu Ci/m^3$ from Table 3-1.

f_i = the fractional abundance of noble gas radionuclide, i of the total noble gas radionuclide release.

The equivalent skin dose factor is calculated as follows:

$$(L+1.1M)_{eq} = \Sigma_i [(L_i + 1.1M_i)(f_i)] \qquad (2\text{-}2)$$

Where:

$(L+1.1M)_{eq}$ = the equivalent skin dose factor due to beta and gamma emissions from all noble gases released weighted by the historical radionuclide distribution in releases.

L_i = the skin dose factor due to the beta emissions for each identified noble gas radionuclide, i, in mrem/yr per $\mu Ci/m^3$ from Table 3-1.

M_i = the air dose factor due to gamma emissions for each identified noble gas radionuclide, i, in mrad/yr per $\mu Ci/m^3$ from Table 3-1 (conversion constant of 1.1 converts air dose-mrad to skin dose-mrem).

f_i = the fractional abundance of noble gas radionuclide, i, of the total noble gas radionuclide release.

2.2.2 Reevaluation

Initially, the equivalent dose factors will be evaluated frequently (at least quarterly) to assure that the best information on isotopic distribution is being used for the dose effective value. The frequency of evaluation may change in the future when historical data show that quarterly evaluations are unnecessary.

2.3 Site Release Rate Limit (Q_{site})

The release rates corresponding to 80% of the whole body (Q_{wb}) and skin (Q_{sk}) dose rate limits are calculated using the equivalent dose factors defined in Section 2.2. The site release rate limit (Q_{site}) is the lower of Q_{wb} or Q_{sk}, thus assuring that the more restrictive dose rate limit will not be exceeded.

The Q_{site} is established as follows:

$$D_{WB} = \left[\frac{(K_{eq})(\chi/Q)_{SB}\ (Q_{wb})}{(0.8)}\right]$$

Solving for $Q_{wb} = \left[\frac{(D_{WB})}{(K_{eq})}\ \frac{(0.8)}{(\chi/Q)_{SB}}\right]$

Where:

D_{WB} = whole body dose rate limit of 500 mrem/yr.

K_{eq} = equivalent whole body dose factor weighted by the radionuclide distribution typical of past operation.

$(\chi/Q)_{SB}$ = 6.49×10^{-6} sec/m^3 , the highest calculated annual average relative concentration from Table 3-2.

Q_{wb} = the release rate (μCi/sec) that would deliver a dose of 80% of the whole body dose rate unit, 500 mrem/yr.

0.8 = administrative factor to provide conservatism to allow for any unexpected variability in the nuclide mix and to ensure that dose rate limits will not be exceeded.

$$D_{SK} = \left[\frac{(L+1.1M)_{eq}\ (\chi/Q)_{SB}\ (Q_{sk})}{(0.8)}\right] \tag{2-4}$$

Solving for Q :

$$Q_{sk} = \left[\frac{(D_{SK})\ (0.8)}{(L+1.1M)_{eq}\ (\chi/Q)_{SB}}\right] \tag{2-4a}$$

Where:

D_{SK}	=	skin dose rate limit of 3000 mrem/yr.
$(L+1.1M)_{eq}$	=	equivalent skin dose factor weighted by the radionuclide distribution typical of past operation.
$(\chi/Q)_{SB}$	=	$6.49X10^{-6}$ sec/m^3 , the highest calculated annual average relative concentration from Table 3-2.
Q_{sk}	=	the release rate that would deliver a dose of 3000 mrem/yr skin.
0.8	=	administrative factor to provide conservatism to allow for any unexpected variability in the nuclide mix and to ensure that dose rate limits will not be exceeded.

The most conservative result of either equation (2-3a) or (2-4a) will be used as the site release rate limit.

2.4 Setpoint Determination

To comply with Technical Specification 3.3.3.9, the alarm/trip setpoints can now be established using the Site Release Rate Limit to ensure that the noble gas releases do not exceed the dose rate limits.

To allow for multiple sources of releases from different or common release points, the effluent monitor setpoint includes an administrative factor which allocates a percentage of the Site Release Rate Limit to each of the release sources.

2.4.1 Monitors RU-141, RU-143, and RU-145

The alarm/trip setpoint for Monitors RU-141, RU-143, and RU-145 is calculated as follows:

$$\text{Monitor Setpoint } (\mu Ci/cc) \leq \left[\frac{(Q_{site})\left(2.12\times10^{-3}\ \frac{cfm}{cc/sec}\right)(a)}{(\text{Flow Rate})}\right] \qquad (2\text{-}5)$$

Where:

Monitor Setpoint = the setpoint for the effluent monitor that would provide a safe margin of assurance that the gamma dose rate limits will not be exceeded.

Q_{site} = site release rate limit as determined in Section 2.3.

Flow Rate = the flow rate in cfm from flow rate monitors or the design maximum flow rate for the release source under consideration.

a = fraction of Q_{site} allocated for each release pathway. The sum of these administrative values will be less than or equal to one.

2.4.2 Monitor RU-12

The alarm/trip setpoint for Monitor RU-12, the Waste Gas Decay Tank Monitor, is calculated as follows:

where:

$$\text{Monitor Setpoint } (\mu Ci/cc) \leq \left[\frac{(Q_{site})\ (2.12\text{x}10^{-3} \frac{cfm}{cc/sec})(0.9)(a)}{(\text{Flow Rate})} \right] \quad (2\text{-}6)$$

Monitor Setpoint = the setpoint for the effluent monitor that would provide a safe margin of assurance that the gamma dose rate limits will not be exceeded.

Q_{site} = site release rate limit as determined in Section 2.3.

Flow Rate = flow rate in cfm from the flow rate monitor.

a = fraction of Q_{site} allocated for each release pathway. This administrative value should be equal to or less than the administrative value used for the Plant Vent.

0.9 = an administrative value to account for potential activity from other gaseous releases in the same release pathway.

If there is no release associated with this monitor, the monitor setpoint should be established as close as practical to background to prevent spurious alarms, and yet assure an alarm should an inadvertent release occur.

2.5 Monitor Calibrations

The calibration factor for each monitor is entered into the Radiation Monitoring System Database and may change whenever the monitor is calibrated. Calibration is performed in accordance with in-plant procedures. The calibration factor may vary with detector age and equipment changes.

The typical calibration conversion factor for the Plant Vent Airborne Monitor (RU-143), Condenser Evacuation Monitor (RU-141), and Fuel Building Vent Exhaust (RU-145) is based on the detector energy response curve and the FSAR source term.

The typical calibration conversion factor for the Waste Gas Decay Tank Monitor (RU-12) is based on Kr-85 calibration as indicated on Figure 2-2.

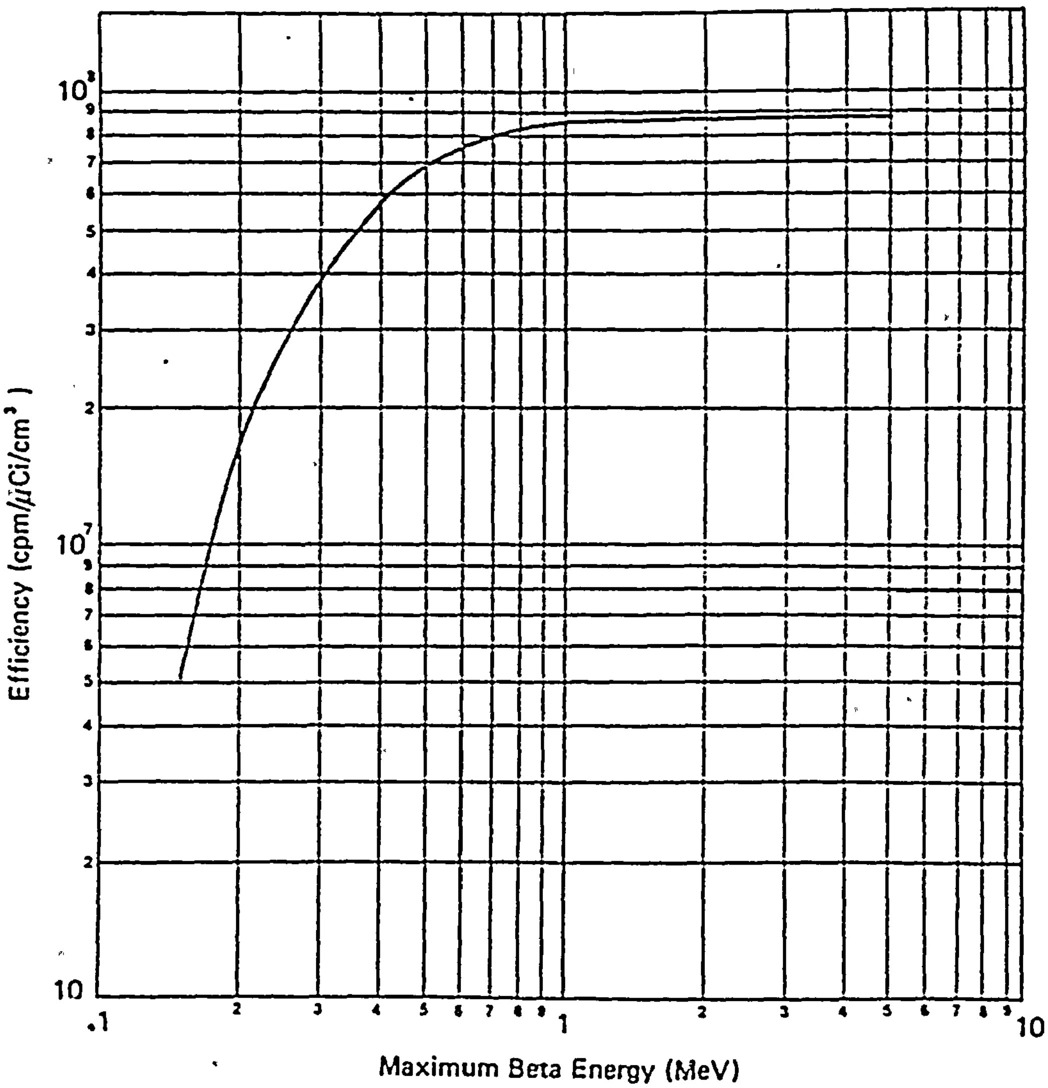


FIGURE 2-1

CALIBRATION CURVE FOR PVNGS EFFLUENT
MONITORS RU-141, RU-143, AND RU-145. REPSONSE
TO NOBLE GAS

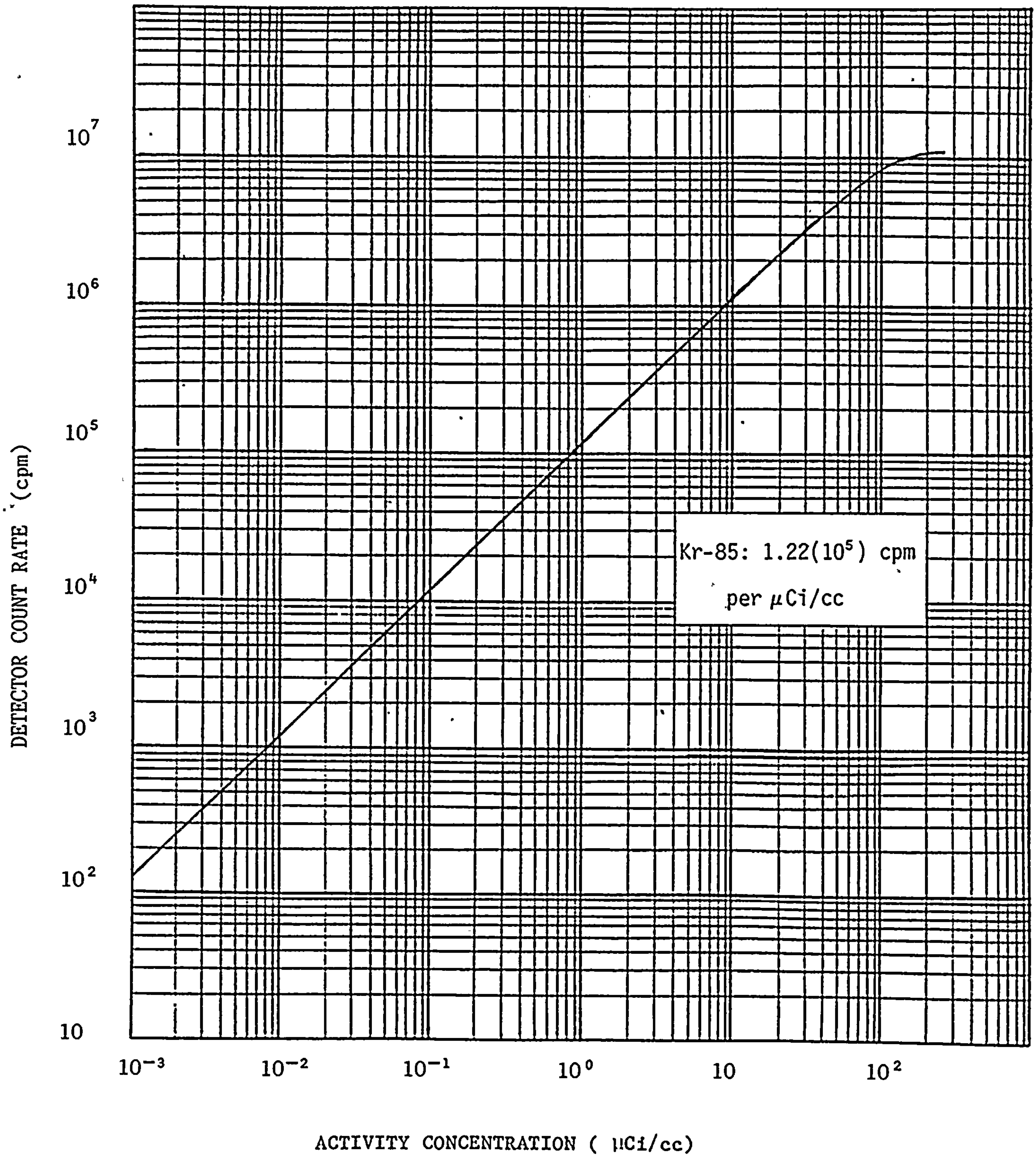


FIGURE 2-2

INITIAL CALIBRATION CURVE FOR PVNGS EFFLUENT MONITOR RU-12
REPSONSE to Kr-85 GAS

3.0 GASEOUS EFFLUENT DOSE RATE

Technical Specification 3.11.2.1 - The dose rate due to radioactive materials released in gaseous effluents from the site (see [Technical Specification] Figures 5.1-1 and 5.1-3) shall be limited to the following:

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

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

3.1 Noble Gases

Noble gas activity monitor setpoints are established at release rates which permit some margin for corrective action to be taken before exceeding offsite dose rates corresponding to the 10 CFR 20 annual dose limits as described in Section 2.0. The methods for sampling and analysis of continuous and batch effluent releases are given in the applicable plant procedures. The dose rate in unrestricted areas due to radioactive materials released in gaseous effluents may be averaged over a 24-hour period and shall be determined by the following equation for whole body dose:

$$D_{wb} = \Sigma_i [(K_i) (X/Q)_{SB} (Q_i)] \quad (3\text{-}1)$$

and by the following equation for skin dose:

$$D_s = \Sigma_i [(L_i + 1.1M_i) (X/Q)_{SB} (Q_i)] \quad (3\text{-}2)$$

Where:

K_i = the whole body dose factor due to gamma emissions for each identified noble gas radionuclide, i, in mrem/yr per $\mu Ci/m^3$ from Table 3-1.

Q_i = the release rate of radionuclide, i, in $\mu Ci/sec$.

$(X/Q)_{SB}$ = $6.49 \times 10^{-6} sec/m^3$, the highest calculated annual average dispersion parameter for any sector at the site boundary from Table 3-2.

D_{wb} = the annual whole body dose (mrem/yr.).

L_i = the skin dose factor due to the beta emissions for each identified noble gas radionuclide, i, in mrem/yr per $\mu Ci/m^3$ from Table 3-1.

M_i = the air dose factor due to gamma emissions for each identified noble gas radionuclide, i, in mrad/yr per $\mu Ci/m^3$ from Table 3-1 (conversion constant of 1.1 converts air dose-mrad to skin dose-mrem).

D_s = the annual skin dose (mrem/yr).

3.2 Radionuclides Other Than Noble Gases

The methods for sampling and analysis of continuous and batch releases for I-131, I-133, tritium and radionuclides in particulate form with half-lives greater than 8 days, are given in the applicable plant procedures. Additional monthly and quarterly analyses shall be performed in accordance with Table

4.11-2 of the PVNGS Technical Specifications. The dose rate in unrestricted areas due to radioactive materials released in gaseous effluents may be averaged over a 24-hour period and shall be determined by the following equation for any critical organ dose:

$$D_o = \Sigma_i \left[(P_i)(\chi/Q)_{SB}\,(Q_i)\right] \qquad (3\text{-}3)$$

Where:

P_i = the dose parameter for radionuclide, i, other than noble gases for the child inhalation pathway in mrem/yr per $\mu Ci/m^3$) from Table 3-3.

$(\chi/Q)_{SB}$ = 6.49×10^{-6} sec/m^3 , the highest calculated annual average dispersion parameter for any sector at the site boundary from Table 3-2.

Q_i = the release rate of radionuclide i in $\mu Ci/sec$ (gaseous effluents).

D_o = the annual organ dose (mrem/yr).

Sample calculations for determining doses to critical organs from radionuclides other than noble gases released from PVNGS are given in Appendix A.

TABLE 3-1

DOSE FACTORS FOR NOBLE GASES AND DAUGHTERS[(a)]

Radionuclide	Whole Body Dose Factor K_i (mrem/yr per $\mu Ci/m^3$)	Skin Dose Factor L_i (mrem/yr per $\mu Ci/m^3$)	Gamma Air Dose Factor M_i (mrad/yr per $\mu Ci/m^3$)	Beta Air Dose Factor N_i (mrad/yr per $\mu Ci/m^3$)
Kr-83m	7.56E-02[(b)]	---	1.93E+01	2.88E+02
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

(a)The listed dose factors are for radionuclides that may be detected in gaseous effluents and derived from Table B-1 in Reg. Guide 1.109.

(b)7.56E-02 = 7.56×10^{-2}.

