ENERGY NORTHWEST
P.O. Box 968 ■ Richland, Washington 99352-0968

February 26, 2002
GO2-02-0032

Docket No. 50-397

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

Gentlemen:

Subject: **COLUMBIA GENERATING STATION, OPERATING LICENSE NPF-21 RADIOACTIVE EFFLUENT RELEASE REPORT FOR JANUARY THROUGH DECEMBER 2001**

In accordance with 10 CFR 50.36a(a)(2), 10CFR72.44(d)(3), and Technical Specification 5.6.3, the annual Radioactive Effluent Release Report is hereby submitted as an enclosure to this letter. As required by the Technical Specification, the report includes a summary of the quantities of radioactive liquid and gaseous effluents and solid waste released from Columbia Generating Station during the reporting period.

A complete copy of the Columbia Generating Station Offsite Dose Calculation Manual (ODCM) is also enclosed with this submittal as required by Technical Specification 5.5.1. This copy of the ODCM includes revisions made to the document since the last submittal.

Respectfully,

GO Smith
Vice President, Generation
Mail Drop PE04

Enclosures

cc: EW Merschoff - NRC RIV
JS Cushing - NRC NRR
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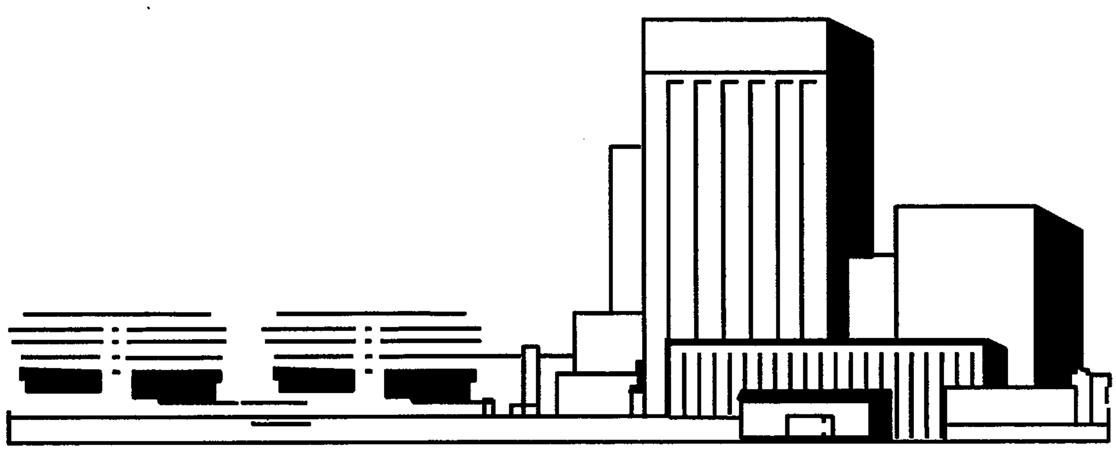
ENERGY NORTHWEST

Columbia Generating Station Radioactive Effluent Release Report

January through December 2001



REFERENCES:
1OCFR50.36a(a)(2)
10CFR72.44(d)(3)

Columbia Generating Station Radioactive Effluent Release Report

January through December 2001

Energy Northwest

February 2002

Table of Contents

1.0 Introduction

This report is submitted in compliance with 10CFR50.36a(a)(2), 10CFR72.44(d)(3), and Technical Specification 5.6.3. It includes a summary of the quantities of radioactive liquid and gaseous effluents and solid radwaste released from Columbia Generating Station during calendar year 2001. Effluent data is summarized on a quarterly basis.

An Independent Spent Fuel Storage Installation (ISFSI) is under construction. No fuel was stored at the facility in 2001. Consequently, there were no effluents.

2.0 Liquid Effluents

No radioactive liquids were discharged from Columbia Generating Station during calendar year 2001.

3.0 Gaseous Effluents

The gaseous radwaste effluents from Columbia Generating Station were released from three (3) release points:

Main Plant Vent -- mixed mode release
Turbine Building -- ground level release
Radwaste Building -- ground level release

The gaseous source terms from each release point are listed in Tables 3-1, 3-2, and 3-3. Table 3-4 provides a summation of the total activity released, the average release rate, gross alpha radioactivity, and the estimated total error associated with the measurements of radioactivity in the gaseous effluents.

Total error estimates are propagated from individual error estimates of sample volume, sample activity and effluent flow rate measurements. The overriding uncertainty in all cases is in the measurement of the effluent activity and sample volumes. The estimated error was determined to be 36 percent at the 95 percent confidence level.

Radioactivity measurements for gaseous effluent releases are performed for fission and activation gases by collecting the samples in a marinelli beaker and analyzing them using gamma spectroscopy. Air is analyzed for tritium by collection of water vapor on a desiccant with subsequent distillation and liquid scintillation counting. Particulates and iodines are sampled using particulate filters and charcoal cartridges. Both are analyzed using gamma spectroscopy. The average energy per disintegration of fission and activation gases is not included in this report as it is not required by Technical Specifications and is not used for gaseous effluent release rate limit calculations.

Noble gas activities are commonly below detection limits in the building effluent ducts. When no radioactive noble gas was detected in an effluent duct, a value of zero was used for release and dose calculations.

Dose calculations were performed for releases using the NRC GASPAR II computer program and parameters as defined in the ODCM. Quarterly and annual doses to the potentially highest-exposed member of the public at and beyond the site boundary were calculated. In addition, quarterly and annual doses were calculated at locations identified in the annual land use census. Comparison of the highest quarterly and annual doses to ODCM effluent limits is summarized in Table 3-0. The ODCM limits are based on Appendix I to Part 50 of Title 10 of the Code of Federal Regulations. The threshold for air dose applies to fission and activation gases and is ten (10) millirad for beta and five (5) millirad for gamma quarterly and twenty (20) millirad for beta and ten (10) millirad for gamma annually. The threshold for organ dose applies to iodine, tritium, and particulates with half-lives greater than eight days and is seven and a half (7.5) millirem quarterly and fifteen (15) millirem annually. Dose calculations were also conducted for members of the public within the site boundary. The results are discussed and tabulated in Section 6.0.

The Kootenai building is located approximately 0.75 miles from the reactor building. Within this building are the Emergency Operations Facility (EOF) and a backup chemistry laboratory. The radiochemical hood within the backup chemistry lab contains a HEPA filter and is monitored for radioactive releases when in operation. All liquids are routed to a sump that is monitored for radioactive material prior to release by a lift pump to the sewage treatment facility. No evidence of gaseous or liquid release of licensed radioactive material was noted in 2001.

There were no abnormal releases of gaseous effluent during this reporting period.

Identified Problems with Effluent Monitoring

Problems with the meteorological tower were encountered in 2001. They are summarized in Section 5. As a result of low data recovery and abnormal bias noted in recovered data, Joint Frequency Distribution Tables were developed from a five-year average (1996 – 2000) and used to calculate the quarterly and annual dispersion and deposition parameters for the 2001 dose calculations.

One of three radwaste building first quarter 2001 composite samples was not analyzed in accordance with ODCM requirement 6.2.2.1.2. The sample was dispersed and lost due to a chemical reaction in a centrifuge during sample preparation. Since these samples are collected from a common header and no strontium activity was detected on the other two samples, no activity was expected on the dispersed sample. However, Section 3a of Regulatory Guide 1.21 Appendix A suggests that, in this case, an estimate should be performed by using the average of the two adjacent data points spanning this period. The first quarter 2001 strontium release estimate is based on this method. Prior to the lost sample, the last positive value for strontium in the Radwaste Building effluent duct was during the fourth quarter of 1999. This 1999 value (1.51E-15 microcuries/cc) was averaged with the second quarter 2001 value (1.91E-15).

The Radwaste Building Intermediate Range Noble Gas Monitor (WEA-RIS-14A) and the Turbine Building Intermediate Range Noble Gas Monitor (TEA-RIS-13A) were out of service for more than 30 days (WEA-RIS-14A was inoperable from 12/13/2000 to 9/5/2001; TEA-RIS-13A was inoperable from 12/08/2000 to 10/9/2001). ODCM specification 6.1.2

requires these monitors to be operable. Problems were encountered in acquiring a replacement detector from the manufacturer.

Revision to the Columbia Generating Station Annual Effluent Report for 2000
The Columbia Generating Station 2000 Radioactive Effluent Release Report should be revised by adding the following to the end of Section 3.0:

The Radwaste Building gaseous effluent sampling station (WEA-SR-25) was declared inoperable on 10/27/00 and a temporary sample system, consisting of a sample pump and tygon tubing, was set up to ensure continuous flow through the iodine cartridge and particulate filter. The temporary sample system was also used to collect eight-hour noble gas grab samples as required by the ODCM. On 11/7/00 it was discovered that the sample pump did not have a required filter installed, and that the eight-hour noble gas grab samples were being collected on the discharge side of the pump (from around the filter housing) and not from the WEA system itself. As a result, samples were not representative of the air in the Radwaste Building effluent duct. No measurable noble gases are routinely detected in the WEA system. The sample rack was declared operable on 11/9/00. Chemistry Procedure 12.5.37 was revised on 1/16/01 to verify that the required filter is present and that grab samples are collected on the suction side of the pump.

Gaseous Effluent Tables

Table 3-0 10 CFR Part 50 Appendix I Dose Compliance

Report Period: January -- December 2001

	1st Quarter	Quarter	3rd Quarter	4th Quarter	Year*
Noble Gas					
Gamma Air Dose (mrad)	3.46E-05	9.78E-04	8.93E-05	3.65E-04	1.32E-03
ODCM Limit	5	5	5	5	10
% of Limit	6.92E-04	1.96E-02	1.79E-03	7.30E-03	1.32E-02
Beta Air Dose (mrad)	1.22E-05	2.58E-03	3.16E-05	1.29E-04	2.62E-03
ODCM Limit	10	10	10	10	20
% of Limit	1.22E-04	2.58E-02	3.16E-04	1.29E-03	1.31E-02
Iodine-131, Iodine-133, Tritium, and Particulates with half-lives greater than eight days.					
Organ Dose (mrem)	2.64E-03	3.17E-03	8.07E-04	2.21E-03	8.40E-03
ODCM Limit	7.5	7.5	7.5	7.5	15
% of Limit	3.52E-02	4.22E-02	1.08E-02	2.94E-02	5.60E-02

* Rather than the sum of the quarters, these values are based on average annual meteorological parameters and total annual effluents.

