OFFSITE DOSE CALCULATION MANUAL

PALO VERDE NUCLEAR GENERATING STATION

UNIT 1

Rev. 0

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1.0 INTRODUCTION

The purpose of this manual is to provide the parameters and methodology to be used in calculating offsite doses and effluent monitor setpoints at the Palo Verde Nuclear Power Plant, Unit 1. Included are methods for determining maximum individual, whole body, and organ doses due to gaseous 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 and monthly individual doses for inclusion in Effluent and Waste Disposal Semi-annual Reports.

The dose models consider only one release mode - airborne. All gaseous effluents are treated as ground level releases. Airborne releases are further subdividied into two subclasses:

a. Iodine - 131 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 inhalation 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.

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b. <u>Noble Gases</u>

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 limits of 10 CFR 50, Appendix I and 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 total 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
TOTAL QUANTITIES RELEASE		
Krypton-85 Released Per Gigawatt-Year		50,000 CURIES
Iodine-129 Released Per Gigawatt-Year		5 MILLICURIES
Combined Plutonium-239 and Other Alpha-emitting Radionuclides with Half Lives Greater than One Year Released per Gigawatt-Year		.5 MILLICURIES

2.0 GASEOUS EFFLUENT MONITOR SETPOINTS

Specification 3.3.3.10 - The radioactive gaseous effluent monitoring instrumentation channels shown in Table 3.3-12 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 in accordance with the methodology described 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 plant gaseous effluent monitor setpoints is based upon vent release concentrations (μCi/cc) derived from site-specific meteorological dispersion conditions, vent flow rates and the maximum permissible concentration (MPC) from 10 CFR Part 20 for the limiting radionuclide. The MPC limits are tabulated in Table 2-1.

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 Unit Technical Specifications.

2.1 Plant Stack - RU-143 & 144

For the purpose of implementation of Specification 3.3.3.10, the alarm setpoint level for noble gas monitors is based on the gaseous effluent flow rate and meterorological dispersion factor.

The setpoint for the detector is determined by using:

$$C \leq (.5)\ (2120)\ \frac{MPC}{(X/Q)_{SB}\ (\text{flow rate})} \qquad (2\text{-}1)$$

Where:

C = the instantaneous concentration at the detector in µCi/cc

MPC = the 10CFR Part 20 concentration for the limiting radionuclide present in sample analysis in µCi/cc (i.e., smallest MPC) from Table 2-1.

flow rate = the plant vent flow rate in cfm
= 140,610 cfm

$(X/Q)_{SB}$ = 6.49 E-6 sec/m^3, the highest annual average atmospheric dispersion parameter from Table 3-2.

2120 = conversion of cfm to m^3/sec

0.5 = an administrative value used to account for potential activity from other gaseous release pathways.

The alarm setting is determined by using the calibration curve for the applicable Plant Stack Airborne Monitor.

The alarm setpoint is the cpm value corresponding to the concentration, C, which is conservatively assumed to be the isotope of greatest sensitivity for the monitor.

2.2 Condenser Evacuation System - RU-141 & 142

For the purpose of implementation of Specification 3.3.3.10, the alarm setpoint level for noble gas monitors is based on the gaseous effluent flow rate and meteorological dispersion factor.

The setpoint for the detector is determined by using:

$$C \leq (.3)\ (2120)\ \frac{MPC}{(X/Q)_{SB}\ (\text{flow rate})} \qquad (2\text{-}2)$$

Where:

C = the instantaneous concentration to the detector in µCi/cc.

MPC = the 10CFR Part 20 concentration for the limiting radionuclide present in sample analysis in µCi/cc (i.e., smallest MPC) from Table 2-1.

flow rate = the condenser evacuation system flow rate in cfm.

= 2,960 cfm.

$(X/Q)_{SB}$ = 6.49 E-6 sec/m^3, annual highest average atmospheric dispersion parameter from Table 3-2.

2120 = conversion of cfm to m^3/sec.

0.3 = an administrative value used to account for potential activity from other gaseous release pathways.

The alarm setting is determined by using the calibration curve for the corresponding Condenser Evacuation System Monitor. The alarm setpoint is the cpm value corresponding to the concentration, C, which is conservatively assumed to be the isotope of greatest sensitivity for the monitor.

2.3 Fuel Building Vent Exhaust - RU-145 & RU-146

For the purpose of implementation of Specification 3.3.3.10, the alarm setpoint level for noble gas monitors is based on the gaseous effluent flow rate and meteorological dispersion factor.

The setpoint for the detector is determined by using:

$$C \leq (.2)\ (2120)\ \frac{MPC}{(X/Q)\ (\text{flow rate})} \qquad (2\text{-}3)$$

Where:

C = instantaneous concentration at the detector in µCi/cc.

MPC = the 10CFR Part 20 concentration for the limiting radionuclide present in sample analysis in µCi/cc (i.e., smallest MPC).

flow rate = fuel building vent exhaust flow rate in cfm
= 55,500 cfm.

$(X/Q)_{SB}$ = the highest annual average dispersion parameter from Table 3-2.

= 6.49E-6 sec/m^3.

2120 = conversion of cfm to m^3/sec.

0.2 = an administrative value used to account for potential activity from other gaseous release pathways.

The alarm setting is determined by using the calibration curve for the applicable Plant Stack Airborne Monitor.

The alarm setpoint is the cpm value coresponding to the concentration, C, which is conservatively assumed to be the isotope of greatest sensitivity for the monitor.

Table 2-1
10CFR20 MPC LIMITS (uCi/cm^3)

NUCLIDE	MPC LIMIT (μCi/cm^3)
KR-83M	3E-8 *
KR-85M	1E-7
KR-85	3E-7
KR-87	2E-8
KR-88	2E-8
KR-89	3E-8
XE-131M	4E-7
XE-133M	3E-7
XE-133	3E-7
XE-135M	3E-8
XE-135	1E-7
XE-137	3E-8
XE-138	3E-8
BR-83	1E-10
BR-84	3E-8
BR-85	3E-8
I-130	1E-10
I-131	1E-10
I-132	3E-9
I-133	4E-10
I-134	6E-9
I-135	1E-9
CO-60	3E-10
CO-58	2E-9
FE-59	2E-9
MN-54	1E-9
CS-137	5E-10
CS-134	4E-10
SR-90	3E-11
SR-89	3E-10
H-3	2E-7
C-14	1E-7
AR-41	4E-8

* 3E-8 = 3×10^{-8}

3.0 GASEOUS EFFLUENT DOSE RATE

Specification 3.11.2.1 - The dose rate due to radioactive materials released in gaseous effluents from the site to areas at and beyond the SITE BOUNDARY shall be limited to the following:

a. 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.

b. Iodine-131, 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 (inhalation pathway only).

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 ventilation 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:

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

and by the following equation for skin dose:

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

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, $\mu Ci/sec$.

$(X/Q)_{SB}$ = the highest calculated annual average relative concentration for any area at the site boundary 6.49 E-6 sec/m^3 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 ventilation releases for radioiodines, radioactive particulates and other radionuclides except noble gases, 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:

$$D_o = \Sigma_i (P_i)(X/Q)_{SB} (Q_i') \quad (3\text{-}3)$$

Where:

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

$(X/Q)_{SB}$ = the highest calculated annual average dispersion parameter for estimating the dose to an individual from Table 3-2.

= 6.49 E-6 sec/m^3 for the inhalation pathway. The location is at the site boundary in the N sector.