Table 3-2

Palo Verde Nuclear Generating Station Unit 1 Dispersion Parameters for Long Term Releases at the Site Boundary

Direction	Distance (meters)	χ/Q (sec/m^3)	D/Q (m^{-2})
N	1037	6.49E-06(a)	1.05E-08
NNE	1057	4.71E-06	1.19E-08
NE	2206	2.81E-06	6.60E-09
ENE	1967	2.96E-06	4.74E-09
E	1927	2.98E-06	3.54E-09
ESE	1967	2.57E-06	2.57E-09
SE	2049	3.34E-06	2.30E-09
SSE	2730	3.58E-06	1.48E-09
S	3006	4.49E-06	1.55E-09
SSW	2258	5.87E-06	2.85E-09
SW	1487	5.88E-06	4.37E-09
WSW	1251	4.41E-06	5.41E-09
W	1225	5.43E-06	9.13E-09
WNW	1244	4.80E-06	7.59E-09
NW	1254	4.12E-06	6.72E-09
NNW	1069	4.39E-06	8.26E-09

(a) 6.49E-06 = 6.49×10^{-6}

Table 3-3

P_i Values for the

Palo Verde Nuclear Generating Station

Isotope	Inhalation Pathway (a) (mrem/yr/µCi/m³)
H 3	1.12E+03 (b)
Mn 54	1.58E+06
Fe 59	1.27E+06
Co 58	1.11E+06
Co 60	7.07E+06
Sr 89	2.16E+06
Sr 90	1.01E+08
I 130	1.85E+06
I 131	1.62E+07
I 132	1.94E+05
I 133	3.85E+06
I 134	5.07E+04
I 135	7.92E+05
Cs 134	1.01E+06
Cs 137	9.07E+05

(a) Child receptor

(b) 1.12E + 03 = 1.12×10^3

4.0 DOSE DUE TO GASEOUS EFFLUENT (AIR)

4.1 Noble Gases

Technical Specification 3.11.2.2 - The air dose due to noble gases released in gaseous effluents, from each reactor unit to areas at and beyond the SITE BOUNDARY (see [Technical Specification] Figures 5.1-1 and 5.1-3) shall be limited to the following:

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

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

The air dose in unrestricted areas beyond the site boundary due to noble gases released in gaseous effluents from the site shall be determined by the following equation for gamma radiation during any specified time period:

$$D_\gamma = (3.17 \times 10^{-8}) \Sigma_i [(M_i) (X/Q)_{SB}(Q_i)] \quad (4\text{-}1)$$

and by the following equation for beta radiation during any specified time period:

$$D_\beta = (3.17 \times 10^{-8}) \Sigma_i [(N_i) (X/Q)_{SB}(Q_i)] \quad (4\text{-}2)$$

Where:

M_i = the air dose factor due to gamma emissions for each identified noble gas radionuclide, i, in mrad/yr per $\mu Ci/m^3$ from Table 3-1.

N_i = the air dose factor due to beta emissions for each identified noble gas radionuclide, i, in mrad/yr per $\mu Ci/m^3$ from Table 3-1.

$(X/Q)_{SB}$ = 5.49×10^{-6} sec/m^3, the highest calculated annual average relative concentration for any sector at the site boundary (sec/m^3) from Table 3-2.

D_γ = the total gamma air dose from gaseous effluents for a specified time period in mrad.

D_β = the total beta air dose for gaseous effluents for a specified time period in mrad.

Q_i = the integrated release of each identified noble gas radionuclide, i, in gaseous effluents for a specified time period in μCi.

3.17×10^{-8} = the inverse of seconds in a year (yr/sec).

The cumulative gamma air dose and beta air dose for a quarterly or annual evaluation shall be based on the calculated dose contribution from each specified time period occurring during the reporting time period.

A discussion of the method used to calculate the individual dose from gaseous effluents is given in Appendix A. Also, Appendix A includes sample calculations for determining gamma and beta air doses from noble gas radionuclides released from the PVNGS.

4.2 Iodine - 131, Tritium, Iodine-133, and All Radionuclides in Particulate Form Other than Noble Gases

Technical Specification 3.11.2.3 - The dose to a MEMBER OF THE PUBLIC from iodine-131, iodine-133, tritium and all radionuclides in particulate form with half-lives greater than 8 days in gaseous effluents released, from each reactor unit, to areas at and beyond the SITE BOUNDARY (see [Technical Specification] Figures 5.1-1 and 5.1-3) shall be limited to the following:

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

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

The dose to an individual from I-131, I-133, tritium, and all radionuclides in particulate form, with half-lives greater than eight days, in gaseous effluents released to unrestricted areas is calculated using the following expressions:

$$D_{o\theta} = (3.17 \times 10^{-8}) \; \Sigma_i \; [\, \Sigma_k \, (R_{ik} \, W_{k\theta})(Q_i)] \qquad (4\text{-}3)$$

Where:

$D_{o\theta}$ = the total projected dose from gaseous effluents to an individual, in mrem, at the nearest residence in Sector θ.

Q_i = the amount of radioiodines, radioactive materials in particulate form, and radionuclides other than noble gases with half-lives greater than eight days, i, released in gaseous effluents, in μCi.

R_{ik} = the dose factor for each identified radionuclide, i, for pathway k (for the inhalation pathway in mrem/yr per µCi/m^3 and for the food and ground plane pathways in m^2 - mrem/yr per µCi/sec) at the controlling location. The R_{ik}'s for each age group are given in Tables 4-1 through 4-15.

$W_{k\theta}$ = the highest annual average dispersion parameter for any sector, used for estimating the dose to an individual at the maximally exposed, closest residence in Sector θ and for pathway k.

$W_{k\theta}$ = χ/Q for the inhalation pathway, including tritium, in sec/m^3. The highest χ/Q for the nearest residence to PVNGS is $3.92 X 10^{-6}$ sec/m^3, given in Table 4-16 and occurs in the N sector. (For the site boundary, use the χ/Q for the N sector from Table 3-2.)

$W_{k\theta}$ = D/Q for the food and ground plane pathways, in m^{-2}. The highest D/Q for the nearest residence to PVNGS is $3.87 X 10^{-9}/m^2$ as given in Table 4-16 and occurs in the NE sector. (For the site boundary, use the D/Q for the NE sector from Table 3-2.)

3.17×10^{-8} = the inverse of seconds per year (yr/sec).

In order to provide a conservative estimate of the doses, each of the nearest residences is assumed to have a milk animal, a meat animal, and a vegetable garden. They provide the maximally exposed individual with 100% of his dietary intake. The R_i values were calculated in accordance with the methodologies in NUREG-0133 and generated using the

GASPAR code. The following site specific information was used to calculate R_i:

	Value
fraction of year milk animals and beef animals are on pasture	0.75
fraction of daily intake of milk animals and beef animals derived from pasture while on pasture	0.35
fraction of year vegetables are grown	0.667
absolute humidity (g/m^3) over the growing season	4

These site specific values are from the PVNGS Environmental Report, Section 2 and Appendix B-7. The long-term meterological dispersion parameters were obtained from Section 2.3 of the PVNGS Environmental Report-Operating License stage.

4.3 Dose Projection

Technical Specification 3.11.2.4 - The GASEOUS RADWASTE SYSTEM and the VENTILATION EXHAUST TREATMENT SYSTEM shall be used to reduce radioactive materials in gaseous waste prior to their discharge when the projected gaseous effluent air doses due to gaseous effluent releases, from each reactor unit, from the site (see [Technical Specification] Figures 5.1-1 and 5.1-3) when averaged over 31 days, would exceed 0.2 mrad for gamma radiation and 0.4 mrad for beta radiation. The VENTILATION EXHAUST TREATMENT SYSTEM shall be used to reduce radioactive materials in gaseous waste prior to their

discharge when the projected doses due to gaseous effluent releases, from each reactor unit, to areas at and beyond the SITE BOUNDARY from the site (see [Technical Specification] Figures 5.1-1 and 5.1-3) when averaged over 31 days would exceed 0.3 mrem to any organ of a member of the public.

4.3.1 Noble Gases

The air dose in unrestricted areas beyond the site boundary due to noble gases released in gaseous effluents from the site shall be projected by the following equation for gamma radiation at least once per 31 days:

$$D_\gamma = (3.17 \times 10^{-8}) \Sigma_i [(M_i)(\chi/Q)_{SB}(Q_i)] \quad (4\text{-}1)$$

and projected by the following equation for beta radiation at least once per 31 days:

$$D_\beta = (3.17 \times 10^{-8}) \Sigma_i [(N_i)(\chi/Q)_{SB}(Q_i)] \quad (4\text{-}2)$$

Where:

M_i = the air dose factor due to gamma emissions for each identified noble gas radionuclide, i, in mrad/yr per $\mu Ci/m^3$ from Table 3-1.

N_i = the air dose factor due to beta emissions for each identified noble gas radionuclide, i, in mrad/yr per $\mu Ci/m^3$ from Table 3-1.

$(\chi/Q)_{SB}$ = $6.49 \times 10^{-6} sec/m^3$, the highest calculated annual average relative concentration for any sector at the site boundary (sec/m^3) from Table 3-2.

D_γ = the projected total gamma air dose from gaseous effluents for a specified time period in mrad.

D_β = the projected total beta air dose from gaseous effluents for a specified time period in mrad.

Q_i = the integrated release of each identified noble gas radionuclide, i, in gaseous effluents during the previous month in μCi.

3.17×10^{-8} = the inverse of seconds per year (yr/sec).

The projected gamma air dose and beta air dose for each month shall be calculated using the previous month's release of each identified noble gas radionuclide.

4.3.2 Iodine - 131, Tritium, Iodine-133, and All Radionuclides in Particulate Form Other than Noble Gases

The projected dose to an individual from I-131, I-133, tritium, and all radionuclides in particulate form, with half-lives greater than eight days, in gaseous effluents released to unrestricted areas is calculated using the following equations and the previous month's release of each identified radionuclide.

$$D_{oSB} = (3.17 \times 10^{-8})\ \Sigma_i\ [\ \Sigma_k\ (R_{ik}\ W_{kSB})(Q_i)] \qquad (4\text{-}3)$$

Where:

D_{oSB} = the total projected dose from gaseous effluents to an individual, in mrem, at the site boundary.

Q_i = the integrated release of radionuclide, i, released in gaseous effluents, in µCi, during the previous month.

R_{ik} = the dose factor for each identified radionuclide, i, for pathway k (for the inhalation pathway in mrem/yr per $\mu Ci/m^3$ and for the food and ground plane pathways in m^2 - mrem/yr per µCi/sec) at the controlling location. The R_{ik}'s for each age group are given in Tables 4-1 through 4-15.

W_{kSB} = the highest annual average dispersion parameter for any sector, used for estimating the dose to an individual at the site boundary, and for pathway k.

W_{kSB} = X/Q for the inhalation pathway in sec/m^3 . The highest X/Q for the site boundary occurs in Sector N, and is $6.49X10^{-6} sec/m^3$, as given in Table 3-2.

W_{kSB} = $6.49\ X10^{-6}\ sec/m^3$, χ/Q for the dose contribution from tritium in all pathways.

W_{kSB} = D/Q for the food and ground plane pathways, in m^{-2}. The highest D/Q for the site boundary occurs in Sector NNE and is $1.19X10^{-8}\ m^{-2}$ as given in Table 3-2.

3.17×10^{-8} = the inverse of seconds per year (yr/sec).

The assumptions used to provide a conservative estimate of these projected doses are stated in Section 4.2.

TABLE 4-1 R VALUES FOR THE PALO VERDE NUCLEAR GENERATING STATION [a]

PATHWAY = GROUND

NUCLIDE	T. BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
Mn 54	1.38E+09[b]	1.38E+09	1.38E+09	1.38E+09	1.38E+09	1.38E+09	1.38E+09	1.62E+09
Fe 59	2.72E+08	2.72E+08	2.72E+08	2.72E+08	2.72E+08	2.72E+08	2.72E+08	3.20E+08
Co 58	3.79E+08	3.79E+08	3.79E+08	3.79E+08	3.79E+08	3.79E+08	3.79E+08	4.44E+08
Co 60	2.15E+10	2.15E+10	2.15E+10	2.15E+10	2.15E+10	2.15E+10	2.15E+10	2.53E+10
Sr 89	2.16E+04	2.16E+04	2.16E+04	2.16E+04	2.16E+04	2.16E+04	2.16E+04	2.50E+04
I 130	5.50E+06	5.50E+06	5.50E+06	5.50E+06	5.50E+06	5.50E+06	5.50E+06	6.67E+06
I 131	1.72E+07	1.72E+07	1.72E+07	1.72E+07	1.72E+07	1.72E+07	1.72E+07	2.09E+07
I 132	1.24E+06	1.24E+06	1.24E+06	1.24E+06	1.24E+06	1.24E+06	1.24E+06	1.46E+06
I 133	2.45E+06	2.45E+06	2.45E+06	2.45E+06	2.45E+06	2.45E+06	2.45E+06	2.98E+06
I 134	4.45E+05	4.45E+05	4.45E+05	4.45E+05	4.45E+05	4.45E+05	4.45E+05	5.29E+05
I 135	2.52E+06	2.52E+06	2.52E+06	2.52E+06	2.52E+06	2.52E+06	2.52E+06	2.94E+06
Cs134	6.83E+09	6.83E+09	6.83E+09	6.83E+09	6.83E+09	6.83E+09	6.83E+09	7.96E+09
Cs137	1.04E+10	1.04E+10	1.04E+10	1.04E+10	1.04E+10	1.04E+10	1.04E+10	1.21E+10

(a) R values are in units of m^2-mrem/yr per µCi/sec.

(b) 1.38E+09 = 1.39 X 10^9.

TABLE 4-2 R VALUES FOR THE PALO VERDE NUCLEAR GENERATING STATION (a)

PATHWAY = VEGET

AGE GROUP = ADULT

NUCLIDE	T. BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
H 3	4.35E+03 (b)	4.35E+03	0.00E-01	4.35E+03	4.35E+03	4.35E+03	4.35E+03	4.35E+03
Mn 54	5.56E+07	8.92E+08	0.00E-01	2.91E+08	8.67E+07	0.00E-01	0.00E-01	0.00E-01
Fe 59	1.00E+08	8.73E+08	1.11E+08	2.62E+08	0.00E-01	0.00E-01	7.32E+07	0.00E-01
Co 58	6.21E+07	5.62E+08	0.00E-01	2.77E+07	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Co 60	3.49E+08	2.98E+09	0.00E-01	1.58E+08	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr 89	2.55E+08	1.42E+09	8.88E+09	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr 90	1.57E+11	1.85E+10	6.40E+11	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
I 130	3.01E+05	6.57E+05	2.59E+05	7.64E+05	1.19E+06	6.47E+07	0.00E-01	0.00E-01
I 131	4.49E+07	2.07E+07	5.47E+07	7.83E+07	1.34E+08	2.57E+10	0.00E-01	0.00E-01
I 132	3.48E+01	1.87E+01	3.71E+01	9.93E+01	1.58E+02	3.48E+03	0.00E-01	0.00E-01
I 133	7.35E+05	2.17E+06	1.39E+06	2.41E+06	4.21E+06	3.54E+08	0.00E-01	0.00E-01
I 134	5.53E-05	1.35E-07	5.69E-05	1.55E-04	2.46E-04	2.68E-03	0.00E-01	0.00E-01
I 135	2.46E+04	7.52E+04	2.54E+04	6.66E+04	1.07E+05	4.39E+06	0.00E-01	0.00E-01
Cs134	8.40E+09	1.80E+08	4.32E+09	1.03E+10	3.32E+09	0.00E-01	1.10E+09	0.00E-01
Cs137	5.67E+09	1.68E+08	6.33E+09	8.65E+09	2.94E+09	0.00E-01	9.77E+08	0.00E-01

(a) R values are in units of mrem/yr per $\mu Ci/m^3$ for tritium, and in units of m^2-mrem/yr per μCi/sec for all others.

(b) 4.35E+03 = 4.35 X 10^3.

TABLE 4-3 R VALUES FOR THE PALO VERDE NUCLEAR GENERATING STATION [(a)]

PATHWAY = VEGET

AGE GROUP = TEEN

NUCLIDE	T. BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
H 3	5.08E+03[b]	5.08E+03	0.00E-01	5.08E+03	5.08E+03	5.08E+03	5.08E+03	5.08E+03
Mn 54	8.58E+07	8.87E+08	0.00E-01	4.33E+08	1.29E+08	0.00E-01	0.00E-01	0.00E-01
Fe 59	1.49E+08	9.10E+08	1.65E+08	3.85E+08	0.00E-01	0.00E-01	1.21E+08	0.00E-01
Co 58	9.35E+07	5.59E+08	0.00E-01	4.06E+07	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Co 60	5.42E+08	3.13E+09	0.00E-01	2.41E+08	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr 89	4.01E+08	1.67E+09	1.40E+10	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr 90	2.00E+11	2.28E+10	8.11E+11	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
I 130	2.67E+05	5.15E+05	2.31E+05	6.70E+05	1.03E+06	5.46E+07	0.00E-01	0.00E-01
I 131	3.97E+07	1.46E+07	5.28E+07	7.40E+07	1.27E+08	2.16E+10	0.00E-01	0.00E-01
I 132	3.15E+01	3.82E+01	3.35E+01	8.76E+01	1.38E+02	2.95E+03	0.00E-01	0.00E-01
I 133	6.66E+05	1.65E+06	1.29E+06	2.18E+06	3.83E+06	3.05E+08	0.00E-01	0.00E-01
I 134	4.90E-05	1.80E-06	5.15E-05	1.36E-04	2.15E-04	2.27E-03	0.00E-01	0.00E-01
I 135	2.19E+04	6.56E+04	2.30E+04	5.92E+04	9.35E+04	3.81E+06	0.00E-01	0.00E-01
Cs134	7.33E+09	1.96E+08	6.71E+09	1.58E+10	5.02E+09	0.00E-01	1.92E+09	0.00E-01
Cs137	4.77E+09	1.95E+08	1.03E+10	1.37E+10	4.66E+09	0.00E-01	1.81E+09	0.00E-01

(a) R values are in units of mrem/yr per $\mu Ci/m^3$ for tritium, and in units of m^2-mrem/yr per μCi/sec for all others.

(b) 5.08E+03 = 5.08 X 10^3.