Table 3-1 Main Plant Vent Releases
Fission Gases and Iodines

Report Period: January -- December 2001

Nuclides Released	1st Quarter (Ci)	2nd Quarter (Ci)	3rd Quarter (Ci)	4th Quarter (Ci)	Year (Ci)
A. Fission gases					
krypton-85	<LLD	<LLD	<LLD	<LLD	<LLD
krypton-85m	<LLD	7.50E-01	<LLD	<LLD	7.50E-01
krypton-87	<LLD	<LLD	<LLD	<LLD	<LLD
krypton-88	<LLD	<LLD	<LLD	<LLD	<LLD
xenon-133	<LLD	2.66E+01	<LLD	<LLD	2.66E+01
xenon-133m	<LLD	<LLD	<LLD	<LLD	<LLD
xenon-135	<LLD	2.34E-01	2.15E-03	<LLD	2.36E-01
xenon-135m	<LLD	<LLD	<LLD	<LLD	<LLD
xenon-138	<LLD	<LLD	<LLD	<LLD	<LLD
argon-41	4.15E-01	4.14E+00	4.61E+00	3.73E+00	1.29E+01
Total for period *	4.15E-01	3.17E+01	4.62E+00	3.73E+00	4.04E+01
B. Iodines					
iodine-131	<LLD	6.80E-04	<LLD	<LLD	6.80E-04
iodine-132	<LLD	<LLD	<LLD	<LLD	<LLD
iodine-133	<LLD	4.58E-08	<LLD	<LLD	4.58E-08
iodine-134	<LLD	<LLD	<LLD	<LLD	<LLD
iodine-135	<LLD	<LLD	<LLD	<LLD	<LLD
Total for period *	<LLD	6.80E-04	<LLD	<LLD	6.80E-04

* Less than (<) values are not included in the totals. See Table 3-6 for LLD values.

Table 3-1 Main Plant Vent Releases (Continued)
Particulates and Tritium

Report Period: January -- December 2001

Nuclides Released	1st Quarter (Ci)	2nd Quarter (Ci)	3rd Quarter (Ci)	4th Quarter (Ci)	Year (Ci)
C. Particulates					
strontium-89	5.89E-06	8.70E-06	<LLD	<LLD	1.46E-05
strontium-90	<LLD	<LLD	5.11E-06	<LLD	5.11E-06
cesium-134	<LLD	<LLD	<LLD	<LLD	<LLD
cesium-137	<LLD	<LLD	<LLD	<LLD	<LLD
barium-lanthanum-140	<LLD	<LLD	<LLD	<LLD	<LLD
silver-110m	<LLD	<LLD	4.59E-05	<LLD	4.59E-05
cerium-141	<LLD	<LLD	<LLD	<LLD	<LLD
cerium-144	<LLD	<LLD	<LLD	<LLD	<LLD
cobalt-58	<LLD	<LLD	1.55E-04	<LLD	1.55E-04
cobalt-60	<LLD	2.22E-04	1.03E-04	<LLD	3.26E-04
iron-59	<LLD	<LLD	<LLD	<LLD	<LLD
manganese-54	<LLD	<LLD	4.65E-05	<LLD	4.65E-05
zinc-65	<LLD	1.05E-04	2.53E-04	<LLD	3.57E-04
chrome-51	<LLD	<LLD	<LLD	<LLD	<LLD
Total for period*	5.89E-06	3.36E-04	6.08E-04	<LLD	9.50E-04
Others with T 1/2 < 8 days					
arsenic-76	<LLD	<LLD	<LLD	<LLD	<LLD
copper-64	<LLD	<LLD	<LLD	<LLD	<LLD
sodium-24	<LLD	<LLD	<LLD	<LLD	<LLD
technetium-99m	<LLD	<LLD	1.11E-03	<LLD	1.11E-03
zinc-69m	<LLD	<LLD	<LLD	<LLD	<LLD
Total with T 1/2 < 8 days*	<LLD	<LLD	1.11E-03	<LLD	1.11E-03
D. Tritium					
tritium	1.68E+00	3.29E+00	1.55E+00	2.14E+00	8.67E+00

* Less than (<) values are not included in the totals. See Table 3-6 for LLD values.

Table 3-2 Turbine Building Releases
Fission Gases and Iodines

Report Period: January -- December 2001

Nuclides Released	1st Quarter (Ci)	2nd Quarter (Ci)	3rd Quarter (Ci)	4th Quarter (Ci)	Year (Ci)
A. Fission gases					
krypton-85	<LLD	<LLD	<LLD	<LLD	<LLD
krypton-85m	<LLD	<LLD	<LLD	<LLD	<LLD
krypton-87	<LLD	<LLD	<LLD	<LLD	<LLD
krypton-88	<LLD	<LLD	<LLD	<LLD	<LLD
xenon-133	<LLD	1.68E+01	<LLD	<LLD	1.68E+01
xenon-133m	<LLD	<LLD	<LLD	<LLD	<LLD
xenon-135	<LLD	<LLD	<LLD	<LLD	<LLD
xenon-135m	<LLD	<LLD	<LLD	<LLD	<LLD
xenon-138	<LLD	<LLD	<LLD	<LLD	<LLD
argon-41	<LLD	<LLD	<LLD	<LLD	<LLD
Total for period *	<LLD	1.68E+01	<LLD	<LLD	1.68E+01
B. Iodines					
iodine-131	<LLD	5.50E-06	<LLD	<LLD	5.50E-06
iodine-132	<LLD	<LLD	<LLD	<LLD	<LLD
iodine-133	<LLD	<LLD	<LLD	<LLD	<LLD
iodine-134	<LLD	<LLD	<LLD	<LLD	<LLD
iodine-135	<LLD	<LLD	<LLD	<LLD	<LLD
Total for period *	<LLD	5.50E-06	<LLD	<LLD	5.50E-06

* Less than (<) values are not included in the totals. See Table 3-6 for LLD values.

Table 3-2 Turbine Building Releases (Continued)

Particulates and Tritium

Report Period: January -- December 2001

Nuclides Released	1st Quarter (Ci)	2nd Quarter (Ci)	3rd Quarter (Ci)	4th Quarter (Ci)	Year (Ci)
C. Particulates					
strontium-89	2.68E-05	1.41E-05	2.17E-05	8.18E-06	7.08E-05
strontium-90	<LLD	4.49E-07	<LLD	<LLD	4.49E-07
cesium-134	<LLD	<LLD	<LLD	<LLD	<LLD
cesium-137	<LLD	<LLD	<LLD	<LLD	<LLD
barium-lanthanum-140	<LLD	<LLD	<LLD	<LLD	<LLD
molybdenum-99	<LLD	<LLD	<LLD	<LLD	<LLD
cerium-141	<LLD	<LLD	<LLD	<LLD	<LLD
cerium-144	<LLD	<LLD	<LLD	<LLD	<LLD
cobalt-58	<LLD	<LLD	<LLD	<LLD	<LLD
cobalt-60	<LLD	<LLD	<LLD	<LLD	<LLD
iron-59	<LLD	<LLD	<LLD	<LLD	<LLD
manganese-54	<LLD	<LLD	<LLD	<LLD	<LLD
zinc-65	<LLD	<LLD	<LLD	<LLD	<LLD
chrome-51	<LLD	<LLD	<LLD	<LLD	<LLD
Total for period*	2.68E-05	1.45E-05	2.17E-05	8.18E-06	7.13E-05
Others with T 1/2 < 8 days					
None					
Total with T 1/2 < 8 days*	No nuclides with half-lives < 8 days were identified				
D. Tritium					
tritium	1.50E+01	1.25E+01	4.02E+00	9.42E+00	4.10E+01

* Less than (<) values are not included in the totals. See Table 3-6 for LLD values.

Table 3-3 Radwaste Building Releases
Fission Gases and Iodines

Report Period: January -- December 2001

Nuclides Released	1st Quarter (Ci)	2nd Quarter (Ci)	3rd Quarter (Ci)	4th Quarter (Ci)	Year (Ci)
A. Fission gases					
krypton-85	<LLD	<LLD	<LLD	<LLD	<LLD
krypton-85m	<LLD	<LLD	<LLD	<LLD	<LLD
krypton-87	<LLD	<LLD	<LLD	<LLD	<LLD
krypton-88	<LLD	<LLD	<LLD	<LLD	<LLD
xenon-133	<LLD	1.31E+00	<LLD	<LLD	1.31E+00
xenon-133m	<LLD	<LLD	<LLD	<LLD	<LLD
xenon-135	<LLD	<LLD	<LLD	<LLD	<LLD
xenon-135m	<LLD	<LLD	<LLD	<LLD	<LLD
xenon-138	<LLD	<LLD	<LLD	<LLD	<LLD
argon-41	<LLD	<LLD	<LLD	<LLD	<LLD
Total for period *	<LLD	1.31E+00	<LLD	<LLD	1.31E+00
B. Iodines					
iodine-131	<LLD	1.41E-04	<LLD	<LLD	1.41E-04
iodine-132	<LLD	<LLD	<LLD	<LLD	<LLD
iodine-133	<LLD	<LLD	<LLD	<LLD	<LLD
iodine-134	<LLD	<LLD	<LLD	<LLD	<LLD
iodine-135	<LLD	<LLD	<LLD	<LLD	<LLD
Total for period *	<LLD	1.41E-04	<LLD	<LLD	1.41E-04

* Less than (<) values are not included in the totals. See Table 3-6 for LLD values.

