OFFSITE DOSE CALCULATION MANUAL
PALO VERDE NUCLEAR GENERATING STATION
UNITS 1, 2 AND 3

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1.0 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) for Unit 1, Unit 2, and Unit 3. Included are methods for determining air dose from beta and gamma radiation, and organ dose at the controlling location 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, in addition to Regulatory Guide 1.109, includes the methods used for determining quarterly individual doses for inclusion in Semiannual Radioactive Effluent Release 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 offsite 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 and are considered to be "long-term" as discussed in NUREG-0133, Section 3.3, page 8. This includes the containment purge and gaseous decay tank releases as well as the normal ventilation system and condenser vacuum exhaust releases. All releases are either greater than 500 hours in duration or are made at random, not depending upon atmospheric conditions or time of day. The releases are lumped together and calculated as an entity. The historical annual average X/Q is therefore used throughout this manual for all gaseous effluent set-point and dose calculations. 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 controlling location is identified for assessing the maximum exposure to a MEMBER OF THE PUBLIC 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 vegetation 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. The release rates of these nuclides will be converted to instantaneous dose rates for comparison to the limits of 10 CFR 20.

1.2.2 Noble Gases

The air dose from both the beta and gamma radiation component of the noble gases will be assessed and compared to the 10 CFR 50, Appendix I design objectives. The noble gas release rate will be converted to instantaneous 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 of Technical Specification 3.11.2.1. Methods are described for determining the annual cumulative dose to a MEMBER OF THE PUBLIC, from gaseous effluents and direct radiation for critical organs, to assure compliance with Technical Specification 3.11.4.

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

The ODCM will be maintained for use as a document of acceptable methodologies and calculations to be used in implementing the Technical Specifications. Changes will be incorporated into the ODCM in accordance with Technical Specification 6.14.

1.3 Nuisance Pathways

This section addresses the potential release pathways which should not contribute more than 10% of the doses evaluated in this manual. Table 1-1 identifies these potential release pathways which would occur primarily due to operation with primary to secondary leakage. The doses from these nuisance pathways will periodically be evaluated to ensure that they do not contribute more than 10% of the doses evaluated in this manual. If any nuisance pathway exceeds this limit then the ODCM methodology for calculation of doses will be applied to each applicable release pathway.

TABLE 1-1

NUISANCE PATHWAYS

Evaporation Pond

Cooling Towers

Laundry Building Exhaust

Unmonitored Secondary System Steam Vents/Reliefs

Turbine Building Ventilation Exhaust

Unmonitored Tank Atmospheric Vents

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.

The general methodology for establishing low range gaseous effluent monitor setpoints is 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. The high alarm of the low range monitors will alarm/trip when the release rate from an individual vent will result in exceeding Technical Specification 3.11.2.1. 80% of Technical Specification 3.11.2.1 limits is considered to be the site release rate limit. The site release rate limit will be allocated among the licensed units' release points. The unit release rate limit will then be utilized for the determination of gaseous effluent monitor setpoints. A fraction of the unit release rate limit is then allotted to each release point and its monitor alert setpoint (µCi/cc) is derived using actual or fan design flow rates.

Administrative values are used to reduce each setpoint to account for the potential activity in other releases. These administrative values shall be reviewed based on actual release data.

For the purpose of implementation of Technical Specification 3.3.3.9, the alarm setpoint levels for low range effluent noble gas monitors are established to ensure that personnel are alerted when the noble gas releases approach 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 of this manual provide the methodology for calculating the gaseous effluent dose rate.

The evaluation of doses due to releases of radioactive material can be simplified by the use of equivalent dose factors as defined in Section 2.1.

The equivalent dose factors will be evaluated periodically to assure that the best information on isotopic distribution is being used for the dose equivalent value.

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 whole 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 μ Ci/m^3 from Table 3-1.

f_i = the fraction of noble gas radionuclide i in the total noble gas radionuclide mix.

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.

f_i = the fraction of noble gas radionuclide i in the total noble gas radionuclide mix.

2.2 Site Release Rate Limit ($\dot{Q}_{SITE}$)

The release rates corresponding to 80% of the whole body ($\dot{Q}_{WB}$) and skin ($\dot{Q}_{SK}$) dose rate limits are calculated using the equivalent dose factors defined in Section 2.1. The site release rate limit ($\dot{Q}_{SITE}$) is the lower of $\dot{Q}_{WB}$ or $\dot{Q}_{SK}$, thus assuring that the more restrictive dose rate limit will not be exceeded.

The $\dot{Q}_{SITE}$ is established as follows:

$$\dot{Q}_{SITE,\ WB} = \frac{(\dot{D}_{WB})}{(K_{eq})} \frac{(0.8)}{(X/Q)_{SBW}} \qquad (2\text{-}3)$$

Where:

$\dot{Q}_{SITE,WB}$ = the site release rate, in μCi/sec, that would deliver a dose rate 80% of the whole body dose rate limit, $\dot{D}_{WB}$.

$\dot{D}_{WB}$ = whole body dose rate limit of 500 mrem/yr.

K_{eq} = equivalent whole body dose factor, in mrem/yr per $\mu Ci/m^3$ weighted by the historical radionuclide distribution.

$(\chi/Q)_{SBW}$ = $8.91X10^{-6}$, the highest calculated annual average dispersion parameter, in sec/m^3, at the Site Boundary for any of the 3 units, from Table 3-2.

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

$$\dot{Q}_{SITE,SK} = \frac{\dot{D}_{(SK)} \quad (0.8)}{(L+1.1M)_{eq} \quad (\chi/Q)_{SBW}} \qquad (2\text{-}4)$$

Where:

$\dot{Q}_{SITE,SK}$ = the site release rate limit, in μCi/sec, that would deliver a dose rate 80% of the skin dose rate limit, $\dot{D}_{SK}$.

$\dot{D}_{SK}$ = skin dose rate limit of 3000 mrem/yr.

$(L+1.1M)_{eq}$ = equivalent skin dose factor, in mrem/yr per μ Ci/m^3, weighted by the radionuclide distribution.

$(\chi/Q)_{SBW}$ = $8.91X10^{-6}$, the highest calculated annual average dispersion parameter, in sec/m^3, at the Site Boundary for any of the three units, from Table 3-2.

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

After determination of the $\dot{Q}_{SITE}$ whole body and skin dose rates (equations 2-3 and 2-4, respectively), the most conservative result will be used as $\dot{Q}_{SITE}$, the site release rate limit.

2.3 Unit Release Rate Limits ($\dot{Q}_{UNIT}$)

Typically $\dot{Q}_{SITE}$ will be divided equally among operating units. If operational history dictates a larger fraction of the $\dot{Q}_{SITE}$ be assigned to a specific unit then a weighted average of each unit's contribution to the $\dot{Q}_{SITE}$ will be utilized to determine the $\dot{Q}_{UNIT}$.

$$\dot{Q}_{UNIT} = (f_{UNIT})\ (\dot{Q}_{SITE}) \qquad (2\text{-}5)$$

where:

$\dot{Q}_{UNIT}$ = unit release rate limit, in μ Ci/sec.

f_{UNIT} = the fraction ($\leq$ 1) of noble gas historically released from a specific operating unit to the total of all noble gas released from the site.

$\dot{Q}_{SITE}$ = the site release rate limit, in μ Ci/sec determined in section 2-2 of this manual.

2.4 Setpoint Determination

To comply with Technical Specification 3.3.3.9, the alarm/trip setpoints can now be established using the unit release rate limit ($\dot{Q}_{UNIT}$) 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 unit release rate limit to each of the release sources. Monitor setpoints will also be adjusted in accordance with Station Manual Procedures to account for monitor-specific characteristics.

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:

$$\text{Monitor Setpoint } (\mu Ci/cc) \leq \frac{(\dot{Q}UNIT)(2.12 \times 10^{-3} \frac{cfm}{cc/sec})(a)}{(\text{Flow Rate})} \qquad (2\text{-}6)$$

Where:

Monitor Setpoint = the setpoint for the effluent monitor, in μCi/cc, which provides a safe margin of assurance that the allowable dose rate limits will not be exceeded.

$\dot{Q}_{UNIT}$ = unit release rate limit, in μ Ci/sec, as determined in Section 2.3.

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

$2.12X10^{-3}$ = conversion factor, cubic feet/minute per cubic centimeter/second.

a = fraction of $\dot{Q}_{UNIT}$ allocated for a specific release point. 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:

$$\text{Monitor Setpoint } (\mu Ci/cc) \leq \frac{[(\dot{Q}_{UNIT})\ (2.12x10^{-3}\ \frac{cfm}{cc/sec})\ (0.9)(a)]}{(\text{Flow Rate})} \quad (2\text{-}7)$$

where:

Monitor Setpoint = the setpoint for the monitor, in μCi/cc at STP, which provides a safe margin of assurance that the allowable dose rate limits will not be exceeded.

$\dot{Q}_{UNIT}$ = unit release rate limit, in μCi/sec, as determined in Section 2.3.

Flow Rate = flow rate, in cfm at STP at which the tank will be released.

a = fraction of $\dot{Q}_{UNIT}$ allocated for a specific release point. 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 increases in activity from other contributors to the same release point.

$2.12X10^{-3}$ = conversion factor, cubic feet/minute per cubic centimeter/second.

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 Calibration

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 Station Manual 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 (Figure 2-1) 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.

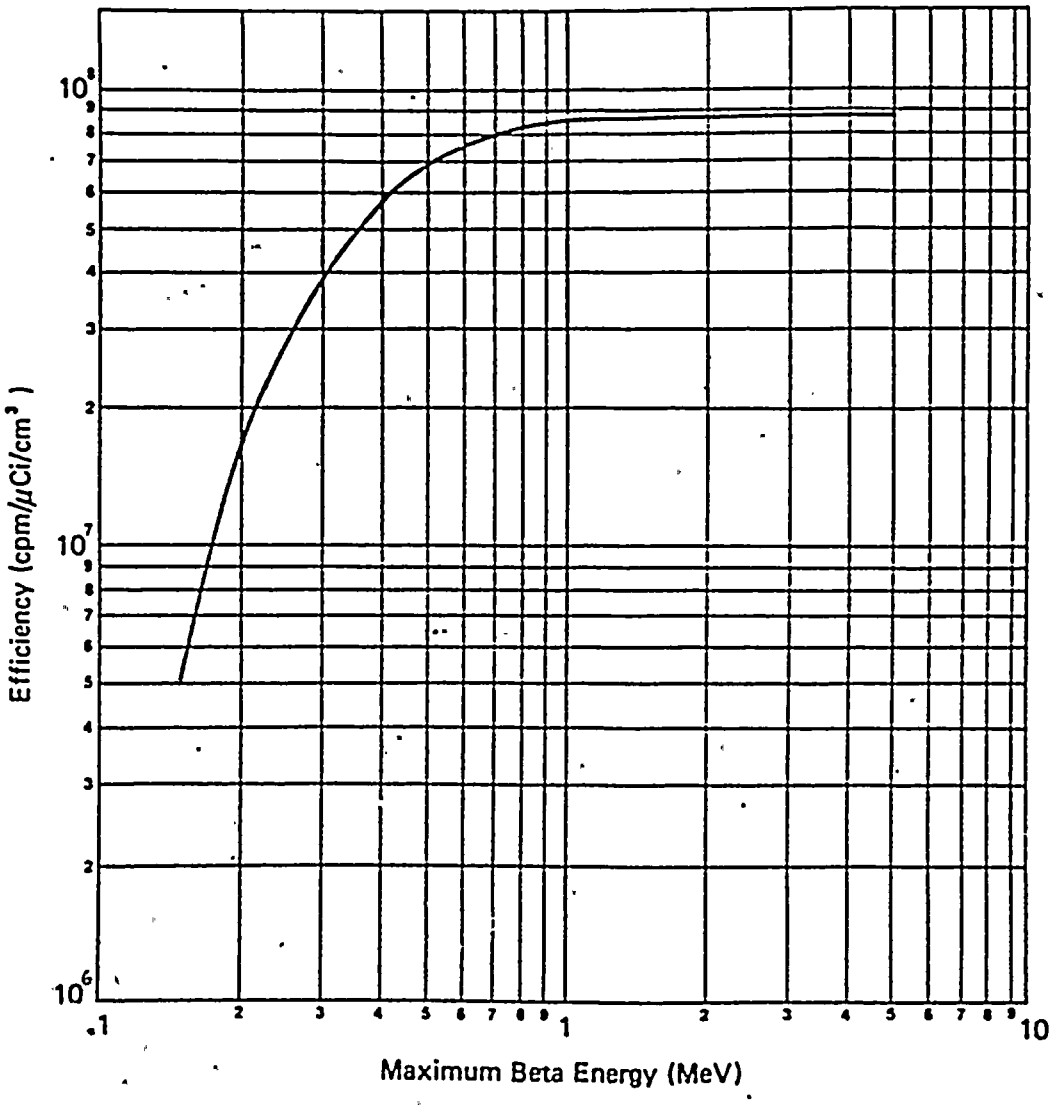


FIGURE 2-1

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

Reference: Kaman Instrumentation Corporation Calibration Report K-82-50-U(R)