TABLE 4-4 R VALUES FOR THE PALO VERDE NUCLEAR GENERATING STATION [(a)]

PATHWAY = VEGET

AGE GROUP = CHILD

NUCLIDE	T. BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
H 3	7.92E+03[b]	7.92E+03	0.00E-01	7.92E+03	7.92E+03	7.92E+03	7.92E+03	7.92E+03
Mn 54	1.70E+08	5.35E+08	0.00E-01	6.37E+08	1.79E+08	0.00E-01	0.00E-01	0.00E-01
Fe 59	2.98E+08	6.24E+08	3.70E+08	5.99E+08	0.00E-01	0.00E-01	1.74E+08	0.00E-01
Co 58	1.85E+08	3.53E+08	0.00E-01	6.05E+07	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Co 60	1.09E+09	2.04E+09	0.00E-01	3.69E+08	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr 89	9.61E+08	1.30E+09	3.36E+10	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr 90	3.43E+11	1.82E+10	1.35E+12	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
I 130	4.23E+05	3.84E+05	4.06E+05	8.21E+05	1.23E+06	9.04E+07	0.00E-01	0.00E-01
I 131	5.67E+07	8.89E+06	9.92E+07	9.98E+07	1.64E+08	3.30E+10	0.00E-01	0.00E-01
I 132	5.02E+01	1.29E+02	5.95E+01	1.09E+02	1.67E+02	5.07E+03	0.00E-01	0.00E-01
I 133	1.10E+06	1.17E+06	2.35E+06	2.90E+06	4.84E+06	5.39E+08	0.00E-01	0.00E-01
I 134	7.81E-05	1.13E-04	9.14E-05	1.70E-04	2.60E-04	3.91E-03	0.00E-01	0.00E-01
I 135	3.48E+04	5.60E+04	4.08E+04	7.35E+04	1.13E+05	6.51E+06	0.00E-01	0.00E-01
Cs134	5.28E+09	1.35E+08	1.53E+10	2.50E+10	7.76E+09	0.00E-01	2.78E+09	0.00E-01
Cs137	3.46E+09	1.47E+08	2.45E+10	2.34E+10	7.63E+09	0.00E-01	2.74E+09	0.00E-01

(a) R values are in units of mrem/yr per $\mu Ci/m^3$ for tritium, and in units of m^2-mrem/yr per μCi/sec for all others.

(b) 7.92E+03 = 7.92×10^3.

TABLE 4-5 R VALUES FOR THE PALO VERDE NUCLEAR GENERATING STATION (a)

PATHWAY = MEAT

AGE GROUP = ADULT

NUCLIDE	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
H 3	6.55E+02[b]	6.55E+02	0.00E-01	6.55E+02	6.55E+02	6.55E+02	6.55E+02	6.55E+02
Mn 54	7.06E+05	1.13E+07	0.00E-01	3.70E+06	1.10E+06	0.00E-01	0.00E-01	0.00E-01
Fe 59	6.51E+07	5.66E+08	7.22E+07	1.70E+08	0.00E-01	0.00E-01	4.74E+07	0.00E-01
Co 58	1.26E+07	1.14E+08	0.00E-01	5.61E+06	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Co 60	7.34E+07	6.25E+08	0.00E-01	3.33E+07	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr 89	2.44E+06	1.36E+07	8.48E+07	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr 90	1.49E+09	1.76E+08	6.08E+09	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
I 130	5.77E-07	1.26E-06	4.96E-07	1.46E-06	2.28E-06	1.24E-04	0.00E-01	0.00E-01
I 131	2.12E+06	9.75E+05	2.58E+06	3.69E+06	6.33E+06	1.21E+09	0.00E-01	0.00E-01
I 133	4.80E-02	1.41E-01	9.05E-02	1.57E-01	2.75E-01	2.31E+01	0.00E-01	0.00E-01
I 135	9.23E-18	2.82E-17	9.55E-18	2.50E-17	4.01E-17	1.65E-15	0.00E-01	0.00E-01
Cs134	5.42E+08	1.16E+07	2.79E+08	6.63E+08	2.15E+08	0.00E-01	7.12E+07	0.00E-01
Cs137	3.64E+08	1.08E+07	4.06E+08	5.56E+08	1.89E+08	0.00E-01	6.27E+07	0.00E-01

(a) R values are in units of mrem/yr per μCi/m^3 for tritium, and in units of m^2-mrem/yr per μCi/sec for all others.

(b) 6.55E+02 = 6.55 X 10^2.

TABLE 4-6 R VALUES FOR THE PALO VERDE NUCLEAR GENERATING STATION (a)

PATHWAY = MEAT

AGE GROUP = TEEN

NUCLIDE	T. BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
H 3	3.91E+02[b]	3.91E+02	0.00E-01	3.91E+02	3.91E+02	3.91E+02	3.91E+02	3.91E+02
Mn 54	5.59E+05	5.79E+06	0.00E-01	2.82E+06	8.41E+05	0.00E-01	0.00E-01	0.00E-01
Fe 59	5.20E+07	3.19E+08	5.77E+07	1.35E+08	0.00E-01	0.00E-01	4.25E+07	0.00E-01
Co 58	9.97E+06	5.97E+07	0.00E-01	4.33E+06	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Co 60	5.82E+07	3.36E+08	0.00E-01	2.58E+07	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr 89	2.05E+06	8.53E+06	7.16E+07	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr 90	9.72E+08	1.10E+08	3.94E+09	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
I 130	4.61E-07	8.87E-07	3.99E-07	1.15E-06	1.78E-06	9.42E-05	0.00E-01	0.00E-01
I 131	1.61E+06	5.94E+05	2.15E+06	3.00E+06	5.17E+06	8.77E+08	0.00E-01	0.00E-01
I 133	3.92E-02	9.71E-02	7.57E-02	1.28E-01	2.25E-01	1.79E+01	0.00E-01	0.00E-01
I 135	7.41E-18	2.22E-17	7.77E-18	2.00E-17	3.16E-17	1.27E-15	0.00E-01	0.00E-01
Cs134	2.42E+08	6.49E+06	2.22E+08	5.22E+08	1.66E+08	0.00E-01	6.33E+07	0.00E-01
Cs137	1.56E+08	6.39E+06	3.38E+08	4.49E+08	1.53E+08	0.00E-01	5.94E+07	0.00E-01

(a) R values are in units of mrem/yr per µCi/m^3 for tritium, and in units of m^2-mrem/yr per µCi/sec for all others.

(b) 3.91E+02 = 3.91 X 10^2.

TABLE 4-7 R VALUES FOR THE PALO VERDE NUCLEAR GENERATING STATION (a)

PATHWAY = MEAT

AGE GROUP = CHILD

NUCLIDE	T. BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
H 3	4.72E+02[b]	4.72E+02	0.00E-01	4.72E+02	4.72E+02	4.72E+02	4.72E+02	4.72E+02
Mn 54	8.59E+05	2.71E+06	0.00E-01	3.23E+06	9.05E+05	0.00E-01	0.00E-01	0.00E-01
Fe 59	8.25E+07	1.72E+08	1.02E+08	1.66E+08	0.00E-01	0.00E-01	4.80E+07	0.00E-01
Co 58	1.55E+07	2.95E+07	0.00E-01	5.06E+06	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Co 60	9.05E+07	1.70E+08	0.00E-01	3.07E+07	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr 89	3.87E+06	5.25E+06	1.36E+08	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr 90	1.29E+09	6.85E+07	5.08E+09	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
I 130	7.43E-07	6.75E-07	7.14E-07	1.44E-06	2.16E-06	1.59E-04	0.00E-01	0.00E-01
I 131	2.27E+06	3.56E+05	3.98E+06	4.00E+06	6.57E+06	1.32E+09	0.00E-01	0.00E-01
I 133	6.58E-02	7.00E-02	1.41E-01	1.74E-01	2.90E-01	3.23E+01	0.00E-01	0.00E-01
I 135	1.20E-17	1.93E-17	1.41E-17	2.53E-17	3.88E-17	2.24E-15	0.00E-01	0.00E-01
Cs134	1.35E+08	3.46E+06	3.91E+08	6.41E+08	1.99E+08	0.00E-01	7.13E+07	0.00E-01
Cs137	8.78E+07	3.73E+06	6.22E+08	5.95E+08	1.94E+08	0.00E-01	6.98E+07	0.00E-01

(a) R values are in units of mrem/yr per μCi/m^3 for tritium, and in units of m^2-mrem/yr per μCi/sec for all others.

(b) 4.72E+02 = 4.72 X 10^2.

TABLE 4-8 R VALUES FOR THE PALO VERDE NUCLEAR GENERATING STATION [(a)]

PATHWAY = COW MILK

AGE GROUP = ADULT

NUCLIDE	T. BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
H 3	1.54E+03[b]	1.54E+03	0.00E-01	1.54E+03	1.54E+03	1.54E+03	1.54E+03	1.54E+03
Mn 54	6.47E+05	1.04E+07	0.00E-01	3.39E+06	1.01E+06	0.00E-01	0.00E-01	0.00E-01
Fe 59	7.28E+06	6.33E+07	8.08E+06	1.90E+07	0.00E-01	0.00E-01	5.31E+06	0.00E-01
Co 58	3.25E+06	2.94E+07	0.00E-01	1.45E+06	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Co 60	1.60E+07	1.36E+08	0.00E-01	7.26E+06	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr 89	1.17E+07	6.55E+07	4.08E+08	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr 90	5.61E+09	6.61E+08	2.29E+10	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
I 130	1.19E+05	2.60E+05	1.02E+05	3.02E+05	4.71E+05	2.56E+07	0.00E-01	0.00E-01
I 131	5.84E+07	2.69E+07	7.12E+07	1.02E+08	1.75E+08	3.34E+10	0.00E-01	0.00E-01
I 132	3.77E-02	2.02E-02	4.03E-02	1.08E-01	1.72E-01	3.77E+00	0.00E-01	0.00E-01
I 133	5.03E+05	1.48E+06	9.48E+05	1.65E+06	2.88E+06	2.42E+08	0.00E-01	0.00E-01
I 134	4.49E-13	1.09E-15	4.62E-13	1.25E-12	2.00E-12	2.17E-11	0.00E-01	0.00E-01
I 135	2.99E+03	9.15E+03	3.09E+03	8.10E+03	1.30E+04	5.34E+05	0.00E-01	0.00E-01
Cs134	4.66E+09	9.97E+07	2.40E+09	5.70E+09	1.84E+09	0.00E-01	6.12E+08	0.00E-01
Cs137	3.08E+09	9.11E+07	3.44E+09	4.70E+09	1.60E+09	0.00E-01	5.31E+08	0.00E-01

(a) R values are in units of mrem/yr per $\mu Ci/m^3$ for tritium, and in units of m^2-mrem/yr per μCi/sec for all others.

(b) 1.54E+03 = 1.54×10^3.

TABLE 4-9 R VALUES FOR THE PALO VERDE NUCLEAR GENERATING STATION (a)

PATHWAY = COW MILK

AGE GROUP = TEEN

NUCLIDE	T. BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
H 3	2.00E+03[b]	2.00E+03	0.00E-01	2.00E+03	2.00E+03	2.00E+03	2.00E+03	2.00E+03
Mn 54	1.12E+06	1.16E+07	0.00E-01	5.65E+06	1.68E+06	0.00E-01	0.00E-01	0.00E-01
Fe 59	1.27E+07	7.78E+07	1.41E+07	3.29E+07	0.00E-01	0.00E-01	1.04E+07	0.00E-01
Co 58	5.63E+06	3.37E+07	0.00E-01	2.44E+06	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Co 60	2.77E+07	1.60E+08	0.00E-01	1.23E+07	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr 89	2.16E+07	8.96E+07	7.53E+08	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr 90	7.99E+09	9.08E+08	3.23E+10	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
I 130	2.08E+05	4.00E+05	1.80E+05	5.20E+05	8.01E+05	4.24E+07	0.00E-01	0.00E-01
I 131	9.72E+07	3.58E+07	1.29E+08	1.81E+08	3.11E+08	5.28E+10	0.00E-01	0.00E-01
I 132	6.71E-02	8.14E-02	7.14E-02	1.87E-01	2.94E-01	6.30E+00	0.00E-01	0.00E-01
I 133	8.96E+05	2.22E+06	1.73E+06	2.94E+06	5.15E+06	4.10E+08	0.00E-01	0.00E-01
I 134	7.81E-13	2.87E-14	8.21E-13	2.18E-12	3.43E-12	3.63E-11	0.00E-01	0.00E-01
I 135	5.25E+03	1.57E+04	5.50E+03	1.42E+04	2.24E+04	9.10E+05	0.00E-01	0.00E-01
Cs134	4.54E+09	1.22E+08	4.16E+09	9.79E+09	3.11E+09	0.00E-01	1.19E+09	0.00E-01
Cs137	2.89E+09	1.18E+08	6.24E+09	8.30E+09	2.82E+09	0.00E-01	1.10E+09	0.00E-01

(a) R values are in units of mrem/yr per $\mu Ci/m^3$ for tritium, and in units of m^2-mrem/yr per μCi/sec for all others.

(b) 2.00E+03 = 2.00 X 10^3.

TABLE 4-10 R VALUES FOR THE PALO VERDE NUCLEAR GENERATING STATION (a)

PATHWAY = COW MILK

AGE GROUP = CHILD

NUCLIDE	T. BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
H 3	3.17E+03[b]	3.17E+03	0.00E-01	3.17E+03	3.17E+03	3.17E+03	3.17E+03	3.17E+03
Mn 54	2.25E+06	7.09E+06	0.00E-01	8.45E+06	2.37E+06	0.00E-01	0.00E-01	0.00E-01
Fe 59	2.64E+07	5.51E+07	3.27E+07	5.29E+07	0.00E-01	0.00E-01	1.53E+07	0.00E-01
Co 58	1.14E+07	2.18E+07	0.00E-01	3.73E+06	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Co 60	5.64E+07	1.06E+08	0.00E-01	1.91E+07	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr 89	5.32E+07	7.21E+07	1.86E+09	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr 90	1.39E+10	7.36E+08	5.46E+10	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
I 130	4.38E+05	3.97E+05	4.20E+05	8.49E+05	1.27E+06	9.36E+07	0.00E-01	0.00E-01
I 131	1.79E+08	2.81E+07	3.13E+08	3.15E+08	5.18E+08	1.04E+11	0.00E-01	0.00E-01
I 132	1.43E-01	3.65E-01	1.69E-01	3.11E-01	4.75E-01	1.44E+01	0.00E-01	0.00E-01
I 133	1.97E+06	2.10E+06	4.21E+06	5.20E+06	8.67E+06	9.67E+08	0.00E-01	0.00E-01
I 134	1.66E-12	2.39E-12	1.94E-12	3.61E-12	5.52E-12	8.30E-11	0.00E-01	0.00E-01
I 135	1.11E+04	1.78E+04	1.30E+04	2.34E+04	3.59E+04	2.07E+06	0.00E-01	0.00E-01
Cs134	3.32E+09	8.49E+07	9.59E+09	1.57E+10	4.88E+09	0.00E-01	1.75E+09	0.00E-01
Cs137	2.12E+09	9.01E+07	1.50E+10	1.44E+10	4.69E+09	0.00E-01	1.69E+09	0.00E-01

(a) R values are in units of mrem/yr per $\mu Ci/m^3$ for tritium, and in units of m^2-mrem/yr per μCi/sec for all others.

(b) 3.17E+03 = 3.17 X 10^3.

TABLE 4-11 R VALUES FOR THE PALO VERDE NUCLEAR GENERATING STATION (a)

PATHWAY = COW MILK

AGE GROUP = INFANT

NUCLIDE	T. BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
H 3	4.80E+03[b]	4.80E+03	0.00E-01	4.80E+03	4.80E+03	4.80E+03	4.80E+03	4.80E+03
Mn 54	3.56E+06	5.77E+06	0.00E-01	1.57E+07	3.48E+06	0.00E-01	0.00E-01	0.00E-01
Fe 59	4.20E+07	5.09E+07	6.10E+07	1.07E+08	0.00E-01	0.00E-01	3.15E+07	0.00E-01
Co 58	1.86E+07	1.86E+07	0.00E-01	7.46E+06	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Co 60	9.21E+07	9.29E+07	0.00E-01	3.90E+07	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr 89	1.02E+08	7.28E+07	3.54E+09	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr 90	1.51E+10	7.42E+08	5.94E+10	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
I 130	7.63E+05	4.07E+05	8.64E+05	1.90E+06	2.09E+06	2.13E+08	0.00E-01	0.00E-01
I 131	3.39E+08	2.75E+07	6.54E+08	7.71E+08	9.00E+08	2.53E+11	0.00E-01	0.00E-01
I 132	2.53E-01	5.77E-01	3.51E-01	7.12E-01	7.94E-01	3.34E+01	0.00E-01	0.00E-01
I 133	3.79E+06	2.19E+06	8.89E+06	1.29E+07	1.52E+07	2.35E+09	0.00E-01	0.00E-01
I 134	2.94E-12	8.53E-12	4.03E-12	8.26E-12	9.23E-12	1.92E-10	0.00E-01	0.00E-01
I 135	1.96E+04	1.95E+04	2.71E+04	5.38E+04	6.00E+04	4.83E+06	0.00E-01	0.00E-01
Cs134	2.91E+09	7.83E+07	1.55E+10	2.88E+10	7.42E+09	0.00E-01	3.04E+09	0.00E-01
Cs137	1.99E+09	8.78E+07	2.40E+10	2.81E+10	7.54E+09	0.00E-01	3.05E+09	0.00E-01

(a) R values are in units of mrem/yr per $\mu Ci/m^3$ for tritium, and in units of m^2-mrem/yr per μCi/sec for all others.

(b) 4.80E+03 = 4.80 X 10^3.