Table 3-3 Radwaste Building Releases (Continued)
Particulates and Tritium

Report Period: January -- December 2001

Nuclides Released	1st Quarter (Ci)	2nd Quarter (Ci)	3rd Quarter (Ci)	4th Quarter (Ci)	Year (Ci)
C. Particulates					
strontium-89	7.56E-07	7.97E-07	<LLD	<LLD	1.55E-06
strontium-90	<LLD	<LLD	<LLD	<LLD	<LLD
cesium-134	<LLD	<LLD	<LLD	<LLD	<LLD
cesium-137	<LLD	<LLD	<LLD	<LLD	<LLD
barium-lanthanum-140	<LLD	<LLD	<LLD	<LLD	<LLD
molybdenum-99	<LLD	<LLD	<LLD	<LLD	<LLD
cerium-141	<LLD	<LLD	<LLD	<LLD	<LLD
cerium-144	<LLD	<LLD	<LLD	<LLD	<LLD
cobalt-58	<LLD	<LLD	<LLD	<LLD	<LLD
cobalt-60	<LLD	<LLD	<LLD	<LLD	<LLD
iron-59	<LLD	<LLD	<LLD	<LLD	<LLD
manganese-54	<LLD	<LLD	<LLD	<LLD	<LLD
zinc-65	<LLD	<LLD	<LLD	<LLD	<LLD
Total for period*	7.56E-07	7.97E-07	<LLD	<LLD	1.55E-06
Others with T 1/2 < 8 days					
None					
Total with T 1/2 < 8 days*	No nuclides with half-lives < 8 days were identified				
D. Tritium					
tritium	2.52E-01	1.54E-01	1.68E-01	3.60E-01	9.35E-01

* Less than (<) values are not included in the totals. See Table 3-6 for LLD values.

Table 3-4 Summation of Releases
Gaseous Effluents

Report Period: January -- December 2001

	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Year	Est* Total %Error
A. Fission and activation gases						
Total release (Ci)	4.15E-01	4.98E+01	4.62E+00	3.73E+00	5.86E+01	3.60E+01
Average release rate (µCi/s)	5.34E-02	6.34E+00	5.81E-01	4.69E-01	1.86E+00	
Percent of ODCM limit (%)	**	**	**	**	**	
B. Iodines						
Total I-131 (Ci)	<LLD	8.26E-04	<LLD	<LLD	8.26E-04	3.60E+01
Average release rate (µCi/s)	<LLD	1.05E-04	<LLD	<LLD	2.62E-05	
Percent of ODCM limit (%)	**	**	**	**	**	
C. Particulates						
Particulates with half-lives >8 days (Ci)	3.35E-05	3.51E-04	6.30E-04	8.18E-06	1.02E-03	3.60E+01
Average release rate (µCi/s)	4.26E-06	4.47E-05	7.93E-05	1.03E-06	3.24E-05	
Percent of ODCM limit (%)	**	**	**	**	**	
Gross alpha radioactivity (Ci)	4.95E-06	5.60E-06	3.42E-06	3.80E-06	1.78E-05	
D. Tritium						
Total release (Ci)	1.70E+01	1.59E+01	5.74E+00	1.19E+01	5.06E+01	3.60E+01
Average release rate (µCi/s)	2.16E+00	2.03E+00	7.22E-01	1.50E+00	1.60E+00	
Percent of ODCM limit (%)	**	**	**	**	**	

* At 95% confidence level

** ODCM limits are based on dose. See Table 3-0 for percent of ODCM limits.

Table 3-5 Gaseous Purges and Vents

Report Period: January -- December 2001

Type	Number	Total Time (hr.)	Maximum Time (hr.)	Minimum Time (hr.)	Mean Time (hr.)
Purge	8.00E+00	2.19E+02	1.01E+02	2.38E+00	2.73E+01
Vent	4.40E+01	1.02E+02	3.23E+01	3.17E-01	2.32E+00

Table 3-6 Lower Limits of Detection
Gaseous Effluents

Report Period: January -- December 2001

Fission Gases

Nuclide	LLD (μCi/cc)
krypton-85	2.60E-07
krypton-85m	3.70E-07
krypton-87	3.00E-09
krypton-88	1.30E-08
xenon-133	1.10E-08
xenon-135	1.32E-09
xenon-135m	4.00E-09
xenon-138	1.20E-08
argon-41	2.60E-09
xenon-137	6.70E-08

Iodines

Nuclide	LLD (μCi/cc)
iodine-131	2.40E-13
iodine-132	3.90E-13
iodine-133	3.50E-13
iodine-134	5.60E-13
iodine-135	1.60E-12

Particulates

Nuclide	LLD (μCi/cc)
strontium-89	5.50E-15
strontium-90	4.20E-15
cesium-134	5.30E-13
cesium-137	3.20E-13
barium-lanthanum-140	1.10E-12
molybdenum-99	3.20E-12
cerium-141	2.30E-13
cerium-144	1.60E-12
cobalt-58	3.20E-13
cobalt-60	6.00E-13
iron-59	1.10E-12
manganese-54	3.70E-13
zinc-65	1.10E-12
Gross Alpha	4.3E-16

4.0 Solid Radwaste

Information required by Columbia Generating Station Offsite Dose Calculation Manual

January -- December 2001.

Class A

1. Container Volumes
   * B-25 Steel Box 92.5 ft^3
   * ES-190 Steel Liner 170.2 ft^3
   * EL-142 Polyethylene HIC 132.4 ft^3
   * Sea Land Container (CVAN) N/A
2. Total Curies
   * 5.40E+02 Ci
3. Principal Radionuclides

Nuclide	Percent	Curies
Co-60	4.75E+01	2.57E+02
Zn-65	2.58E+01	1.39E+02
Mn-54	9.45E+00	5.10E+01
Co-58	6.91E+00	3.73E+01
Cr-51	3.15E+00	1.70E+01
Fe-55	1.95E+00	1.05E+01
Nb-95	1.40E+00	7.56E+00
Ag-110m	9.95E-01	5.37E+00
Zr-95	7.79E-01	4.20E+00
Ni-63	5.07E-01	2.74E+00
Fe-59	4.76E-01	2.57E+00
Ni-59	4.22E-01	2.28E+00
Sb-125	2.12E-01	1.15E+00
Cs-137	1.91E-01	1.03E+00
C-14	1.16E-01	6.24E-01

4. Source
   * Resins 5.13E+02 Ci
   * DAW 2.64E+01 Ci
   * Irradiated Components None
   * Other (Sealed Source) None

5. Type of Container
   * All containers shipped as Limited Quantity, LSA, SCO or Radioactive material, n.o.s. in IP-1, IP-2 or Type A (including casks) as appropriate.

6. Solidification Agent
   * None

Class B

1. Container Volumes
   * EL-50 Polyethylene HIC 51.2 ft^3

2. Total Curies
   * 9.85E+01 Ci

3. Principal Radionuclides

Nuclide	Percent	Curies
Co-60	3.90E+01	3.84E+01
Zn-65	2.26E+01	2.23E+01
Cr-51	2.23E+01	2.20E+01
Co-58	4.33E+00	4.26E+00
Mn-54	3.28E+00	3.23E+00
Nb-95	2.71E+00	2.67E+00
Fe-55	1.60E+00	1.58E+00
Sb-125	1.57E+00	1.55E+00
Zr-95	1.41E+00	1.39E+00
Cs-134	4.28E-01	4.22E-01
Ni-59	3.16E-01	3.11E-01
Sr-89	2.13E-01	2.10E-01
Ni-63	1.63E-01	1.61E-01
Cs-137	8.63E-03	8.50E-03

4. Source
    * Resins — None
    * DAW — 9.85E+01 Ci
    * Irradiated Components — None
    * Other (Sealed Source) — None
5. Type of Container
    * Shipped as Radioactive material, n.o.s. in a Type B cask.
6. Solidification Agent
    * None

Class C

1. Container Volumes
    * EL-50 Polyethylene HIC — 51.2 ft^3
2. Total Curies
    * 4.16E-03 Ci
3. Principal Radionuclides

Nuclide	Percent	Curies
Sr-90	1.00E+02	4.16E-03

4. Source
    * Resins — None
    * DAW — None
    * Irradiated Components — None
    * Other (Sealed Source) — 4.16E-03
5. Type of Container
    * All containers shipped as Radioactive material, n.o.s. in Type B cask.
6. Solidification Agent
    * None

Information required by Reg. Guide 1.21

January -- December 2001.

Solid waste shipped offsite for burial or disposal (not irradiated fuel).

1. Type of Waste

Waste Stream	Unit	Annual Cumulative	Est. Total Error %
a. Spent resins, filter sludge, evaporator	m^3	1.28E+02	
bottoms, etc.	Ci	5.13E+02	2.5E+01%
b. Dry Active Waste	m^3	1.16E+02	
	Ci	1.25E+02	2.5E+01%
c. Irradiated Components	m^3	0	
	Ci	0	None
d. Other Waste (Sealed Source)	m^3	8.02E-06	
	Ci	4.16E-03	2.5E+01%

2. Estimate of major nuclide composition (by type of waste)

a. Dewatered Spent Resins -- All Classes

Nuclide	%	Curies
Co-60	4.79E+01	2.46E+02
Zn-65	2.59E+01	1.33E+02
Mn-54	9.76E+00	5.01E+01
Co-58	7.05E+00	3.62E+01
Cr-51	2.25E+00	1.15E+01
Fe-55	1.97E+00	1.01E+01
Nb-95	1.34E+00	6.88E+00
Ag-110m	1.05E+00	5.37E+00
Zr-95	7.50E-01	3.85E+00
Ni-63	5.17E-01	2.65E+00
Fe-59	5.00E-01	2.57E+00
Ni-59	3.86E-01	1.98E+00
Cs-137	1.87E-01	9.59E-01
Sb-125	1.42E-01	7.28E-01
C-14	1.19E-01	6.12E-01

b. Dry Active Waste (DAW) -- All Classes

Nuclide	%	Curies
Co-60	3.91E+01	4.88E+01
Zn-65	2.26E+01	2.83E+01
Cr-51	2.20E+01	2.74E+01
Co-58	4.30E+00	5.37E+00
Mn-54	3.30E+00	4.13E+00
Nb-95	2.68E+00	3.35E+00
Fe-55	1.61E+00	2.01E+00
Sb-125	1.58E+00	1.97E+00
Zr-95	1.40E+00	1.74E+00
Ni-59	4.87E-01	6.08E-01
Cs-134	4.28E-01	5.35E-01
Sr-89	2.10E-01	2.63E-01
Ni-63	1.94E-01	2.43E-01

c. Irradiated Components
None

d. Other Waste (Sealed Source)

Nuclide	%	Curies
Sr-90	1.00E+02	4.16E-03

3. Solid Waste Disposition

Number of Shipments	Mode of Transportation	Destination
21	Tractor - Trailer via Public Highway	US Ecology, Inc. P.O. Box 638 Hanford Reservation Richland, WA. 99352
18*	Tractor - Trailer via Public Highway	ATG, Inc. 2025 Battelle Blvd. Richland, WA. 99352

* After volume reduction by ATG, Inc., portions of these shipments were forwarded to US Ecology, Inc. in six (6) shipments.