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

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

Sample calculations for determing 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
Ar141	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)	X/Q (Sec/cub.meter)	D/Q (per sq.meter)
N	1037.	6.49E-06	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

TABLE 3-3

P Values for the Palo Verde Nuclear Generating Station

- child - inhalation pathway

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4.0 DOSE DUE TO GASEOUS EFFLUENT

4.1 Noble Gases

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 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.

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 specific time period:

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

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

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

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.

$(X/Q)_{SB}$ = the highest calculated annual average relative concentration for any area 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 (mrad).

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

Q_i = the integrated release of each identified noble gas radionuclide, i, in gaseous effluents for a specified time period (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, sample calculations for determining gamma and beta air doses from noble gas radionuclides released from the PVNGS are given there.

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

Specification 3.11.2.3 - The dose to a MEMBER OF THE PUBLIC from iodine-131, tritium and all radionuclides in particulate form with half-lives greater than 8 days at or beyond the SITE BOUNDARY shall be limited to the following:

a. During any calendar quarter - Less than or equal to 7.5 mrems to any organ.

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

The dose to a realistic individual from radioiodines, radioactive materials in particulate form and all rdionuclides other than noble gases with half-lives greater than eight days in gaseous effluents released to unrestricted areas is calculated using the following expressions:

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

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 $\mu Ci/m^3$ 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.

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

= (X/Q) for the inhalation pathway in sec/m^3. The (X/Q) for the nearest residence in Sector, θ, is given in Tables 4-16.

= (D/Q) for the food and ground plane pathways in m^{-2}. The (D/Q) for the nearest residence in Sector θ is given in Table 4-16.

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 assume 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 them:

	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 the Section 2.3 of the PVNGS ER-OL.

TABLES 4-1 - 4-15

R Values for the Palo Verde Nuclear Generating Station

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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/cub.meter)	D/Q (per sq.meter)
N	2300.	3.92E-06	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

5.0 TOTAL DOSE

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 cumulative dose to any member of the public due to radioactive releases from the PVNGS site is determined by summing the calculated doses to critical organs from the previously-discussed effluent sources. The annual dose to critical organs of a real individual for the noble gases released in the gaseous effluents is determined by using.

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

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

Where:

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

Q_i = the release rate of radionuclide, i.

$(X/Q)_\theta$ = the highest calculated annual average relative concentration for the nearest residence in Sector, θ, in sec/m^3 from Table 4-16.

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

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).

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

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

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 rdionuclides 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 $\mu Ci/m^3$ 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.

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

= (X/Q) for the inhalation pathway in sec/m^3. The (X/Q) for the nearest residence in Sector θ, is given in Table 4-16.

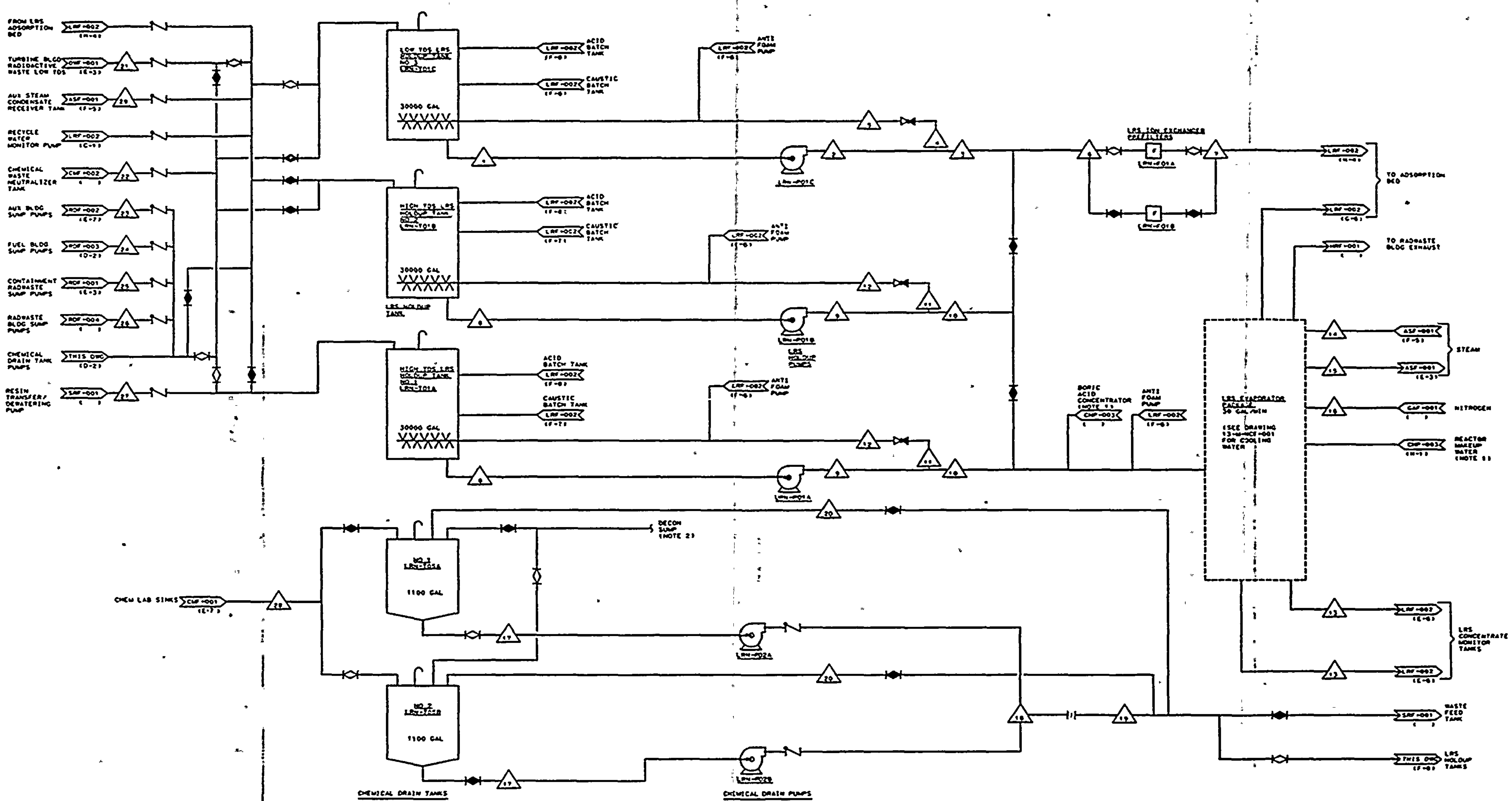
= (D/Q) for the food and ground plane pathways in m^{-2}.
The (D/Q) for the nearest residence in Sector θ is given in Tables 4-16.

For all dose calculations from gaseous effluents, the 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.