TABLE 4-12 R VALUES FOR THE PALO VERDE NUCLEAR GENERATING STATION (a)

PATHWAY = INHAL

AGE GROUP = ADULT

NUCLIDE	T. BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
H 3	1.26E+03[b]	1.26E+03	0.00E-01	1.26E+03	1.26E+03	1.26E+03	1.26E+03	1.26E+03
Mn 54	6.29E+03	7.72E+04	0.00E-01	3.95E+04	9.83E+03	0.00E-01	1.40E+06	0.00E-01
Fe 59	1.05E+04	1.88E+05	1.17E+04	2.77E+04	0.00E-01	0.00E-01	1.01E+06	0.00E-01
Co 58	2.07E+03	1.06E+05	0.00E-01	1.58E+03	0.00E-01	0.00E-01	9.27E+05	0.00E-01
Co 60	1.48E+04	2.84E+05	0.00E-01	1.15E+04	0.00E-01	0.00E-01	5.96E+06	0.00E-01
Br 85	1.28E+01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr 89	8.71E+03	3.49E+05	3.04E+05	0.00E-01	0.00E-01	0.00E-01	1.40E+06	0.00E-01
Sr 90	6.09E+06	7.21E+05	9.91E+07	0.00E-01	0.00E-01	0.00E-01	9.59E+06	0.00E-01
I 130	5.27E+03	7.68E+03	4.57E+03	1.34E+04	2.08E+04	1.13E+06	0.00E-01	0.00E-01
I 131	2.05E+04	6.27E+03	2.52E+04	3.57E+04	6.12E+04	1.19E+07	0.00E-01	0.00E-01
I 132	1.16E+03	4.06E+02	1.16E+03	3.25E+03	5.18E+03	1.14E+05	0.00E-01	0.00E-01
I 133	4.51E+03	8.87E+03	8.63E+03	1.48E+04	2.58E+04	2.15E+06	0.00E-01	0.00E-01
I 134	6.14E+02	1.01E+00	6.43E+02	1.73E+03	2.75E+03	2.98E+04	0.00E-01	0.00E-01
I 135	2.56E+03	5.24E+03	2.68E+03	6.97E+03	1.11E+04	4.47E+05	0.00E-01	0.00E-01
Cs134	7.27E+05	1.04E+04	3.72E+05	8.47E+05	2.87E+05	0.00E-01	9.75E+04	0.00E-01
Cs137	4.27E+05	8.39E+03	4.78E+05	6.20E+05	2.22E+05	0.00E-01	7.51E+04	0.00E-01

(a) R values are in units of mrem/yr per $\mu Ci/m^3$.

(b) 1.26E+03 = 1.26×10^3.

TABLE 4-13 R VALUES FOR THE PALO VERDE NUCLEAR GENERATING STATION [(a)]

PATHWAY = INHAL

AGE GROUP = TEEN

NUCLIDE	T. BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
H 3	1.27E+03[b]	1.27E+03	0.00E-01	1.27E+03	1.27E+03	1.27E+03	1.27E+03	1.27E+03
Mn 54	8.39E+03	6.67E+04	0.00E-01	5.10E+04	1.27E+04	0.00E-01	1.98E+06	0.00E-01
Fe 59	1.43E+04	1.78E+05	1.59E+04	3.69E+04	0.00E-01	0.00E-01	1.53E+06	0.00E-01
Co 58	2.77E+03	9.51E+04	0.00E-01	2.07E+03	0.00E-01	0.00E-01	1.34E+06	0.00E-01
Co 60	1.98E+04	2.59E+05	0.00E-01	1.51E+04	0.00E-01	0.00E-01	8.71E+06	0.00E-01
Br 85	1.83E+01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr 89	1.25E+04	3.71E+05	4.34E+05	0.00E-01	0.00E-01	0.00E-01	2.41E+06	0.00E-01
Sr 90	6.67E+06	7.64E+05	1.08E+08	0.00E-01	0.00E-01	0.00E-01	1.65E+07	0.00E-01
I 130	7.16E+03	9.11E+03	6.23E+03	1.79E+04	2.75E+04	1.49E+06	0.00E-01	0.00E-01
I 131	2.64E+04	6.48E+03	3.54E+04	4.90E+04	8.39E+04	1.46E+07	0.00E-01	0.00E-01
I 132	1.57E+03	1.27E+03	1.59E+03	4.37E+03	6.91E+03	1.51E+05	0.00E-01	0.00E-01
I 133	6.21E+03	1.03E+04	1.21E+04	2.05E+04	3.59E+04	2.92E+06	0.00E-01	0.00E-01
I 134	8.39E+02	2.04E+01	8.87E+02	2.32E+03	3.66E+03	3.95E+04	0.00E-01	0.00E-01
I 135	3.48E+03	6.94E+03	3.69E+03	9.43E+03	1.49E+04	6.20E+05	0.00E-01	0.00E-01
Cs134	5.48E+05	9.75E+03	5.02E+05	1.13E+06	3.75E+05	0.00E-01	1.46E+05	0.00E-01
Cs137	3.11E+05	8.47E+03	6.69E+05	8.47E+05	3.04E+05	0.00E-01	1.21E+05	0.00E-01

(a) R values are in units of mrem/yr per $\mu Ci/m^3$.

(b) 1.27E+03 = 1.27×10^3.

TABLE 4-14 R VALUES FOR THE PALO VERDE NUCLEAR GENERATING STATION (a)

PATHWAY = INHAL

AGE GROUP = CHILD

NUCLIDE	T. BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
H 3	1.12E+03[b]	1.12E+03	0.00E-01	1.12E+03	1.12E+03	1.12E+03	1.12E+03	1.12E+03
Mn 54	9.50E+03	2.29E+04	0.00E-01	4.29E+04	1.00E+04	0.00E-01	1.57E+06	0.00E-01
Fe 59	1.67E+04	7.06E+04	2.07E+04	3.34E+04	0.00E-01	0.00E-01	1.27E+06	0.00E-01
Co 58	3.16E+03	3.43E+04	0.00E-01	1.77E+03	0.00E-01	0.00E-01	1.10E+06	0.00E-01
Co 60	2.26E+04	9.61E+04	0.00E-01	1.31E+04	0.00E-01	0.00E-01	7.06E+06	0.00E-01
Br 85	2.53E+01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr 89	1.72E+04	1.67E+05	5.99E+05	0.00E-01	0.00E-01	0.00E-01	2.15E+06	0.00E-01
Sr 90	6.43E+06	3.43E+05	1.01E+08	0.00E-01	0.00E-01	0.00E-01	1.47E+07	0.00E-01
I 130	8.42E+03	5.10E+03	8.17E+03	1.64E+04	2.44E+04	1.84E+06	0.00E-01	0.00E-01
I 131	2.72E+04	2.84E+03	4.80E+04	4.80E+04	7.87E+04	1.62E+07	0.00E-01	0.00E-01
I 132	1.87E+03	3.20E+03	2.11E+03	4.06E+03	6.24E+03	1.93E+05	0.00E-01	0.00E-01
I 133	7.68E+03	5.47E+03	1.66E+04	2.03E+04	3.37E+04	3.84E+06	0.00E-01	0.00E-01
I 134	9.94E+02	9.53E+02	1.17E+03	2.16E+03	3.30E+03	5.06E+04	0.00E-01	0.00E-01
I 135	4.14E+03	4.43E+03	4.91E+03	8.72E+03	1.34E+04	7.91E+05	0.00E-01	0.00E-01
Cs134	2.24E+05	3.84E+03	6.50E+05	1.01E+06	3.30E+05	0.00E-01	1.21E+05	0.00E-01
Cs137	1.28E+05	3.61E+03	9.05E+05	8.24E+05	2.82E+05	0.00E-01	1.04E+05	0.00E-01

(a) R values are in units of mrem/yr per $\mu Ci/m^3$.

(b) 1.12E+03 = 1.12×10^3.

TABLE 4-15 R VALUES FOR THE PALO VERDE NUCLEAR GENERATING STATION [(a)]

PATHWAY = INHAL

AGE GROUP = INFANT

NUCLIDE	T. BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
H 3	6.46E+02[b]	6.46E+02	0.00E-01	6.46E+02	6.46E+02	6.46E+02	6.46E+02	6.46E+02
Mn 54	4.98E+03	7.05E+03	0.00E-01	2.53E+04	4.98E+03	0.00E-01	9.98E+05	0.00E-01
Fe 59	9.46E+03	2.47E+04	1.35E+04	2.35E+04	0.00E-01	0.00E-01	1.01E+06	0.00E-01
Co 58	1.82E+03	1.11E+04	0.00E-01	1.22E+03	0.00E-01	0.00E-01	7.76E+05	0.00E-01
Co 60	1.18E+04	3.19E+04	0.00E-01	8.01E+03	0.00E-01	0.00E-01	4.50E+06	0.00E-01
Br 85	2.04E+01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr 89	1.14E+04	6.39E+04	3.97E+05	0.00E-01	0.00E-01	0.00E-01	2.03E+06	0.00E-01
Sr 90	2.59E+06	1.31E+05	4.08E+07	0.00E-01	0.00E-01	0.00E-01	1.12E+07	0.00E-01
I 130	5.56E+03	1.99E+03	6.35E+03	1.39E+04	1.52E+04	1.59E+06	0.00E-01	0.00E-01
I 131	1.96E+04	1.06E+03	3.79E+04	4.43E+04	5.17E+04	1.48E+07	0.00E-01	0.00E-01
I 132	1.26E+03	1.90E+03	1.69E+03	3.54E+03	3.94E+03	1.69E+05	0.00E-01	0.00E-01
I 133	5.59E+03	2.15E+03	1.32E+04	1.92E+04	2.24E+04	3.55E+06	0.00E-01	0.00E-01
I 134	6.64E+02	1.29E+03	9.20E+02	1.87E+03	2.08E+03	4.45E+04	0.00E-01	0.00E-01
I 135	2.77E+03	1.83E+03	3.86E+03	7.59E+03	8.46E+03	6.95E+05	0.00E-01	0.00E-01
Cs134	7.44E+04	1.33E+03	3.96E+05	7.02E+05	1.90E+05	0.00E-01	7.95E+04	0.00E-01
Cs137	4.54E+04	1.33E+03	5.48E+05	6.11E+05	1.72E+05	0.00E-01	7.12E+04	0.00E-01

(a) R values are in units of mrem/yr per $\mu Ci/m^3$.

(b) 6.46E+02 = 6.46 X 10^2.

Table 4-16

Palo Verde Nuclear Generating Station Unit 1 Dispersion Parameters for long term releases at the Nearest residences

Direction	Distance (meters)	X/Q (Sec/m^3)	D/Q (m^{-2})
N	2300.	3.92E-06 (a)	3.60E-09
NNE	2900.	2.12E-06	2.82E-09
NE	3000.	1.98E-06	3.87E-09
ENE	4300.	1.27E-06	1.21E-09
E	5100.	9.63E-07	6.02E-10
ESE	5700.	6.59E-07	3.19E-10
SSE	7300.	1.25E-06	2.60E-10
S	7200.	2.35E-06	4.39E-10
SSW	5500.	2.97E-06	7.48E-10
SW	6800.	1.86E-06	4.61E-10
NW	3600.	1.69E-06	1.41E-09
NNW	3700.	1.57E-06	1.38E-09

(a) 3.92 E-06 = 3.92×10^{-6}

5.0 TOTAL DOSE

Technical Specification 3.11.4 - The annual (calendar year) dose or dose commitment to any MEMBER OF THE PUBLIC due to releases of radioactivity and to radiation from uranium fuel cycle sources shall be limited to less than or equal to 25 mrems to the total body or any organ, except the thyroid, which shall be limited to less than or equal to 75 mrems.

The annual whole body or skin dose accumulated by a member of the public for the noble gases released in the gaseous effluents is determined by using:

$$D_{wb} = (3.17 \times 10^{-8}) \quad \Sigma_i \left[(K_i)\ (X/Q)_\theta \quad (Q_i)\right] \tag{5-1}$$

or:

$$D_{sk} = (3.17 \times 10^{-8}) \quad \Sigma_i \left[(L_i + 1.1M_i)(X/Q)_\theta \quad (Q_i)\right] \tag{5-2}$$

Where:

K_i = the whole body dose factor due to gamma emissions for each identified noble gas radionuclide, i, in mrem/yr per $\mu Ci/m^3$ from Table 3-1.

Q_i = the release of radionuclide, i, in μCi for a specified time period.

$(X/Q)_\theta$ = 3.92×10^{-8} sec/m^3, the highest calculated annual average relative concentration for the nearest residence of any sector from Table 4-16.

D_{wb} = the annual whole body dose in mrem/yr due to gamma emissions.

L_i = the skin dose factor due to the beta emissions for each identified noble gas radionuclide, i, in mrem/yr per $\mu Ci/m^3$ from Table 3-1.

M_i = the air dose factor due to gamma emissions for each identified noble gas radionuclide, i, in mrad/yr per $\mu Ci/m^3$ from Table 3-1 (the conversion constant of 1.1 converts air dose-mrad to skin dose-mrem).

D_{sk} = the annual skin dose in mrem/yr.

The annual dose to critical organs of an individual for the radionuclides other than noble gases released in the gaseous effluents is determined by using:

$$D_{o\theta} = (3.17 \times 10^{-8}) \quad \Sigma_i \quad [\ \Sigma_k (R_{ik} W_{k\theta})(Q_i)] \qquad (4\text{-}3)$$

Where:

$D_{o\theta}$ = the total projected dose from gaseous effluents to an individual, in mrem, at the nearest residence in Sector θ .

Q_i = the integrated release of radionuclide i, released in gaseous effluents in μCi for a specified time period.

R_{ik} = the dose factor for each identified radionuclide, i, for pathway k (for the inhalation pathway in mrem/yr per $\mu Ci/m^3$ and for the food and ground plane pathways in m^2 -mrem/yr per $\mu Ci/sec$) at the controlling location. The R_{ik}'s for each age group are given in Tables 4-1 through 4-15.

$W_{k\theta}$ = the highest annual average dispersion parameter for any sector, used for estimating the dose to an individual at the maximally exposed closest residence in Sector θ and for pathway k.

$W_{k\theta}$ = X/Q for the inhalation pathway, in sec/m^3. The highest X/Q for the nearest residence, $3.92X10^{-6} sec/m^3$, is given in Table 4-16.

$W_{k\theta}$ = $3.92 X10^{-6} sec/m^3$, X/Q for the dose contribution from tritium in all pathways,.

$W_{k\theta}$ = D/Q for the food and ground plane pathways, in m^{-2}. The highest D/Q for the nearest residence occurs in sector NE, and is given in Table 4-16 as $3.87\ 10^{-9}/m^2$.

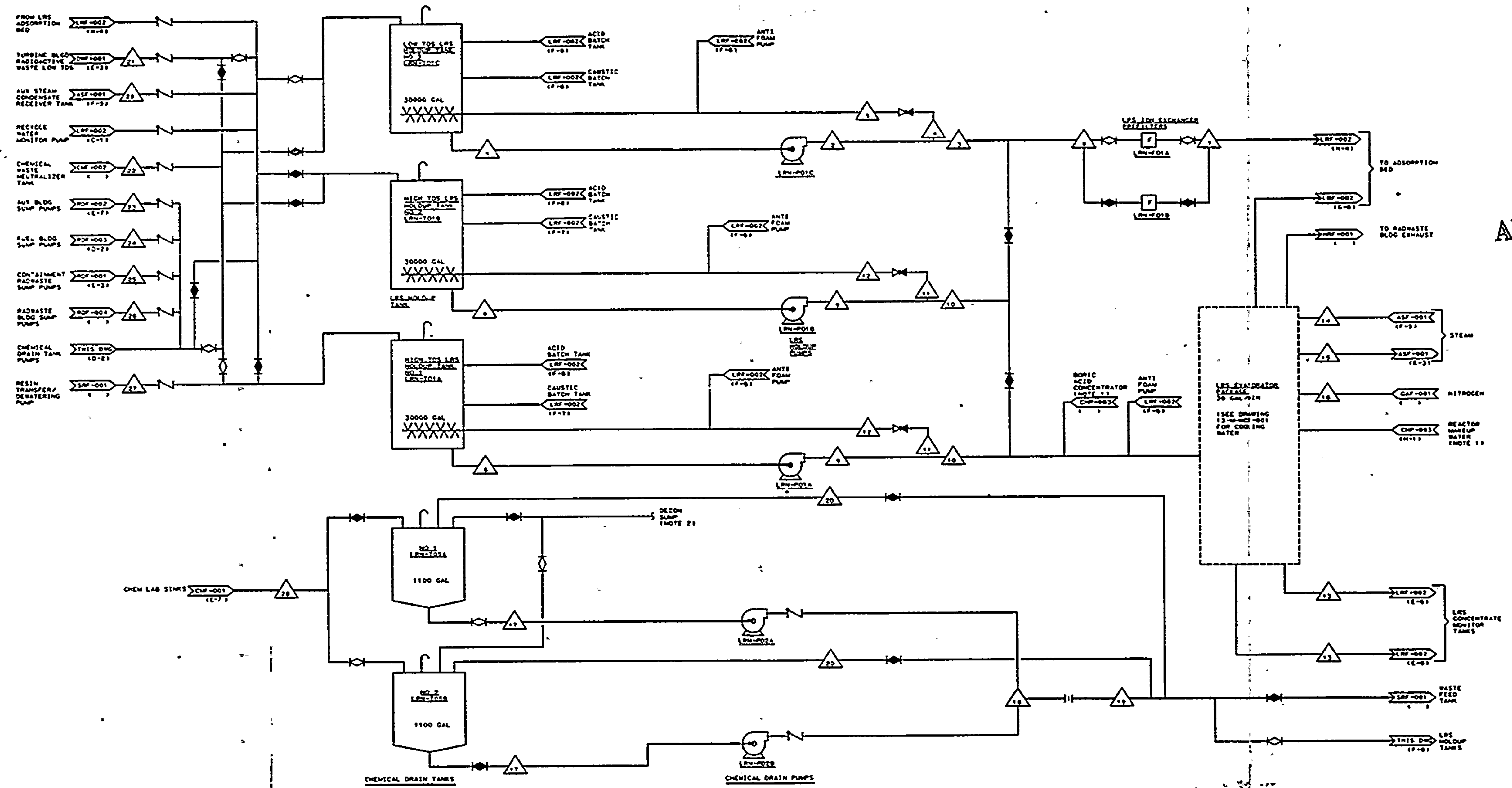
For all dose calculations from gaseous effluents, the highest annual average relative concentration or relative deposition rate used in the analysis should be at the receptor location of the individual being evaluated (the nearest residence in each sector). These annual average dispersion parameters are given in Table 4-16.

Technical Specification 6.9.1.8 - For the purpose of evaluating the dose to MEMBERS OF THE PUBLIC due to their activities within the SITE BOUNDARY the preceding calculations will be used. These activities have been determined to be limited to the vicinity of the Visitor Center located near the SITE BOUNDARY west of Unit 1. An assumption was made that no MEMBER OF THE PUBLIC would spend more than eight hours per year at this location which is 0.1% of the annual occupancy of a MEMBER OF THE PUBLIC at the SITE BOUNDARY. The most restrictive X/Q value will be used for this calculation.