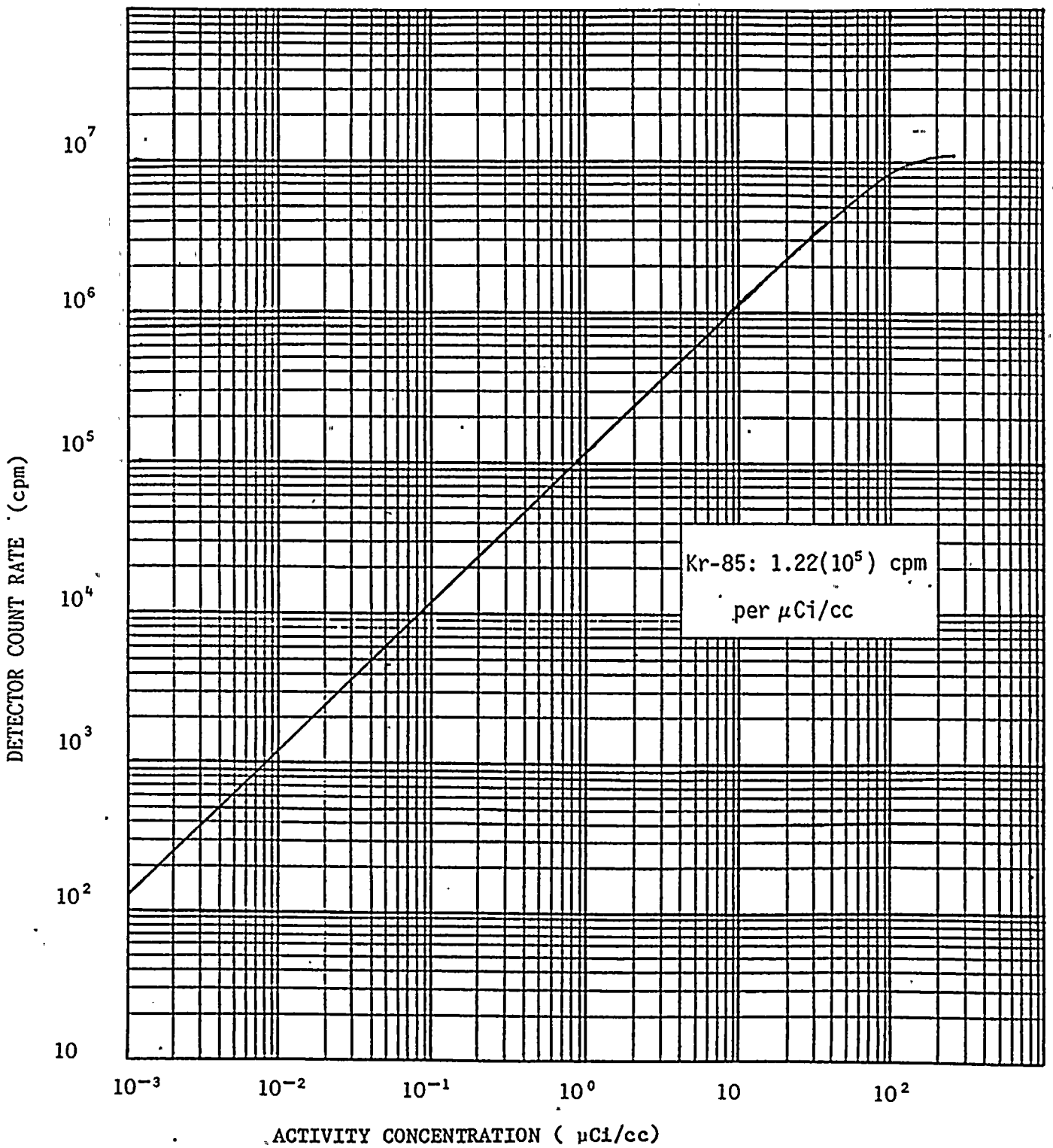


FIGURE 2-2

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

Reference: Kaman Instrumentation Corporation Calibration Report K-83-30-U(R)

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 and 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 Station Manual Procedures. The dose rate in unrestricted areas shall be determined using the following equations.

For whole body dose rate:

$$\dot{D}_{WB} = \Sigma_i [(K_i) (\chi/Q)_{SBW} (\dot{Q}_i)] \quad (3\text{-}1)$$

For skin dose rate:

$$\dot{D}_{SK} = \Sigma_i [(L_i + 1.1M_i) (\chi/Q)_{SBW} (\dot{Q}_i)] \quad (3\text{-}2)$$

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.

$\dot{Q}_i$ = the release rate of radionuclide i, in $\mu Ci/sec$.

$(\chi/Q)_{SBW}$ = 8.91×10^{-6}, the highest calculated annual average dispersion parameter, in sec/m^3, for any of the three units, from Table 3-2.

$\dot{D}_{WB}$ = the annual whole body dose rate (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).

$\dot{D}_{SK}$ = the annual skin dose rate (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 total organ dose rate in unrestricted areas shall be determined by the following equation:

$$\dot{D}_o = \Sigma_i [(P_i)(\chi/Q)_{SBW} (\dot{Q}_i)] \qquad (3\text{-}3)$$

Where:

P_i = the dose factor, in mrem/yr per $\mu Ci/m^3$, for radionuclide i, for the child inhalation pathway, from Table 3-3.

$(\chi/Q)_{SBW}$ = 8.91×10^{-6}, the highest calculated annual average dispersion parameter, in sec/m^3, at the Site Boundary, for any of the three units,

$\dot{Q}_i$ = the release rate of radionuclide i, in $\mu Ci/sec$

$\dot{D}_o$ = the total organ dose rate (mrem/yr).

TABLE 3-1

DOSE FACTORS FOR NOBLE GASES AND DAUGHTERS[a]

Radionuclide	Whole Body Dose Factor K_i (mrem/yr per μCi/m³)	Skin Dose Factor L_i (mrem/yr per μCi/m³)	Gamma Air Dose Factor M_i (mrad/yr per μCi/m³)	Beta Air Dose Factor N_i (mrad/yr per μCi/m³)
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 noble gases that may be detected in gaseous effluents.

[b] 7.56E-02 = 7.56×10^{-2}.

Reference: Regulatory Guide 1.109, Table B-1.

TABLE 3-2
(Sheet 1 of 3)

PALO VERDE NUCLEAR GENERATING STATION DISPERSION AND DEPOSITION PARAMETERS FOR LONG TERM RELEASES AT THE SITE BOUNDARY CENTERED ON UNIT 1

DIRECTION	DISTANCE (METERS)	χ/Q (SEC/m^3)	D/Q (m^{-2})
N	1037	4.93 E-06[a]	9.24 E-09
NNE	1057	4.14 E-06	1.19 E-08
NE	2206	2.84 E-06	6.84 E-09
ENE	1967	2.51 E-06	4.43 E-09
E	1927	2.56 E-06	3.24 E-09
ESE	1967	2.61 E-06	2.46 E-09
SE	2049	3.56 E-06	2.36 E-09
SSE	2730	3.80 E-06	1.58 E-09
S	3006	5.07 E-06	1.78 E-09
SSW	2258	6.52 E-06	3.20 E-09
SW	1487	7.47 E-06	5.65 E-09
WSW	1251	4.52 E-06	5.93 E-09
W	1225	4.73 E-06	9.49 E-09
WNW	1244	3.76 E-06	6.76 E-09
NW	1254	3.43 E-06	5.87 E-09
NNW	1069	3.70 E-06	7.26 E-09

(a) 4.93 E-06 = 4.93×10^{-6}

Reference: Distances are from the PVNGS ER-OL, Table 2.3-33. Dispersion and Deposition parameters are from a September, 1985, calculation by NUS Corporation based on 9 years of meteorological data; NUS Corporation letter NUS-ANPP-1386, dated October 4, 1985.

TABLE 3-2
(Sheet 2 of 3)

PALO VERDE NUCLEAR GENERATING STATION DISPERSION AND DEPOSITION PARAMETERS FOR LONG TERM RELEASES AT THE SITE BOUNDARY CENTERED ON UNIT 2

DIRECTION	DISTANCE (METERS)	X /Q (SEC/m^3)	D/Q (m^{-2})
N	1318	3.85 E-06	6.17 E-09
NNE	1342	3.18 E-06	7.93 E-09
NE	2545	2.42 E-06	5.34 E-09
ENE	2206	2.22 E-06	3.64 E-09
E	2163	2.27 E-06	2.66 E-09
ESE	2067	2.32 E-06	2.11 E-09
SE	2101	3.47 E-06	2.26 E-09
SSE	3026	3.43 E-06	1.32 E-09
S	2699	5.16 E-06	1.97 E-09
SSW	1836	7.90 E-06	4.56 E-09
SW	1208	7.72 E-06	6.88 E-09
WSW	1014	5.55 E-06	8.44 E-09
W	993	5.86 E-06	1.34 E-08
WNW	1010	4.67 E-06	9.60 E-09
NW	1191	3.62 E-06	6.40 E-09
NNW	1342	2.85 E-06	4.87 E-09

Reference: Distances are from the PVNGS ER-OL, Table 2.3-33. Dispersion and Deposition parameters are from a September, 1985, calculation by NUS Corporation based on 9 years of meteorological data; NUS Corporation letter NUS-ANPP-1386, dated October 4, 1985.

TABLE 3-2
(Sheet 3 of 3)

PALO VERDE NUCLEAR GENERATING STATION DISPERSION AND DEPOSITION PARAMETERS FOR LONG TERM RELEASES AT THE SITE BOUNDARY CENTERED ON UNIT 3

DIRECTION	DISTANCE (METERS)	χ/Q (SEC/m^3)	D/Q (m^{-2})
N	1661	3.54 E-06	4.86 E-09
NNE	1693	2.86 E-06	6.23 E-09
NE	2756	2.21 E-06	4.65 E-09
ENE	2337	2.08 E-06	3.30 E-09
E	2290	2.14 E-06	2.41 E-09
ESE	2023	2.37 E-06	2.10 E-09
SE	2256	3.24 E-06	2.00 E-09
SSE	2786	3.72 E-06	1.52 E-09
S	2346	5.90 E-06	2.51 E-09
SSW	1607	8.91 E-06	5.73 E-09
SW	1057	8.68 E-06	8.61 E-09
WSW	889	5.34 E-06	8.83 E-09
W	871	6.72 E-06	1.67 E-08
WNW	885	5.37 E-06	1.19 E-08
NW	1045	4.17 E-06	7.98 E-09
NNW	1561	2.93 E-06	4.58 E-09

Reference: Distances are from the PVNGS ER-OL, Table 2.3-33. Dispersion and Deposition parameters are from a September, 1985, calculation by NUS Corporation based on 9 years of meteorological data; NUS Corporation letter NUS-ANPP-1386, dated October 4, 1985.

TABLE 3-3

P_i Values for the

Palo Verde Nuclear Generating Station

Isotope	Inhalation Pathway [a] (mrem/yr/μCi/m^3)
H 3	1.12E+03[b]
Cr 51	1.70E+04
Mn 54	1.57E+06
Fe 59	1.27E+06
Co 58	1.10E+06
Co 60	7.06E+06
Zn 65	9.94E+05
Sr 89	2.15E+06
Sr 90	1.01E+08
Zr 95	2.23E+06
Sb 124	3.24E+06
I 131	1.62E+07
I 133	3.84E+06
Cs 134	1.01E+06
Cs 137	8.24E+05
Ba 140	1.74E+06
Ce 141	5.43E+05
Ce 144	1.19E+07

(a) Child receptor

(b) 1.12E+03 = 1.12×10^3

References: NUREG-0133, Section 5.2.1.1 (Calculation of P_i (inhalation))
Regulatory Guide 1.109, Table E-5, Table E-9.
NUS Corporation letter NUS-ANPP-1385, dated 9/26/85.

4.0 DOSE DUE TO GASEOUS EFFLUENT

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 each unit during any specified time period shall be determined by the following equations:

For gamma radiation:

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

For beta radiation:

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

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.

$(\chi/Q)_{SBu}$ = the highest calculated annual average dispersion parameter, in sec/m^3, at the site boundary for the particular unit, from Table 3-2.

$= 7.47X10^{-6}$ from Unit 1
$= 7.90X10^{-6}$ from Unit 2
$= 8.91X10^{-6}$ from Unit 3

$D_{\gamma u}$ = the total gamma air dose, for the particular unit, in mrad, due to noble gases released in gaseous effluents for a specified time period at the SITE BOUNDARY.

$D_{\beta u}$ = the total beta air dose, for the particular unit, in mrad, due to noble gases released in gaseous effluents for a specified time period at the SITE BOUNDARY.

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

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.

4.2 Iodine - 131, Iodine-133, Tritium, and All Radionuclides in Particulate Form With Half-Lives Greater Than 8 Days

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 organ 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 from each reactor unit is calculated using the following expressions:

$$D_{ou} = (3.17 \times 10^{-8}) \Sigma_i [\Sigma_k (R_{ik} W_k) (Q_i)] \quad (4-3)$$

Where:

D_{ou} = the total accumulated organ dose from gaseous effluents for a particular unit, to a MEMBER OF THE PUBLIC, in mrem, at the SITE BOUNDARY or at the controlling location.

Q_i = the quantity of radionuclide i, in μ Ci, released in gaseous effluents from a particular unit.

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.

$3.17X10^{-8}$ = the inverse of seconds per year (yr/sec).

W_k = the highest annual average dispersion or deposition parameter for the particular unit, used for estimating the dose at the site boundary or to a MEMBER OF THE PUBLIC at the controlling location for the particular unit.

= $(\chi/Q)_{SBU}$, in sec/m^3 for the inhalation pathway and for all tritium calculations, for organ dose at the site boundary, from Table 3-2.

= $7.47X10^{-6}$ from Unit 1
= $7.90X10^{-6}$ from Unit 2
= $8.91X10^{-6}$ from Unit 3

= $(\chi/Q)_{RU}$, in sec/m^3 for the inhalation pathway and for all tritium calculations, for organ dose at the controlling location, from Table 4-16.

= $2.92X10^{-6}$ from Unit 1
= $2.19X10^{-6}$ from Unit 2
= $2.31X10^{-6}$ from Unit 3

= ($D/Q)_{SBU}$, in m^{-2}, for the food and ground plane pathways, for organ dose at the site boundary, from Table 3-2.