The direct radiation from the site should be determined from the environmental monitoring program's direct radiation (TLD) monitors. 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	INTER-MITTENT	-
NORMAL OPERATION	FLOW (GPM)	250	250	100	150	150	100	100	250	250	30	220	220	50	
	TEMPERATURE (°F)	80	80	80	80	80	80	80	80	80	80	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	120	120	120	120	120	120	120	120	120	120	224	
	PRESSURE (PSIA)	24	112	107	117	45	92	67	24	112	107	111	57	50	
	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	INTER-MITTENT	INTER-MITTENT	INTER-MITTENT	INTER-MITTENT	BATCH	INTER-MITTENT	INTER-MITTENT
NORMAL OPERATION	FLOW (GPM)	22,000 (1)	22,000 (1)	-	30	30	30	-	120 (3)	-	50 (3)	150 (3)	55 (3)	50 (3)	100	6 (9)	-
	TEMPERATURE (°F)	340	300	AMB	80	80	80	-	80	-	80	85	80	80	80	80	-
	PRESSURE (PSIA)	50	50	25 (8)	17	38	65	-	30	-	50	38	25	30	30	15	-
SAMPLE MODE	FLOW (GPM)	-	-	-	55	55	55	55	-	-	-	-	-	-	-	-	-
	TEMPERATURE (°F)	-	-	-	120	120	120	120	-	-	-	-	-	-	-	-	-
	PRESSURE (PSIA)	-	-	-	15	36	21	15	-	-	-	-	-	-	-	-	-
MAXIMUM DESIGN	FLOW (GPM)	22,000 (1)	22,000 (1)	-	55	55	55	55	200 (6)	400	130 (4)	325 (4)	70 (4)	70 (4)	100	8 (9)	100 (7)
	TEMPERATURE (°F)	340	300	AMB	120	120	120	120	120	120	120	140	120	120	120	120	212
	PRESSURE (PSIA)	50	50	25 (8)	15	36	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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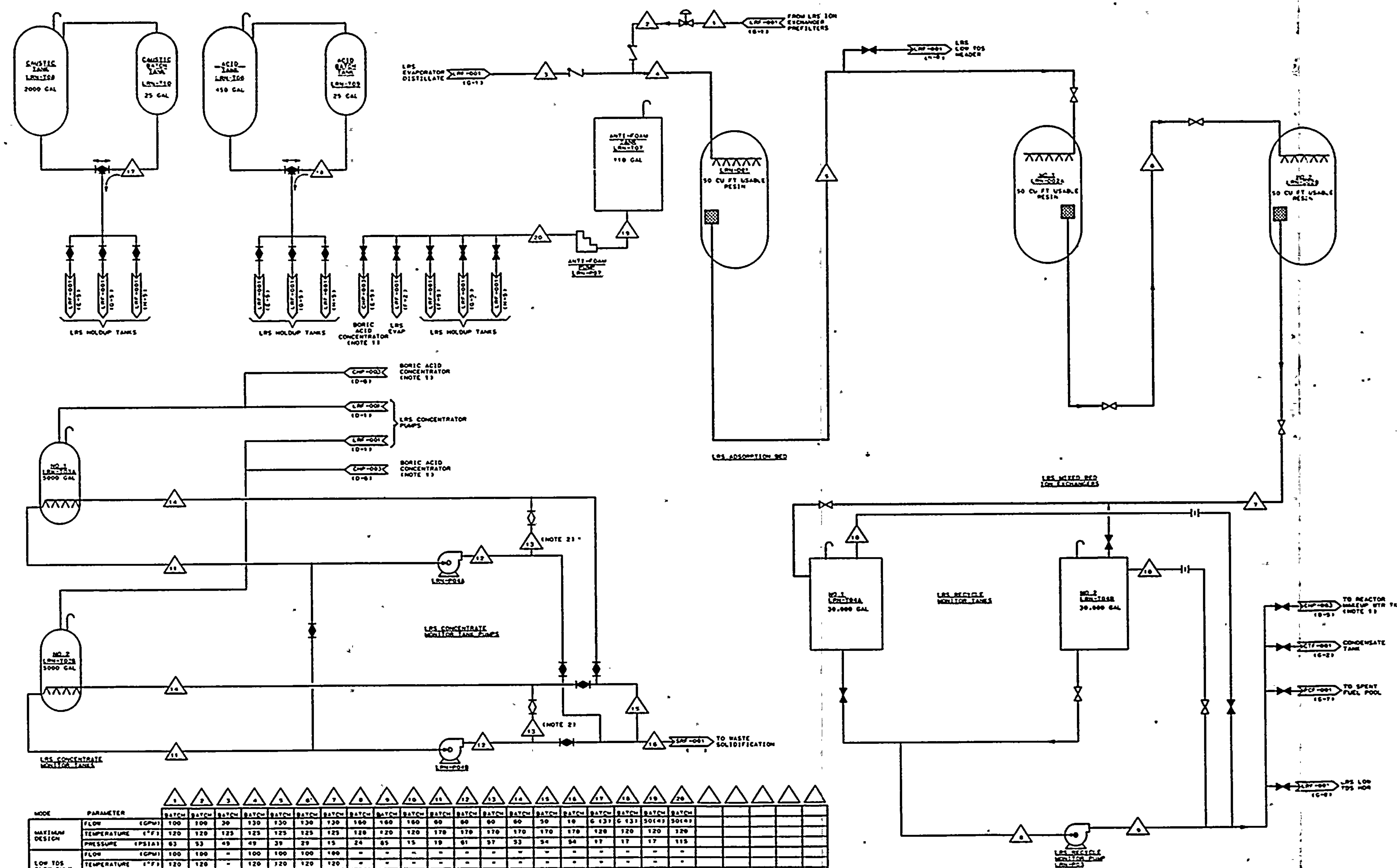
Palo Verde Nuclear Generating Station

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

FIGURE 6-1



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	G (3)	G (3)	50(4)	50(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	19	61	57	53	54	54	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	-	-	G (3)	G (3)	50(4)	50(4)					
	TEMPERATURE (°F)	80	80	125	125	125	125	125	80	80	-	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)	-	-	-	-	-	-	-	160	160	160	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 SOLIDIFI-CATION	FLOW (GPM)	-	-	-	-	-	-	-	-	-	-	50	50	-	50	50	10	-		-	-					
	TEMPERATURE (°F)	-	-	-	-	-	-	-	-	-	-	170	170	-	170	170	170	-		-	-					
	PRESSURE (PSIA)	-	-	-	-	-			-	-	-	16	64	-	44	54	54	-	-	-						