The direct radiation from the site should be determined from the environmental monitoring program's direct radiation (TLD) monitors (comprised of a network of TLDs). Since all other uranium fuel cycle sources are greater than 20 miles away, only the PVNGS site need be considered as a uranium fuel cycle source for meeting the EPA regulations.

6.0 OPERABILITY OF EQUIPMENT

The flow diagrams defining the treatment paths and the components of the radioactive liquid, gaseous, and solid waste management systems are shown in Figures 6-1 through 6-3.



MODE	PARAMETER	1	2	3	4	5	6	7	8	9	10	11	12	13
		BATCH	BATCH	BATCH	BATCH	BATCH	BATCH	BATCH	BATCH	BATCH	BATCH	BATCH	BATCH	[illegible]
NORMAL OPERATION	FLOW (GPM)	250	250	100	150	150	100	100	250	250	30	220	220	53 [or 59]
	TEMPERATURE (°F)	80	80	80	80	80	80	80	80	80	60	80	80	224
	PRESSURE (PSIA)	18	112	107	107	42	92	87	18	112	107	107	55	50
SAMPLE MODE	FLOW (GPM)	160	160	-	160	160	-	-	230	230	-	230	230	-
	TEMPERATURE (°F)	120	120	-	120	120	-	-	120	120	-	120	120	-
	PRESSURE (PSIA)	14	120	-	117	45	-	-	12	115	-	111	57	-
MAXIMUM DESIGN	FLOW (GPM)	250	250	100	160	160	100	100	250	250	30	230	230	50
	TEMPERATURE (°F)	120	120	125	125	120	120	120	120	120	120	120	120	224
	PRESSURE (PSIA)	24	112	107	117	45	92	87	24	112	107	111	57	55
	FLOW (GPM)													
	TEMPERATURE (°F)													
	PRESSURE (PSIA)													
	FLOW (GPM)													
	TEMPERATURE (°F)													
	PRESSURE (PSIA)													
	FLOW (GPM)													
	TEMPERATURE (°F)													
	PRESSURE (PSIA)													

MODE	PARAMETER	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
		BATCH	BATCH	BATCH	BATCH	BATCH	BATCH	BATCH	BATCH	BATCH	[illegible]	[illegible]	[illegible]	[illegible]	BATCH	[illegible]	[illegible]
NORMAL OPERATION	FLOW (GPM)	22,000 (1)	22,000 (1)	-	30	30	30	-	120 (3)	-	50 (3)	150 (3)	50 (3)	50 (3)	100	6 (9)	-
	TEMPERATURE (°F)	340	300	AMB	80	80	80	-	80	-	80	80	80	60	80	80	-
	PRESSURE (PSIA)	50	50	25 (8)	17	88	65	-	30	-	50	30	33	30	30	15	-
SAMPLE MODE	FLOW (GPM)	-	-	-	55	55	55	55	-	-	-	-	-	-	-	-	-
	TEMPERATURE (°F)	-	-	-	120	120	120	120	-	-	-	-	-	-	-	-	-
	PRESSURE (PSIA)	-	-	-	15	88	21	15	-	-	-	-	-	-	-	-	-
MAXIMUM DESIGN	FLOW (GPM)	22,000 (1)	22,000 (1)	-	55	55	55	55	200 (6)	400	130 (4)	325 (3)	70 (4)	70 (4)	100	6 (9)	100 (7)
	TEMPERATURE (°F)	340	300	AMB	120	120	120	120	120	120	125	140	120	120	120	120	212
	PRESSURE (PSIA)	50	50	25 (8)	15	88	21	15	30	100	100	45	43	65	30	15	80
	FLOW (GPM)																
	TEMPERATURE (°F)																
	PRESSURE (PSIA)																
	FLOW (GPM)																
	TEMPERATURE (°F)																
	PRESSURE (PSIA)																
	FLOW (GPM)																
	TEMPERATURE (°F)																
	PRESSURE (PSIA)																

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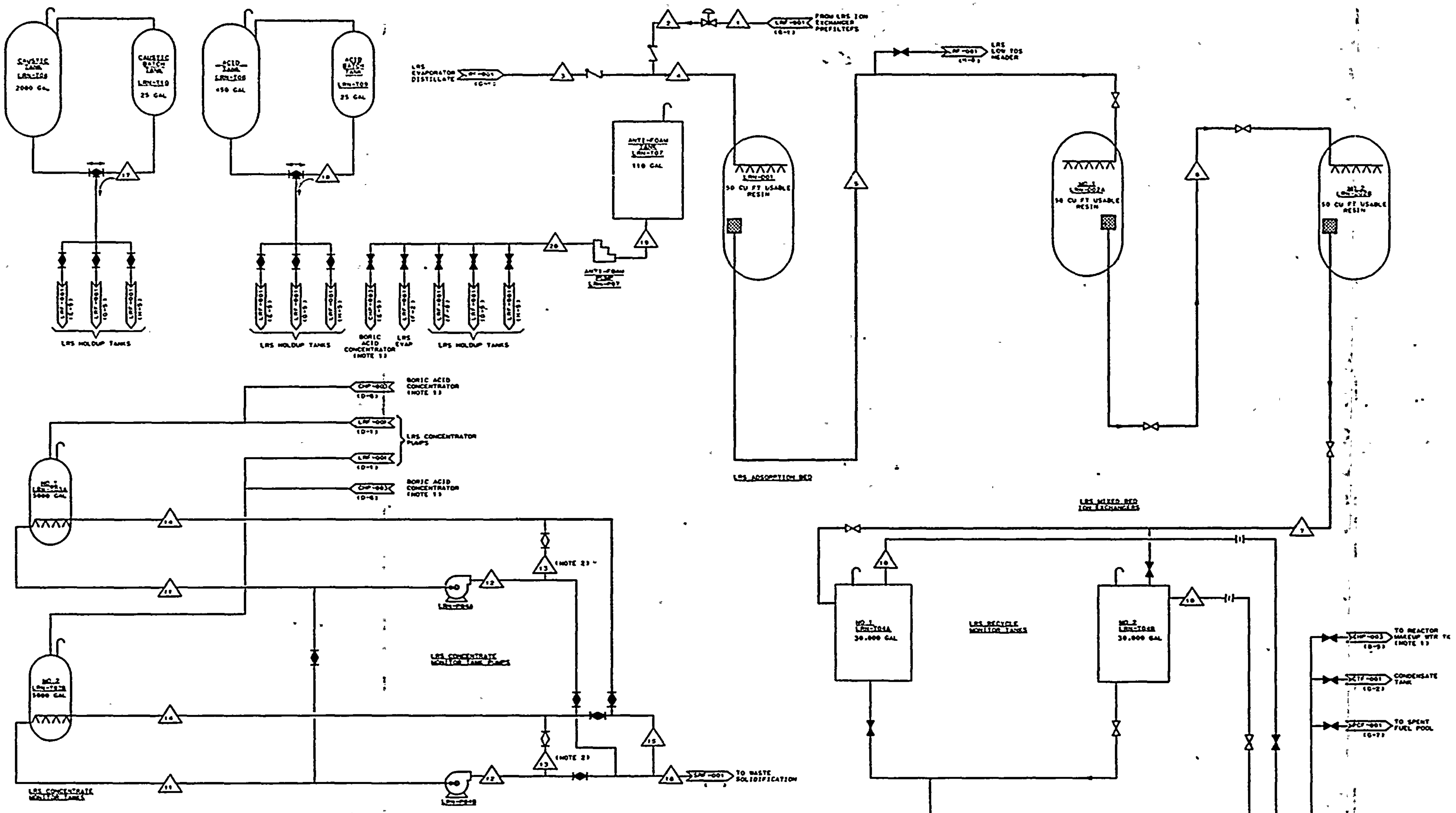
Palo Verde Nuclear Generating Station

BASIC FLOW DIAGRAM
LIQUID RADWASTE SYSTEM
(Sheet 1 of 2)

FIGURE 6-1   Rev.0
10/31/84



MODE	PARAMETER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20					
		BATCH	BATCH	BATCH	BATCH	BATCH	BATCH	BATCH	BATCH	BATCH	BATCH	BATCH	BATCH	BATCH	BATCH	BATCH	BATCH	BATCH	BATCH	BATCH	BATCH					
MAXIMUM DESIGN	FLOW (GPM)	100	100	30	130	130	130	130	160	160	160	60	60	60	60	50	10	6 (3)	6 (3)	30(4)	30(4)					
	TEMPERATURE (°F)	120	120	125	125	125	125	125	120	120	120	170	170	170	170	170	170	120	120	120	120					
	PRESSURE (PSIA)	63	53	49	49	39	29	15	24	85	15	35	61	57	53	34	34	17	17	17	115					
LOW TDS FLOW ONLY	FLOW (GPM)	100	100	-	100	100	100	100	-	-	-	-	-	-	-	-	-	-	-	-	-					
	TEMPERATURE (°F)	120	120	-	120	120	120	120	-	-	-	-	-	-	-	-	-	-	-	-	-					
	PRESSURE (PSIA)	63	44	-	40	33	26	15	-	-	-	-	-	-	-	-		-	-	-	-					
EVAPORATOR DISTILLATE ONLY	FLOW (GPM)	-	-	30	30	30	30	30	-	-	-	-	-		-	-	-	-	-	-	-					
	TEMPERATURE (°F)	-	-	125	125	125	125	125	-	-	-	-	-	-	-	-		-		-	-					
	PRESSURE (PSIA)	-	-	29	29	25	21	15	-	-	-	-	-	-		-	-	-	-	-	-					
NORMAL OPERATION	FLOW (GPM)	100	100	30	130	130	130	130	150	150	-	60	60	60	60	-	-	6 (3)	6 (3)	30(4)	30(4)					
	TEMPERATURE (°F)	80	80	125	125	125	125	125	80	40	-	170	170	170	170	-	-	80	80	80	80					
	PRESSURE (PSIA)	63	53	49	49	39	29	15	18	63	-	16	61	57	53	-	-	17	17	17	115					
SAMPLE MODE	FLOW (GPM)	-	-	-	-	-	-	-	100	100	100	60	60	60	60	-	-	-	-	-	-					
	TEMPERATURE (°F)	-	-	-	-	-	-	-	120	120	120	170	170	170	170	-	-		-	-	-					
	PRESSURE (PSIA)	-	-	-	-	-	-	-	18	85	15	16	61	57	53	-	-	-	-	-	-					
CONCENTRATE TRANSFER TO WASTE SOLIDIFICATION	FLOW (GPM)	-	-	-	-	-	-	-	-	-	-	50	50	-	50	50	10	-		-	-					
	TEMPERATURE (°F)	-	-	-	-	-	-	-	-	-	-	170	170	-	170	170	170	-		-	-					
	PRESSURE (PSIA)	-	-	-	-	-			-	-	-	16	64	-	44	34	34	-	-	-						

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NOTE:

1. THE CH SYSTEM HAS NO FLOW DIAGRAM
2. WHEN CONCENTRATE SOLUTION CONTAINS A CRYSTALINE SLURRY CONCENTRATE MONITOR TANK CONTENTS MUST BE CONTINUOUSLY RECIRCULATED USING THE SAMPLE MODE RETURN LOOP (VIA NODE 13) TO MAINTAIN SUSPENSION OF CRYSTALS IN SOLUTION.
3. GRAVITY FLOW
4. GAL/HR

THE DATA SHOWN ON THIS FLOW DIAGRAM ARE FOR DESIGN PURPOSES ONLY, AND WHILE USEFUL AS GUIDES IN OPERATION, DO NOT REPRESENT EXACT OR GUARANTEED OPERATING CONDITIONS.

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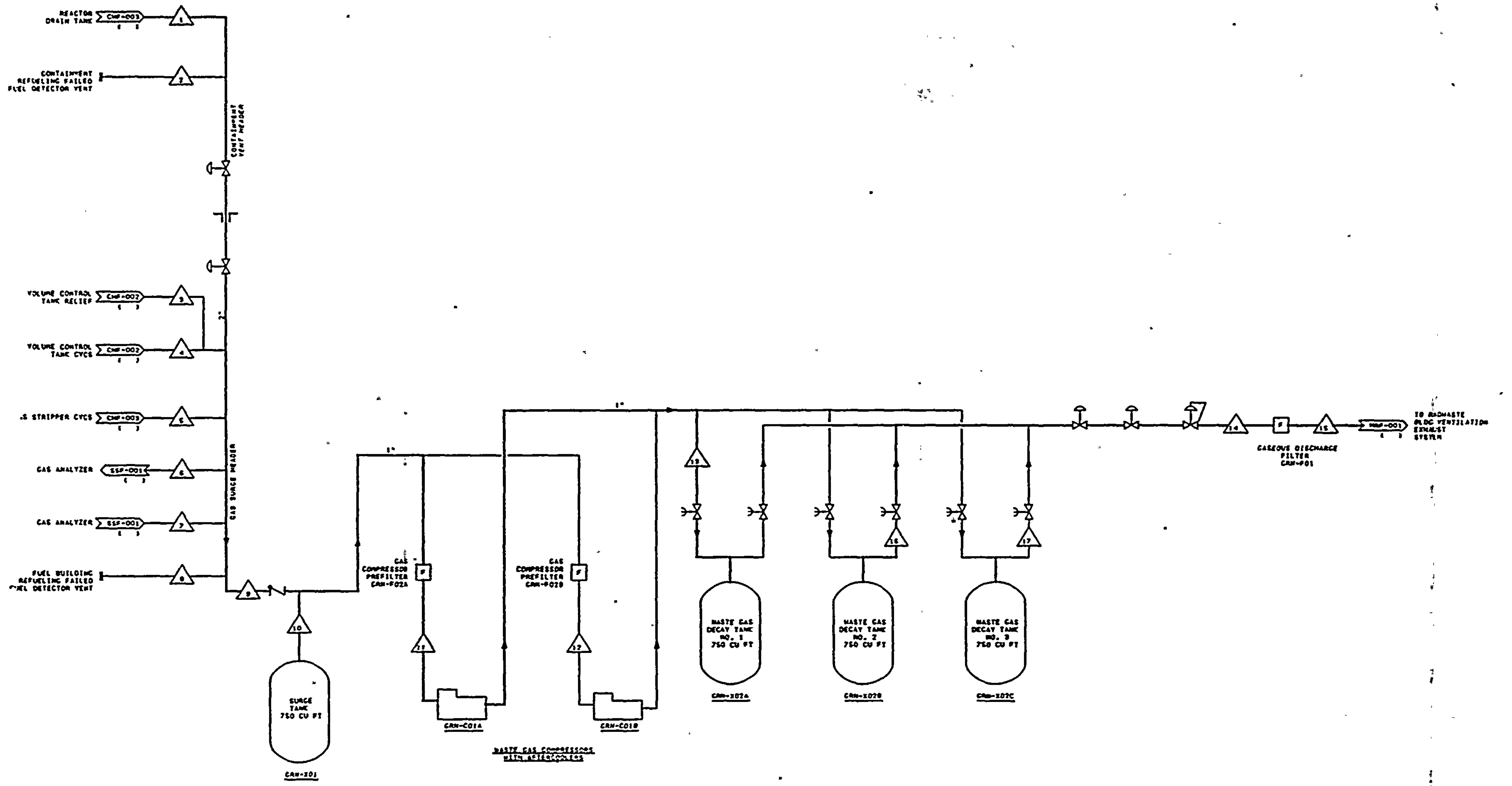
Palo Verde Nuclear Generating Station

BASIC FLOW DIAGRAM
LIQUID RADWASTE SYSTEM
(Sheet 2 of 2)

FIGURE 6-1 Rev.0 10/31/84



MODE	PARAMETER		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
MAXIMUM COLLECTION AND STORAGE	FLOW	(SCFM)	20	1	0	0	20	0	0.2	1	42.2	22.2	10	10	20	0	0	3	0
	TEMPERATURE	(°F)	120	125	AMB	AMB	145	AMB	145	125	145	145	145	145	171	AMB	AMB	AMB	AMB
	PRESSURE	(PSIA)	17.7	17.7	17.7	17.7	17.7	17.7	17.7	17.7	17.7	17.7	17.7	17.7	364.7	14.7	14.7	364.7	14.7
NORMAL DISCHARGE	FLOW	(SCFM)	0.001	0	0	0	0.34	0	0.64	0	0.98	9.62	10	0	10	50	50	50	0
	TEMPERATURE	(°F)	120	AMB	AMB	AMB	145	AMB	145	AMB	145	145	145	AMB	171	25	AMB	AMB	AMB
	PRESSURE	(PSIA)	17.7	17.7	17.7	17.7	17.7	17.7	17.7	17.7	17.7	17.7	17.7	17.7	364.7	25.3	14.7	364.7	14.7
VENTING VCT	FLOW	(SCFM)	0	0	0	20	0	0	0	0	20	0	10	10	20	0	0	0	0
	TEMPERATURE	(°F)	120	AMB	AMB	140	145	AMB	145	AMB	145	145	145	145	171	AMB	AMB	AMB	AMB
	PRESSURE	(PSIA)	18.2	18.2	74.7	74.7	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	364.7	14.7	14.7	364.7	14.7
RELIEVING VCT	FLOW	(SCFM)	0	0	90	0	0	0	0	0	90	70	10	10	20	0	0	0	0
	TEMPERATURE	(°F)	120	AMB	140	140	145	AMB	145	AMB	140	140	140	140	171	AMB	AMB	AMB	AMB
	PRESSURE	(PSIA)	18.2	18.2	84.7	84.7	18.2	18.2	18.2	18.2	18.2	18.2	18.2	18.2	364.7	14.7	14.7	364.7	14.7
EXPECTED * COLLECTION AND STORAGE	FLOW	(SCFM)	0.001	0	0	0	0.34	0	0.64	0	0.98	9.62	10 000	0	10	0	0	0	0
	TEMPERATURE	(°F)	100	AMB	AMB	AMB	120	AMB	125	AMB	120	100	100	AMB	175	AMB	AMB	AMB	AMB
	PRESSURE	(PSIA)	17.7	17.7	17.7	17.7	17.7	17.7	17.7	17.7	17.7	17.7	17.7	17.7	200	14.7	14.7	364.7	14.7

THE DATA SHOWN ON THIS FLOW DIAGRAM ARE FOR DESIGN PURPOSES ONLY, AND WHILE USEFUL AS GUIDES IN OPERATION DO NOT REPRESENT EXACT OR GUARANTEED OPERATING CONDITIONS.