= $1.19X10^{-8}$ from Unit 1
= $1.34X10^{-8}$ from Unit 2
= $1.67X10^{-8}$ from Unit 3

= ($D/Q)_{RU}$, in m^{-2}, for the food and ground plane pathways, for organ dose at the controlling location, from Table 4-16.

= $3.25X10^{-9}$ from Unit 1
= $3.88X10^{-10}$ from Unit 2
= $4.21X10^{-10}$ from Unit 3

Residences, vegetable gardens and meat and milch animals located within 5 miles of the site will be identified during the annual land use census. The controlling pathway and location will be identified and will be used for all MEMBER OF THE PUBLIC dose evaluations.

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 milch animals and beef animals are on pasture, f_p	0.75
fraction of daily intake of milch animals and beef animals derived from pasture while on pasture, f_s	0.35

fraction of year vegetables are grown, f_1 approximation	0.667
absolute humidity (g/m^3) over the growing season, H	4

These site specific values are from the PVNGS Environmental Report, Section 2 and Appendix 5-B.

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 (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.

Where possible, consideration for expected operational evolutions (i.e., outages, etc.) should be taken in the dose projections.

4.3.1 Noble Gas Dose Projection

For the purpose of satisfying requirements of Technical Specification 3.11.2.4, the air dose at the site boundary due to noble gases released in gaseous effluents from a particular unit is projected at least once per 31 days.

The air dose, in mrads for the current quarter is determined using the methodology described in Section 4.1 of this manual. This information is used to determine an air dose projection for the next 31 days using the following equations:

For gamma radiation:

$$31 \text{ day}_{\gamma} = (D_{\gamma} \text{ qtr}/Tqtr)\ 31 + CD_{\gamma} \qquad (4\text{-}4)$$

For beta radiation:

$$31 \text{ day}_{\beta} = (D_{\beta} \text{ qtr}/Tqtr)\ 31 + CD_{\beta} \qquad (4\text{-}5)$$

where:

D_{γ} qtr = the total gamma air dose due to noble gases released in gaseous effluents for the current quarter, in mrads, at the site boundary.

D_{β} qtr = the total beta air dose due to noble gases released in gaseous effluents for the current quarter, in mrads, at the site boundary.

Tqtr = the time period, in days, over which D_{γ} qtr and D_{β} qtr were integrated.

31 = the number of days over which the dose projections are made.

31 day γ = the 31 day projected gamma air dose due to noble gases released in gaseous effluents, in mrads, at the site boundary.

31 day β = the 31 day projected beta air dose due to noble gases released in gaseous effluents, in mrads, at the site boundary.

CD γ = any current or projected gamma air dose, in mrads, due to noble gases released in gaseous effluents, which could have a significant impact on 31 day γ .

CD β = any current or projected beta air dose, in mrads, due to noble gases released in gaseous effluents, which could have a significant impact on 31 day β .

4.3.2 Organ Dose Projection

For the purpose of satisfying requirements of Technical Specification 3.11.2.4 for a particular unit, the organ dose, in mrem, for the current quarter is determined using the methodology described in Section 4.2 of this manual. This information is used to determine an organ dose projection for the next 31 days using the following equation:

$$31day_o = (D_o\ qtr/Tqtr)31 + CD_o \qquad (4\text{-}6)$$

where:

D_o qtr = the total organ dose from a particular unit due to I-131, I-133, tritium, and all radionuclides in particulate form with half-lives greater than eight days, released in gaseous effluents for the current quarter, in mrem.

Tqtr = the time period, in days, over which $D_o$qtr was integrated.

31 = the number of days over which the dose projections are made.

31 day_o = the 31 day projected organ dose, in mrem, from a particular unit.

CD_o = any current or projected organ dose for a particular unit, in mrem, which could have a significant impact on 31 day_o.

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
Cr 51	4.65E+06	4.65E+06	4.65E+06	4.65E+06	4.65E+06	4.65E+06	4.65E+06	5.49E+06
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	2.52E+10
Zn 65	7.44E+08	7.44E+08	7.44E+08	7.44E+08	7.44E+08	7.44E+08	7.44E+08	8.56E+08
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
Zr 95	2.45E+08	2.45E+08	2.45E+08	2.45E+08	2.45E+08	2.45E+08	2.45E+08	2.84E+08
Sb124	5.98E+08	5.98E+08	5.98E+08	5.98E+08	5.98E+08	5.98E+08	5.98E+08	6.91E+08
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 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
Cs134	6.82E+09	6.82E+09	6.82E+09	6.82E+09	6.82E+09	6.82E+09	6.82E+09	7.96E+09
Cs137	1.03E+10	1.03E+10	1.03E+10	1.03E+10	1.03E+10	1.03E+10	1.03E+10	1.20E+10
Ba140	2.05E+07	2.05E+07	2.05E+07	2.05E+07	2.05E+07	2.05E+07	2.05E+07	2.34E+07
Ce141	1.36E+07	1.36E+07	1.36E+07	1.36E+07	1.36E+07	1.36E+07	1.36E+07	1.54E+07
Ce144	6.95E+07	6.95E+07	6.95E+07	6.95E+07	6.95E+07	6.95E+07	6.95E+07	8.03E+07

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

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

Reference: NUREG-0133; NUS Corporation letter NUS-ANPP-1385, dated 9/26/85.

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	4.34E+03(b)	4.34E+03	0.00E-01	4.34E+03	4.34E+03	4.34E+03	4.34E+03	4.34E+03
Mn 54	5.65E+07	9.07E+08	0.00E-01	2.96E+08	8.81E+07	0.00E-01	0.00E-01	0.00E-01
Cr 51	3.99E+04	1.00E+07	0.00E-01	0.00E-01	8.79E+03	2.38E+04	5.29E+04	0.00E-01
Fe 59	1.02E+08	8.91E+08	1.14E+08	2.67E+08	0.00E-01	0.00E-01	7.47E+07	0.00E-01
Co 58	6.38E+07	5.77E+08	0.00E-01	2.85E+07	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Co 60	3.51E+08	2.99E+09	0.00E-01	1.59E+08	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Zn 65	4.31E+08	6.01E+08	3.00E+08	9.54E+08	6.38E+08	0.00E-01	0.00E-01	0.00E-01
Sr 89	2.60E+08	1.45E+09	9.06E+09	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr 90	1.41E+11	1.66E+10	5.76E+11	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Zr 95	2.35E+05	1.10E+09	1.08E+06	3.47E+05	5.45E+05	0.00E-01	0.00E-01	0.00E-01
Sb124	3.78E+07	2.71E+09	9.53E+07	1.80E+06	0.00E-01	2.31E+05	7.42E+07	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 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
Cs134	8.62E+09	1.85E+08	4.43E+09	1.05E+10	3.41E+09	0.00E-01	1.13E+09	0.00E-01
Cs137	5.42E+09	1.60E+08	6.05E+09	8.28E+09	2.81E+09	0.00E-01	9.34E+08	0.00E-01
Ba140	6.17E+06	1.94E+08	9.42E+07	1.18E+05	4.03E+04	0.00E-01	6.78E+04	0.00E-01
Ce141	1.33E+04	4.47E+08	1.73E+05	1.17E+05	5.43E+04	0.00E-01	0.00E-01	0.00E-01
Ce144	1.67E+06	1.05E+10	3.11E+07	1.30E+07	7.72E+06	0.00E-01	0.00E-01	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) 4.34E+03 = 4.34×10^3.

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	8.72E+07	9.02E+08	0.00E-01	4.40E+08	1.31E+08	0.00E-01	0.00E-01	0.00E-01
Cr 51	5.58E+04	9.37E+06	0.00E-01	0.00E-01	1.22E+04	3.10E+04	7.96E+04	0.00E-01
Fe 59	1.52E+08	9.28E+08	1.68E+08	3.92E+08	0.00E-01	0.00E-01	1.24E+08	0.00E-01
Co 58	9.60E+07	5.74E+08	0.00E-01	4.17E+07	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Co 60	5.44E+08	3.14E+09	0.00E-01	2.41E+08	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Zn 65	6.64E+08	6.03E+08	4.10E+08	1.42E+09	9.11E+08	0.00E-01	0.00E-01	0.00E-01
Sr 89	4.09E+08	1.70E+09	1.43E+10	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr 90	1.80E+11	2.05E+10	7.29E+11	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Zr 95	3.56E+05	1.19E+09	1.64E+06	5.18E+05	7.60E+05	0.00E-01	0.00E-01	0.00E-01
Sb124	5.73E+07	2.96E+09	1.47E+08	2.70E+06	0.00E-01	3.33E+05	1.28E+08	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 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
Cs134	7.52E+09	2.02E+08	6.89E+09	1.62E+10	5.15E+09	0.00E-01	1.97E+09	0.00E-01
Cs137	4.56E+09	1.86E+08	9.84E+09	1.31E+10	4.46E+09	0.00E-01	1.73E+09	0.00E-01
Ba140	6.87E+06	1.65E+08	1.07E+08	1.31E+05	4.43E+04	0.00E-01	8.79E+04	0.00E-01
Ce141	2.00E+04	4.97E+08	2.60E+05	1.74E+05	8.18E+04	0.00E-01	0.00E-01	0.00E-01
Ce144	2.74E+06	1.28E+10	5.11E+07	2.11E+07	1.26E+07	0.00E-01	0.00E-01	0.00E-01

(a) R values are in units of mrem/yr per μ Ci/m^3 for tritium, and in units of m^2-mrem/yr per μ Ci/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	7.91E+03(b)	7.91E+03	0.00E-01	7.91E+03	7.91E+03	7.91E+03	7.91E+03	7.91E+03
Mn 54	1.73E+08	5.44E+08	0.00E-01	6.48E+08	1.82E+08	0.00E-01	0.00E-01	0.00E-01
Cr 51	1.08E+05	5.73E+06	0.00E-01	0.00E-01	1.64E+04	6.00E+04	1.09E+05	0.00E-01
Fe 59	3.04E+08	6.36E+08	3.78E+08	6.11E+08	0.00E-01	0.00E-01	1.77E+08	0.00E-01
Co 58	1.90E+08	3.63E+08	0.00E-01	6.22E+07	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Co 60	1.09E+09	2.05E+09	0.00E-01	3.70E+08	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Zn 65	1.31E+09	3.70E+08	7.92E+08	2.11E+09	1.33E+09	0.00E-01	0.00E-01	0.00E-01
Sr 89	9.80E+08	1.33E+09	3.43E+10	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr 90	3.08E+11	1.64E+10	1.22E+12	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Zr 95	7.27E+05	8.52E+08	3.72E+06	8.17E+05	1.17E+06	0.00E-01	0.00E-01	0.00E-01
Sb124	1.19E+08	2.12E+09	3.38E+08	4.39E+06	0.00E-01	7.47E+05	1.88E+08	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 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
Cs134	5.42E+09	1.39E+08	1.57E+10	2.57E+10	7.96E+09	0.00E-01	2.86E+09	0.00E-01
Cs137	3.31E+09	1.40E+08	2.34E+10	2.24E+10	7.30E+09	0.00E-01	2.63E+09	0.00E-01
Ba140	1.28E+07	1.11E+08	2.20E+08	1.93E+05	6.27E+04	0.00E-01	1.15E+05	0.00E-01
Ce141	4.54E+04	3.82E+08	6.14E+05	3.06E+05	1.34E+05	0.00E-01	0.00E-01	0.00E-01
Ce144	6.61E+06	1.01E+10	1.24E+08	3.89E+07	2.15E+07	0.00E-01	0.00E-01	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) 7.91E+03 = 7.91×10^3.

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	8.29E+05	1.33E+07	0.00E-01	4.34E+06	1.29E+06	0.00E-01	0.00E-01	0.00E-01
Cr 51	2.04E+03	5.12E+05	0.00E-01	0.00E-01	4.48E+02	1.22E+03	2.70E+03	0.00E-01
Fe 59	7.78E+07	6.77E+08	8.64E+07	2.03E+08	0.00E-01	0.00E-01	5.67E+07	0.00E-01
Co 58	1.51E+07	1.37E+08	0.00E-01	6.74E+06	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Co 60	8.49E+07	7.23E+08	0.00E-01	3.85E+07	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Zn 65	2.36E+08	3.29E+08	1.64E+08	5.23E+08	3.50E+08	0.00E-01	0.00E-01	0.00E-01
Sr 89	2.91E+06	1.63E+07	1.02E+08	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr 90	1.58E+09	1.86E+08	6.45E+09	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Zr 95	1.46E+05	6.85E+08	6.74E+05	2.16E+05	3.39E+05	0.00E-01	0.00E-01	0.00E-01
Sb124	2.78E+06	1.99E+08	7.01E+06	1.32E+05	0.00E-01	1.70E+04	5.45E+06	0.00E-01
I 131	2.31E+06	1.06E+06	2.81E+06	4.03E+06	6.90E+06	1.32E+09	0.00E-01	0.00E-01
I 133	5.14E-02	1.52E-01	9.69E-02	1.69E-01	2.94E-01	2.48E+01	0.00E-01	0.00E-01
Cs134	6.39E+08	1.37E+07	3.28E+08	7.81E+08	2.53E+08	0.00E-01	8.39E+07	0.00E-01
Cs137	4.05E+08	1.20E+07	4.52E+08	6.18E+08	2.10E+08	0.00E-01	6.98E+07	0.00E-01
Ba140	4.97E+05	1.56E+07	7.59E+06	9.54E+03	3.24E+03	0.00E-01	5.46E+03	0.00E-01
Ce141	3.23E+02	1.09E+07	4.21E+03	2.85E+03	1.32E+03	0.00E-01	0.00E-01	0.00E-01
Ce144	3.67E+04	2.31E+08	6.84E+05	2.86E+05	1.70E+05	0.00E-01	0.00E-01	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) 6.55E+02 = 6.55×10^2.