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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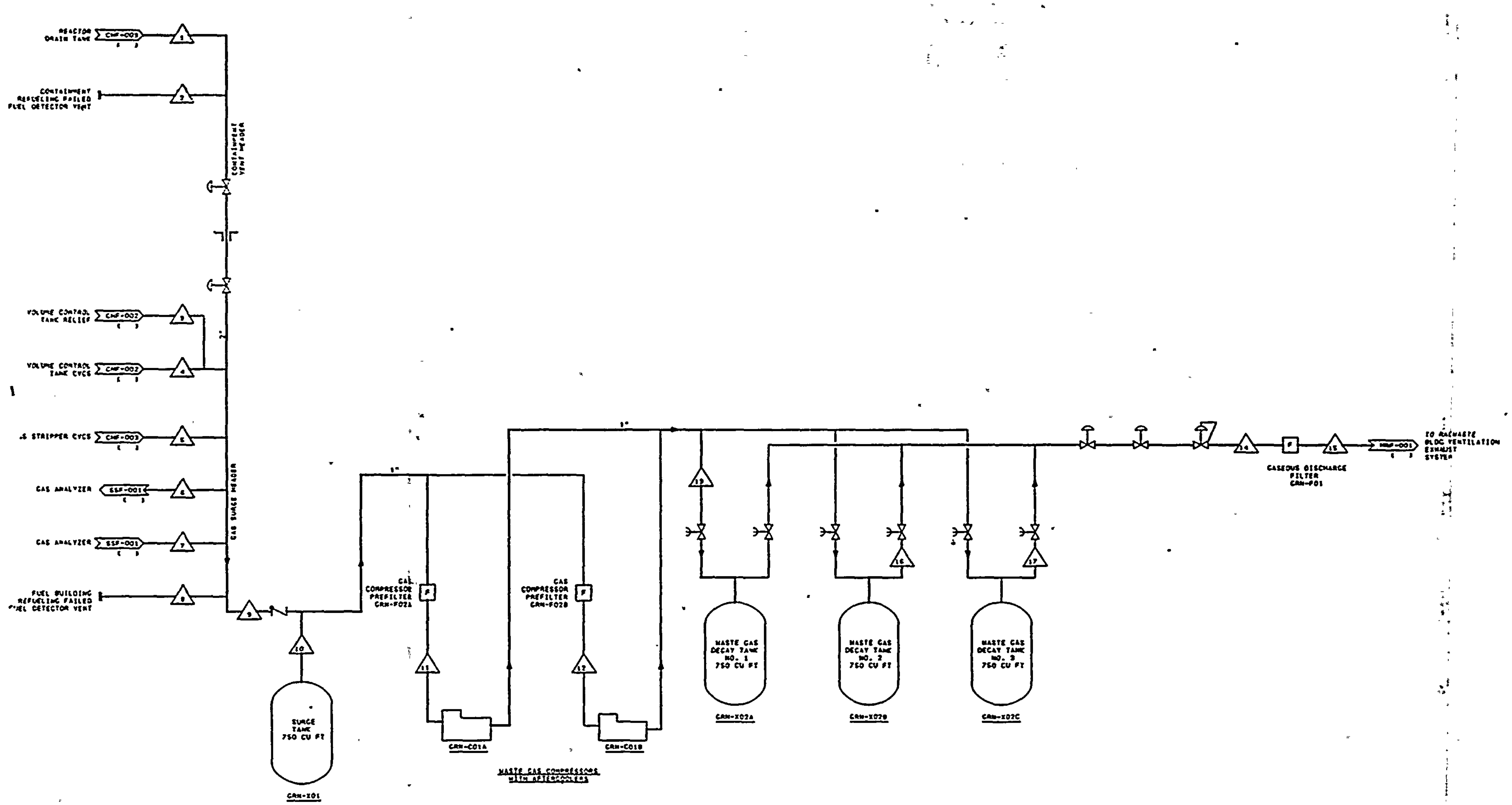
Palo Verde Nuclear Generating Station

FLOW DIAGRAM
LIQUID RADWASTE SYSTEM
(Sheet 2 of 2)

FIGURE 6-1



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	0	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	0.04	0	0.38	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	0.04	0	0.38	9.62	10.000	0	10	0	0	0	0
	TEMPERATURE (°F)	100	AMB	AMB	AMB	120	AMB	120	AMB	120	100	100	AMB	125	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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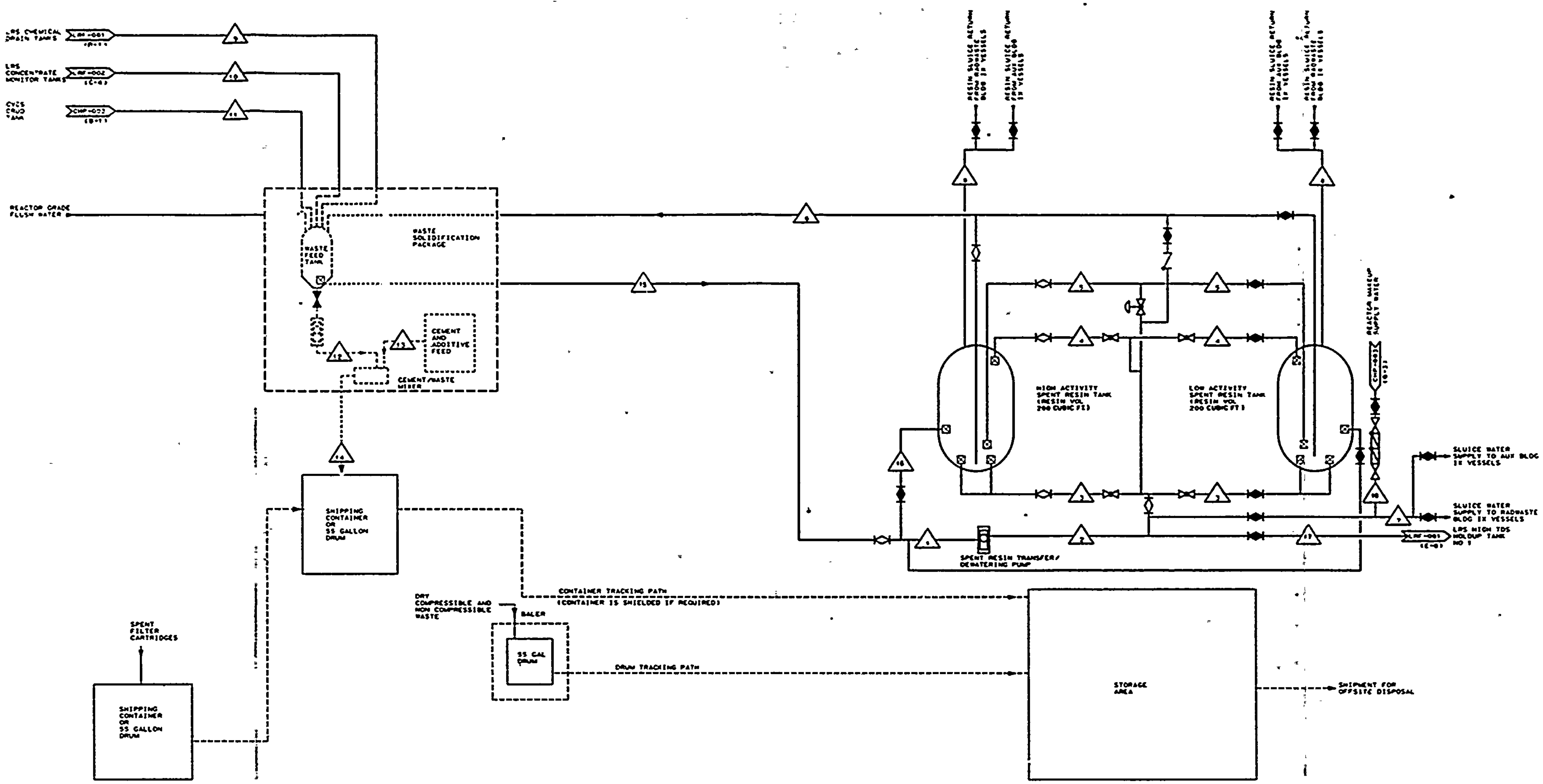
Palo Verde Nuclear Generating Station

BASIC FLOW DIAGRAM
GASEOUS RADWASTE SYSTEM

Figure 6-2



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	121.2	—	—	—	22.8	—	—	—	—	—	—	—	—	15	—	—	—
SLUICING RESIN FROM A SPENT RESIN TANK TO WASTE FEED TANK	FLOW (GPM)	75	75	5	15	55	75	0	0	0	0	0	0	0	0	75	—	—	—
	TEMPERATURE (°F)	170	170	170	120	120	120	—	—	—	—	—	—	—	—	170	—	—	—
	PRESSURE (PSIA)	109	121.2	83.1	83.1	83.1	22.8	—	—	—	—	—	—	—	—	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)	30	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*	380*	—	—	—	—
	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	0	0	0	0	0	0	—	75	75	75
	TEMPERATURE (°F)	170	170	—	—	—	—	70	120	—	—	—	—	—	—	—	70	70	120
	PRESSURE (PSIA)	10	150	—	—	—	—	150	20	—	—	—	—	—	—	—	20	100	130

* POUNDS OF CEMENT PER MINUTE

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Palo Verde Nuclear Generating Station