Irradiated Fuel Shipments (Disposition)

Number of Shipments	Mode of Transportation	Destination
None	N/A	N/A

5.0 Meteorology

A meteorological tower is located 2500-ft (762 m) west of Columbia Generating Station. Data was recovered from instruments at the 33 ft (10 m) and 245 ft (75 m) levels. The meteorological data is a composite file from the automated data recovery systems and is archived on the Energy Northwest Local Area Network. Several equipment and instrumentation failures contributed to problems with data recovery and accuracy during 2001. These problems are discussed below.

Total precipitation measured at the Hanford Meteorology Station was 6.66 inches, 95% of the normal annual rainfall (6.98 inches). November was the wettest month with 1.67 inches of precipitation. July was the driest month with 0.05 inches of precipitation. There was a total of 2.3 inches of snow in January, compared to the normal 4.2 inches. February received 4.3 inches, 1.7 inches above normal, and there was no snowfall recorded in March. Normal snowfall for the period of January through March is 7.2 inches. A total of 5.0 inches fell in November and 3.5 inches fell in December. The normal total snowfall for the November-December period is 8.1 inches.

Calendar year 2001 was slightly warmer than normal, averaging 54.3°F (12.4°C) or 0.7°F above normal. The warmest day occurred on July 4 with high temperature of 106°F (41.1°C). The coldest day occurred on December 25, with a low temperature of 16°F (-8.9°C). Occurrences of fog, haze, and blowing dust in 2001 were similar to those observed in previous years. In summary, the dispersive environment for Columbia Generating Station for 2001 was near normal.

Joint data recovery for 2001 was 71.6% from the 245-foot level and 73.1% from the 33-foot level. Several outages of the windspeed wind direction and temperature channels occurred, due either to sensor or recorder problems. There were several extended outages in 2001 related to instrument failures. In January, a problem with the wind direction sensor at the 245-foot level resulted in a data recovery of 66.5% for the month. The problem carried over into February, along with problems with the delta-T signal. This resulted in data recovery of 38.1% at the 245-foot level and 57.1% at the 33-foot level for February. Problems with a temperature sensor caused the data recovery for March to be 74.2% at both levels. The delta-T instrument was out of service for all of April and eight days in May. Data recovery in April was 0% and for May it was 70.7%. New instruments, with two sets of sensors at each level, were installed on the meteorological tower in late October and mid-November. The data recovery for October was 73.5% at both levels and November's data recovery was 33.2%. Lightning strikes and thunderstorms were of minor concern and had no significant effect on meteorological tower operations. Data below 0.07 mph has been determined to result from system malfunction and is not included in the results.

A review of the 2001 data revealed a significant bias from the most recent five-year average, particularly in the first and second quarters. Consequently, given the data recovery problems discussed above, the average data for 1996 - 2000 was used for estimating doses from releases in 2001.

The data contained in Tables 5-1 through 5-8 represent the five-year average joint frequency distributions from 1996 - 2000 by quarter at the 33-ft and 245-ft levels. Tables 5-9 and 5-10 list the five-year average annual joint frequency distributions for those levels. This five-year average data was used in 2001 dose calculations. The NRC stability classes A through G and seven wind categories along with the 16 wind sectors were used to prepare each joint frequency table.

Joint Frequency Distribution Tables (1996 – 2000 Averages)

Table 5-1 1st Quarter Average, 33 FT Above Ground Level (AGL)

JOINT FREQUENCY DISTRIBUTION FOR THE TIME PERIOD 01/01-03/31
DATA AVERAGED FROM 1996-2000 HOURLY DATA.

The average total hours available are 2170, 2002 hours read and 168 missing.

NRC CATEGORY A

			MPH				
deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
0.00	0	3	2	1	1	0	0
11.25	0	3	2	0	0	0	0
33.75	0	1	3	1	0	0	0
56.25	0	1	0	0	0	0	0
78.75	0	0	0	0	0	0	0
101.25	2	0	1	0	0	0	0
123.75	0	1	1	2	0	0	0
146.25	0	0	2	2	0	0	0
168.75	0	1	1	2	1	0	0
191.25	0	1	1	1	0	0	0
213.75	0	0	1	0	0	0	0
236.25	0	1	0	0	0	0	0
258.75	0	1	1	0	0	0	0
281.25	0	1	1	0	0	0	0
303.75	0	0	2	3	0	0	0
326.25	0	2	6	4	2	0	0

NRC CATEGORY B

			MPH				
deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
0.00	0	0	2	1	0	0	0
11.25	0	0	1	0	0	0	0
33.75	0	0	0	1	0	0	0
56.25	0	0	0	0	0	0	0
78.75	0	0	0	0	0	0	0
101.25	1	0	0	0	0	0	0
123.75	0	0	0	0	0	0	0
146.25	0	0	0	2	0	0	0
168.75	0	0	2	3	1	0	0
191.25	0	1	1	1	1	1	0
213.75	0	0	0	0	1	1	0
236.25	0	0	0	0	0	0	0
258.75	0	0	0	0	0	0	0
281.25	0	1	0	0	0	0	0
303.75	0	0	1	1	0	0	0
326.25	0	1	2	1	1	0	0

NRC CATEGORY C

			MPH				
deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
0.00	0	1	3	2	1	0	0
11.25	0	1	1	1	0	0	0
33.75	0	1	0	1	0	0	0
56.25	0	0	0	0	0	0	0
78.75	0	0	0	0	0	0	0
101.25	1	0	0	0	1	0	0
123.75	0	0	1	1	0	0	0
146.25	0	1	2	2	0	0	0
168.75	0	0	1	2	1	0	0
191.25	0	1	0	1	2	1	0
213.75	0	1	1	0	2	1	0
236.25	0	0	0	0	0	1	0
258.75	0	0	0	0	0	1	0
281.25	0	0	1	0	0	1	0
303.75	0	1	2	0	0	0	0
326.25	0	1	3	2	2	0	0

NRC CATEGORY D

			MPH				
deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
0.00	1	6	16	12	4	0	0
11.25	1	4	9	3	1	2	0
33.75	0	2	3	4	2	2	2
56.25	1	2	1	0	0	0	1
78.75	0	1	0	0	0	0	0
101.25	10	2	1	0	0	0	1
123.75	1	2	8	7	1	0	0
146.25	1	3	14	14	3	0	0
168.75	0	5	10	14	8	1	1
191.25	0	4	7	9	12	7	3
213.75	1	4	4	5	6	3	2
236.25	1	4	4	3	6	3	1
258.75	0	6	4	3	3	1	0
281.25	0	6	7	7	10	2	1
303.75	0	9	26	22	7	1	1
326.25	0	7	24	23	8	1	0

NRC CATEGORY E

			MPH				
deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
0.00	0	8	14	5	4	1	0
11.25	1	5	11	4	3	2	0
33.75	0	4	6	4	2	1	1
56.25	0	2	2	1	1	0	0
78.75	0	2	1	0	1	0	0
101.25	18	3	3	3	1	0	0
123.75	1	4	13	15	4	0	0
146.25	1	5	22	26	10	1	0
168.75	0	7	17	24	15	3	0
191.25	1	6	10	14	24	12	4
213.75	1	6	8	8	7	5	1
236.25	1	7	9	5	5	2	1
258.75	1	9	8	12	3	1	0
281.25	1	13	23	31	10	2	1
303.75	0	11	44	29	7	1	0
326.25	1	9	32	17	6	1	0

NRC CATEGORY F

			MPH				
deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
0.00	1	12	16	2	0	0	0
11.25	0	5	11	2	0	0	0
33.75	0	4	4	3	0	0	0
56.25	0	3	0	1	0	0	0
78.75	0	2	1	1	0	0	0
101.25	10	1	2	1	0	0	0
123.75	0	2	5	7	1	0	0
146.25	0	5	21	31	5	0	0
168.75	0	6	22	19	4	1	0
191.25	0	8	14	9	6	3	0
213.75	1	7	6	3	2	0	0
236.25	0	8	6	4	1	0	0
258.75	1	13	7	5	1	0	0
281.25	0	15	13	11	3	0	0
303.75	1	14	32	14	1	0	0
326.25	1	15	25	5	1	0	0

NRC CATEGORY G

deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
0.00	0	7	8	1	0	0	0
11.25	0	6	4	1	0	0	0
33.75	1	2	2	0	0	0	0
56.25	0	1	0	0	0	0	0
78.75	0	1	0	0	0	0	0
101.25	4	1	0	0	0	0	0
123.75	1	3	2	1	0	0	0
146.25	1	3	16	11	1	0	0
168.75	1	4	14	8	1	0	0
191.25	1	4	5	4	0	0	0
213.75	0	7	4	1	0	0	0
236.25	0	5	2	1	0	0	0
258.75	0	6	4	1	0	0	0
281.25	1	8	9	3	0	0	0
303.75	0	11	27	5	0	0	0
326.25	1	11	19	1	0	0	0

(MPH)

Table 5-2 1st Quarter Average, 245 Ft AGL

JOINT FREQUENCY DISTRIBUTION FOR THE TIME PERIOD 01/01-03/31
DATA AVERAGED FROM 1996-2000 HOURLY DATA.