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	6.57E+05	6.79E+06	0.00E-01	3.31E+06	9.88E+05	0.00E-01	0.00E-01	0.00E-01
Cr 51	1.63E+03	2.74E+05	0.00E-01	0.00E-01	3.57E+02	9.04E+02	2.32E+03	0.00E-01
Fe 59	6.22E+07	3.81E+08	6.91E+07	1.61E+08	0.00E-01	0.00E-01	5.08E+07	0.00E-01
Co 58	1.20E+07	7.16E+07	0.00E-01	5.19E+06	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Co 60	6.72E+07	3.89E+08	0.00E-01	2.99E+07	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Zn 65	1.87E+08	1.70E+08	1.15E+08	4.01E+08	2.57E+08	0.00E-01	0.00E-01	0.00E-01
Sr 89	2.45E+06	1.02E+07	8.57E+07	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr 90	1.03E+09	1.17E+08	4.17E+09	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Zr 95	1.17E+05	3.93E+08	5.40E+05	1.70E+05	2.50E+05	0.00E-01	0.00E-01	0.00E-01
Sb124	2.23E+06	1.15E+08	5.72E+06	1.05E+05	0.00E-01	1.30E+04	5.00E+06	0.00E-01
I 131	1.76E+06	6.48E+05	2.34E+06	3.27E+06	5.64E+06	9.56E+08	0.00E-01	0.00E-01
I 133	4.19E-02	1.04E-01	8.11E-02	1.38E-01	2.41E-01	1.92E+01	0.00E-01	0.00E-01
Cs134	2.85E+08	7.64E+06	2.61E+08	6.14E+08	1.95E+08	0.00E-01	7.45E+07	0.00E-01
Cs137	1.74E+08	7.11E+06	3.75E+08	4.99E+08	1.70E+08	0.00E-01	6.60E+07	0.00E-01
Ba140	4.04E+05	9.68E+06	6.28E+06	7.69E+03	2.61E+03	0.00E-01	5.17E+03	0.00E-01
Ce141	2.71E+02	6.75E+06	3.53E+03	2.36E+03	1.11E+03	0.00E-01	0.00E-01	0.00E-01
Ce144	3.10E+04	1.45E+08	5.76E+05	2.38E+05	1.42E+05	0.00E-01	0.00E-01	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 $\mu Ci/sec$ for all others.

(b) 3.91E+02 = 3.91×10^2.

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	4.72E+02	0.00E-01	4.72E+02	4.72E+02	4.72E+02	4.72E+02	4.72E+02
Mn 54	1.01E+06	3.18E+06	0.00E-01	3.79E+06	1.06E+06	0.00E-01	0.00E-01	0.00E-01
Cr 51	2.54E+03	1.35E+05	0.00E-01	0.00E-01	3.85E+02	1.41E+03	2.57E+03	0.00E-01
Fe 59	9.87E+07	2.06E+08	1.22E+08	1.98E+08	0.00E-01	0.00E-01	5.74E+07	0.00E-01
Co 58	1.86E+07	3.54E+07	0.00E-01	6.07E+06	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Co 60	1.05E+08	1.96E+08	0.00E-01	3.54E+07	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Zn 65	2.87E+08	8.11E+07	1.73E+08	4.62E+08	2.91E+08	0.00E-01	0.00E-01	0.00E-01
Sr 89	4.63E+06	6.28E+06	1.62E+08	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr 90	1.37E+09	7.26E+07	5.39E+09	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Zr 95	1.88E+05	2.20E+08	9.59E+05	2.11E+05	3.02E+05	0.00E-01	0.00E-01	0.00E-01
Sb124	3.63E+06	6.47E+07	1.04E+07	1.34E+05	0.00E-01	2.28E+04	5.74E+06	0.00E-01
I 131	2.48E+06	3.88E+05	4.34E+06	4.36E+06	7.16E+06	1.44E+09	0.00E-01	0.00E-01
I 133	7.05E-02	7.50E-02	1.51E-01	1.86E-01	3.10E-01	3.46E+01	0.00E-01	0.00E-01
Cs134	1.59E+08	4.07E+06	4.60E+08	7.55E+08	2.34E+08	0.00E-01	8.40E+07	0.00E-01
Cs137	9.77E+07	4.14E+06	6.91E+08	6.62E+08	2.16E+08	0.00E-01	7.76E+07	0.00E-01
Ba140	6.76E+05	5.87E+06	1.16E+07	1.01E+04	3.30E+03	0.00E-01	6.05E+03	0.00E-01
Ce141	4.93E+02	4.14E+06	6.66E+03	3.32E+03	1.46E+03	0.00E-01	0.00E-01	0.00E-01
Ce144	5.80E+04	8.88E+07	1.09E+06	3.41E+05	1.89E+05	0.00E-01	0.00E-01	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 $\mu Ci/sec$ for all others.

(b) 4.72E+02 = 4.72×10^2.

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	7.60E+05	1.22E+07	0.00E-01	3.98E+06	1.18E+06	0.00E-01	0.00E-01	0.00E-01
Cr 51	8.26E+03	2.08E+06	0.00E-01	0.00E-01	1.82E+03	4.94E+03	1.10E+04	0.00E-01
Fe 59	8.71E+06	7.57E+07	9.67E+06	2.27E+07	0.00E-01	0.00E-01	6.35E+06	0.00E-01
Co 58	3.90E+06	3.53E+07	0.00E-01	1.74E+06	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Co 60	1.85E+07	1.58E+08	0.00E-01	8.39E+06	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Zn 65	9.11E+08	1.27E+09	6.33E+08	2.02E+09	1.35E+09	0.00E-01	0.00E-01	0.00E-01
Sr 89	1.40E+07	7.84E+07	4.89E+08	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr 90	5.95E+09	7.01E+08	2.43E+10	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Zr 95	7.37E+01	3.45E+05	3.39E+02	1.09E+02	1.71E+02	0.00E-01	0.00E-01	0.00E-01
Sb124	3.61E+06	2.59E+08	9.11E+06	1.72E+05	0.00E-01	2.21E+04	7.09E+06	0.00E-01
I 131	6.36E+07	2.93E+07	7.76E+07	1.11E+08	1.90E+08	3.64E+10	0.00E-01	0.00E-01
I 133	5.39E+05	1.59E+06	1.02E+06	1.77E+06	3.08E+06	2.60E+08	0.00E-01	0.00E-01
Cs134	5.49E+09	1.18E+08	2.82E+09	6.72E+09	2.17E+09	0.00E-01	7.21E+08	0.00E-01
Cs137	3.43E+09	1.01E+08	3.83E+09	5.23E+09	1.78E+09	0.00E-01	5.91E+08	0.00E-01
Ba140	4.65E+05	1.46E+07	7.10E+06	8.92E+03	3.03E+03	0.00E-01	5.11E+03	0.00E-01
Ce141	6.68E+02	2.25E+07	8.71E+03	5.89E+03	2.74E+03	0.00E-01	0.00E-01	0.00E-01
Ce144	5.41E+04	3.40E+08	1.01E+06	4.21E+05	2.50E+05	0.00E-01	0.00E-01	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 $\mu Ci/sec$ 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	1.32E+06	1.36E+07	0.00E-01	6.63E+06	1.98E+06	0.00E-01	0.00E-01	0.00E-01
Cr 51	1.44E+04	2.42E+06	0.00E-01	0.00E-01	3.16E+03	8.01E+03	2.06E+04	0.00E-01
Fe 59	1.52E+07	9.31E+07	1.69E+07	3.94E+07	0.00E-01	0.00E-01	1.24E+07	0.00E-01
Co 58	6.75E+06	4.04E+07	0.00E-01	2.93E+06	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Co 60	3.20E+07	1.85E+08	0.00E-01	1.42E+07	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Zn 65	1.58E+09	1.43E+09	9.73E+08	3.38E+09	2.16E+09	0.00E-01	0.00E-01	0.00E-01
Sr 89	2.58E+07	1.07E+08	9.01E+08	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr 90	8.46E+09	9.62E+08	3.43E+10	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Zr 95	1.29E+02	4.32E+05	5.93E+02	1.87E+02	2.75E+02	0.00E-01	0.00E-01	0.00E-01
Sb124	6.34E+06	3.27E+08	1.62E+07	2.99E+05	0.00E-01	3.68E+04	1.42E+07	0.00E-01
I 131	1.06E+08	3.90E+07	1.41E+08	1.97E+08	3.39E+08	5.75E+10	0.00E-01	0.00E-01
I 133	9.60E+05	2.38E+06	1.86E+06	3.15E+06	5.52E+06	4.40E+08	0.00E-01	0.00E-01
Cs134	5.35E+09	1.43E+08	4.90E+09	1.15E+10	3.66E+09	0.00E-01	1.40E+09	0.00E-01
Cs137	3.22E+09	1.31E+08	6.94E+09	9.23E+09	3.14E+09	0.00E-01	1.22E+09	0.00E-01
Ba140	8.26E+05	1.98E+07	1.28E+07	1.57E+04	5.33E+03	0.00E-01	1.06E+04	0.00E-01
Ce141	1.23E+03	3.05E+07	1.60E+04	1.07E+04	5.02E+03	0.00E-01	0.00E-01	0.00E-01
Ce144	9.96E+04	4.66E+08	1.85E+06	7.67E+05	4.58E+05	0.00E-01	0.00E-01	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 $\mu Ci/sec$ for all others.

(b) 2.00E+03 = 2.00×10^3.

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	2.64E+06	8.33E+06	0.00E-01	9.92E+06	2.78E+06	0.00E-01	0.00E-01	0.00E-01
Cr 51	2.94E+04	1.56E+06	0.00E-01	0.00E-01	4.46E+03	1.63E+04	2.98E+04	0.00E-01
Fe 59	3.15E+07	6.59E+07	3.91E+07	6.33E+07	0.00E-01	0.00E-01	1.84E+07	0.00E-01
Co 58	1.37E+07	2.61E+07	0.00E-01	4.48E+06	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Co 60	6.51E+07	1.22E+08	0.00E-01	2.21E+07	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Zn 65	3.16E+09	8.93E+08	1.91E+09	5.08E+09	3.20E+09	0.00E-01	0.00E-01	0.00E-01
Sr 89	6.37E+07	8.63E+07	2.23E+09	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr 90	1.47E+10	7.80E+08	5.79E+10	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Zr 95	2.70E+02	3.16E+05	1.38E+03	3.03E+02	4.34E+02	0.00E-01	0.00E-01	0.00E-01
Sb124	1.35E+07	2.40E+08	3.84E+07	4.99E+05	0.00E-01	8.48E+04	2.13E+07	0.00E-01
I 131	1.95E+08	3.06E+07	3.42E+08	3.44E+08	5.64E+08	1.14E+11	0.00E-01	0.00E-01
I 133	2.11E+06	2.25E+06	4.51E+06	5.58E+06	9.29E+06	1.04E+09	0.00E-01	0.00E-01
Cs134	3.91E+09	1.00E+08	1.13E+10	1.85E+10	5.75E+09	0.00E-01	2.06E+09	0.00E-01
Cs137	2.36E+09	1.00E+08	1.67E+10	1.60E+10	5.21E+09	0.00E-01	1.88E+09	0.00E-01
Ba140	1.81E+06	1.57E+07	3.09E+07	2.71E+04	8.82E+03	0.00E-01	1.62E+04	0.00E-01
Ce141	2.91E+03	2.45E+07	3.93E+04	1.96E+04	8.60E+03	0.00E-01	0.00E-01	0.00E-01
Ce144	2.44E+05	3.73E+08	4.57E+06	1.43E+06	7.93E+05	0.00E-01	0.00E-01	0.00E-01

(a) R values are in units of mrem/yr per μ Ci/m^3 for tritium, and in units of m^2-mrem/yr per μ Ci/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	4.18E+06	6.78E+06	0.00E-01	1.85E+07	4.09E+06	0.00E-01	0.00E-01	0.00E-01
Cr 51	4.66E+04	1.36E+06	0.00E-01	0.00E-01	6.64E+03	3.04E+04	5.92E+04	0.00E-01
Fe 59	5.03E+07	6.09E+07	7.30E+07	1.28E+08	0.00E-01	0.00E-01	3.77E+07	0.00E-01
Co 58	2.23E+07	2.23E+07	0.00E-01	8.96E+06	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Co 60	1.06E+08	1.07E+08	0.00E-01	4.51E+07	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Zn 65	4.05E+09	7.42E+09	2.56E+09	8.79E+09	4.26E+09	0.00E-01	0.00E-01	0.00E-01
Sr 89	1.22E+08	8.71E+07	4.24E+09	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Sr 90	1.60E+10	7.87E+08	6.30E+10	0.00E-01	0.00E-01	0.00E-01	0.00E-01	0.00E-01
Zr 95	4.23E+02	2.97E+05	2.45E+03	5.97E+02	6.43E+02	0.00E-01	0.00E-01	0.00E-01
Sb124	2.30E+07	2.29E+08	7.41E+07	1.09E+06	0.00E-01	1.97E+05	4.64E+07	0.00E-01
I 131	3.69E+08	3.00E+07	7.13E+08	8.40E+08	9.81E+08	2.76E+11	0.00E-01	0.00E-01
I 133	4.06E+06	2.35E+06	9.52E+06	1.39E+07	1.63E+07	2.52E+09	0.00E-01	0.00E-01
Cs134	3.43E+09	9.23E+07	1.82E+10	3.40E+10	8.74E+09	0.00E-01	3.58E+09	0.00E-01
Cs137	2.21E+09	9.76E+07	2.67E+10	3.12E+10	8.38E+09	0.00E-01	3.39E+09	0.00E-01
Ba140	3.28E+06	1.56E+07	6.37E+07	6.37E+04	1.51E+04	0.00E-01	3.91E+04	0.00E-01
Ce141	5.60E+03	2.46E+07	7.80E+04	4.76E+04	1.47E+04	0.00E-01	0.00E-01	0.00E-01
Ce144	3.67E+05	3.76E+08	6.54E+06	2.68E+06	1.08E+06	0.00E-01	0.00E-01	0.00E-01

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

(b) 4.80E+03 = 4.80×10^3.