BASIC FLOW DIAGRAM
SOLID RADWASTE SYSTEM

Figure 6-3

7.0 RADIOLOGICAL ENVIRONMENTAL PROGRAM

7.1 Radiological Environmental Monitoring Program

Specification 4.12.1.1 - 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

Specification 3.12.2 - A land use census shall be conducted and shall identify within a distance of 8 km (5 miles) the loation 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 calclated dose or dose commitment greater than the values calculated from current sample lcoations, 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:

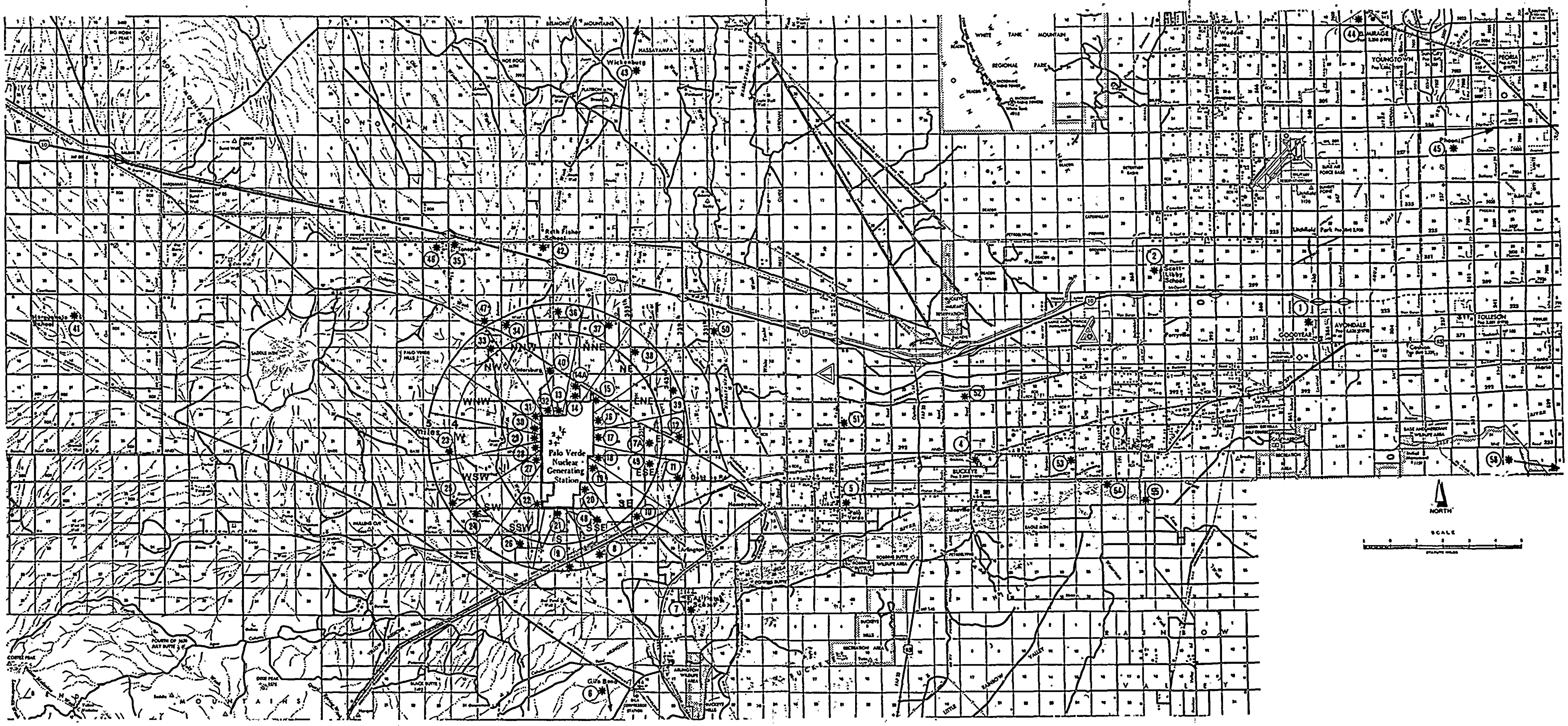
1. If the D/Q is at least 20% greater than a previously high D/Q, one of the existing sample locations may be replaced after an evaluation* with a new one within 60 days.

---

*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.



Palo Verde Nuclear Generating Station

RADIOLOGICAL ENVIRONMENTAL
MONITORING PROGRAM SAMPLE SITES

Figure 7-1

TABLE 7-1

RADIOLOGICAL ENVIRONMENTAL MONITORING SAMPLE COLLECTION LOCATIONS

SAMPLE SITE	SAMPLE TYPE	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] 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	Corner of 339th Ave. & Dobbins Rd
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
16	TLD[b]	ENE2	ENE Site Boundary

TABLE 7-1

SAMPLE SITE	SAMPLE TYPE	LOCATION DESIGNATION[a]	LOCATION DESCRIPTION
17	TLD[b]	E2	E Site Boundary
17A	Air	E4	351st Ave., 1 mi. S of B-S 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	S3	S Site Boundary
22	TLD[b]	SSW3	SSW Site Boundary
23	TLD[b]	W5	Benchmark at Baseline
24	TLD[b], Water	SW5	Ward Rd. @ Well 18bbb
25	TLD[b]	WSW5	Ward Rd. @ DF Well 2 Rd.
26	TLD[b], Water	SSW5	Well 21 Cbb$_2$
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	LOCATION DESIGNATION[a]	LOCATION DESCRIPTION
32	TLD[b]	NNW1	NNW Site Boundary
33	TLD[b]	NW5	Yuma Rd. 1/2 mi. W. of Belmont Rd.
34	TLD[b]	NNW5	Corner Belmont Rd. & Van Buren Rd.
35	TLD[b], Air	NNW9	Tonopah, Palo Verde Inn Fire Station
36	TLD[b]	N5	Corner of Wintersburg Rd. & Van Buren
37	TLD[b]	NNE5	Corner of 363rd Ave. & Van Buren
38	TLD[b]	NE5	Corner of 355th Ave. & Yuma Rd.
39	TLD[b]	ENE5	343rd Ave., 1/2 mi. S. of L. Buckeye
40	TLD[b], Air[b], Water	N3	Trailer Park; Water at Red Quail Str.
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	ENE35	APS El Mirage Office (Sun City)
45	TLD	ENE50	APS Headquarters (Phoenix)
46	Water[b], Veg.[b]	NNW9	McArthur's Farm, Tonopah

TABLE 7-1

SAMPLE SITE	SAMPLE TYPE	LOCATION DESIGNATION[a]	LOCATION DESCRIPTION
47	Water	NNW6	Winter's Wells
48	Water[b]	SSE4	Well 14dbb
49	Water[b]	ESE4	Glover Residence, 351st Ave. & Dobbins
50	Milk[b]	NE7	Baisley Dairy, 331st Ave. & Van Buren
51	Milk[b], Veg.[b]	E15	Butler Dairy, P. Verde Rd. & Southern
52	Vegetation[b]	E15	Cambron Farm, Miller Rd. & Broadway
53	Milk	E20	Kerr Dairy, Dean & Buckeye Rds.
54	Milk	E25	Skousen Dairy, Airport & Dobbins
55	Milk[b]	E25	Lueck Dairy, Jackrabbit & Hazen Rds.
56	Milk	E50	Paxton Dairy, McQueen & Ryan Rds.

(a) Table J-1, NUREG-0654; distances are from centerline of Unit 2 containment.