The average total hours available are 2170, 2011 hours read and 159 missing.

NRC CATEGORY A

			MPH				
deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
0.00	0	1	5	2	3	0	0
11.25	0	3	2	0	1	0	0
33.75	0	0	2	0	0	1	0
56.25	0	0	1	0	0	0	0
78.75	0	1	0	0	0	0	0
101.25	0	1	1	0	0	0	0
123.75	0	1	0	0	0	0	0
146.25	0	0	2	2	1	0	0
168.75	0	1	2	2	1	0	0
191.25	0	1	1	2	1	0	0
213.75	0	1	1	1	1	1	1
236.25	0	1	1	0	0	0	0
258.75	0	1	0	0	0	0	0
281.25	0	0	1	0	0	0	0
303.75	0	2	2	1	1	0	0
326.25	0	1	3	3	3	0	0

NRC CATEGORY B

			MPH				
deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
0.00	0	0	2	1	1	0	0
11.25	0	0	1	0	0	0	0
33.75	0	0	0	1	0	0	0
56.25	0	0	0	0	0	0	0
78.75	0	0	0	0	0	0	0
101.25	0	0	0	0	0	0	0
123.75	0	0	0	0	0	0	0
146.25	0	0	0	1	0	0	0
168.75	0	0	1	2	1	0	0
191.25	0	1	2	3	1	1	0
213.75	0	0	0	0	1	1	1
236.25	0	0	0	0	0	1	0
258.75	0	0	0	0	0	0	0
281.25	0	0	0	0	1	0	0
303.75	0	1	1	1	0	0	0
326.25	0	1	1	2	1	0	0

NRC CATEGORY C

			MPH				
deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
0.00	0	1	1	2	1	0	0
11.25	0	1	1	2	0	0	0
33.75	0	1	0	0	0	0	0
56.25	0	1	0	0	0	0	0
78.75	0	0	0	0	0	0	0
101.25	0	0	0	0	0	0	0
123.75	0	0	1	0	0	0	0
146.25	0	1	1	1	0	0	0
168.75	0	1	1	3	1	1	0
191.25	0	1	1	2	2	2	0
213.75	0	1	1	1	2	1	0
236.25	0	0	1	0	0	1	1
258.75	0	1	0	0	0	0	1
281.25	0	0	1	0	0	0	1
303.75	0	1	1	0	0	0	0
326.25	0	1	2	3	1	0	0

NRC CATEGORY D

deg	0.07	0.60	MPH 3.00	7.00	12.00	18.00	24.00
0.00	0	4	11	9	8	2	0
11.25	1	4	6	5	2	1	1
33.75	0	2	5	2	2	0	2
56.25	0	1	1	0	1	0	0
78.75	0	1	1	0	0	0	0
101.25	0	2	1	0	0	0	0
123.75	0	3	5	3	2	0	0
146.25	1	2	8	12	3	1	0
168.75	1	5	10	12	7	3	1
191.25	1	6	8	10	14	8	9
213.75	1	5	6	6	8	6	10
236.25	0	5	3	4	5	6	3
258.75	0	3	4	3	3	5	2
281.25	0	3	6	9	11	7	3
303.75	1	7	16	21	13	4	0
326.25	0	5	18	20	7	3	0

NRC CATEGORY E

deg	0.07	0.60	MPH 3.00	7.00	12.00	18.00	24.00
0.00	1	4	14	13	5	1	1
11.25	0	4	6	10	2	1	0
33.75	0	3	6	5	2	1	1
56.25	0	3	3	1	1	0	1
78.75	0	2	1	1	1	0	1
101.25	1	3	2	1	1	0	0
123.75	1	3	5	5	5	0	0
146.25	1	3	10	16	8	4	1
168.75	1	5	12	21	19	10	3
191.25	1	4	11	11	23	18	20
213.75	1	7	6	8	15	16	20
236.25	1	5	6	5	6	6	6
258.75	0	3	6	6	4	5	4
281.25	0	4	13	17	27	14	5
303.75	1	4	19	35	28	7	1
326.25	0	4	18	24	9	4	1

NRC CATEGORY F

deg	0.07	0.60	MPH 3.00	7.00	12.00	18.00	24.00
0.00	1	7	14	7	2	0	0
11.25	1	2	11	6	0	0	0
33.75	1	3	8	4	1	0	0
56.25	0	2	3	2	0	0	0
78.75	0	2	3	1	0	0	0
101.25	0	2	1	1	0	0	0
123.75	0	2	5	4	1	0	0
146.25	0	3	10	11	11	2	0
168.75	1	4	11	18	17	4	1
191.25	1	4	10	17	17	7	4
213.75	1	3	10	9	7	4	4
236.25	0	3	8	5	2	2	1
258.75	1	4	7	3	5	2	0
281.25	1	4	5	7	10	5	2
303.75	1	3	11	13	21	5	0
326.25	3	4	17	14	8	3	1

NRC CATEGORY G

deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
			MPH				
0.00	0	3	6	2	1	0	0
11.25	0	2	7	2	0	0	0
33.75	0	1	4	3	1	0	0
56.25	0	1	4	0	0	0	0
78.75	0	2	1	0	0	0	0
101.25	1	2	1	0	0	0	0
123.75	0	2	3	2	1	0	0
146.25	1	2	9	8	4	1	0
168.75	0	5	13	9	3	1	0
191.25	0	2	11	8	4	1	0
213.75	0	4	9	8	1	1	0
236.25	0	3	5	2	1	0	0
258.75	0	2	4	2	1	0	0
281.25	0	1	3	2	3	1	0
303.75	1	2	6	7	13	1	0
326.25	0	4	7	10	6	0	0

Table 5-3 2nd Quarter Average, 33 Ft AGL

JOINT FREQUENCY DISTRIBUTION FOR THE TIME PERIOD 04/01-06/30
DATA AVERAGED FROM 1996-2000 HOURLY DATA

The average total hours available are 2184, 1994 hours read and 190 missing.

NRC CATEGORY A

			MPH				
deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
0.00	0	4	10	10	5	0	0
11.25	0	3	10	12	4	0	0
33.75	1	3	5	4	2	0	0
56.25	0	3	3	0	0	0	0
78.75	1	4	2	1	0	0	0
101.25	0	5	8	2	0	0	0
123.75	0	4	9	8	1	0	0
146.25	0	5	15	14	2	0	0
168.75	0	8	16	17	16	3	0
191.25	0	3	9	11	8	1	0
213.75	0	4	8	7	5	3	1
236.25	0	4	5	3	4	2	0
258.75	0	3	4	4	1	0	1
281.25	0	4	5	3	3	2	1
303.75	0	4	7	3	3	1	0
326.25	0	4	8	5	2	0	0

NRC CATEGORY B

			MPH				
deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
0.00	0	1	3	2	1	0	0
11.25	0	1	2	2	0	0	0
33.75	0	1	1	1	0	0	0
56.25	0	1	1	0	0	0	0
78.75	0	1	1	0	0	0	0
101.25	0	1	1	0	0	0	0
123.75	0	2	3	2	0	0	0
146.25	0	1	4	4	1	0	0
168.75	0	0	5	5	3	0	0
191.25	0	1	1	4	4	1	0
213.75	0	1	3	3	3	1	1
236.25	0	1	1	1	1	1	0
258.75	0	1	1	2	2	0	0
281.25	0	1	2	2	1	1	1
303.75	0	1	2	3	1	0	1
326.25	0	1	2	3	0	0	0

NRC CATEGORY C

			MPH				
deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
0.00	0	1	2	2	1	0	0
11.25	0	2	2	3	0	0	0
33.75	0	0	1	1	1	0	0
56.25	0	0	1	0	0	0	0
78.75	0	1	0	0	0	0	0
101.25	0	1	0	1	0	0	0
123.75	0	1	2	1	0	0	0
146.25	0	0	3	3	0	0	0
168.75	0	0	3	5	3	1	0
191.25	0	1	3	5	4	2	0
213.75	0	0	1	3	3	2	0
236.25	0	1	2	3	2	2	0
258.75	0	1	1	2	1	0	0
281.25	0	0	1	2	1	1	1
303.75	0	0	2	1	1	1	0
326.25	0	0	3	1	0	0	0

NRC CATEGORY D

deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
			MPH				
0.00	0	2	10	7	2	0	0
11.25	0	4	5	5	1	0	0
33.75	0	2	5	4	1	0	0
56.25	0	2	3	2	0	0	0
78.75	0	2	4	3	0	0	0
101.25	1	2	6	3	1	0	0
123.75	0	4	6	7	0	0	0
146.25	0	2	14	15	3	0	0
168.75	0	3	16	20	9	1	0
191.25	0	14	10	15	16	4	0
213.75	0	3	7	11	7	3	1
236.25	0	2	7	6	9	5	0
258.75	1	2	6	8	7	2	1
281.25	0	1	6	9	16	7	2
303.75	0	1	7	9	11	4	1
326.25	0	1	6	12	4	1	1

NRC CATEGORY E

deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
			MPH				
0.00	0	3	8	5	2	0	0
11.25	0	4	6	1	1	0	0
33.75	0	2	5	1	0	0	0
56.25	0	2	5	1	0	0	0
78.75	0	1	4	1	0	0	0
101.25	0	4	4	1	0	0	0
123.75	0	3	10	9	1	0	0
146.25	0	5	19	17	2	0	0
168.75	1	7	19	18	7	0	0
191.25	0	6	13	9	8	3	0
213.75	0	3	8	7	5	2	1
236.25	0	4	12	5	3	1	0
258.75	0	4	9	14	6	0	0
281.25	0	6	11	31	28	8	1
303.75	0	6	13	24	16	3	0
326.25	0	4	14	10	5	2	0