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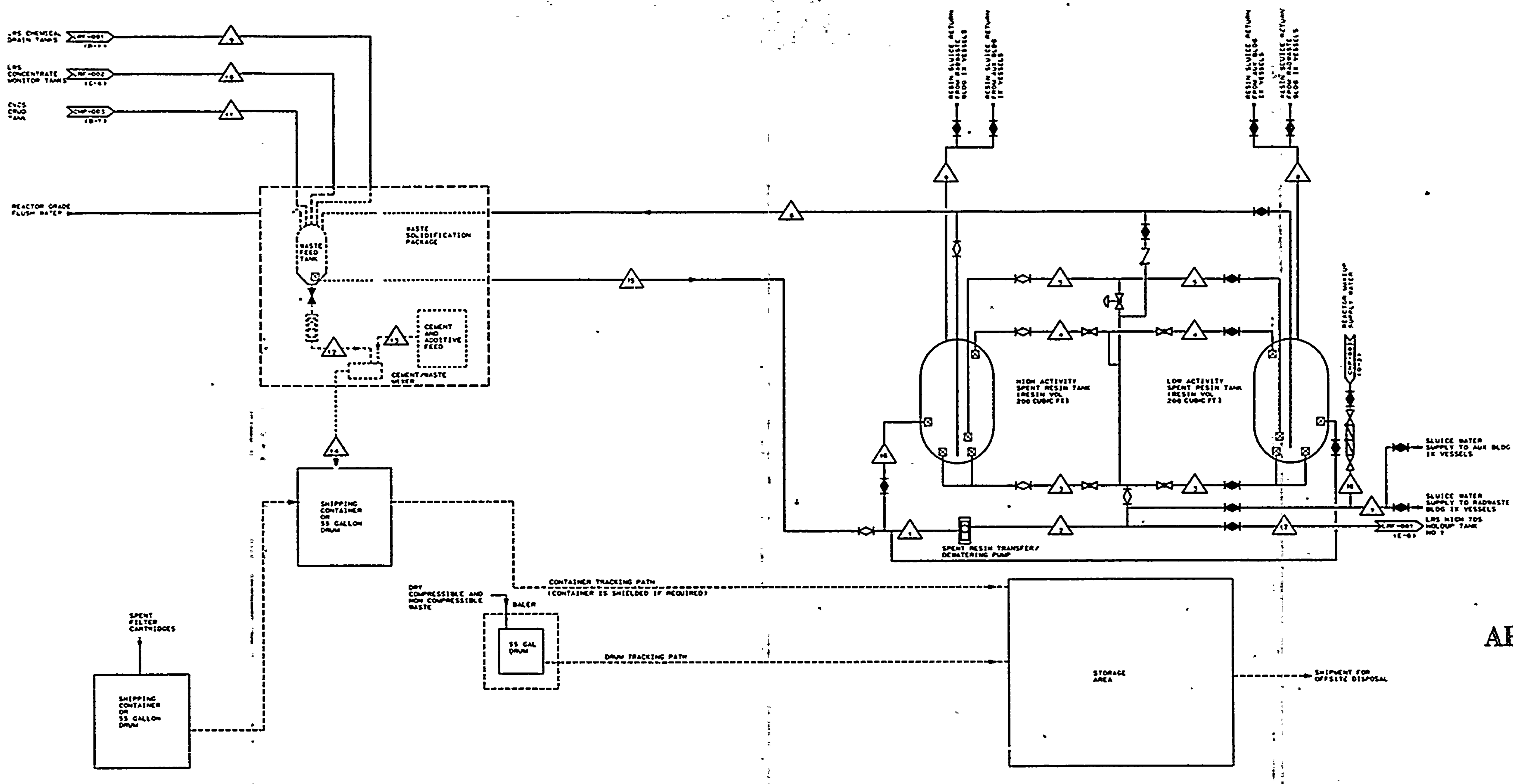
BASIC FLOW DIAGRAM
GASEOUS RADWASTE SYSTEM

Figure 6-2 Rev.0 10/31/84



MODE	PARAMETER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
RECIRCULATING WASTE FEED TANK PRIOR TO RESIN SLUICING	FLOW (GPM)	75	75	0	0	0	75	0	0	0	0	0	0	0	0	75	—	—	—
	TEMPERATURE (°F)	170	170	—	—	—	170	—	—	—	—	—	—	—	—	170	—	—	—
	PRESSURE (PSIA)	109	1212	—	—	—	228	—	—	—	—	—	—	—	—	15	—	—	—
SLUICING RESIN FROM A SPENT RESIN TANK TO WASTE FEED TANK	FLOW (GPM)	75	75	5	15	36	75	0	0	0	0	0	0	0	0	75	—	—	—
	TEMPERATURE (°F)	170	170	170	120	120	120	—	—	—	—	—	—	—	—	170	—	—	—
	PRESSURE (PSIA)	109	1212	831	831	831	228	—	—	—	—	—	—	—	—	15	—	—	—
RESIN TRANSFER FROM RADWASTE BUILDING I.X. TO A SPENT RESIN TANK	FLOW (GPM)	75	75	0	0	0	0	75	75	0	0	0	0	0	0	—	75	75	75
	TEMPERATURE (°F)	120	120	—	—	—	—	120	120	—	—	—	—	—	—	—	120	120	120
	PRESSURE (PSIA)	10	150	—	—	—	—	150	20	—	—	—	—	—	—	—	20	100	130
FLOW INPUTS TO WASTE FEED TANK	FLOW (GPM)	—	—	—	—	—	—	—	—	55	10	50	—	—	—	—	—	—	—
	TEMPERATURE (°F)	—	—	—	—	—	—	—	—	120	170	70	—	—	—	—	—	—	—
	PRESSURE (PSIA)	—	—	—	—	—	—	—	—	65	54	200	—	—	—	—	—	—	—
SOLIDIFICATION SYSTEM PROCESSING WASTE	FLOW (GPM)	—	—	—	—	—	—	—	—	—	—	—	16	250*	300*	—	—	—	—
	TEMPERATURE (°F)	—	—	—	—	—	—	—	—	—	—	—	170	—	—	—	—	—	—
	PRESSURE (PSIA)	—	—	—	—	—	—	—	—	—	—	—	120	—	—	—	—	—	—
SLUICING RESIN FROM AN AUX. BLDG I.X. TO A SPENT RESIN TANK	FLOW (GPM)	75	75	0	0	0	0	75	75	C	0	0	0	0	0	—	75	75	75
	TEMPERATURE (°F)	170	170	—	—	—	—	70	120	—	—	—	—	—	—	—	70	70	120
	PRESSURE (PSIA)	10	150	—	—	—	—	150	20	—	—	—	—	—	—	—	20	180	130

* POUNDS OF CEMENT PER MINUTE

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Palo Verde Nuclear Generating Station

BASIC FLOW DIAGRAM
SOLID RADWASTE SYSTEM

Figure 6-3 Rev.0 10/31/84

7.0 RADIOLOGICAL ENVIRONMENTAL PROGRAM

7.1 Radiological Environmental Monitoring Program

Technical Specification 4.12.1 - The radiological environmental monitoring samples shall be collected pursuant to Table 3.12-1 [of the Technical Specifications] from the specific locations given in the table and figure(s) in the ODCM, and shall be analyzed pursuant to the requirements of Table 3.12-1, and the detection capabilities required by Table 4.12-1 [of the Technical Specifications].

Environmental samples will be collected at locations shown in Figure 7-1 and described in Table 7-1. Analytical techniques used will ensure that the detection capabilities in Table 7-2 are achieved. Environmental samples will be collected and analyzed according to Table 7-3.

The results of the radiological environmental monitoring program are intended to supplement the results of the radiological effluent monitoring by verifying that the measurable concentrations of radioactive materials and levels of radiation are not higher than expected on the basis of the effluent measurements and modeling of the environmental exposure pathways. Thus, the specified environmental monitoring program provides measurements of radiation and of radioactive materials in those exposure pathways and for those radionuclides which lead to the highest potential radiation exposures of individuals resulting from station operation. The initial radiological environmental monitoring program will be conducted for the first three years of commercial operation of Unit 1. Following this period, program changes may be proposed based on operational experience. Deviations are

permitted from the required sampling schedule if specimens are unobtainable due to hazardous conditions, seasonal unavailability, malfunction of automatic sampling equipment, and other legitimate reasons.

If specimens are unobtainable due to sampling equipment malfunction, an effort shall be made to complete corrective action prior to the end of the next sampling period. All deviations from the sampling schedule shall be documented in the annual report.

7.2 Census Program

Technical Specification 3.12.2 - A land use census shall be conducted and shall identify within a distance of 8 km (5 miles) the location in each of the 16 meterological sectors of the nearest milk animal, the nearest residence and the nearest garden of greater than 50 m^2 (500 ft^2) producing broad leaf vegetation.

A land use census will be conducted to identify the location of the nearest milk animal and the nearest residence in each of the 16 meteorological sectors within a distance of five miles. When a land use census identifies a location(s) which yields a calculated dose or dose commitment greater than the values calculated from current sample locations, appropriate changes in the sample locations will be made. If a land use census identifies a location(s) with a higher average annual deposition rate (D/Q) than a current indicator location, the following shall apply:

1. If the D/Q is at least 20% greater than a previously high D/Q, one of the existing sample locations may be replaced after an evaluation with a new one within 60 days. The evaluation will be based on past history of the location, availability of sample, milk production history, and other environmental conditions.

2. If the D/Q is not 20% greater than the previously highest D/Q, distance and D/Q will be considered in deciding whether to replace one of the existing sample locations. If applicable, replacement shall be within 30 days.

A land use census will be conducted at least once per calendar year by a door-to-door or aerial survey, by consulting local agricultural authorities, or by any combination of these methods.

7.3 Interlaboratory Comparison Program

Technical Specification 3.12.3 - Analyses shall be performed on radioactive materials supplied as part of an Interlaboratory Comparison Program that has been approved by the Commission that corresponds to samples required by [Technical Specification] Table 3.12-1.

PVNGS laboratories or contract laboratories which perform analyses for the Radiological Environmental Monitoring Program will participate in the Environmental Protection Agency's (EPA's) Environmental Radioactivity Laboratory Intercomparisons Studies (Crosscheck) Program. This participation will include all of the determinations (sample medium-radionuclide combination) that are offered by EPA and that also are included in the monitoring program. The results of analyses of these crosscheck samples will be included in the annual report.

TABLE 7-1
(Page 1 of 4)

RADIOLOGICAL ENVIRONMENTAL MONITORING SAMPLE COLLECTION LOCATIONS

SAMPLE SITE	SAMPLE TYPE[c]	LOCATION DESIGNATION[a]	LOCATION DESCRIPTION
1	TLD, Air	E30	APS Goodyear Office
2	TLD[b]	ENE24	Scott-Libby School
3	TLD[b]	E25	Liberty School
4	TLD, Air	E20	APS Buckeye Office
5	TLD	ESE15	Palo Verde
6	TLD, Air[b]	SSE35	APS Gila Bend Substation
7	TLD,[b]	SE8	1.25 miles north of Arlington School
7A	Air	SE8	Arlington School
8	TLD[b]	SSE5	Corner of 363rd Ave. & SPP Rd.
9	TLD[b]	S5	Corner of 371st Ave. & SPP Rd.
10	TLD[b]	SE5	Corner of 355th Ave. & Ward Rd.
11	TLD[b]	ESE5	2 miles east of 351st on Dobbins
12	TLD[b]	E5	Corner of 339th Ave. & B-S Rd.
13	TLD[b]	N1	N Site Boundary
14	TLD[b]	NNE2	NNE Site Boundary
14A	Air[b]	NNE2	Buckeye-Salome Rd. & 371st Ave.
15	TLD[b], Air[b]	NE2	NE Site Boundary

TABLE 7-1

SAMPLE SITE	SAMPLE TYPE[c]	LOCATION DESIGNATION[a]	LOCATION DESCRIPTION
16	TLD[b]	ENE2	ENE Site Boundary
17	TLD[b]	E2	E Site Boundary
17A	Air	E4	351st Ave., 1 mi. S of Buckeye Salome Rd.
18	TLD[b]	ESE2	ESE Site Boundary
19	TLD[b]	SE2	SE Site Boundary
20	TLD[b]	SSE2	SSE Site Boundary
21	TLD[b], Air[b]	S3	S Site Boundary
22	TLD[b]	SSW3	SSW Site Boundary
23	TLD[b]	W5	2 mi. N of Ward Rd, 3 mi. W of Wintersburg Rd
24	TLD[b]	SW5	Ward Rd. 0.75 mi E. of Well 18bbb
25	TLD[b]	WSW5	Ward Rd. at DF Well 2 Rd.
26	TLD[b], Water	SSW5	Well 21 Cbb_2 (Shepherds Farm)
27	TLD[b]	SW2	SW Site Boundary
28	TLD[b]	WSW1	WSW Site Boundary
29	TLD[b], Air[b]	W1	W Site Boundary
30	TLD[b]	WNW1	WNW Site Boundary
31	TLD[b]	NW2	NW Site Boundary

TABLE 7-1

SAMPLE SITE	SAMPLE TYPE[c]	LOCATION DESIGNATION[a]	LOCATION DESCRIPTION
32	TLD[b]	NNW1	NNW Site Boundary
33	TLD[b]	NW5	1/2 mi. S of Buckeye Salome Hwy on 339th Avenue
34	TLD[b]	NNW5	Corner of 395th Avenue & Van Buren Rd.
35	TLD[b], Air	NNW9	Tonopah, Palo Verde Inn Fire Station
36	TLD[b]	N5	Corner of Wintersburg Rd. & Van Buren Rd.
37	TLD[b]	NNE5	Corner of 363rd Ave. & Van Buren Rd.
38	TLD[b]	NE5	Corner of 355th Ave. & Yuma Rd.
39	TLD[b],	ENE5	343rd Ave., 1/2 mi. South of Lower Buckeye Rd.
40	TLD[b], Air[b]	N3	Trailer Park at Wintersburg
41	TLD [b]	WNW20	Harquahala Valley School
42	TLD[b]	N8	Ruth Fisher School
43	TLD[b]	N45	Vulture Mine Rd. School, Wickenburg
44	TLD[b], Air[b]	ENE35	APS El Mirage Office (Sun City)
45	TLD	On Site	PVNGS Lead Sheilding
46	Water [b], Veg.	NNW9	McArthur's Farm, Tonopah

SAMPLE SITE	SAMPLE TYPE (c)	LOCATION DESIGNATION (a)	LOCATION DESCRIPTION
47	Veg.	E3	355th Avenue & Southern Ave.
48	Water (b)	SW5	Well 18bbb
49	Water (b)	ESE4	Glover Residence, 351st Ave. & Dobbins Rd.
50	Milk (b)	NE7	Baisley Dairy, 331st Ave. & Van Buren Rd.
51	Milk (b), Veg.	E15	Butler Dairy, Palo Verde Rd. & Southern Ave.
52	Vegetation	E15	Cambron Farm, Miller Rd. & Broadway Rd.
53	Milk	E20	Kerr Dairy, Dean & Buckeye Rds.
54	Milk	E50	Skousen Dairy, Airport & Dobbins Rd.
55	Milk (b)	E25	Lueck Dairy, Jackrabbit & Hazen Rds.
56	Milk	E75	Hamstra Dairy #2, McQueen & Ryan Rds.
57	Water (b)	On Site	Well 27ddc
58	Water (b)	On Site	Well 34abb
59	Surface Water (b)	On Site	PVNGS Evaporation Pond
60	Surface Water (b)	On Site	PVNGS Reservoir

(a) Location Designation based on Sector and Zone Nomenclature from Table J-1, NUREG-0654. Distances are from the centerline of Unit 2 containment.

(b) These samples fulfill the requirements of the PVNGS Technical Specifications. The other samples fulfill PVNGS station requirements.

(c) Refer to Figure 7-1 for relative locations of sample sites.

TABLE 7-2
(Page 1 of 2)

DETECTION CAPABILITIES FOR ENVIRONMENTAL SAMPLE ANALYSIS
Lower Limit of Detection (LLD)[a]

Analysis	Water (pCi/l)	Airborne Particulate or Gas (pCi/m^3)	Milk (pCi/l)	Food Products (pCi/kg, wet)
Gross Beta	4	1×10^{-2}	-	-
H-3	2000[b]	-	-	-
Mn-54	15	-	-	-
Fe-59	30	-	-	-
Co-58	15	-	-	-
Co-60	15	-	-	-
Zn-65	30	-	-	-
Zr-95	30	-	-	-
Nb-95	15	-	-	-
I-131	1	7×10^{-2}	1	60
Cs-134	15	5×10^{-2}	15	60
Cs-137	18	6×10^{-2}	18	80
Ba-140	60	-	60	-
La-140	15	-	15	-

TABLE 7-2
(Page 2 of 2)

(a)The LLD is the smallest concentration of radioactive material in a sample that will be detected with 95% probability and with 5% probability of falsely concluding that a blank observation rep- resents a "real" signal.

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

$$LLD = \frac{4.66 S_b}{2.22\ EVY\ \exp\ (-\lambda \Delta t)}$$

Where:

LLD is the "a priori" lower limit of detection as defined above (as pCi per unit mass or volume),

S_b is the standard deviation of the backgound counting rate or of the counting rate of a blank sample as appropriate (as counts per minute),

2.22 is the number of disintegrations per minute per picocurie,

E is the counting efficiency (as counts per transformation),

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

Y is the fractional radiochemical yield (when applicable),

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

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

In calculating the LLD for a radionuclide determined by gamma-ray spectrometry, the background should include the contributions of other radionuclides normally present in the samples (e.g., potassium-40 milk samples). Typical values for E, V, Y, and t should be used in the calculations.

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

(b)LLD for drinking water.