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
Cr 51	9.99E+01	3.32E+03	0.00E-01	0.00E-01	2.28E+01	5.94E+01	1.44E+04	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
Zn 65	4.65E+04	5.34E+04	3.24E+04	1.03E+05	6.89E+04	0.00E-01	8.63E+05	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
Zr 95	2.32E+04	1.50E+05	1.07E+05	3.44E+04	5.41E+04	0.00E-01	1.77E+06	0.00E-01
Sb124	1.24E+04	4.06E+05	3.12E+04	5.88E+02	0.00E-01	7.54E+01	2.48E+06	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 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
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
Ba140	2.56E+03	2.18E+05	3.90E+04	4.90E+01	1.67E+01	0.00E-01	1.27E+06	0.00E-01
Ce141	1.53E+03	1.20E+05	1.99E+04	1.35E+04	6.25E+03	0.00E-01	3.61E+05	0.00E-01
Ce144	1.84E+05	8.15E+05	3.43E+06	1.43E+06	8.47E+05	0.00E-01	7.76E+06	0.00E-01

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

(b) 1.26E+03 = 1.26 X 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
Cr 51	1.35E+02	3.00E+03	0.00E-01	0.00E-01	3.07E+01	7.49E+01	2.09E+04	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
Zn 65	6.23E+04	4.66E+04	3.85E+04	1.33E+05	8.63E+04	0.00E-01	1.24E+06	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
Zr 95	3.15E+04	1.49E+05	1.45E+05	4.58E+04	6.73E+04	0.00E-01	2.68E+06	0.00E-01
Sb124	1.68E+04	3.98E+05	4.30E+04	7.92E+02	0.00E-01	9.75E+01	3.84E+06	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 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
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
Ba140	3.51E+03	2.28E+05	5.46E+04	6.69E+01	2.28E+01	0.00E-01	2.03E+06	0.00E-01
Ce141	2.16E+03	1.26E+05	2.84E+04	1.89E+04	8.87E+03	0.00E-01	6.13E+05	0.00E-01
Ce144	2.62E+05	8.63E+05	4.88E+06	2.02E+06	1.21E+06	0.00E-01	1.33E+07	0.00E-01

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

(b) 1.27E+03 = 1.27 X 10^3.

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

PATHWAY = INHAL

AGE GROUP = CHILD

NUCLIDE	T.BODY (b)	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
H 3	1.12E+03	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
Cr 51	1.54E+02	1.08E+03	0.00E-01	0.00E-01	2.43E+01	8.53E+01	1.70E+04	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
Zn 65	7.02E+04	1.63E+04	4.25E+04	1.13E+05	7.13E+04	0.00E-01	9.94E+05	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
Zr 95	3.69E+04	6.10E+04	1.90E+05	4.17E+04	5.95E+04	0.00E-01	2.23E+06	0.00E-01
Sb124	2.00E+04	1.64E+05	5.73E+04	7.39E+02	0.00E-01	1.26E+02	3.24E+06	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 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
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
Ba140	4.32E+03	1.02E+05	7.39E+04	6.47E+01	2.11E+01	0.00E-01	1.74E+06	0.00E-01
Ce141	2.89E+03	5.65E+04	3.92E+04	1.95E+04	8.53E+03	0.00E-01	5.43E+05	0.00E-01
Ce144	3.61E+05	3.88E+05	6.76E+06	2.11E+06	1.17E+06	0.00E-01	1.19E+07	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
Cr 51	8.93E+01	3.56E+02	0.00E-01	0.00E-01	1.32E+01	5.75E+01	1.28E+04	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
Zn 65	3.10E+04	5.13E+04	1.93E+04	6.25E+04	3.24E+04	0.00E-01	6.46E+05	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
Zr 95	2.03E+04	2.17E+04	1.15E+05	2.78E+04	3.10E+04	0.00E-01	1.75E+06	0.00E-01
Sb124	1.20E+04	5.90E+04	3.79E+04	5.55E+02	0.00E-01	1.00E+02	2.64E+06	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 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
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
Ba140	2.89E+03	3.83E+04	5.59E+04	5.59E+01	1.34E+01	0.00E-01	1.59E+06	0.00E-01
Ce141	1.99E+03	2.15E+04	2.77E+04	1.66E+04	5.24E+03	0.00E-01	5.16E+05	0.00E-01
Ce144	1.76E+05	1.48E+05	3.19E+06	1.21E+06	5.37E+05	0.00E-01	9.83E+06	0.00E-01

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

(b) 6.46E+02 = 6.46×10^2.

TABLE 4-16
(Sheet 1 of 3)

PALO VERDE NUCLEAR GENERATING STATION DISPERSION
AND DEPOSITION PARAMETERS FOR LONG TERM RELEASES
AT THE NEAREST PATHWAY LOCATIONS CENTERED ON UNIT 1

DIRECTION	RESIDENCE(c)		GARDEN(c)		MILK(c)	
	χ/Q (Sec/m^3)	D/Q (m^{-2})	χ/Q (Sec/m^3)	D/Q (m^{-2})	χ/Q (Sec/m^3)	D/Q (m^{-2})
N	2.92E-06(b)	3.25E-09	2.92E-06	3.25E-09	7.03E-07(a)	3.48E-10(a)
NNE	1.81E-06	2.88E-09	4.70E-07(a)	4.04E-10(a)	4.70E-07(a)	4.04E-10(a)
NE	1.95E-06	3.85E-09	1.76E-06	3.29E-09	5.77E-07(a)	6.51E-10(a)
ENE	1.03E-06	1.08E-09	1.03E-06	1.08E-09	3.86E-07(a)	2.86E-10(a)
E	9.39E-07	6.68E-10	3.71E-07(a)	1.87E-10(a)	3.71E-07(a)	1.87E-10(a)
ESE	6.37E-07	2.84E-10	4.12E-07	1.60E-10	4.12E-07	1.60E-10
SE	8.83E-07	2.61E-10	8.83E-07	2.61E-10	5.84E-07(a)	1.52E-10(a)
SSE	1.27E-06	2.61E-10	1.09E-06(a)	2.15E-10(a)	1.09E-06(a)	2.15E-10(a)
S	2.58E-06	4.85E-10	2.09E-06	3.59E-10	2.13E-06	3.71E-10
SSW	3.26E-06	8.26E-10	2.28E-06(a)	4.53E-10(a)	2.28E-06(a)	4.53E-10(a)
SW	2.80E-06	9.10E-10	1.58E-06(a)	3.56E-10(a)	1.58E-06(a)	3.56E-10(a)
WSW	1.95E-06	1.09E-09	8.55E-07(a)	3.18E-10(a)	8.55E-07(a)	3.18E-10(a)
W	7.54E-07(a)	4.44E-10(a)	7.54E-07(a)	4.44E-10(a)	7.54E-07(a)	4.44E-10(a)
WNW	6.03E-07(a)	3.25E-10(a)	6.03E-07(a)	3.25E-10(a)	6.03E-07(a)	3.25E-10(a)
NW	8.24E-07	5.25E-10	7.55E-07	4.61E-10	6.02E-07(a)	3.27E-10(a)
NNW	1.46E-06	1.47E-09	5.20E-07(a)	3.04E-10(a)	5.20E-07(a)	3.04E-10(a)

(a) 5-mile value used since there is no pathway located within the sector up to five miles.

(b) 2.92E-06 = 2.92 x 10^{-6}

(c) Locations of these residences, gardens and milch animals are given in Table A-1, sheet 1. Controlling locations are discussed in Appendix A.

References: 1984 Land Use Census (letter ANPM-21221-JRM/LEB).
NUS Corporation letters NUS-ANPP-1385 and NUS-ANPP-1386.

TABLE 4-16
(Sheet 2 of 3)

PALO VERDE NUCLEAR GENERATING STATION DISPERSION
AND DEPOSITION PARAMETERS FOR LONG TERM RELEASES
AT THE NEAREST PATHWAY LOCATIONS CENTERED ON UNIT 2

DIRECTION	RESIDENCE(c)		GARDEN(c)		MILK(c)	
	X/Q (Sec/m^3)	D/Q (m^{-2})	X/Q (Sec/m^3)	D/Q (m^{-2})	X/Q (Sec/m^3)	D/Q (m^{-2})
N	2.73E-06(b)	2.92E-09	2.39E-06	2.35E-09	7.03E-07(a)	3.48E-10(a)
NNE	2.20E-06	3.87E-09	2.20E-06	3.87E-09	4.70E-07(a)	4.04E-10(a)
NE	1.85E-06	3.55E-09	1.57E-06	2.78E-09	5.77E-07(a)	6.51E-10(a)
ENE	1.03E-06	1.08E-09	1.03E-06	1.08E-09	3.86E-07(a)	2.86E-10(a)
E	8.80E-07	6.06E-10	3.71E-07(a)	1.87E-10(a)	3.71E-07(a)	1.87E-10(a)
ESE	6.25E-07	2.76E-10	3.96E-07	1.51E-10	3.96E-07	1.51E-10
SE	9.06E-07	2.72E-10	9.06E-07	2.72E-10	5.84E-07(a)	1.52E-10(a)
SSE	1.34E-06	2.81E-10	1.09E-06(a)	2.15E-10(a)	1.09E-06(a)	2.15E-10(a)
S	2.63E-06	5.01E-10	2.19E-06	3.88E-10	2.19E-06	3.88E-10
SSW	3.48E-06	9.19E-10	2.28E-06(a)	4.53E-10(a)	2.28E-06(a)	4.53E-10(a)
SW	2.93E-06	9.75E-10	1.58E-06(a)	3.56E-10(a)	1.58E-06(a)	3.56E-10(a)
WSW	2.01E-06	1.16E-09	8.55E-07(a)	3.18E-10(a)	8.55E-07(a)	3.18E-10(a)
W	7.54E-07(a)	4.44E-10(a)	7.54E-07(a)	4.44E-10(a)	7.54E-07(a)	4.44E-10(a)
WNW	6.03E-07(a)	3.25E-10(a)	6.03E-07(a)	3.25E-10(a)	6.03E-07(a)	3.25E-10(a)
NW	7.84E-07	4.88E-10	7.84E-07	4.88E-10	6.02E-07(a)	3.27E-10(a)
NNW	1.46E-06	1.47E-09	5.20E-07	3.04E-10	5.20E-07(a)	3.04E-10(a)

(a) 5-mile value used since there is no pathway located within the sector up to five miles.

(b) 2.73E-06 = 2.73×10^{-6}

(c) Locations of these residences, gardens and milch animals are given in Table A-1, sheet 2. Controlling locations are discussed in Appendix A.

References: 1984 Land Use Census (letter ANPM-21221-JRM/LEB).
NUS Corporation letters NUS-ANPP-1385 and NUS-ANPP-1386.

TABLE 4-16
(Sheet 3 of 3)

PALO VERDE NUCLEAR GENERATING STATION DISPERSION
AND DEPOSITION PARAMETERS FOR LONG TERM RELEASES
AT THE NEAREST PATHWAY LOCATIONS CENTERED ON UNIT 3

DIRECTION	RESIDENCE(c)		GARDEN(c)		MILK(c)	
	X/Q (Sec/m^3)	D/Q (m^{-2})	X/Q (Sec/m^3)	D/Q (m^{-2})	X/Q (Sec/m^3)	D/Q (m^{-2})
N	2.58E-06(b)	2.47E-09	2.42E-06	2.22E-09	7.03E-07(a)	3.48E-10(a)
NNE	1.85E-06	2.97E-09	1.85E-06	2.97E-09	4.70E-07(a)	4.04E-10(a)
NE	1.66E-06	3.00E-09	1.48E-06	2.54E-09	5.77E-07(a)	6.51E-10(a)
ENE	8.75E-07	8.86E-10	8.75E-07	8.86E-10	3.86E-07(a)	2.86E-10(a)
E	8.90E-07	6.17E-10	4.06E-07	2.15E-10	4.25E-07	2.31E-10
ESE	6.37E-07	2.84E-10	5.80E-07	2.46E-10	3.73E-07(a)	1.37E-10(a)
SE	5.84E-07(a)	1.52E-10(a)	5.84E-07(a)	1.52E-10(a)	5.84E-07(a)	1.52E-10(a)
SSE	1.36E-06	2.88E-10	1.09E-06(a)	2.15E-10(a)	1.09E-06(a)	2.15E-10(a)
S	2.65E-06	5.25E-10	2.25E-06	4.06E-10	2.31E-06	4.21E-10
SSW	3.64E-06	9.82E-10	2.28E-06(a)	4.53E-10(a)	2.28E-06(a)	4.53E-10(a)
SW	3.19E-06	1.11E-09	1.58E-06(a)	3.56E-10(a)	1.58E-06(a)	3.56E-10(a)
WSW	2.12E-06	1.26E-09	8.55E-07(a)	3.18E-10(a)	8.55E-07(a)	3.18E-10(a)
W	7.54E-07(a)	4.44E-10(a)	7.54E-07(a)	4.44E-10(a)	7.54E-10(a)	4.44E-10(a)
WNW	6.03E-07(a)	3.25E-10(a)	6.03E-07(a)	3.25E-10(a)	6.03E-07(a)	3.25E-10(a)
NW	6.83E-07	4.05E-10	6.82E-07	4.05E-10	6.02E-07(a)	3.27E-10(a)
NNW	1.34E-06	1.26E-09	5.16E-07	3.01E-10	5.20E-07(a)	3.04E-10(a)

(a) 5-mile value used since there is no pathway located within the sector up to five miles.