NRC CATEGORY F

deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
			MPH				
0.00	0	7	9	0	0	0	0
11.25	0	6	7	0	0	0	0
33.75	0	5	4	1	0	0	0
56.25	0	2	2	0	0	0	0
78.75	0	1	2	0	0	0	0
101.25	0	3	3	0	0	0	0
123.75	0	2	9	4	0	0	0
146.25	0	7	25	11	0	0	0
168.75	0	9	21	13	1	0	0
191.25	0	5	12	6	0	0	0
213.75	0	4	8	3	0	0	0
236.25	1	5	6	2	0	0	0
258.75	0	5	5	6	0	0	0
281.25	1	3	11	11	2	0	0
303.75	0	8	14	10	0	0	0
326.25	1	7	16	4	0	0	0

NRC CATEGORY G

deg	0.07	0.60	3.00 MPH	7.00	12.00	18.00	24.00
0.00	0	9	9	0	0	0	0
11.25	0	9	9	0	0	0	0
33.75	0	6	4	1	0	0	0
56.25	0	3	1	0	0	0	0
78.75	1	2	0	0	0	0	0
101.25	0	2	0	0	0	0	0
123.75	0	4	6	0	0	0	0
146.25	1	7	19	6	0	0	0
168.75	0	5	14	4	0	0	0
191.25	0	5	5	2	0	0	0
213.75	0	4	3	0	0	0	1
236.25	1	4	2	0	0	0	0
258.75	0	3	2	1	0	0	0
281.25	0	5	3	1	0	0	0
303.75	0	8	11	3	0	0	0
326.25	1	9	11	1	0	0	0

Table 5-4 2nd Quarter Average, 245 Ft AGL

JOINT FREQUENCY DISTRIBUTION FOR THE TIME PERIOD 04/01-06/30
DATA AVERAGED FROM 1996-2000 HOURLY DATA

The average total hours available are 2184, 1986 hours read and 198 missing.

NRC CATEGORY A

			MPH				
deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
0.00	0	2	7	9	5	0	0
11.25	0	3	6	11	7	3	0
33.75	0	1	5	7	3	0	0
56.25	0	2	4	1	1	0	0
78.75	0	2	5	1	0	0	0
101.25	0	4	4	3	1	0	0
123.75	0	3	9	6	2	0	0
146.25	0	4	14	12	2	0	0
168.75	0	5	12	21	10	3	1
191.25	0	2	10	11	17	5	1
213.75	0	2	6	10	7	3	2
236.25	0	2	6	4	3	2	1
258.75	0	2	4	3	3	1	2
281.25	0	1	6	2	4	2	1
303.75	0	2	5	3	3	2	2
326.25	0	2	8	4	4	0	0

NRC CATEGORY B

			MPH				
deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
0.00	0	1	2	2	2	0	0
11.25	0	0	2	3	1	0	0
33.75	0	1	1	2	0	0	0
56.25	0	1	1	0	0	0	0
78.75	0	0	0	0	0	0	0
101.25	0	1	1	1	0	0	0
123.75	0	0	2	1	0	0	0
146.25	0	1	3	3	1	0	0
168.75	0	0	4	6	2	0	0
191.25	0	1	2	4	4	2	0
213.75	0	0	1	3	4	2	1
236.25	0	0	2	2	3	1	1
258.75	0	0	1	1	2	1	1
281.25	0	0	1	1	1	1	1
303.75	0	1	2	3	1	1	2
326.25	0	1	2	1	1	0	0

NRC CATEGORY C

			MPH				
deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
0.00	0	0	4	2	1	0	0
11.25	0	0	1	1	1	0	0
33.75	0	0	1	2	1	0	0
56.25	0	0	1	0	0	0	0
78.75	0	1	1	0	0	0	0
101.25	0	0	1	0	0	0	0
123.75	0	0	1	1	1	0	0
146.25	0	1	3	2	0	0	0
168.75	0	1	2	4	3	0	0
191.25	0	1	2	4	7	2	0
213.75	0	0	2	3	1	4	2
236.25	1	1	2	2	3	3	2
258.75	0	0	1	2	1	1	0
281.25	0	0	0	1	2	1	1
303.75	0	0	2	1	1	1	1
326.25	0	0	1	2	1	0	0

NRC CATEGORY D

deg	0.07	0.60	MPH 3.00	7.00	12.00	18.00	24.00
0.00	0	1	7	6	3	0	0
11.25	0	1	5	4	4	0	0
33.75	0	1	4	5	2	0	0
56.25	0	1	3	5	1	0	0
78.75	0	2	1	4	0	0	0
101.25	0	1	4	3	2	0	0
123.75	1	3	5	4	3	0	0
146.25	1	2	8	9	4	0	0
168.75	0	3	12	13	9	2	0
191.25	0	14	8	21	19	8	3
213.75	0	1	6	12	9	7	4
236.25	1	2	4	8	8	6	5
258.75	0	1	5	5	6	6	3
281.25	0	1	5	9	11	6	6
303.75	0	1	3	5	11	8	9
326.25	0	2	9	6	5	2	1

NRC CATEGORY E

deg	0.07	0.60	MPH 3.00	7.00	12.00	18.00	24.00
0.00	0	1	5	5	3	1	0
11.25	0	2	4	4	2	0	0
33.75	0	0	3	5	0	0	0
56.25	0	1	3	2	0	0	0
78.75	0	1	3	4	0	0	0
101.25	0	1	5	1	1	1	0
123.75	0	1	4	5	3	1	0
146.25	0	3	7	7	6	0	0
168.75	0	3	9	11	12	4	0
191.25	0	3	6	12	13	7	3
213.75	0	4	7	10	7	8	5
236.25	0	1	7	8	5	3	2
258.75	0	2	6	9	7	3	2
281.25	0	2	7	13	22	28	19
303.75	0	1	7	14	25	22	12
326.25	0	3	6	11	7	5	2

NRC CATEGORY F

deg	0.07	0.60	MPH 3.00	7.00	12.00	18.00	24.00
0.00	1	2	8	5	2	0	0
11.25	1	2	4	2	0	0	0
33.75	0	2	6	3	1	1	0
56.25	0	1	4	3	0	0	0
78.75	0	1	2	3	0	0	0
101.25	0	2	2	1	0	0	0
123.75	1	1	3	1	1	0	0
146.25	0	2	6	8	3	1	0
168.75	1	3	8	14	7	1	1
191.25	0	2	9	9	6	3	0
213.75	2	3	6	5	4	1	0
236.25	0	3	11	4	1	0	0
258.75	0	3	6	7	4	1	0
281.25	1	2	4	8	15	13	2
303.75	0	1	6	8	13	5	1
326.25	1	0	6	9	5	1	0

NRC CATEGORY G

deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
			MPH				
0.00	0	2	9	6	0	0	0
11.25	0	2	6	3	0	0	0
33.75	0	2	4	3	1	1	0
56.25	0	2	5	2	1	0	0
78.75	0	1	3	0	0	0	0
101.25	0	1	1	0	0	0	0
123.75	1	1	2	1	0	0	0
146.25	1	4	9	6	1	0	0
168.75	1	3	11	10	2	0	0
191.25	1	1	8	8	4	1	0
213.75	1	5	7	5	0	0	0
236.25	0	2	4	1	0	0	0
258.75	0	1	2	2	1	0	0
281.25	0	1	2	3	2	1	0
303.75	0	1	3	6	5	2	0
326.25	0	2	6	9	4	0	0

Table 5-5 3rd Quarter Average, 33 Ft AGL

JOINT FREQUENCY DISTRIBUTION FOR THE TIME PERIOD 07/01-09/30
DATA AVERAGED FROM 1996-2000 HOURLY DATA

The average total hours available are 2208, 2091 hours read and 117 missing.

NRC CATEGORY A

			MPH				
deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
0.00	0	8	14	10	1	0	0
11.25	0	7	12	7	1	0	0
33.75	0	9	12	3	0	0	0
56.25	0	4	7	3	0	0	0
78.75	0	5	5	1	0	0	0
101.25	0	6	8	4	0	0	0
123.75	0	5	16	8	1	0	0
146.25	0	4	22	21	2	0	0
168.75	0	4	13	18	9	1	0
191.25	0	4	7	6	3	0	0
213.75	0	2	4	4	2	1	0
236.25	0	3	4	2	1	1	0
258.75	0	3	2	3	0	1	0
281.25	0	3	2	1	0	2	0
303.75	0	5	5	1	1	0	0
326.25	0	7	10	4	0	0	0

NRC CATEGORY B

			MPH				
deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
0.00	0	1	3	1	0	0	0
11.25	0	1	2	3	0	0	0
33.75	0	1	4	2	0	0	0
56.25	0	1	1	1	0	0	0
78.75	0	1	1	1	0	0	0
101.25	0	1	2	1	0	0	0
123.75	0	0	2	1	0	0	0
146.25	0	1	4	3	1	0	0
168.75	0	2	4	2	1	0	0
191.25	0	1	2	1	1	0	0
213.75	0	1	1	2	1	0	0
236.25	0	0	1	1	0	1	0
258.75	0	2	1	1	0	1	0
281.25	0	1	1	1	1	1	0
303.75	0	1	1	1	1	0	0
326.25	0	3	2	1	0	0	0

NRC CATEGORY C

			MPH				
deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
0.00	0	1	3	1	0	0	0
11.25	0	1	3	1	0	0	0
33.75	0	2	2	1	0	0	0
56.25	0	1	1	0	0	0	0
78.75	0	1	2	0	0	0	0
101.25	0	1	1	1	0	0	0
123.75	0	1	2	2	1	0	0
146.25	0	1	3	3	0	0	0
168.75	0	2	4	3	2	0	0
191.25	0	1	1	1	2	1	0
213.75	0	1	1	2	1	1	0
236.25	0	1	1	2	1	1	0
258.75	0	0	1	2	0	1	0
281.25	0	1	1	1	1	0	0
303.75	0	1	2	0	0	1	0
326.25	0	1	2	1	1	0	0