TABLE 7-3

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
PVNGS

Exposure Pathway and/or Sample	Sampling and Collection Frequency	Type and Frequency of Analysis	Sampling Locations
Airborne radioiodine and particulates	Continuous sampling collected weekly	Gross beta weekly; I-131 weekly; gamma spectrum monthly; composite of filters	Six locations as listed in Table 7-1 Control locations are 6 and 44 (alternate)
Direct radiation	TL dosimeters at location changed quarterly and annually	Gamma dose quarterly and annually	40 locations as described in Table 7-1 Control locations are 43 and 44
Waterborne:			
Surface	Monthly Composite of weekly grab sample	Gamma spectrum monthly; tritium quarterly	On-site reservoir and evaporation pond (sample locations 59 and 60)
Ground	Quarterly grab sample	Tritium and gamma spectrums quarterly	On-site well Nos. 34abb and 27ddc (sample locations 57 and 58)
Drinking (well)	Composite sample one-month period	Gross beta and gamma spectrums monthly; tritium quarterly	48, 46, 49 Control location is 46
Ingestion Milk	Semimonthly for animals on pasture, otherwise monthly	Gamma spectrum and radioiodine semimonthly or monthly	50, 51, 55 Control location is 55

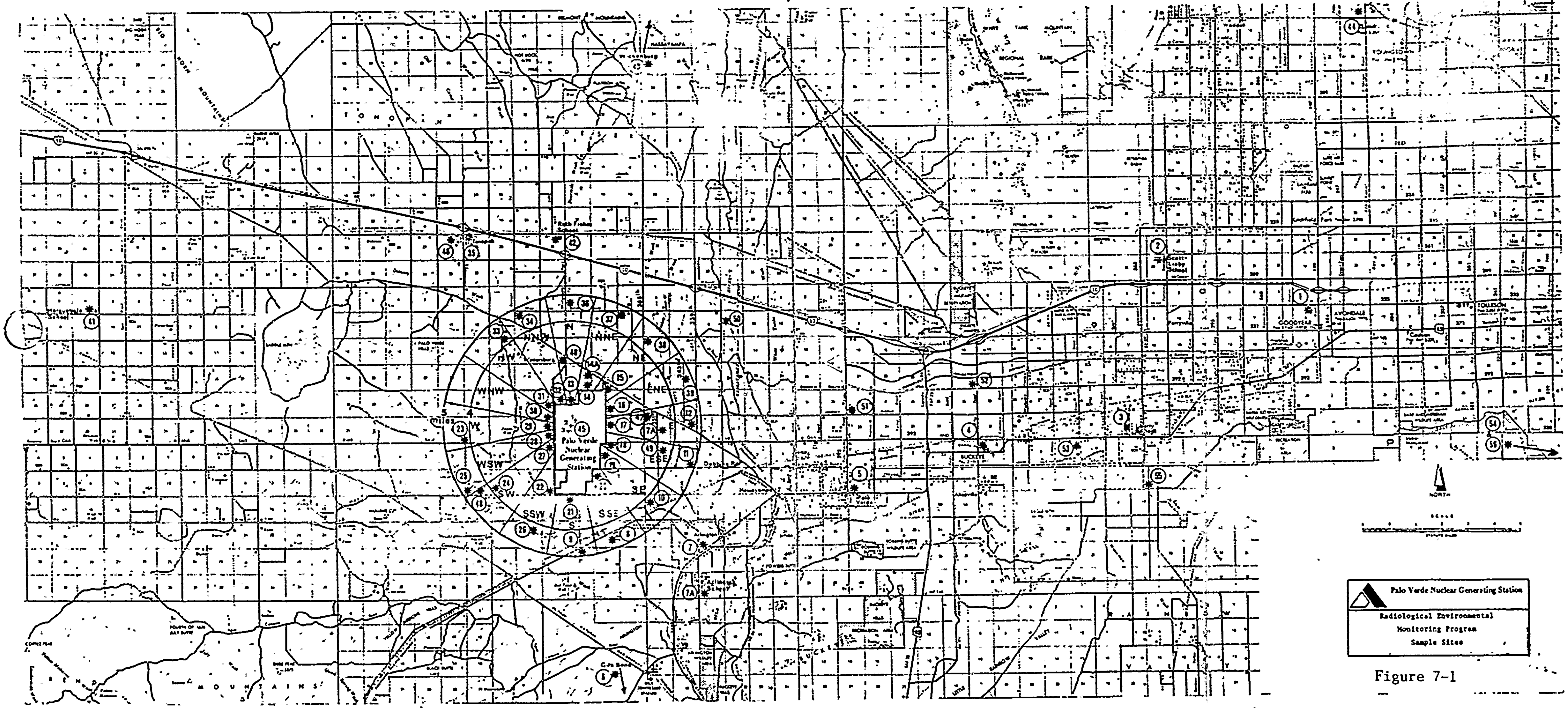

Figure 7-1

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10/31/84

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APPENDIX A

SAMPLE CALCULATIONS

A.1 GASEOUS EFFLUENT MONITOR SETPOINTS

Effluent monitor setpoints will be established at PVNGS to ensure that the Limits of Technical Specification 3.11.2.1 will not be exceeded. The methodology for monitor setpoint determination presented in Section 2.1 of the text uses the isotopic distribution information from Table 11.3-6 of the PVNGS FSAR, "Annual Releases per Unit for Normal Operation."

A.1.1 Equivalent Dose Factor Determination

Equations (2-1) and (2-2) are used to determine the equivalent dose factors for whole body (K_{eq}) and skin [$(L+1.1M)_{eq}$].

The quantity of radioactive materials released to the atmosphere will be obtained from PVNGS records.

For example, a three-month period might show the following quantities released:

Radionuclide	Quantity Released (Ci)	f_i (Fraction of Total Release)
Kr-85	5000	0.683
Kr-88	2.8	0.0004
Xe-131m	100	0.014

Radionuclide	Quantity Released (Ci)	f_i (Fraction of Total Release)
Xe-133m	14	0.002
Xe-133	2200	0.3
Xe-135	7.5	0.001
	7320	

To determine the equivalent dose factor for whole body (K_{eq}) the following equation is used:

$$K_{eq} = \Sigma_i [(K_i)(f_i)] \qquad (2\text{-}1)$$

where:

K_i =	16.1	$\frac{\text{mrem/yr}}{\mu\text{Ci/m}^3}$	for	Kr-85
=	14700	"	for	Kr-88
=	91.5	"	for	Xe-131m
=	251	"	for	Xe-133m
=	294	"	for	Xe-133
=	1810	"	for	Xe-135

$$K_{eq} = [(16.1)(0.683) + (14700)(0.0004) + (91.5)(0.014) + (251)(0.002) + (294)(0.3) + (1810)(0.001)]$$

$$K_{eq} = 109 \quad \frac{\text{mrem/yr}}{\mu\text{Ci/m}^3}$$

To determine the equivalent dose factor for skin, $(L+1.1M)_{eq}$, the following equation is used:

$$(L+1.1M)_{eq} = \Sigma_i [(L_i + 1.1M_i)(f_i)] \qquad (2\text{-}2)$$

where:

$$L_i = 1340 \ \frac{\text{mrem/yr}}{\mu\text{Ci/m}^3} \quad \text{for Kr-85}$$

L_i =	1340	$\frac{\text{mrem/yr}}{\mu\text{Ci/m}^3}$	for	Kr-85
=	2370	"	for	Kr-88
=	476	"	for	Xe-131m
=	994	"	for	Xe-133m
=	306	"	for	Xe-133
=	1860	"	for	Xe-135

M_i =	17.2	$\frac{\text{mrem/yr}}{\mu\text{Ci/m}^3}$	for	Kr-85
=	15200	"	for	Kr-88
=	156	"	for	Xe-131m
=	327	"	for	Xe-133m
=	353	"	for	Xe-133
=	1920	"	for	Xe-135

$$\begin{aligned}(L+1.1M)_{eq} = \{ & [1340 + 1.1(17.2)]\ 0.683 + \\ & [2370 + 1.1(15200)]\ 0.0004 + \\ & [476 + 1.1(156)]\ 0.014 + \\ & [994 + 1.1(327)]\ 0.002 + \\ & [306 + 1.1(353)]\ 0.3 + \\ & [1860 + 1.1(1920]\ 0.001]\}\end{aligned}$$

$$(L+1.1M)_{eq} = 1160 \ \frac{\text{mrem/yr}}{\mu\text{Ci/m}^3}$$

A.1.2 Site Release Rate Limit (Q_{site}) Determination

Using the equivalent dose factors for whole body and skin calculated in Section A.1.1, the release rate corresponding to 80% of the whole body and skin dose rate limits can be calculated.

For whole body:

(2-3a)

$$Q_{wb} = \left[\frac{(D_{wb})\ (0.8)}{(K\ )\ (X/Q\ )}\right]$$

$$= \left[\frac{(500\ mrem/yr)\ (0.8)}{(109\ \frac{mrem}{\mu Ci/m^3})(6.49\ X10^{-6}\ sec/m^3)}\right]$$

$$Q_{wb} = 5.65\ X10^{5}\ \mu Ci/sec$$

For skin:

(2-4a)

$$Q_{sk} = \left[\frac{(D_{sk})\ (0.8)}{(L+1.1M)_{eq}(X/Q)_{SB}}\right]$$

$$= \left[\frac{(3000\ mrem/yr)\ 0.8}{(1.16\ X10^{3}\frac{mrem/yr}{\mu Ci/m^3})(6.49\ X10^{-6} sec/m^3)}\right]$$

$$Q_{sk} = 3.19\ X10^{5}\ \mu Ci/sec$$

Therefore:

$$Q_{site} = Q_{sk} = 3.19\ X10^{5}\ \mu Ci/sec$$

The lower value of Q_{wb} and Q_{sk} will be used as the site release rate limit (Q_{site}). For the example above, the Q_{site} would be 3.19 $X10^5$ µCi/sec and this value will be used in the setpoint determinations of Section A.1.4.

A.1.3 Administrative Allotment

To allow for multiple sources of release, the effluent monitor setpoint calculation includes an administrative factor (a), which allocates a fraction of the Q_{site} to each release point. Typical administrative allotment values ("a" from equation (2-5)) are listed below:

Plant Stack	0.80
Fuel Building Vent Exhaust	0.10
Condenser Evacuation System	0.09
Reserve	0.01

These factors may be reviewed and revised to reflect the fraction of the total release which has occurred through each effluent release point. The total of these administrative factors shall not exceed 1.0 for the site.

A.1.4 Setpoint Determination

The effluent monitor setpoints are calculated using equation (2-5) for monitors RU-141, RU-143, and RU-145, and equation (2-6) for monitor RU-12. The flow rate of each effluent release point will be calculated using either actual flow rate information (where available) or design maximum flow rates. Flow rates are maintained in accordance with PVNGS station manual procedures. The following examples use typical flow rates for each release point:

$$\text{Monitor Setpoint } (\mu Ci/cc) \leq \frac{(Q_{site})}{(\text{Flow Rate})} \left(2.12 \times 10^{-3} \frac{cfm}{cc/sec}\right) (a)] \qquad (2\text{-}5)$$

Plant Stack RU-143

$$\text{Monitor Setpoint } (\mu Ci/cc) \leq \left[\frac{(3.19 \text{ X}10^{5})}{(110{,}600)}\right] (2.12 \text{ X } 10 \quad) (0.8)$$

$$\text{Monitor Setpoint} \leq 4.94 \text{ X}10^{-3} \mu Ci/cc$$

Fuel Building Vent Exhaust RU-145

$$\text{Monitor Setpoint} \leq \frac{(3.1910^{5})(2.12\text{X}10^{-3})(0.1)}{43{,}500}$$

$$\text{Monitor Setpoint} \leq 1.57 \text{ X}10^{-3} \mu Ci/cc$$

Condenser Evacuation System RU-141

$$\text{Monitor Setpoint} \leq \frac{(3.19\text{X}10^{5})(2.12\text{X}10^{-3})(0.09)}{1480}$$

$$\text{Monitor Setpoint} \leq 4.15 \text{ X}10^{-2} \mu Ci/cc$$

Waste Gas Decay Tank RU-12

$$\text{Monitor Setpoint} \leq \left[\frac{(Q_{site})}{(\text{actual flow rate})} \left(2.12\text{X}10^{-3} \frac{\text{cfm}}{\text{cc/sec}}\right) (0.9)(a)\right] \quad (2\text{-}6)$$

$$\leq \frac{(3.19\text{X}10^{5})(2.12\text{X}10^{-3})(0.8)(0.9)}{50}$$

$$\text{Monitor Setpoint} \leq 9.83 \mu Ci/cc$$

When no release is occurring through the Waste Gas Decay Tank pathway, the monitor setpoint should be established as close as practical to background to prevent a spurious alarm and yet assure an alarm should an inadvertent release occur.

A.2 GASEOUS EFFLUENT DOSE RATE

A.2.1 Noble Gases

The methods used to calculate the whole body or skin dose rates are discussed in Section 3.1 of the text. The dose factors (K_i, L_i, M_i, N_i) for noble gases and their daughters are taken from Table 3-1. The highest annual average dispersion parameter at the site boundary occurs in the north sector and the value is taken from Table 3-2. Assuming a noble gas release rate of 279 µCi/sec of Xe-133 and 634 µCi/sec of Kr-85, the whole body dose is to be calculated, using equation (3-1), as follows:

$$D_{wb} = \Sigma_i [(K_i)(X/Q)_{SB}(Q_i)] \qquad (3\text{-}1)$$

Where:

$$K_i = 16.1 \frac{mrem/yr}{\mu Ci/m^3} \text{ for Kr-85}$$

$$= 294 \frac{mrem/yr}{\mu Ci/m^3} \text{ for Xe-133}$$

$$(X/Q)_{SB} = 6.49 \times 10^{-6} \text{ sec/m}^3$$

$$Q_i = 279 \ \mu Ci/sec \text{ for Xe-133}$$

$$= 634 \ \mu Ci/sec \text{ for Kr-85}$$

$$D_{wb} = [(16.1 \frac{mrem/yr}{\mu Ci/m^3}) (6.49 \times 10^{-6} sec/m^3) (634 \ \mu Ci/sec)] +$$

$$[(294 \frac{mrem/yr}{\mu Ci/m^3}) (6.49 \times 10^{-6} sec/m^3) (279 \ \mu Ci/sec)]$$

$$D_{wb} = 0.60 \text{ mrem/yr from Kr-85 and Xe-133}$$

The skin dose is to be calculated using equation (3-2) as follows:

$$D_s = {}_i[(L_i + 1.1M_i)\ (\chi/Q)_{SB}(Q_i)] \qquad (3\text{-}2)$$

Where:

$$L_i = 1340\ \frac{\text{mrem/yr}}{\mu\text{Ci/m}^3} \text{ for Kr-85}$$

$$= 306\ \frac{\text{mrem/yr}}{\mu\text{Ci/m}^3} \text{ for Xe-133}$$

$$M_i = 17.2\ \frac{\text{mrad/yr}}{\mu\text{Ci/m}^3} \text{ for Kr-85}$$

$$= 353\ \frac{\text{mrad/yr}}{\mu\text{Ci/m}^3} \text{ for Xe-133}$$

$$(\chi/Q)_{SB} = 6.49\ \text{X}10^{-6}\ \text{sec/m}^3$$

$$Q_i = 634\ \mu\text{Ci/sec for Kr-85}$$

$$= 279\ \mu\text{Ci/sec for Xe-133}$$

$$D_s = \{[(1340\ \frac{\text{mrem/yr}}{\mu\text{Ci/m}^3}) + 1.1(17.2\ \frac{\text{mrad/yr}}{\mu\text{Ci/m}^3})]\ (6.49\ \text{X}10^{-6}\text{sec/m}^3)(634\ \mu\text{Ci/sec})\} +$$

$$\{[(3.06\ \frac{\text{mrem/yr}}{\mu\text{Ci/m}^3}) + 1.1(353\ \frac{\text{mrad/yr}}{\mu\text{Ci/m}^3})]\ (6.49\ \text{X}10^{-6}\text{sec/m}^3)(279\ \mu\text{Ci/sec})\}$$

$$D_s = 6.85 \text{ mrem/yr from Kr-85 and Xe-133}$$

A.2.2 Radionuclides Other Than Noble Gases

The methods used to calculate the critical organ dose rate are discussed in Section 3.2 of the text. The dose parameter, P_i, is taken from Table 3-3. The highest annual average dispersion parameter at the site boundary occurs in the north sector and the value is taken from Table 3-2. Assuming a release rate of 5.31 $X10^{-4}$ μCi/sec of I-131, 2.54 $X10^{-5}$ μCi/sec of Cs-137, and 31.7 μCi/sec of H-3 , the critical organ annual dose rate is calculated, using equation (3-3), as follows:

$$D_o = \Sigma_i [(P_i)(X/Q)_{SB}(Q_i)] \qquad (3\text{-}3)$$

Where:

$$P_i = 1.62 \text{ X}10^7 \ \frac{\text{mrem/yr}}{\mu\text{Ci/m}^3} \text{ for I-131}$$

$$= 9.07 \text{ X}10^5 \ \frac{\text{mrem/yr}}{\mu\text{Ci/m}^3} \text{ for Cs-137}$$

$$= 1120 \ \frac{\text{mrem/yr}}{\mu\text{Ci/m}^3} \text{ for H-3}$$

$$(X/Q)_{SB} = 6.49 \text{ X}10^{-6} \text{ sec/m}^3$$

$$Q_i = 5.31 \text{ X}10^{-4} \mu\text{Ci/sec for I-131}$$

$$= 2.54 \text{ X}10^{-5} \mu\text{Ci/sec for Cs-137}$$

$$= 31.7 \ \mu\text{Ci/sec for H-3}$$

$$D_o = [(1.62 \times 10^{7} \frac{mrem/yr}{\mu Ci/m^3})(6.49 \times 10^{-6} sec/m^3)(5.31 \times 10^{-4} \mu Ci/sec)] +$$

$$[(9.07 \times 10^{5} \frac{mrem/yr}{\mu Ci/m^3})(6.49 \times 10^{-6} sec/m^3)(2.54 \times 10^{-5} \mu Ci/sec)] +$$

$$[(1120 \frac{mrem/yr}{\mu Ci/m^3})(6.49 \times 10^{-6} sec/m^3)(31.7 \mu Ci/sec)]$$

$$D_o = 0.29 \text{ mrem/yr}$$

A.3 DOSE DUE TO GASEOUS EFFLUENT

A.3.1 Noble Gases

The methods used to calculate the beta and gamma air doses are discussed in Section 4.1 of the text. The dose factors (M_i and N_i), for noble gases and their daughters are taken from Table 3-1. The highest annual average dispersion parameter (X/Q) at the site boundary occurs in the north sector and the value is taken from Table 3-2. Assuming an annual release of 8.8 X10^9 μCi Xe-133 and 2.0 X10^{10} μCi Kr-85, the gamma air dose is calculated as follows using equation (4-1):

$$D\gamma = (3.17 \times 10^{-8}) \; \Sigma_i \left[(M_i \; (X/Q)_{SB} \; (Q_i) \right] \qquad (4\text{-}1)$$