(b) 2.58E-06 = 2.58×10^{-6}

(c) Locations of these residences, gardens and milch animals are given in Table A-1, sheet 3. Controlling locations are discussed in Appendix A.

References: 1984 Land Use Census (letter ANPM-21221-JRM/LEB).
NUS Corporation letters NUS-ANPP-1385 and NUS-ANPP-1386.

5.0 TOTAL DOSE AND DOSE TO PUBLIC ONSITE

5.1 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.

Since all other uranium fuel cycle sources are greater than 20 miles away, only the PVNGS site need be considered.

The total dose to any MEMBER OF THE PUBLIC will be determined based on a sum of the doses from all three units' releases and doses from direct radiation from PVNGS.

This dose evaluation is done annually and submitted with the Semiannual Radioactive Effluent Release Report for July through December to assure compliance with 40CFR Part 190, Environmental Radiation Protection Standards for Nuclear Power Operation. This dose evaluation will also be performed whenever calculated doses associated with effluent releases exceed twice the limits of any one of the Technical Specifications 3.11.2.2 or 3.11.2.3.

5.1.1 Doses from Releases

The annual whole body dose accumulated by a MEMBER OF THE PUBLIC for the noble gases released in gaseous effluents is determined by using the following equation:

$$D_{WB} = (3.17 \times 10^{-8}) \sum_i [(K_i)\ (\chi/Q)_{RU}\ (Q_i)] \qquad (5\text{-}1)$$

Where:

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

Q_i = the integrated release of radionuclide i, in μ Ci for the previous calendar year.

$(\chi/Q)_{RU}$ = the highest calculated annual average dispersion parameter, in sec/m^3, for a particular unit, at the controlling location, from Table 4-16, or concurrent meteorological data if available.

$= 2.92 \times 10^{-6}$ from Unit 1
$= 2.19 \times 10^{-6}$ from Unit 2
$= 2.31 \times 10^{-6}$ from Unit 3

D_{WB} = the annual whole body dose in mrem to a MEMBER OF THE PUBLIC at the controlling location due to noble gases released in gaseous effluents.

The annual dose to any organ accumulated by a MEMBER OF THE PUBLIC for iodine-131, iodine-133, tritium and all radionuclides in particulate form with half-lives greater than 8 days released in gaseous effluents is determined by using the following equation:

$$D_o = (3.17 \times 10^{-8}) \sum_i \left[\sum_k (R_{ik} W_k)(Q_i) \right] \quad (4\text{-}3)$$

Where:

D_o = the total annual organ dose from gaseous effluents to a MEMBER OF THE PUBLIC, in mrem, at the controlling location.

Q_i = the integrated release of radionuclide i, in μCi, for the previous calendar year.

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 = the highest annual average dispersion or deposition parameter for the particular unit, used for estimating the total annual organ dose to a MEMBER OF THE PUBLIC at the controlling location for the particular unit.

= $(\chi/Q)_{RU}$, in sec/m^3 for the inhalation pathway and for all tritium calculations, for organ dose at the controlling location, from Table 4-16 or concurrent meteorological data if available.

= 2.92×10^{-6} from Unit 1
= 2.19×10^{-6} from Unit 2
= 2.31×10^{-6} from Unit 3

= $(D/Q)_{RU}$, in m^{-2}, for the food and ground plane pathways, for organ dose at the controlling location, from Table 4-16 or concurrent meteorological data if available.

= 3.25×10^{-9} from Unit 1
= 3.88×10^{-10} from Unit 2
= 4.21×10^{-10} from Unit 3

5.1.2 Dose Due to Direct Radiation

The component of dose to a MEMBER OF THE PUBLIC due to direct radiation will be evaluated by first determining the direct radiation dose at the site boundary in each sector, and then extrapolating the site boundary dose to the controlling location by the inverse square law of distance.

5.2 Dose to Public Onsite

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 following methodology will be used. These activities have been determined to be limited to the vicinity of the Visitor Center located inside 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.

A χ/Q, determined for the Visitor Center, will be used for this assessment.

Equations 5-1 and 4-3 in Sections 5.1.1 and 5.1.2 should be used for this assessment. Q_i should be the integrated release of radionuclide i, in μ Ci, for 8 hours (determined from the yearly Q_i).

6.0 OPERABILITY OF EQUIPMENT

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

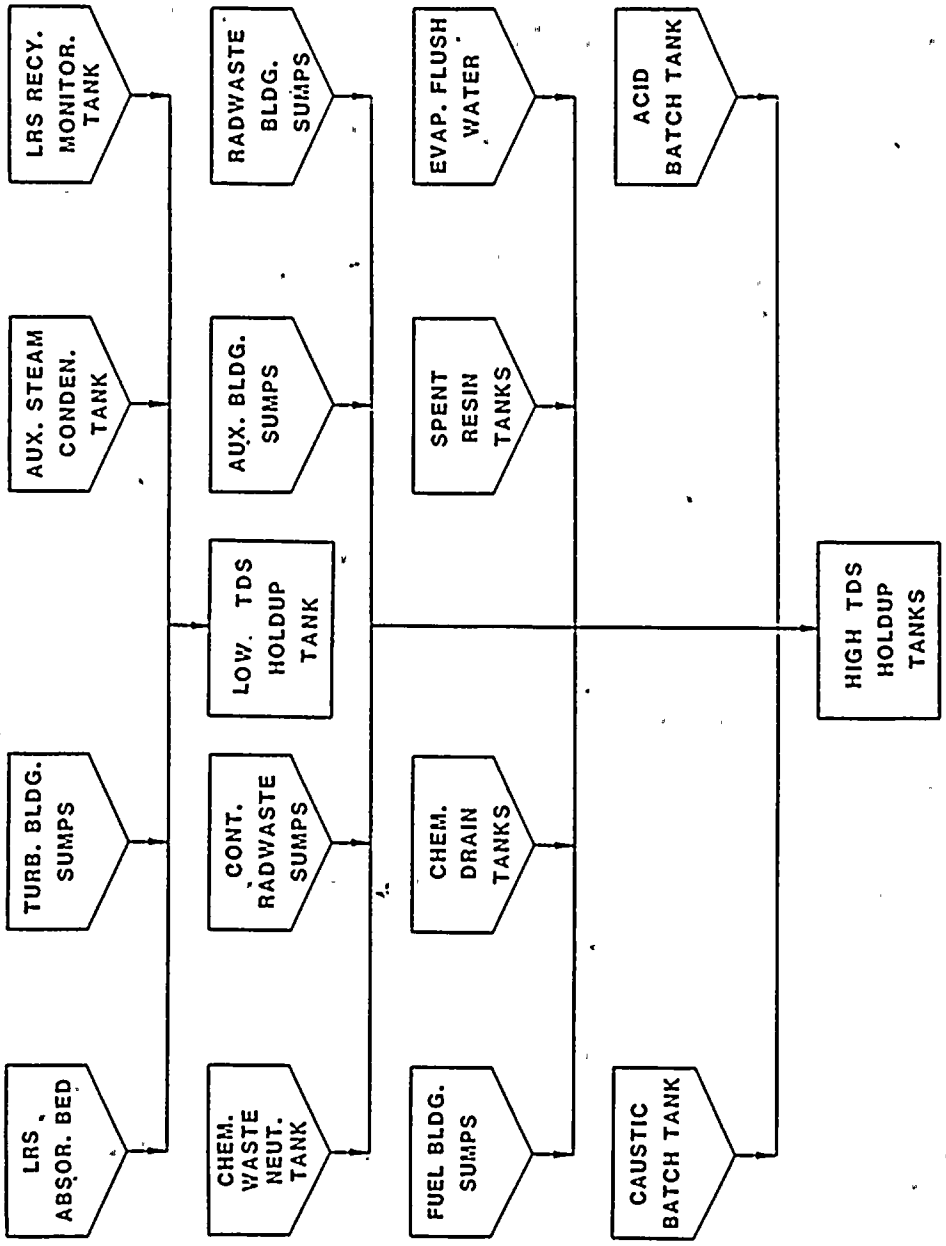


FIGURE 6-1
PROCESS FLOW DIAGRAM
LIQUID RADWASTE SYSTEM
(Sheet 1 of 2)

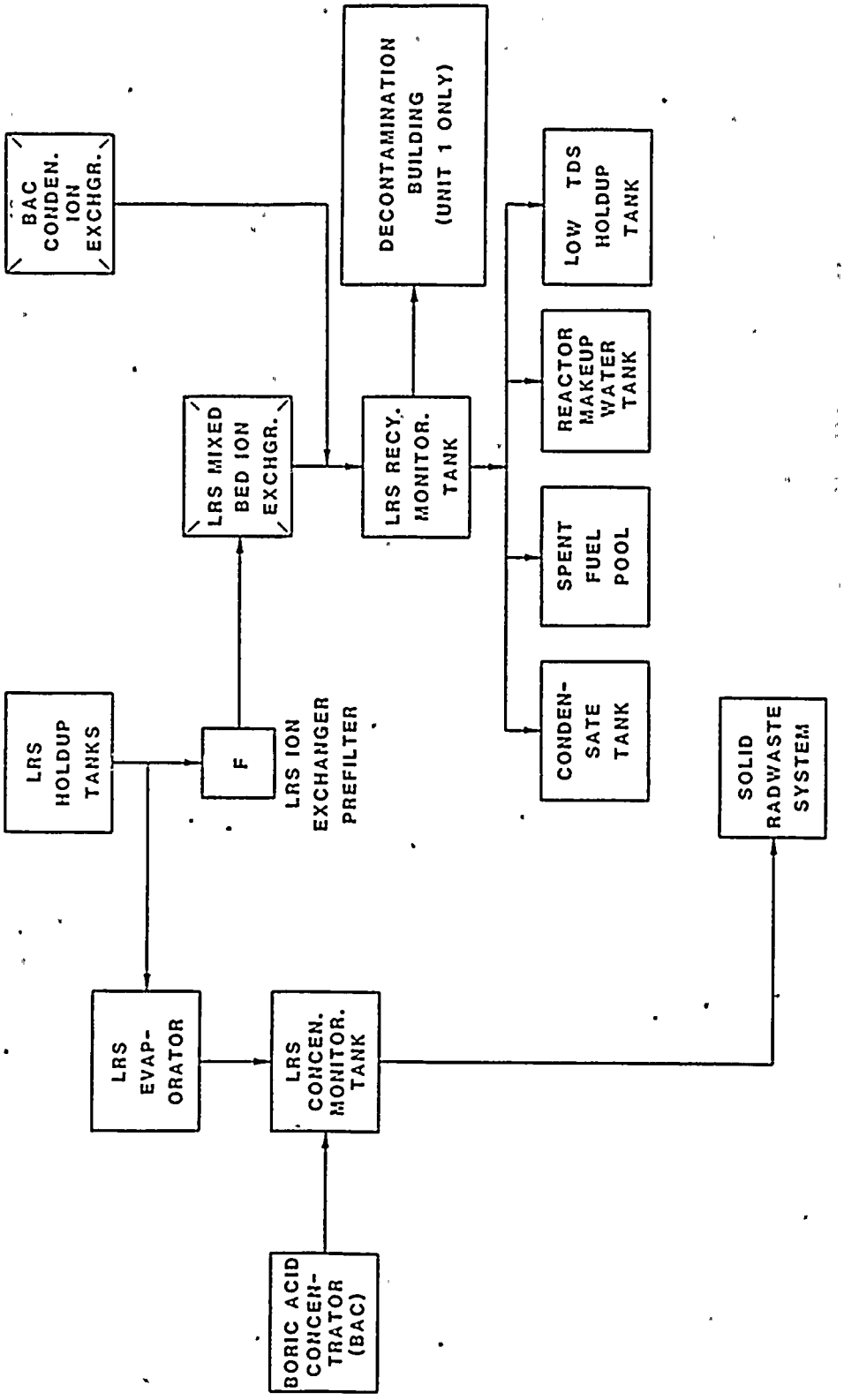


FIGURE 6-1

PROCESS FLOW DIAGRAM

LIQUID RADWASTE SYSTEM

(Sheet 2 of 2)