NRC CATEGORY D

deg	0.07	0.60	MPH 3.00	7.00	12.00	18.00	24.00
0.00	0	4	10	5	3	0	0
11.25	0	3	9	7	3	1	0
33.75	0	3	7	5	0	0	0
56.25	0	4	6	3	0	0	0
78.75	0	3	7	3	0	0	0
101.25	0	2	5	4	0	0	0
123.75	0	3	9	9	2	0	0
146.25	0	3	15	17	2	0	0
168.75	0	2	8	13	7	1	0
191.25	0	3	6	10	8	2	0
213.75	0	2	4	5	3	1	1
236.25	0	2	4	5	1	2	0
258.75	0	1	3	7	3	2	1
281.25	1	2	4	7	7	4	1
303.75	0	2	5	5	7	5	1
326.25	0	2	6	5	2	2	1

NRC CATEGORY E

deg	0.07	0.60	MPH 3.00	7.00	12.00	18.00	24.00
0.00	0	6	16	9	1	0	0
11.25	0	4	21	8	1	0	0
33.75	0	6	14	4	0	0	0
56.25	0	4	6	4	0	0	0
78.75	0	3	2	1	0	0	0
101.25	0	3	5	8	1	0	0
123.75	0	6	15	13	1	0	0
146.25	0	6	20	20	4	0	0
168.75	0	4	18	14	3	0	0
191.25	0	5	10	7	4	1	0
213.75	0	6	10	4	3	0	0
236.25	0	4	6	5	2	1	0
258.75	1	5	9	8	5	0	0
281.25	1	7	11	27	23	6	1
303.75	0	5	13	23	15	3	1
326.25	1	6	17	11	6	2	0

NRC CATEGORY F

deg	0.07	0.60	MPH 3.00	7.00	12.00	18.00	24.00
0.00	1	10	13	1	0	0	0
11.25	0	10	14	1	0	0	0
33.75	1	8	8	2	0	0	0
56.25	0	3	4	2	0	0	0
78.75	0	2	2	0	0	0	0
101.25	1	3	2	1	0	0	0
123.75	1	4	12	11	0	0	0
146.25	1	8	24	18	0	0	0
168.75	1	9	27	12	0	0	0
191.25	1	7	14	6	1	0	0
213.75	1	4	8	2	0	0	0
236.25	0	5	6	2	0	0	0
258.75	0	5	7	3	0	0	0
281.25	0	7	8	8	1	0	0
303.75	0	8	15	9	0	0	0
326.25	0	9	16	4	0	0	0

NRC CATEGORY G

			MPH				
deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
0.00	2	22	25	1	0	0	0
11.25	2	24	29	0	0	0	0
33.75	2	16	15	2	0	0	0
56.25	1	6	4	1	0	0	0
78.75	1	2	0	0	0	0	0
101.25	1	3	1	0	0	0	0
123.75	1	5	5	1	0	0	0
146.25	1	10	17	7	0	0	0
168.75	1	7	17	5	0	0	0
191.25	1	8	7	5	0	0	0
213.75	1	7	3	1	0	0	0
236.25	1	4	1	0	0	0	0
258.75	0	4	1	0	0	0	0
281.25	1	5	4	0	0	0	0
303.75	1	9	9	3	0	0	0
326.25	1	17	17	1	0	0	0

Table 5-6 3rd Quarter Average, 245 Ft AGL

JOINT FREQUENCY DISTRIBUTION FOR THE TIME PERIOD 07/01-09/30
DATA AVERAGED FROM 1996-2000 HOURLY DATA

The average total hours available are 2208, 2078 hours read and 130 missing.

NRC CATEGORY A

			MPH				
deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
0.00	5	4	11	4	2	0	0
11.25	3	4	10	10	2	1	0
33.75	0	4	8	5	0	0	0
56.25	0	5	6	4	0	0	0
78.75	0	3	7	2	0	0	0
101.25	0	4	8	5	0	0	0
123.75	1	4	8	8	2	0	0
146.25	1	5	18	15	2	1	0
168.75	1	3	15	24	7	1	0
191.25	0	2	8	13	12	2	1
213.75	1	2	5	4	3	2	0
236.25	0	3	4	3	1	1	1
258.75	1	1	3	3	1	1	1
281.25	1	3	3	1	1	0	0
303.75	1	4	4	0	0	0	2
326.25	0	3	9	3	1	0	0

NRC CATEGORY B

			MPH				
deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
0.00	0	0	2	2	0	0	0
11.25	0	1	1	2	0	0	0
33.75	0	0	3	2	0	0	0
56.25	0	0	1	1	0	0	0
78.75	0	0	2	2	0	0	0
101.25	0	1	1	1	0	0	0
123.75	0	1	2	1	0	0	0
146.25	0	0	2	4	0	0	0
168.75	0	0	4	4	1	0	0
191.25	0	0	3	2	2	1	0
213.75	0	1	1	1	2	1	0
236.25	0	0	1	1	0	0	1
258.75	0	1	1	1	1	1	0
281.25	0	1	1	1	1	1	0
303.75	0	1	1	1	0	1	0
326.25	0	2	2	1	1	0	0

NRC CATEGORY C

			MPH				
deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
0.00	1	0	2	2	1	0	0
11.25	0	0	1	2	1	0	0
33.75	0	1	2	1	0	0	0
56.25	0	1	2	1	0	0	0
78.75	0	1	1	1	0	0	0
101.25	0	0	0	1	0	0	0
123.75	0	1	1	1	0	0	0
146.25	0	1	2	4	0	0	0
168.75	0	2	4	3	1	0	0
191.25	0	0	2	3	2	3	0
213.75	0	0	1	2	1	1	1
236.25	0	1	1	1	2	1	0
258.75	0	1	1	1	1	0	0
281.25	0	1	1	1	1	1	0
303.75	0	0	1	1	1	1	0
326.25	0	0	2	2	1	0	0

NRC CATEGORY D

deg	0.07	0.60	MPH 3.00	7.00	12.00	18.00	24.00
0.00	0	2	7	7	2	1	0
11.25	0	1	5	9	4	1	2
33.75	1	3	5	5	1	0	0
56.25	0	1	4	3	0	0	0
78.75	0	2	6	4	1	0	0
101.25	0	2	4	5	1	0	0
123.75	0	2	4	9	2	1	0
146.25	0	2	8	10	2	0	0
168.75	0	3	11	18	7	1	0
191.25	0	1	8	12	10	7	1
213.75	0	2	4	6	6	3	3
236.25	0	2	1	5	4	1	2
258.75	0	1	3	5	4	2	2
281.25	0	2	2	5	5	5	3
303.75	0	1	4	4	5	6	9
326.25	1	1	4	4	2	1	2

NRC CATEGORY E

deg	0.07	0.60	MPH 3.00	7.00	12.00	18.00	24.00
0.00	1	2	9	9	2	0	0
11.25	0	2	12	13	2	0	1
33.75	0	1	10	6	1	1	0
56.25	0	1	7	5	1	0	0
78.75	0	2	6	4	1	0	0
101.25	0	3	5	5	2	0	0
123.75	0	3	7	10	3	0	0
146.25	0	3	9	12	6	1	0
168.75	0	4	13	18	10	3	0
191.25	0	3	7	12	10	5	1
213.75	0	1	6	5	6	4	2
236.25	0	3	7	5	3	2	1
258.75	1	1	6	9	7	3	1
281.25	1	2	7	10	18	21	12
303.75	0	2	8	18	20	27	12
326.25	1	2	8	11	6	6	2

NRC CATEGORY F

deg	0.07	0.60	MPH 3.00	7.00	12.00	18.00	24.00
0.00	1	4	8	6	1	0	0
11.25	0	3	7	6	1	0	0
33.75	0	2	6	4	2	0	0
56.25	0	4	5	3	1	1	0
78.75	0	2	4	1	0	0	0
101.25	1	3	3	1	0	0	0
123.75	0	4	6	3	3	0	0
146.25	0	3	8	9	5	1	1
168.75	0	4	13	18	11	0	0
191.25	0	3	11	13	10	2	0
213.75	0	5	8	7	3	1	0
236.25	0	4	9	6	1	0	0
258.75	1	3	8	5	3	0	0
281.25	0	1	6	7	11	5	0
303.75	1	3	6	12	15	6	0
326.25	2	3	8	9	5	0	0

NRC CATEGORY G

deg	0.07	0.60	MPH 3.00	7.00	12.00	18.00	24.00
0.00	1	4	16	8	1	0	0
11.25	0	5	14	5	1	0	0
33.75	0	2	14	8	2	0	0
56.25	0	2	11	5	1	1	0
78.75	0	4	5	1	1	0	0
101.25	1	2	4	0	0	0	0
123.75	0	3	5	1	1	0	0
146.25	0	6	13	9	3	0	0
168.75	1	6	18	10	3	0	0
191.25	0	5	13	10	3	0	0
213.75	0	6	7	5	2	1	0
236.25	0	3	7	4	0	0	0
258.75	0	4	3	1	0	0	0
281.25	0	3	5	2	2	1	0
303.75	1	2	5	9	6	0	0
326.25	3	3	13	15	5	0	0

Table 5-7 4th Quarter Average, 33 Ft AGL

JOINT FREQUENCY DISTRIBUTION FOR THE TIME PERIOD 10/01-12/31
DATA AVERAGED FROM 1996-2000 HOURLY DATA

The average total hours available are 2208, 1986 hours read and 222 missing.