Where:

$$M_i = 17.2 \; \frac{\text{mrad/yr}}{\mu\text{Ci/m}^3} \text{ for Kr-85}$$

$$= 353 \; \frac{\text{mrad/yr}}{\mu\text{Ci/m}^3} \text{ for Xe-133}$$

$$(X/Q)_{SB} = 6.49 \text{ X}10^{-6} \text{ sec/m}^3$$

$$Q_i = 2.0 \text{ X}10^{10} \; \mu\text{Ci for Kr-85}$$

$$= 8.8 \text{ X}10^{9} \; \mu\text{Ci for Xe-133}$$

$$D\gamma = (3.17 \text{ X}10^{-8}\text{yr/sec})\{[(17.2 \; \frac{\text{mrad/yr}}{\mu\text{Ci/m}^3}) \; (6.49 \text{ X}10^{-6}\text{sec/m}^3) \; (2.0 \text{ X}10^{10}\mu\text{Ci})] +$$

$$[(353 \; \frac{\text{mrad/yr}}{\mu\text{Ci/m}^3}) \; (6.49 \text{ X}10^{-6}\text{ sec/m}^3) \; (8.8 \text{ X}10^{9} \; \mu\text{Ci})]\}$$

$$= 0.71 \text{ mrad/yr}$$

The annual beta air dose is calculated as follows using equation (4-2):

$$D_\beta = \{ (3.17 \times 10^{-8}) \Sigma_i [(N_i) (\chi/Q)_{SB} (Q_i)]\} \quad (4-2)$$

Where:

$N_i = 1950 \frac{mrad/yr}{\mu Ci/m^3}$ for Kr-85

$= 1050 \frac{mrad/yr}{\mu Ci/m^3}$ for Xe-133

$(\chi/Q)_{SB} = 6.49 \times 10^{-6}$ sec/m³

$Q_i = 2.0 \times 10^{10}$ μCi for Kr-85

$= 8.8 \times 10^{9}$ μCi for Xe-133

$$D_\beta = 3.17 \times 10^{-8}\{[(1950 \frac{mrad/yr}{\mu Ci/m^3}) (6.49 \times 10^{-6} sec/m^3) (2.0 \times 10^{10} \mu Ci)] + [(1050 \frac{mrad/yr}{\mu Ci/m^3}) (6.49 \times 10^{-6} sec/m^3) (8.8 \times 10^{9} \mu Ci)]\}$$

$= 9.92$ mrad/yr

A.3.2 Radionuclides Other Than Noble Gases

The methods used to calculate the critical organ dose from actual releases received by members of the public is discussed in Section 4.2 of the text. These doses are calculated at the nearest residence with the highest annual average atmospheric dispersion parameter, 2300 meters north for χ/Q and 3000 meters NE for D/Q, and the values are taken from Table 4-16. The dose factor, R_{ik}, is taken from Tables 4-1 through 4-15. The doses are calculated for the child and infant age groups using the appropriate exposure pathways. Assuming an annual release of 8.1 $X10^4$ µCi of I-131, 800 µCi of Cs-137, and 1.0 $X10^9$ µCi of H-3, the critical organ (thyroid, bone, and total body) dose is calculated as follows using equation 4-2:

$$D_{o\theta} = \{(3.17 \times 10^{-8} \text{yr/sec})\ \Sigma_i\ (Q_i)[\ \Sigma_k\ (R_{ik}\ W_{k\theta})] \qquad (4\text{-}3)$$

Where:

Q_i = 8.1 $X10^4$ µCi for I-131
= 800 µCi for Cs-137
= 1.0 $X10^9$ µCi for H-3

$W_{k\theta}$ = 3.92 $X10^{-6}$ sec/m^3, χ/Q for the inhalation pathway

and

H-3 doses from all pathways, from Table 4-16.

$W_{k\theta}$ = 3.87 $X10^{-9}$ /m^2 , D/Q for the food and ground plane pathways, from Table 4-16.

R_{ik} = valves from Tables 4-1, 4-4, 4-7, 4-10, and 4-14 for the child pathway.

R_{ik} = valves from Tables 4-1, 4-11, and 4-15 for the infant pathway

The doses to the child from the ground-plane, vegetable, meat, milk, and inhalation pathways are:

THYROID, CHILD:

$$D_{thyroid,\ I-131} = \{(3.17\ X10^{-8}\ yr/sec)(8.1\ X10^{4}\ \mu Ci)\ [(1.72\ X10^{7}\ \frac{m^2\ mrem/yr}{\mu Ci/sec})$$

$$(3.87\ X10^{-9}/m^2) + (3.3\ X10^{10}\ \frac{m^2\ mrem/yr}{\mu Ci/sec})\ (3.87\ X10^{-9}/m^2) +$$

$$(1.32\ X10^{9}\ \frac{m^2\ mrem/yr}{\mu Ci/sec})\ (3.87\ X10^{-9}/m^2) +$$

$$(1.04\ X10^{11}\ \frac{m^2\ mrem/yr}{\mu Ci/sec})\ (3.87\ X10^{-9}/m^2) +$$

$$(1.62\ X\ 10^{7}\ \frac{mrem/yr}{\mu Ci/m^3})\ (3.92\ X10^{-6}\ sec/m^3)]\}$$

= 1.90 mrem/yr to the thyroid from I-131

$$D_{thyroid,\ Cs-137} = [(3.17\ X10^{-8}\ yr/sec)\ (800\ \mu Ci)\ (1.04\ X10^{10})\ (3.89\ X10^{-9})]$$

$= 1.02\ X10^{-3}$ mrem/yr from Cs-137

$$D_{thyroid,\ H-3} = \{(3.17\ X10^{-8})\ (1.0\ X10^{9}\ \mu Ci)\ [(7920)\ (3.92\ X10^{-6}) +$$

$$(472)\ (3.92\ X10^{-6}) + (3170)\ (3.92\ X10^{-6}) +$$

$$(1120)\ (3.92\ X10^{-6})]\}$$

= 1.58 mrem/yr from H-3

$D_{thyroid,\ total}$ $= 1.90$ mrem/yr $+ 1.02 \times 10^{-3}$ mrem/yr $+ 1.58$ mrem/yr

$= 3.48$ mrem/yr from I-131, Cs-137, and H-3.

BONE, CHILD:

$D_{bone,\ I\text{-}131}$ $=\{(3.17 \times 10^{-8}) (8.1 \times 10^{4}) [(1.72 \times 10^{7}) (3.87 \times 10^{-9}) + (9.92 \times 10^{7})(3.87 \times 10^{-9}) + (3.98 \times 10^{6}) (3.87 \times 10^{-9}) + (3.13 \times 10^{8}) (3.87 \times 10^{-9}) + (4.8 \times 10^{4}) (3.92 \times 10^{-6})]\}$

$= 4.79 \times 10^{-3}$ mrem/yr from I-131

$D_{bone,\ Cs\text{-}137}$ $=\{(3.17 \times 10^{-8}) (8.0 \times 10^{2}) [(1.04 \times 10^{10}) (3.87 \times 10^{-9}) + (2.45 \times 10^{10}) (3.87 \times 10^{-9}) + (6.22 \times 10^{8}) (3.87 \times 10^{-9}) + (1.50 \times 10^{10}) (3.87 \times 10^{-9}) + (9.05 \times 10^{5}) (3.92 \times 10^{-6})]\}$

$= 5.05 \times 10^{-3}$ mrem/yr from Cs-137

$D_{bone,\ H3}$ $= 0$ mrem/yr

$D_{bone,\ total}$ $= 9.84 \times 10^{-3}$ mrem/yr from I-131, Cs-137, and H-3

TOTAL BODY, CHILD:

$D_{total\ body,\ I\text{-}131}$ $=\{(3.17 \times 10^{-8}) (8.1 \times 10^{4}) [(1.72 \times 10^{7}) (3.87 \times 10^{-9}) + (5.67 \times 10^{7}) (3.87 \times 10^{-9}) + (2.27 \times 10^{6}) (3.87 \times 10^{-9}) + (1.79 \times 10^{8}) (3.87 \times 10^{-9}) + (2.72 \times 10^{4}) (3.92 \times 10^{-6})]\}$

$= 2.81 \times 10^{-3}$ mrem/yr from I-131

$D_{total\ body,\ Cs-137}$ = {(3.17 X10^{-8}) (800) [(1.04 X10^{10}) (3.87 X10^{-9}) + (3.46 X10^{9}) (3.87 X10^{-9}) + (8.78 X10^{7}) (3.89 X10^{-9}) + (2.12 X10^{9}) (3.87 X10^{-9}) + (1.28 X10^{5}) (3.92 X10^{-6})]}

= 1.59 X10^{-3} mrem/yr from Cs-137

$D_{total\ body,\ H-3}$ = {(3.17 X10^{-8}) (1.0 X10^{9}) [(7920) (3.92 X10^{-6}) + (472) (3.92 X10^{-6}) + (3170) (3.92 X10^{-6}) + (1120) (3.92 X10^{-6})]}

= 1.58 mrem/yr from H-3

$D_{total\ body}$ = (2.82 X10^{-3} + 1.60 X10^{-3} + 1.58) mrem/yr

= 1.58 mrem/yr from I-131, Cs-137, and H-3

Doses to the infant listed by critical organ via the ground, milk, and inhalation pathways are:

THYROID, INFANT:

$$D_{I-131} = \{(3.17 \times 10^{-8})(8.1 \times 10^{4})(1.72 \times 10^{7})(3.87 \times 10^{-9})$$
$$(2.53 \times 10^{11})(3.87 \times 10^{-9}) + (1.48 \times 10^{7})(3.92 \times 10^{-6})]\}$$
$$= 2.66 \text{ mrem/yr from I-131}$$

$$D_{Cs-137} = \{(3.17 \times 10^{-8})(800)[(1.04 \times 10^{10})(3.87 \times 10^{-9})]\}$$
$$= 1.02 \times 10^{-3} \text{ mrem/yr from Cs-137}$$

$$D_{H-3} = \{(3.17 \times 10^{-8})(1.0 \times 10^{9})[(4800)(3.92 \times 10^{-6}) +$$
$$(646)(3.92 \times 10^{-6})]\}$$
$$= 0.68 \text{ mrem/yr from H-3}$$

$$D_{thyroid} = (0.68 + 1.02 \times 10^{-3} + 2.68) \text{ mrem/yr}$$
$$= 3.34 \text{ mrem/yr from I-131, Cs-137, and H-3.}$$

BONE, INFANT:

$$D_{I-131} = \{(3.17 \times 10^{-8})(8.1 \times 10^{4})[(1.72 \times 10^{7})(3.87 \times 10^{-9}) + (6.54 \times 10^{8})(3.87 \times 10^{-9}) + (3.79 \times 10^{4})(3.92 \times 10^{-6})]\}$$

$= 7.05 \times 10^{-3}$ mrem/yr from I-131

$$D_{Cs-137} = \{(3.17 \times 10^{-8})(800)[(1.04 \times 10^{10})(3.87 \times 10^{-9}) + (2.4 \times 10^{10})(3.87 \times 10^{-9}) + (5.48 \times 10^{5})(3.92 \times 10^{-6})]\}$$

$= 3.43 \times 10^{-3}$ mrem/yr from Cs137

D_{H-3} = no dose contribution from H-3

$D_{bone,\ infant}$ = 1.05×10^{-2} mrem/yr from I-131, Cs-137, and H-3

TOTAL BODY, INFANT:

$$D_{I-131} = \{(3.17 \times 10^{-8})(8.1 \times 10^{4})[(1.72 \times 10^{7})(3.87 \times 10^{-9}) + (3.37 \times 10^{8})(3.87 \times 10^{-9}) + (1.96 \times 10^{4})(3.92 \times 10^{-6})]\}$$

$= 3.74 \times 10^{-3}$ mrem/yr from I-131

$$D_{Cs-137} = \{(3.17 \times 10^{-8})(800)[(1.04 \times 10^{10})(3.87 \times 10^{-9}) + (1.99 \times 10^{9})(3.87 \times 10^{-9}) + (4.54 \times 10^{4})(3.92 \times 10^{-6})]\}$$

$= 1.22 \times 10^{-3}$ mrem/yr from Cs-137

$$D_{H-3} = \{(3.17 \times 10^{-8})(1.0 \times 10^{-9})[(4800)(3.92 \times 10^{-6}) + (646)(3.92 \times 10^{-6})]\}$$

= 0.677 mrem/yr from H-3

$$D_{total\ body,\ infant} = (3.74 \times 10^{-3} + 1.22 \times 10^{-3} + 0.677)\ mrem/yr$$

$$= 0.68\ mrem/yr \text{ from I-131, Cs-137, and H-3}$$

A.3.3 Dose Projection

A.3.3.1 Noble Gases

The methods used to project the beta and gamma air doses are discussed in Section 4.3 of the text. The dose factors, M_i and N_i, for noble gases and their daughters are taken from Table 3-1. The highest annual average dispersion parameter (X/Q) at the site boundary occurs in the north sector and the value is taken from Table 3-2. Assuming a release of 7.3 X10^8 µCi Xe-133 over the previous month, the gamma air dose is calculated as follows using equation (4-1):

$$D_\gamma = (3.17 \times 10^{-8})\ \Sigma_i [(M_i)\ (X/Q)_{SB}\ (Q_i)] \qquad (4-1)$$

Where:

M_i = 353 $\frac{mrad/yr}{\mu Ci/m^3}$ for Xe-133

$(X/Q)_{SB}$ = 6.49 X10^3 sec/m^3

Q_i = 7.3 X10^8 µCi/mo for Xe-133, the amount released during the previous month.

$$D_\gamma = (3.17 \times 10^{-8}\ \text{yr/sec})\ [(353\ \frac{\text{mrad/yr}}{\mu\text{Ci/m}^3})\ (6.49 \times 10^{-6}\ \text{sec/m}^3)\ (7.3 \times 10^{8}\ \mu\text{Ci/mo})]$$

$$= 0.05\ \text{mrad}$$

The annual beta air dose is calculated as follows using equation (4-2):

$$D_\beta = 3.17 \times 10^{-8}\ \Sigma_i\ [(N_i)\ (X/Q)_{SB}\ (Q_i)] \qquad (4\text{-}2)$$

Where:

$N_i = 1050\ \frac{\text{mrad/yr}}{\mu\text{Ci/m}^3}$ for Xe-133

$(X/Q)_{SB} = 6.49 \times 10^{-6}$ sec/m^3

$Q_i = 7.3 \times 10^{8}$ μCi/mo for Xe-133, the amount released during the previous month.

$$D_\beta = (3.17 \times 10^{-8})\ [(1050\ \frac{\text{mrad/yr}}{\mu\text{Ci/m}^3})\ (6.49 \times 10^{-6}\ \text{sec/m}^3)\ (7.3 \times 10^{8}\ \mu\text{Ci/mo})]$$

$$= 0.16\ \text{mrad}$$

A.3.3.2 Radionuclides Other Than Noble Gases

The methods used to project the critical organ dose from actual releases beyond the site boundary are discussed in Section 4.3 of the text. These doses are calculated at the site boundary in the sector with the highest annual average atmospheric dispersion parameter, north for X/Q and NNE for D/Q, and the values are taken from Table 3-2. The dose factor, R_{ik}, is taken from Tables 4-1 through 4-15. The doses are calculated for the infant age group using the appropriate exposure pathways. Assuming a release during the previous month of 2000 μCi of I-131, the critical organ (thyroid) dose is calculated as follows:

$$D_{oSB} = (3.17 \times 10^{-8} \text{ yr/sec})\{\Sigma_i(Q_i) [\Sigma_k(R_{ik} W_{kSB})]\}$$

Where:

Q_i = 2000 μCi for I-131, the amount released during the previous month.

W_{kSB} = 6.49×10^{-6} sec/m^3, X/Q for the inhalation pathway and H-3 doses from all pathways, from Table 3-2.
= 1.19×10^{-8} /m^2, D/Q for the food and ground plane pathways, from Table 3-2.

R_{ik} = from Tables 4-1, 4-11, and 4-15 for the infant pathway

Doses to the infant by critical organ via the ground, milk and inhalation pathways are:

THYROID, INFANT:

$$D_{I-131} = \{(3.17 \times 10^{-8})\ (2000)\ [(1.72 \times 10^{7})\ (1.19 \times 10^{-8}) + (2.53 \times 10^{11})\ (1.19 \times 10^{-8}) + (1.48 \times 10^{7})\ (6.49 \times 10^{-6})]$$

$$= 0.20 \text{ mrem from I-131}$$

A.4 TOTAL DOSE

This dose is calculated to the nearest resident. Using the χ/Q and D/Q from Table 4-16, the maximally exposed resident is in the north sector at 2,300 meters.

A.4.1 Noble Gases

$$D_{wb} = (3.17 \times 10^{-8}) \{\Sigma_i [(K_i (X/Q)_\theta (Q_i)]\} \qquad (5\text{-}1)$$

$$D_{sk} = (3.17 \times 10^{-8}) \{\Sigma_i [(L_i + 1.1 M_i)(\chi/Q)_\theta (Q_i)]\} \qquad (5\text{-}2)$$

If the source term is:

8.8×10^{9} µCi Xe-133

2.0×10^{10} µCi Kr-85

Then:

$$D_{wb} = (3.17 \times 10^{-8})\{[(294)(3.92 \times 10^{-6})(8.8 \times 10^{9})] + [(16.1)(3.92 \times 10^{-6})(2.0 \times 10^{10})]\}$$

$$= 0.36 \text{ mrem/yr}$$

$$D_{sk} = (3.17 \times 10^{-8})\{[(306) + (1.1)(353)] (3.92 \times 10^{-6})(8.8 \times 10^{9}) +$$

$$[(1340) + 1.1 (17.2)] (3.92 \times 10^{-6})(2.0 \times 10^{10})\}$$

$$= 4.14 \text{ mrem/yr}$$

A.4.2 Radionuclides Other Than Noble Gases

Since all other uranium fuel cycle sources are greater than 20 miles away, only PVNGS Unit 1 needs to be considered for meeting the EPA regulation, 40 CFR 190. The total dose to an individual from radionuclides other than noble gases can be calculated in the same manner as Section A.3.2 of this Appendix.

A.4.3 Direct Radiation

The direct radiation to any member of the public due to operations at PVNGS should be determined from the results of the environmental monitoring program.