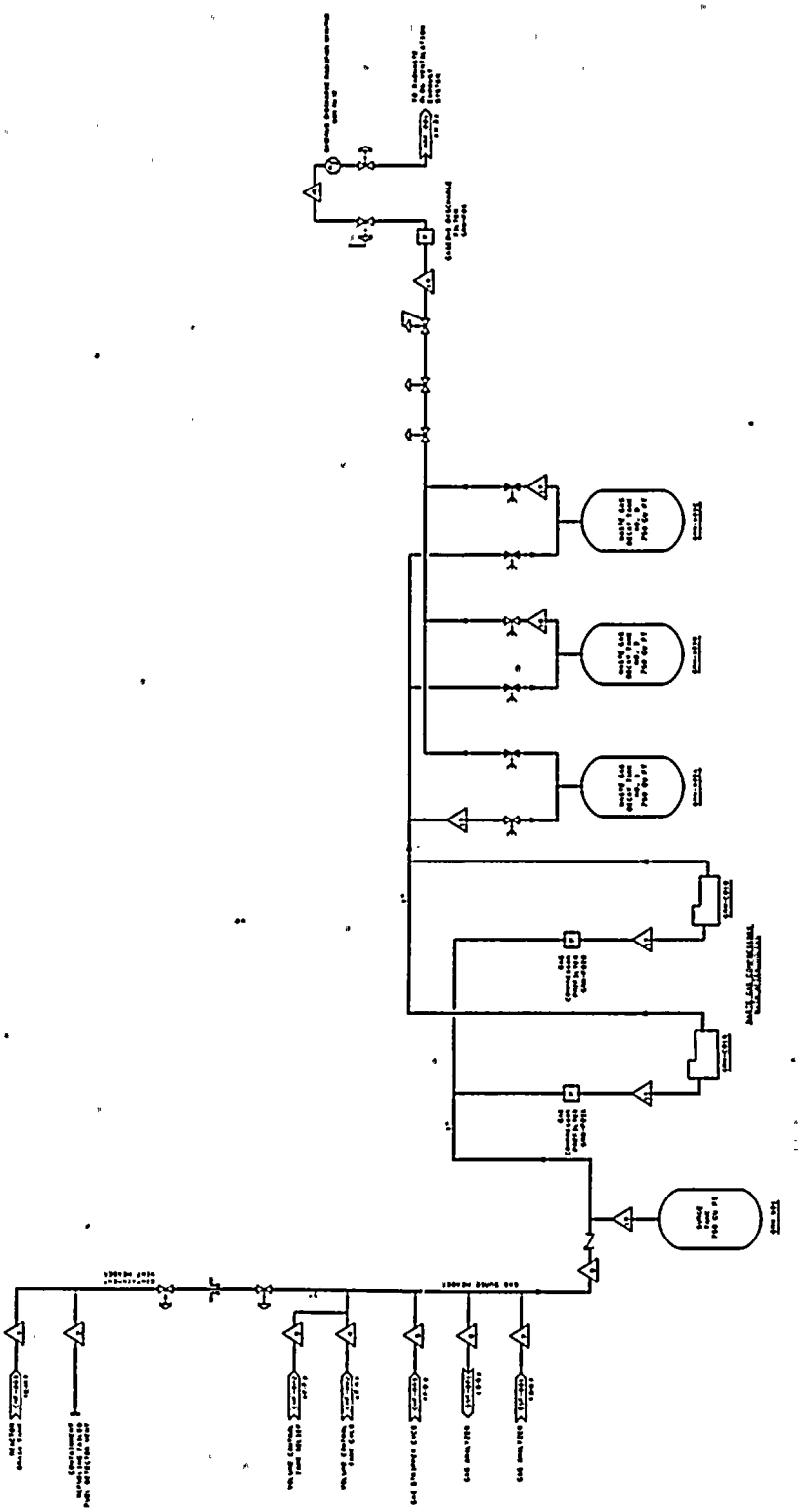


FIGURE 6-2

BASIC FLOW DIAGRAM

GASEOUS RADWASTE SYSTEM

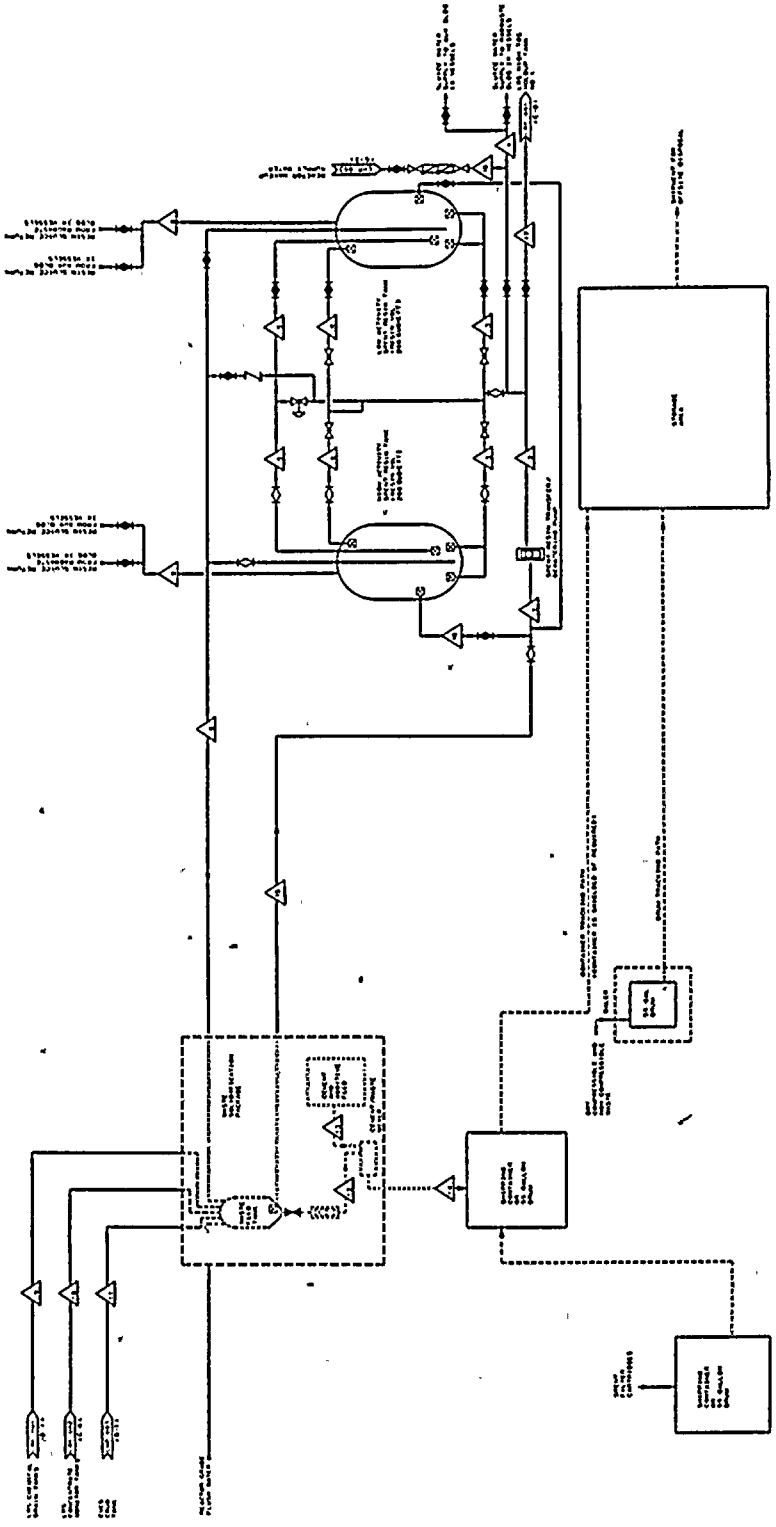


FIGURE 6-3
BASIC FLOW DIAGRAM
SOLID RADWASTE SYSTEM

7.0 RADIOLOGICAL ENVIRONMENTAL PROGRAM

7.1 Radiological Environmental Monitoring Program

Technical Specification 3.12.1 - The radiological environmental monitoring program shall be conducted as specified in Table 3.12-1 [of the Technical Specifications].

Samples shall be collected as specified in Table 3.12-1 [of the Technical Specifications] and 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 are collected at locations shown in Figures 7-1 and 7-2 and described in Table 7-1. Analytical techniques used ensure that the detection capabilities in Table 7-2 are achieved. Environmental samples are 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 program by verifying that the measurable concentrations of radioactive materials and levels of radiation are not higher than expected based on 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 to 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 is made to complete corrective action prior to the end of the next sampling period. All deviations from the sampling schedule are documented in the annual report.

7.2 Land Use Census

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 meteorological 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 is conducted in accordance with Technical Specification 3.12.2. 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 are 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 applies:

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 30 days. The

evaluation is 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 are considered in deciding whether to replace one of the existing sample locations. If applicable, replacement is made within 30 days.

A land use census is 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 correspond to samples required by [Technical Specification] Table 3.12-1.

PVNGS laboratories or contract laboratories which perform analyses for the Radiological Environmental Monitoring Program participate in the Environmental Protection Agency's (EPA's) Environmental Radioactivity Laboratory Intercomparisons Studies (Crosscheck) Program. This participation includes 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 are included in the annual report.

TABLE 7-1
(Sheet 1 of 4)

RADIOLOGICAL ENVIRONMENTAL MONITORING SAMPLE COLLECTION LOCATIONS

SAMPLE SITE	SAMPLE TYPE	LOCATION DESIGNATION[a]	LOCATION DESCRIPTION
1	TLD, Air	E30	APS Goodyear Office
2	TLD	ENE24	Scott-Libby School
3	TLD	E25	Liberty School
4	TLD, Air	E20	APS Buckeye Office
5	TLD	ESE15	Palo Verde, AZ
6	TLD, Air (Control)[b]	SSE35	APS Gila Bend Substation
7	TLD,[b]	SE7	Old U.S. 85 and Arlington School Road
7A	Air	SE8	Arlington School
8	TLD[b]	SSE5	Corner of 363rd Ave. & Southern Pacific Pipeline Rd.
9	TLD[b]	S5	Corner of 371st Ave. & Southern Pacific Pipeline 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. & Buckeye-Salome Rd.
13	TLD[b]	N1	N Site Boundary
14	TLD[b]	NNE2	NNE Site Boundary
14A	Air[b]	NNE3	Buckeye-Salome Rd. & 371st Ave.
15	TLD[b], Air[b]	NE2	NE Site Boundary
16	TLD[b]	ENE2	ENE Site Boundary
17	TLD[b]	E2	E Site Boundary

TABLE 7-1
(Sheet 2 of 4)

SAMPLE SITE	SAMPLE TYPE	LOCATION DESIGNATION (a)	LOCATION DESCRIPTION
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 miles N. of Ward Rd., 3 miles W. of Wintersburg Rd.
24	TLD(b)	SW4	Ward Rd. at Desert Farms
25	TLD(b)	WSW5	Ward Rd. at Cattle Guard
26	TLD(b)	SSW5	Shepard 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
32	TLD(b)	NNW1	NNW Site Boundary
33	TLD(b)	NW5	Yuma Rd., 1/2 mile W of Belmont Rd.
34	TLD(b)	NNW5	Corner of 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 Rd.
37	TLD(b)	NNE5	Corner of 363rd Ave. & Van Buren Rd.

TABLE 7-1
(Sheet 3 of 4)

SAMPLE SITE	SAMPLE TYPE	LOCATION DESIGNATION (a)	LOCATION DESCRIPTION
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	Wintersburg, AZ
41	TLD (b)	WNW2Q	Harquahala Valley School
42	TLD(b)	N8	Ruth Fisher School
43	TLD(b)	N45	Vulture Peak School (Wickenburg, AZ)
44	TLD(b), Air (b)	ENE35	APS El Mirage Office (Sun City, AZ))
45	TLD(b) (Control)	E20	REMP Lab. (Buckeye, AZ) (Lead PIG)
46	Water(b) (Control)	NNW9	McArthur's Farm (Tonopah, AZ))
47	Vegetation (b)	NE3	Adams Residence
48	Water(b)	SW5	Desert Farms
49	Water(b)	ESE4	Wedgeworth Residence, 351st Ave. & Dobbins
50	Milk(b)	NE7	Baisley Dairy, 331st Ave. & Van Buren Rd.
51	Milk(b), Vegetation	E11	Butler Dairy, Palo Verde Rd. & Southern Ave.
52	Vegetation(b)	E15	Cambron Farm, Miller Rd. & Broadway Rd.
53	Milk(b)	E26	Kerr Dairy, Dean & Buckeye Rds.
54	Milk	E27	Skousen Dairy, Airport & Dobbins Rd.
55	Milk	E28	Lueck Dairy, Jackrabbit & Hazen Rds.
56	Milk(b) (Control)	E75	Hamstra Dairy #2, McQueen & Ryan Rds.
57	Water(b)	Onsite	Well 27ddc
58	Water(b)	Onsite	Well 34abb

TABLE 7-1
(Sheet 4 of 4)

SAMPLE SITE	SAMPLE TYPE	LOCATION DESIGNATION (a)	LOCATION DESCRIPTION
59	Surface Water(b)	Onsite	PVNGS Evaporation Pond
60	Surface Water(b)	Onsite	PVNGS Reservoir
61	Citrus (Control)	E80	Cooley Farms, Inc. (Higley, Arizona)
62	Vegetation(b) (Control)	E60	AJM Farms, Inc., Chandler Industrial Park

(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.

(c) Refer to Figures 7-1 and 7-2 for relative locations of Sample sites.

TABLE 7-2
(Sheet 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
(Sheet 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 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),

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.