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

TABLE 7-2

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	

[illegible]

TABLE 7-2

[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 represents 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)

E is the counting efficiency (as counts per transformation)

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

2.22 is the number of disintegrations per minute per picocurie

Y is the fractional radiochemical yield (when applicable)

λ is the radioactive decay constant for the particular 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 the the LLD is defined as a priori (before the fact) limit representing the capability of a measurement system and not as a posteriori (after the fact) limit for a particular measurement.

[b]LLD for drinking water.

TABLE 7-3

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

Exposure Pathway and/or Sample	Sampling and Collection Frequency	Type and Frequency of Analysis	Sampling Locations[a]
Airborne radioiodine and particulates	Continuous sampling collected weekly	Gross beta weekly; I-131 weekly; gamma spectrum monthly; composite of filters	Twelve locations as listed in Table 7-1
Direct radiation	TL dosimeters at location changed quarterly and annually	Gamma dose quarterly and annually	45 locations (Nos. 1-45) as described in Table 7-1
Waterborne Surface	Monthly Composite of weekly grab sample	Gamma spectrum monthly; tritium quarterly	On-site reservoir and evaporation pond[b]
Ground	Quarterly grab sample	Tritium and gamma spectrums quarterly	On-site well Nos. 34abb, 27ddc.
Drinking (well)	Composite sample one-month period	Gross beta and gamma spectrums monthly; tritium quarterly	24, 46, 49
Ingestion Milk	Semimonthly for animals on pasture, otherwise monthly	Gamma spectrum and radioiodine semimonthly or monthly	50, 51, 53-56
Food products	Monthly when available	Gamma spectrum and radioiodine monthly	46, 51,52

APPENDIX A
SAMPLE CALCULATIONS

A.1 GASEOUS EFFLUENT MONITOR SETPOINTS

The monitor setpoints are calculated using the isotope of greatest sensitivity for the monitor, Kr-85, and equations 2-1, 2-2, and 2-3. The MPC limit for Kr-85 is given in Table 2-1 and is 3.0 E-7 $\mu Ci/cm^3$. The highest annual average atmospheric dispersion parameter at the site boundary occurs in the north sector and is 6.49 E-6 sec/m^3, and is found in Table 3-2.

A.1.1 Plant Stack

$$C \leq (0.5)\ (2120)\ \frac{MPC}{(X/Q)_{SB}\ (\text{flow rate})} \qquad (2\text{-}1)$$

$$C \leq \frac{(0.5)\ \left(2120\ \frac{\text{cfm}}{m^3/\text{sec}}\right)\ (3.0\ E\text{-}7\ \mu Ci/cm^3)}{(6.49\ E\text{-}6\ sec/m^3)\ (140{,}610\ \text{cfm})}$$

$$C \leq 3.48\ E\text{-}4\ \mu Ci/cm^3$$

A.1.2 Condenser Evacuation System

The setpoint for these monitors will be calculated by the method described in Section 2.2, and equation 2-2. The flow rate of this system is 2,960 cfm.

$$C \leq \frac{(0.3)\ \left(2120\ \frac{\text{cfm}}{m^3/\text{sec}}\right)\ (MPC)}{(X/Q)_{SB}\ (\text{flow rate})} \qquad (2\text{-}2)$$

$$C \leq \frac{(0.3)\ (2120\ \frac{cfm}{m^3/sec})\ (3.0\ E\text{-}7\ \mu Ci/cm^3)}{(6.49\ E\text{-}6\ sec/m^3)\ (2{,}960\ cfm)}$$

$C \leq 9.93\ E\text{-}3\ \mu Ci/cm^3$

This alarm setpoint is the cpm value corresponding to the setpoint concentration, C. This cpm value will be determined during the calibration of these monitors.

A.1.3 Fuel Building Vent Exhaust

The setpoint for these monitors will be calculated by the method described in Section 2.3 and equation 2-3. The flow rate for this vent is 55,500 cfm.

$$C \leq \frac{(0.2)\ (2120\ \frac{cfm}{m^3/sec})\ (MPC)}{(X/Q)_{SB}\ (flow\ rate)} \quad (2\text{-}3)$$

$$C \leq \frac{(0.2)\ (2120\ \frac{cfm}{m^3/sec})\ (3.0\ E\text{-}7\ \mu Ci/cm^3)}{(6.49\ E\text{-}6\ sec/m^3)\ (55{,}000\ cfm)}$$

$C \leq 3.53\ E\text{-}4\ \mu Ci/cm^3$

This alarm setpoint is the cpm value corresponding to the setpoint concentration, C. This cpm value will be determined during the calibration of these monitors.

A.2 GASEOUS EFFLUENT DOSE RATE

A.2.1 Noble Gases

The methods used to calculate the annual 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 279µCi/sec of Xe-133, and 634µCi/sec of Kr-85, the whole body is to be calculated, using equations 3-1, as follows:

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

Where:

$$K_i = 1.61 \text{ E+1} \; \frac{\text{mrem/yr}}{\mu\text{Ci/m}^3} \text{ for Kr-85}$$

$$= 2.94 \text{ E+1} \; \frac{\text{mrem/yr}}{\mu\text{Ci/m}^3} \text{ for Xe-133}$$

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

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

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

$$D_{wb} = \left[(1.61 \text{ E+1} \; \frac{\text{mrem/yr}}{\mu\text{Ci/m}^3}) \; (6.49 \text{ E-6 sec/m}^3) \; (634 \; \mu\text{Ci/sec})\right] +$$

$$\left[(2.94 \text{ E+2} \; \frac{\text{mrem/yr}}{\mu\text{Ci/m}^3}) \; (6.49 \text{ E-6 sec/m}^3) \; (279 \; \mu\text{Ci/sec})\right]$$

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

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

$$D_s = \Sigma_i \, (L_i + 1.1M_i) \, (X/Q)_{SB} \, Q_i' \qquad (3\text{-}2)$$

Where:

$L_i = 1.34\text{ E+3 } \frac{\text{mrem/yr}}{\mu\text{Ci/m}^3}$ for Kr-85

$= 3.06\text{ E+2 } \frac{\text{mrem/yr}}{\mu\text{Ci/m}^3}$ for Xe-133

$M_i = 1.72\text{ E+1 } \frac{\text{mrad/yr}}{\mu\text{Ci/m}^3}$ for Kr-85

$= 3.53\text{ E+2 } \frac{\text{mrad/yr}}{\mu\text{Ci/m}^3}$ for Xe-133

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

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

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

$$D_s = \left(\left[\left(1.34\text{ E+3 } \frac{\text{mrem/yr}}{\mu\text{Ci/m}^3}\right) + 1.1\left(1.72\text{ E+1 } \frac{\text{mrad/yr}}{\mu\text{Ci/m}^3}\right)\right] (6.49\text{ E-6 sec/m}^3)(634\ \mu\text{Ci/sec})\right) +$$
$$\left(\left[\left(3.06\text{ E+2 } \frac{\text{mrem/yr}}{\mu\text{Ci/m}^3}\right) + 1.1\left(3.53\text{ E-2 } \frac{\text{mrad/yr}}{\mu\text{Ci/m}^3}\right)\right] (6.49\text{ E-6 sec/m}^3)(279\ \mu\text{Ci/sec})\right)$$

$D_s = 6.15$ mrem/yr from Kr-85 and Xe-133

A.2.2 Radionuclides Other Than Noble Gases

The methods used to calculate the annual critical organ dose rate is 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 taken from Table 3-2. Assuming a release rate of 5.31 E-4 μCi/sec of I-131, 2.54 E-1 μCi/sec of C-14, 2.54 E-5 μCi/sec of Cs-137 and 3.17 E+1 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:

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

$$= 3.59\ E{+}4\ \frac{mrem/yr}{\mu Ci/m^3} \text{ for C-14}$$

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

$$= 1.12\ E{+}3\ \frac{mrem/yr}{\mu Ci/m^3} \text{ for H-3}$$

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

$$Q_i' = 5.31\ E{-}4\ \mu Ci/sec \text{ for I-131}$$

$$= 2.54\ E{-}1\ \mu Ci/sec \text{ for C-14}$$

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

$$= 3.17\ E{+}1\ \mu Ci/sec \text{ for H-3}$$

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

$$\left[(3.59\ E{+}4\ \frac{mrem/yr}{\mu Ci/m^3})\ (6.49\ E{-}6\ sec/m^3)\ (2.54\ E{-}1\ \mu Ci/sec)\right] +$$

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

$$\left[(1.12\ E{+}3\ \frac{mrem/yr}{\mu Ci/m^3}\ (6.49\ E{-}6\ sec/m^3)\ (3.17\ E{+}1\ \mu Ci/sec)\right]$$

$$D_o = 0.35\ mrem/yr$$

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 at the site boundary occurs in the north sector and the value as taken from Table 3-2. Assuming an annual release of 8.8 E+9 μCi Xe-133 and 2.0 E+10 μCi Kr-85, the gamma air dose is calculated as follows using equation 4-1.

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

Where:

$$M_i = 1.72\ E{+}1\ \frac{mrad/yr}{\mu Ci/m^3} \text{ for Kr-85}$$

$$= 3.53\ E{+}2\ \frac{mrad/yr}{\mu Ci/m^3} \text{ for Xe-133}$$

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

Q_i = 2.0 E+10 μCi/yr for Kr-85

= 8.8 E+9 μCi/yr for Xe-133

$$D_\gamma = (3.17\ E\text{-}8\ yr/sec)\left[(1.72\ E\text{+}1\ \frac{mrad/yr}{\mu Ci/m^3})\ (6.49\ E\text{-}6\ sec/m^3)\ (2.0\ E\text{+}10\ \mu Ci/yr) + (3.53\ E\text{+}2\ \frac{mrad/yr}{\mu Ci/m^3})\ (6.49\ E\text{-}6\ sec/m^3)\ (8.8\ E\text{+}9\ \mu Ci/yr)\right]$$

= 0.71 mrad/yr

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

$$D_\beta = 3.17\ E\text{-}8\ \Sigma_i\ N_i \cdot (X/Q)_{SB}\ Q_i \qquad (4\text{-}2)$$

Where:

N_i = 1.95 E+3 $\frac{mrad/yr}{\mu Ci/m^3}$ for Kr-85

= 1.05 E+3 $\frac{mrad/yr}{\mu Ci/m^3}$ for Xe-133

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

Q_i = 2.0 E+10 μCi/yr for Kr-85

= 8.8 E+9 μCi/yr for Xe-133

$$D_\beta = 3.17\text{ E-8} \left[(1.95\text{ E+3 } \frac{\text{mrad/yr}}{\mu\text{Ci/m}^3}) (6.49\text{ E-6 sec/m}^3) (2.0\text{ E+10 } \mu\text{Ci/yr}) + (1.05\text{ E+3 } \frac{\text{mrad/yr}}{\mu\text{Ci/m}^3}) (6.49\text{ E-6 sec/m}^3) (8.8\text{ E+9 } \mu\text{Ci/yr}) \right]$$

$$= 9.92\text{ mrad/yr}$$

A.3.2 Radionuclides Other Than Noble Gases

The methods used to calculate the critical organ dose from actual releases received by real 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, 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 E+4 µCi/yr of I-131, 8.0 E+2 µCi of Cs-137, 8.0 E+6 µCi/yr of C-14, and 1.0 E+9 µCi/yr of H-3, the critical organ dose is calculated as follows using equation 4-2. The critical organs used are thyroid, bone and total body.

$$D_{o\theta} = (3.17\text{ E-8 yr/sec}) \sum_i Q_i \left(\sum_k R_{ik} W_{k\theta}\right) \qquad (4\text{-}3)$$

Where:

Q_i = 8.1 E+4 µCi/yr for I-131
= 8.0 E+2 µCi/yr for Cs-137
= 8.0 E+6 µCi/yr for C-14
= 1.0 E+9 µCi/yr for H-3

$W_{k\theta}$ = X/Q for the inhalation pathway, 3.92 E-6 sec/m^3, from Table 4-16.

= D/Q for the food and ground plane pathways, 3.60 E-9/m^2, from Table 4-16.

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

from Tables 4-1, 4-11, and 4-15 for the infant pathway

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

THYROID, CHILD:

$$D_{thyroid,\ I\text{-}131} = 3.17\ E\text{-}8\ yr/sec\ \ (8.1\ E{+}4\ \mu Ci/yr\cdot I\text{-}131)\Big[(1.72\ E{+}7\ \frac{m^2\ mrem/yr}{\mu Ci/sec})\ (3.6\ E\text{-}9/m^2) + (3.3\ E{+}10\ \frac{m^2\ mrem/yr}{\mu Ci/sec})\ (3.6\ E\text{-}9/m^2) + (1.32\ E{+}9\ \frac{m^2\ mrem/yr}{\mu Ci/sec})\ (3.6\ E\text{-}9/m^2) + (1.40\ E{+}11\ \frac{m^2\ mrem/yr}{\mu Ci/sec})\ (3.6\ E\text{-}9/m^2) + (1.62\ E{+}7\ \frac{m^2\ mrem/yr}{\mu Ci/sec})\ (3.92\ E\text{-}6\ sec/m^3)\Big]$$

= 1.77 mrem/yr to the thyroid from I-131

$$D_{thyroid,\ Cs\text{-}137} = (3.17\ E\text{-}8\ yr/sec)\ (8.0\ E{+}2\ \mu Ci/yr)\ (1.04\ E{+}10)\ (3.6\ E\text{-}9)$$

= 9.49 E-4 mrem/yr from Cs-137

$D_{thyroid, C-14}$ = (3.17 E-8) (8.0 E+6 µCi/yr) [(6.92 E+5) (3.6 E-9) + (1.07 E+5)(3.6 E-9) + (3.32 E+5) (3.6 E-9)]

= 1.03 E-3 mrem/yr from C-14

$D_{thyroid, H-3}$ = (3.17 E-8) (1.0 E+9 µCi/yr) [(7.92 E+3) (3.92 E-6) + (4.72 E+2) (3.92 E-6) + (3.17 E+3) (3.92 E-6) + (1.12 E+3) (3.92 E-6)]

= 1.58 mrem/yr from H-3

$D_{thyroid, total}$ = 1.77 mrem/yr + 9.49 E-4 mrem/yr + 1.03 E-3 mrem/yr + 1.58 mrem/yr

= 3.35 mrem/yr from I-131, Cs-137, C-14 and H-3.

BONE, CHILD:

D_{I-131} = (3.17 E-8) (8.1 E+4) [(1.72 E+7) (3.6 E-9) + (9.92 E+7)(3.6 E-9) + (3.98 E+6) (3.6 E-9) + (3.13 E+8) (3.6 E-9) + (4.8 E+4) (3.92 E-6)]

= 4.50 E-3 mrem/yr from I-131

D_{Cs-137} = (3.17 E-8) (8.0 E+2) [(1.04 E+10) (3.6 E-9) + (2.45 E+10) (3.6 E-9) + (6.62 E+8) (3.6 E-9) + (1.53 E+10) (3.6 E-9) + (9.05 E+5) (3.92 E-6)]

= 4.70 E-3 mrem/yr from Cs-137

[illegible]

$$D_{C-14} = (3.17\ E-8)\ (8.0\ E+6) [(3.46\ E+6)\ (3.6\ E-9) + (5.33\ E+5)\ (3.6\ E-9) + (1.66\ E+6)\ (3.6\ E-9)]$$

$$= 5.16\ E-3 \text{ mrem/yr from C-14}$$

$$D_{bone,\ total} = 1.43\ E-2 \text{ mrem/yr from I-131, Cs-137, H-3 and C-14}$$

TOTAL BODY, CHILD:

$$D_{I-131} = (3.17\ E-8)\ (8.1\ E+4) [(1.72\ E+7)\ (3.6\ E-9) + (5.67\ E+7)\ (3.6\ E-9) + (2.27\ E+6)\ (3.6\ E-9) + (1.79\ E+8)\ (3.6\ E-9) + (2.72\ E+4)\ (3.92\ E-6)]$$

$$= 2.63\ E-3 \text{ mrem/yr from I-131}$$

$$D_{Cs-137} = (3.17\ E-8)\ (8.0\ E+2) [(1.04\ E+10)\ (3.6\ E-9) + (3.46\ E+9)\ (3.6\ E-9) + (8.78\ E+7)\ (3.6\ E-9) + (2.2\ E+9)\ (3.6\ E-9) + (1.28\ E+5)\ (3.92\ E-6)]$$

$$= 1.48\ E-3 \text{ mrem/yr from Cs-137}$$

$$D_{C-14} = (3.17\ E-8)\ (8.0\ E+6) [(6.92\ E+5)\ (3.6\ E-9) + (1.07\ E+5)\ (3.6\ E-9) + (3.32\ E+5)\ (3.6\ E-9)]$$

$$= 1.03\ E-3 \text{ mrem/yr from C-14}$$

$$D_{thyroid,\ H-3} = (3.17\ E-8)\ (1.0\ E+9) [(7.92\ E+3)\ (3.92\ E-6) + (4.72\ E+2)\ (3.92\ E-6) + (3.17\ E+3)\ (3.92\ E-6) + (1.12\ E+3)\ (3.92\ E-6)]$$

$$= 1.58 \text{ mrem/yr from H-3}$$

$$D_{total\ body,\ child} = (2.63\ E\text{-}3 + 1.48\ E\text{-}3 + 1.03\ E\text{-}3 + 1.58)\ mrem/yr$$

$$= 1.58\ mrem/yr\ \text{from I-131, Cs-137, C-14 and H-3}$$

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

THYROID, INFANT:

$$D_{I\text{-}131} = (3.17\ E\text{-}8)\ (8.1\ E\text{+}4) \left[(1.72\ E\text{+}7)\ (3.6\ E\text{-}9) + (2.53\ E\text{+}11)\ (3.6\ E\text{-}9) + (1.48\ E\text{+}7)\ (3.92\ E\text{-}6)\right]$$

$$= 2.49\ mrem/yr\ \text{from I-131}$$

$$D_{Cs\text{-}137} = (3.17\ E\text{-}8)\ (8.0\ E\text{+}2)\ (1.04\ E\text{+}10)\ (3.6\ E\text{-}9)$$

$$= 9.5\ E\text{-}4\ mrem/yr\ \text{from Cs-137}$$

$$D_{C\text{-}14} = (3.17\ E\text{-}8)\ (8.0\ E\text{+}6)\ (6.94\ E\text{+}5)\ (3.6\ E\text{-}9)$$

$$= 6.33\ E\text{-}4\ mrem/yr\ \text{from C-14}$$

$$D_{H\text{-}3} = (3.17\ E\text{-}8)\ (1.0\ E\text{+}9) \left[(4.8\ E\text{+}3)\ (3.92\ E\text{-}6) + (6.46\ E\text{+}2)\ (3.92\ E\text{-}6)\right]$$

$$= 0.68\ mrem/yr\ \text{from H-3}$$

$$D_{thyroid} = (0.68 + 6.33\ E\text{-}4 + 9.5\ E\text{-}4 + 2.49)\ mrem/yr$$

$$= 3.17\ mrem/yr\ \text{from I-131, Cs-137, C-14 and H-3.}$$

BONE, INFANT:

$$D_{I-131} = (3.17\ E-8)\ (8.1\ E+4)\left[(1.72\ E+7)\ (3.6\ E-9) + (6.54\ E+8)\ (3.6\ E-9) + (3.79\ E+4)\ (3.92\ E-6)\right]$$

$$= 6.59\ E-3 \text{ mrem/yr from I-131}$$

$$D_{Cs-137} = (3.17\ E-8)\ (8.0\ E+2)\left[(1.04\ E+10)\ (3.6\ E-9) + (2.4\ E+10)\ (3.6\ E-9) + (5.48\ E+5)\ (3.92\ E-6)\right]$$

$$= 3.19\ E-3 \text{ mrem/yr from Cs137}$$

$$D_{C-14} = (3.17\ E-8)\ (8.0\ E+6)\ (3.25\ E+6)\ (3.6\ E-9)$$

$$= 2.97\ E-3 \text{ mrem/yr from C-14}$$

$$D_{H-3} = \text{no dose contribution from H-3}$$

$$D_{bone,\ infant} = 1.28\ E-2 \text{ mrem/yr from I-131, Cs137, C-14 and H-3}$$

TOTAL BODY, INFANT:

$$D_{I-131} = (3.17\ E-8)\ (8.1\ E+4)\left[(1.72\ E+7)\ (3.6\ E-9) + (3.39\ E+8)\ (3.6\ E-9) + (1.96\ E+4)\ (3.92\ E-6)\right]$$

$$= 3.49\ E-3 \text{ mrem/yr from I-131}$$

$$D_{Cs-137} = (3.17\ E-8)\ (8.0\ E+2)\left[(1.04\ E+10)\ (3.6\ E-9) + (1.99\ E+9)\ (3.6\ E-9) + (4.54\ E+4)\ (3.92\ E-6)\right]$$

$$= 1.14\ E-3 \text{ mrem/yr from Cs-137}$$

D_{C-14} = (3.17 E-8) (8.0 E+6) (6.94 E+5) (3.6 E-9)

= 6.34 E-4 mrem/yr from C-14

D_{H-3} = (3.17 E-8) (1.0 E+9) [(4.80 E+3) (3.92 E-6) +

(6.49 E+2) (3.92 E-6)]

= 6.77 E-1 mrem/yr from H-3

$D_{\text{total body, infant}}$ = (3.49 E-3 + 1.14 E-3 + 6.34 E-4 + 6.77 E-1) mrem/yr

= 0.68 mrem/yr from I-131, Cs-137, C-14 and H-3

A.4 TOTAL DOSE

This dose is calculated to the nearest real resident. Use the X/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

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

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

If the source term is:

8.8 E+9 μCi Xe-133

2.0 E+10 μCi Kr-85

Then:

D_{wb} = 3.17 x 10^{-8} (1.61 E+1) (3.92 E-6) (8.8 E+9) + (2.49 E+2) (3.92 E-6) (8.8 E+9)

= 0.29 mrem/yr

$$D_{sk} = 3.17 \times 10^{-8}\left(\left[(3.06\ E+2) + (1.1)\ (3.53\ E+2)\right](3.92\ E-6)\ (8.8\ E+9)\right) + \left(\left[(1.34\ E+3) + 1.1\ (1.72\ E+1)\right](3.92\ E-6)\ (2.0\ E+10)\right)$$

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

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, 40CFR190. 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.