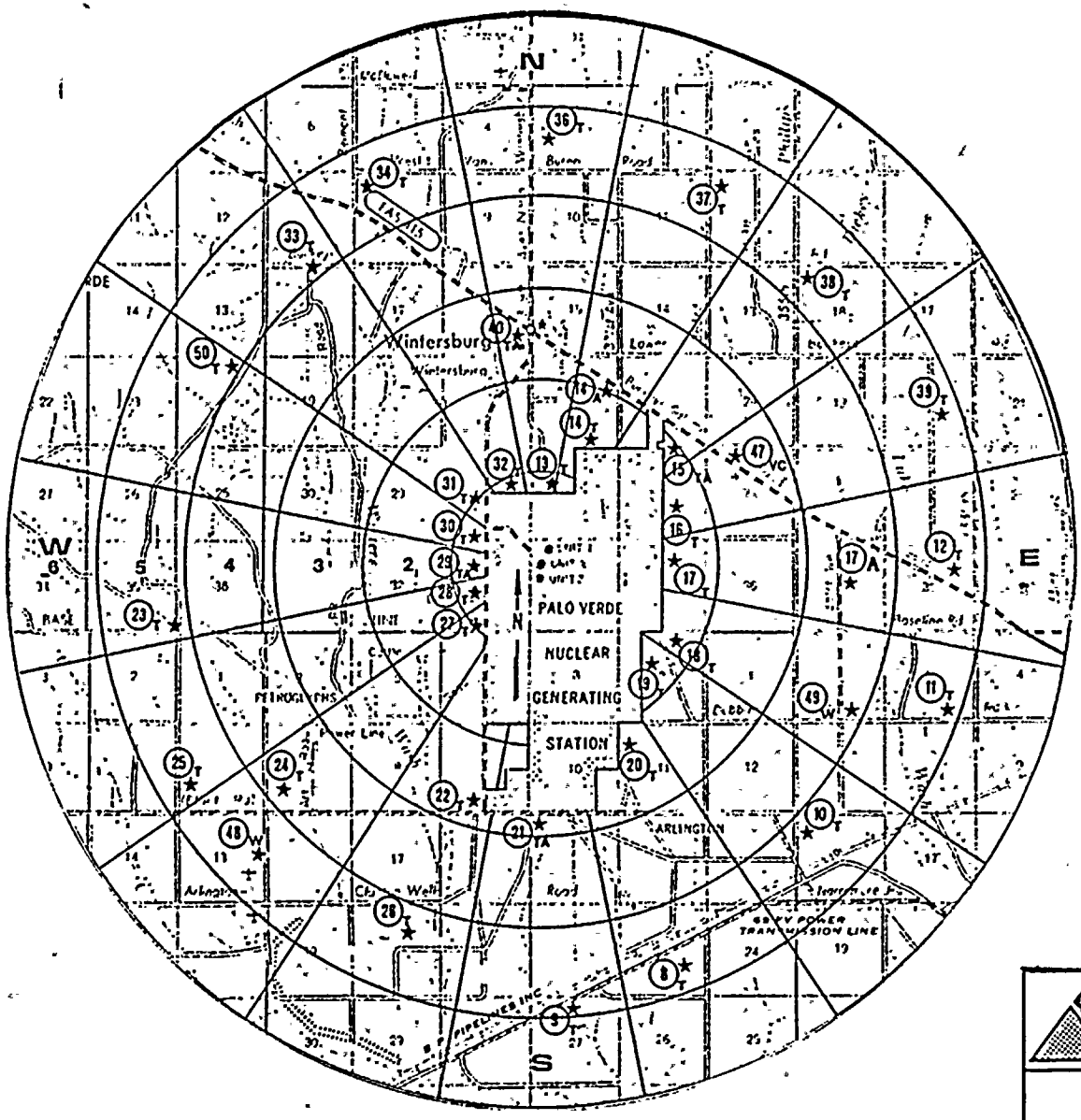
It should be recognized that the LLD is defined as a priori (before the fact) limit representing the capability of a measurement system and not as a posteriori (after the fact) limit for a particular measurement.

(b) LLD for drinking water.

TABLE 7-3

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
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	Gamma dose quarterly	Forty locations as listed 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 or grab sample one-month period	Gross beta and gamma spectrums monthly; tritium quarterly	Locations 46, 48 & 49. Control location is 46.
Ingestion: Milk	Semimonthly for animals on pasture, otherwise monthly	Gamma spectrum and radioiodine semimonthly or monthly	Locations 50, 51, 53 and 56. Control location is 56.
Food Products	Once per harvest	Gamma spectrum and radioiodine per sample	Locations 47, 52 and 62.



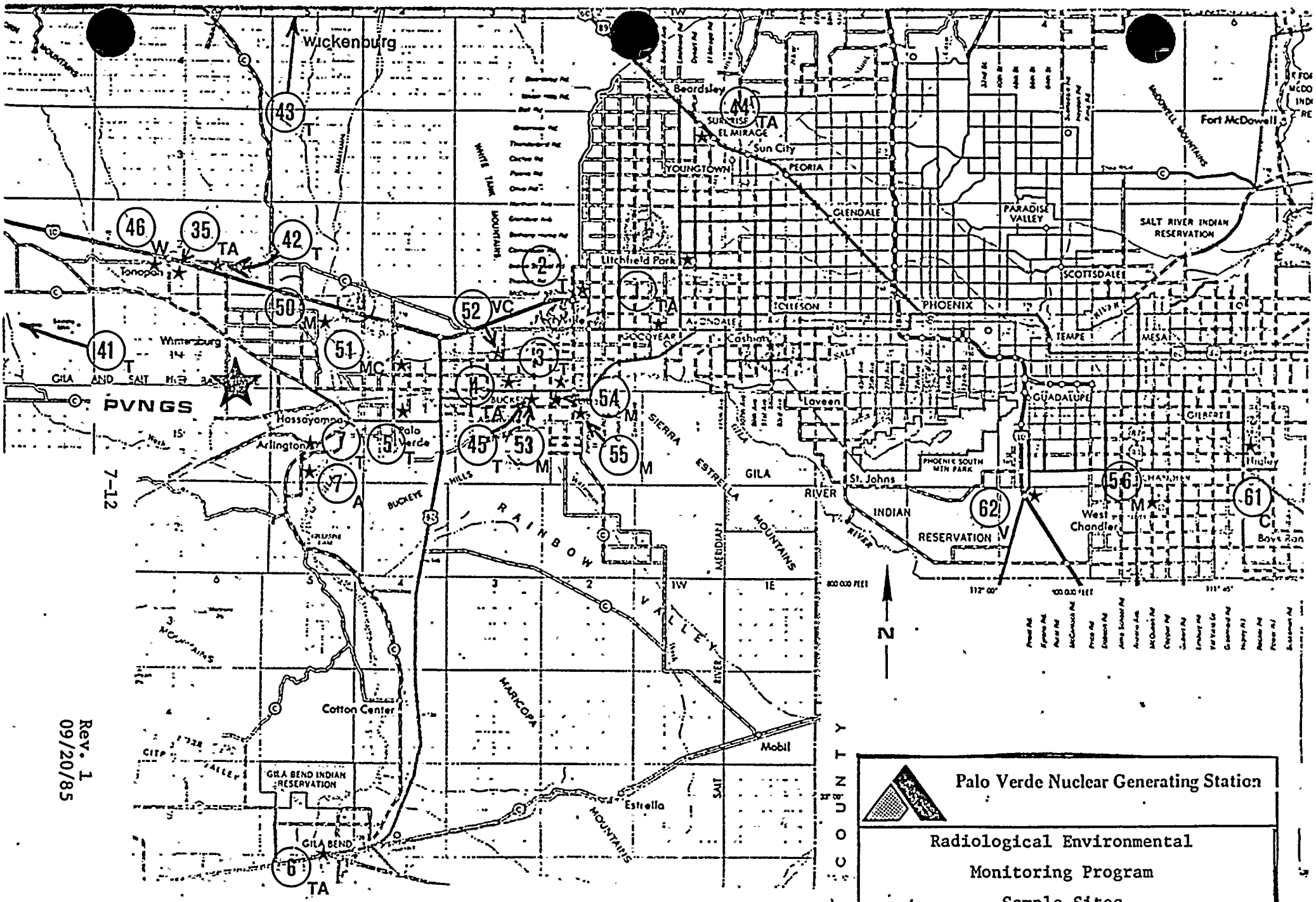
Palo Verde Nuclear Generating Station

Radiological Environmental

Monitoring Program

Sample Sites
0 to 5 miles

Figure 7-1



Palo Verde Nuclear Generating Station

Radiological Environmental Monitoring Program

Sample Sites Beyond 5 Miles

Figure 7-2

APPENDIX A

DETERMINATION OF CONTROLLING LOCATION

The controlling location is the location of the MEMBER OF THE PUBLIC who receives the highest doses.

The determination of a controlling location for implementation of 10CFR50 for radioiodines and particulates is known to be a function of:

(1) Isotopic release rates

(2) Meteorology

(3) Exposure pathway

(4) Receptor's age

The incorporation of these parameters into Equation 4-3 results in the respective equations at the controlling location. The isotopic release rates are based upon the source terms calculated using the PVNGS Environmental Report, Operating License Stage, Table 3.5-12, without carbon.

All of the locations and exposure pathways, identified in the 1984 Land Use Census, have been evaluated. These include cow milk ingestion, goat milk ingestion, vegetable ingestion, inhalation, and ground plane exposure. An infant is assumed to be present at all milk pathway locations. A child is assumed to be present at all vegetable garden locations. The ground plane exposure pathway is only considered to be present where an infant is not present. Naturally, inhalation is present everywhere an individual is present.

For the determination of the controlling locations, the highest χ/Q and D/Q values, based on the 9 year meteorological data base, for the vegetable garden, cow milk, and goat milk pathways, are selected for each unit. The receptor organ doses have been calculated at each of these locations. Based upon these calculations, it is determined that the controlling receptor pathway is a function of unit location. For Unit 1, the controlling receptor is a garden-child pathway; for releases from Unit 2 and Unit 3 the controlling receptor is a cow milk-infant pathway. These determinations are based upon Table 4-16 which, in turn, is based upon the 1984 Land Use Census. Locations of the nearest residences, gardens and milch animals, as determined in the 1984 Land Use Census, are given in Table A-1.

TABLE A-1
(Sheet 1 of 3)
EXPOSURE PATHWAY LOCATIONS NEAREST TO PVNGS UNIT 1

Sector Designator(a)	Nearest Residence Distance Miles(a)	Location Designator (b)	Nearest Garden Distance Miles(a)	Location Designator (b)	Nearest Milch Animal Distance Miles(a)	Location Designator (b)	Animal Type
N	1.4	3	1.4	3	(c)		
NNE	1.8	20	(c)		(c)		
NE	1.9	4	2.1	5	(c)		
ENE	2.7	6	2.7	6	(c)		
E	2.8	9	(c)		(c)		
ESE	3.7	8	4.6	9	4.6	9	Goat
SE	4.1	10	4.1	10	(c)		
SSE	4.7	11	(c)		(c)		
S	4.6	19	5.2	12	5.1	12	Cow
SSW	3.5	13	(c)		(c)		
SW	2.9	14	(c)		(c)		
WSW	2.6	15	(c)		(c)		
W	(c)		(c)		(c)		
WNW	(c)		(c)		(c)		
NW	3.8	21	4.1	16	(c)		
NNW	2.0	17	(c)		(c)		

(a) Sector designators and distances derive from the 1984 Land Use Census (letter ANPM-21221-JRM/LEB), and are specific to the subject PVNGS unit.

(b) Location designators, and animal types at locations indicated, are from the 1984 Land Use Census (letter ANPM-21221-JRM/LEB).

(c) Postulated to be at 5 mile distance since the 1984 Land Use Census identified no pathway (residence, garden or milch animal as appropriate) within the sector and within 5 miles.

TABLE A-1
(Sheet 2 of 3)
EXPOSURE PATHWAY LOCATIONS NEAREST TO PVNGS UNIT 2

Sector Designator(a)	Nearest Residence Distance Miles(a)	Location Designator (b)	Nearest Garden Distance Miles(a)	Location Designator (b)	Nearest Milch Animal Distance Miles(a)	Location Designator (b)	Animal Type
N	1.5	1	1.7	2	(c)		
NNE	1.5	3	1.5	3	(c)		
NE	2.0	4	2.3	5	(c)		
ENE	2.7	6	2.7	6	(c)		
E	3.0	7	(c)		(c)		
ESE	3.7	8	4.7	9	4.7	9	Goat
SE	4.0	10	4.0	10	(c)		
SSE	4.5	11	(c)		(c)		
S	4.5	19	5.0	12	5.0	12	Cow
SSW	3.2	13	(c)		(c)		
SW	2.7	14	(c)		(c)		
WSW	2.5	15	(c)		(c)		
W	(c)		(c)		(c)		
WNW	(c)		(c)		(c)		
NW	4.0	16	4.0	16	(c)		
NNW	2.0	17	5.0	18	(c)		

(a) Sector designators and distances derive from the 1984 Land Use Census (letter ANPM-21221-JRM/LEB), and are specific to the subject PVNGS unit.

(b) Location designators, and animal types at locations indicated, are from the 1984 Land Use Census (letter ANPM-21221-JRM/LEB).

(c) Postulated to be at 5 mile distance since the 1984 Land Use Census identified no pathway (residence, garden or milch animal as appropriate) within the sector and within 5 miles.

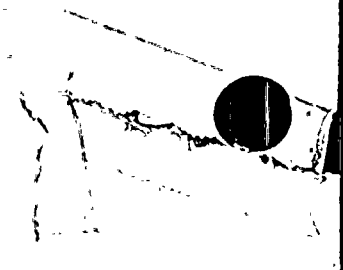


TABLE A-1
(Sheet 3 of 3)
EXPOSURE PATHWAY LOCATIONS NEAREST TO PVNGS UNIT 3

Sector Designator(a)	Nearest Residence Distance Miles(a)	Location Designator (b)	Nearest Garden Distance Miles(a)	Location Designator (b)	Nearest Milch Animal Distance Miles(a)	Location Designator (b)	Animal Type
N	1.8	1	1.9	2	(c)		
NNE	1.7	3	1.7	3	(c)		
NE	2.2	4	2.4	5	(c)		
ENE	2.9	6	2.9	6	(c)		
E	3.0	7	4.6	9	4.5	9	Goat
ESE	3.7	8	4.0	10	(c)		
SE	(c)		(c)		(c)		
SSE	4.4	11	(c)		(c)		
S	4.2	19	4.9	12	4.8	12	Cow
SSW	3.1	13	(c)		(c)		
SW	2.5	14	(c)		(c)		
WSW	2.4	15	(c)		(c)		
W	(c)		(c)		(c)		
WNW	(c)		(c)		(c)		
NW	4.3	16	4.3	16	(c)		
NNW	2.2	17	5.0	18	(c)		

(a) Sector designators and distances derive from the 1984 Land Use Census (letter ANPM-21221-JRM/LEB), and are specific to the subject PVNGS unit.

(b) Location designators, and animal types at locations indicated, are from the 1984 Land Use Census (letter ANPM-21221-JRM/LEB).

(c) Postulated to be at 5 mile distance since the 1984 Land Use Census identified no pathway (residence, garden or milch animal as appropriate) within the sector and within 5 miles.