NRC CATEGORY A

			MPH				
deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
0.00	0	6	7	7	2	0	0
11.25	0	6	6	4	1	0	0
33.75	0	5	5	1	0	0	0
56.25	0	2	1	0	0	0	0
78.75	0	1	1	0	0	0	0
101.25	0	2	1	0	0	0	0
123.75	0	2	2	3	0	0	0
146.25	0	2	6	6	1	0	0
168.75	0	3	4	7	4	1	1
191.25	0	3	1	3	3	0	0
213.75	0	1	2	1	1	0	0
236.25	0	1	0	0	1	0	0
258.75	0	1	2	1	1	1	1
281.25	0	2	1	1	2	2	0
303.75	1	3	3	3	1	0	0
326.25	0	4	9	5	1	0	0

NRC CATEGORY B

			MPH				
deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
0.00	0	1	3	1	0	0	0
11.25	0	1	2	1	0	0	0
33.75	0	0	1	0	0	0	0
56.25	0	0	0	0	0	0	0
78.75	0	0	0	0	0	0	0
101.25	0	0	0	0	0	0	0
123.75	0	0	1	0	1	0	0
146.25	0	1	1	1	1	0	0
168.75	0	1	1	3	3	0	0
191.25	0	0	2	1	1	1	0
213.75	0	0	0	0	0	1	0
236.25	0	1	0	0	0	0	0
258.75	0	0	0	0	1	0	0
281.25	0	0	0	0	1	0	0
303.75	0	1	1	1	0	0	0
326.25	0	0	1	1	0	0	0

NRC CATEGORY C

			MPH				
deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
0.00	0	1	2	2	0	0	0
11.25	0	0	2	1	0	0	0
33.75	0	0	1	0	0	0	0
56.25	0	0	1	0	0	0	0
78.75	0	0	0	0	0	0	0
101.25	0	0	0	0	0	0	0
123.75	0	0	0	1	1	0	0
146.25	0	0	2	3	1	0	0
168.75	0	0	1	3	2	1	0
191.25	0	0	1	1	1	1	0
213.75	0	0	1	1	1	0	0
236.25	0	0	1	0	0	0	0
258.75	0	0	0	0	1	0	0
281.25	0	0	1	0	1	0	0
303.75	0	0	2	1	0	0	0
326.25	0	0	2	2	0	0	0

NRC CATEGORY D

deg	0.07	0.60	MPH 3.00	7.00	12.00	18.00	24.00
0.00	0	7	14	5	1	0	0
11.25	0	6	9	4	1	1	0
33.75	0	5	7	4	0	1	0
56.25	0	3	1	0	0	0	0
78.75	0	1	1	0	0	0	0
101.25	0	2	1	0	0	0	0
123.75	0	3	6	4	1	0	0
146.25	1	4	14	14	6	1	0
168.75	1	5	14	16	10	6	1
191.25	0	4	6	7	7	6	2
213.75	0	4	6	4	4	6	3
236.25	0	3	4	2	1	2	1
258.75	1	3	4	3	2	0	0
281.25	0	6	8	6	3	1	0
303.75	0	7	20	18	4	1	0
326.25	0	9	22	14	3	0	0

NRC CATEGORY E

deg	0.07	0.60	MPH 3.00	7.00	12.00	18.00	24.00
0.00	1	9	11	3	0	0	0
11.25	1	8	9	1	1	1	0
33.75	2	2	7	3	0	1	0
56.25	1	4	1	0	0	0	0
78.75	0	2	1	0	0	0	0
101.25	0	1	1	1	0	0	0
123.75	1	6	9	13	4	0	0
146.25	0	7	25	35	13	0	0
168.75	0	10	23	30	21	3	1
191.25	1	11	16	11	17	12	4
213.75	2	11	11	9	10	7	4
236.25	1	8	12	6	3	1	0
258.75	1	10	9	8	2	1	0
281.25	1	16	23	15	5	1	0
303.75	2	19	41	21	5	0	0
326.25	1	15	30	13	2	0	0

NRC CATEGORY F

deg	0.07	0.60	MPH 3.00	7.00	12.00	18.00	24.00
0.00	1	11	16	0	0	0	0
11.25	0	11	11	0	0	0	0
33.75	0	5	8	2	0	0	0
56.25	1	2	1	0	0	0	0
78.75	1	2	0	0	0	0	0
101.25	0	1	1	0	0	0	0
123.75	0	2	4	7	0	0	0
146.25	0	3	21	20	2	0	0
168.75	1	8	24	18	5	0	0
191.25	1	7	14	9	5	1	0
213.75	1	8	7	3	2	0	0
236.25	0	8	6	4	1	0	0
258.75	1	9	7	6	1	0	0
281.25	1	13	17	7	1	0	0
303.75	1	15	22	11	1	0	0
326.25	1	12	28	4	0	0	0

NRC CATEGORY G

deg	0.07	0.60	MPH 3.00	7.00	12.00	18.00	24.00
0.00	1	11	14	0	0	0	0
11.25	0	8	13	0	0	0	0
33.75	0	4	7	1	0	0	0
56.25	0	2	1	0	0	0	0
78.75	0	2	0	0	0	0	0
101.25	0	0	0	0	0	0	0
123.75	0	3	1	1	0	0	0
146.25	1	3	7	7	0	0	0
168.75	0	6	16	6	1	0	0
191.25	0	6	8	2	0	0	0
213.75	1	6	4	1	0	0	0
236.25	0	7	5	1	0	0	0
258.75	0	6	4	1	0	0	0
281.25	1	9	8	1	0	0	0
303.75	1	10	18	4	0	0	0
326.25	1	11	25	3	0	0	0

Table 5-8 4th Quarter Average, 245 Ft AGL

JOINT FREQUENCY DISTRIBUTION FOR THE TIME PERIOD 10/01-12/31
DATA AVERAGED FROM 1996-2000 HOURLY DATA

The average total hours available are 2208, 1984 hours read and 224 missing.

NRC CATEGORY A

			MPH				
deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
0.00	0	5	8	7	4	1	1
11.25	0	5	7	4	1	0	0
33.75	0	2	3	1	0	0	0
56.25	0	1	1	0	0	0	0
78.75	0	2	2	0	0	0	0
101.25	0	2	1	0	0	0	0
123.75	0	3	3	1	0	0	0
146.25	0	2	4	5	1	0	0
168.75	0	1	3	7	3	0	0
191.25	0	2	3	2	6	2	2
213.75	0	1	2	1	1	1	0
236.25	0	1	1	1	1	0	1
258.75	0	1	1	1	1	0	1
281.25	0	1	2	1	1	2	0
303.75	1	2	2	2	1	1	0
326.25	0	3	6	7	2	0	0

NRC CATEGORY B

			MPH				
deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
0.00	0	1	2	2	0	0	0
11.25	0	1	2	1	1	0	0
33.75	0	0	1	0	0	0	0
56.25	0	0	1	0	0	0	0
78.75	0	0	0	0	0	0	0
101.25	0	0	0	0	0	0	0
123.75	0	0	0	0	0	0	0
146.25	0	1	1	1	1	0	0
168.75	0	1	1	3	3	1	0
191.25	0	1	1	1	2	1	0
213.75	0	0	0	0	0	1	1
236.25	0	0	0	0	1	0	0
258.75	0	0	0	0	1	0	0
281.25	0	0	0	0	1	0	0
303.75	0	0	1	1	0	0	0
326.25	0	1	1	1	0	0	0

NRC CATEGORY C

			MPH				
deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
0.00	0	1	1	2	1	0	0
11.25	0	0	2	1	0	0	0
33.75	0	0	1	0	0	0	0
56.25	0	0	1	0	0	0	0
78.75	0	0	0	0	0	0	0
101.25	0	0	0	0	0	0	0
123.75	0	0	0	0	0	0	0
146.25	0	0	1	0	1	0	0
168.75	0	0	2	3	2	1	0
191.25	0	0	1	2	2	0	1
213.75	0	1	1	0	1	0	2
236.25	0	0	0	0	0	0	0
258.75	0	0	0	0	1	1	0
281.25	0	1	0	1	0	0	0
303.75	0	0	1	1	0	0	0
326.25	0	0	2	2	1	0	0

NRC CATEGORY D

deg	0.07	0.60	MPH 3.00	7.00	12.00	18.00	24.00
0.00	0	6	13	8	5	2	1
11.25	0	3	8	7	2	0	1
33.75	0	2	7	3	2	0	1
56.25	0	2	5	1	0	0	0
78.75	0	1	1	0	0	0	0
101.25	0	1	1	0	0	0	0
123.75	0	3	2	2	0	0	0
146.25	0	2	8	9	4	0	0
168.75	1	3	11	18	6	5	1
191.25	0	3	7	8	10	9	11
213.75	0	4	5	4	4	5	14
236.25	1	4	2	3	4	1	3
258.75	0	4	3	2	1	1	1
281.25	0	3	5	4	5	3	2
303.75	0	3	13	15	7	2	0
326.25	0	4	19	22	6	2	0

NRC CATEGORY E

deg	0.07	0.60	MPH 3.00	7.00	12.00	18.00	24.00
0.00	0	7	19	9	5	0	0
11.25	0	5	11	6	1	1	1
33.75	0	3	6	4	1	0	2
56.25	0	4	5	2	0	0	0
78.75	1	4	2	0	0	0	0
101.25	0	3	1	0	0	0	0
123.75	1	4	5	5	1	1	0
146.25	0	4	12	18	14	6	1
168.75	1	6	13	18	22	14	3
191.25	0	7	13	15	23	20	15
213.75	1	7	7	7	10	15	25
236.25	1	5	5	4	5	3	4
258.75	1	5	10	5	5	3	3
281.25	0	6	13	11	11	10	2
303.75	1	6	20	27	17	4	1
326.25	1	5	23	21	11	4	0

NRC CATEGORY F

deg	0.07	0.60	MPH 3.00	7.00	12.00	18.00	24.00
0.00	1	3	14	8	1	0	0
11.25	0	4	12	6	0	0	0
33.75	0	3	9	6	1	0	0
56.25	0	2	5	3	0	0	0
78.75	1	3	3	0	0	0	0
101.25	0	2	2	0	0	0	0
123.75	0	4	4	3	1	0	0
146.25	1	4	11	15	9	1	0
168.75	0	4	12	15	10	3	0
191.25	0	4	10	13	11	6	2
213.75	0	3	10	6	6	7	2
236.25	0	2	7	3	2	1	0
258.75	0	4	6	4	5	3	1
281.25	0	3	7	7	9	5	1
303.75	0	3	7	16	14	3	0
326.25	0	3	14	17	10	0	0

NRC CATEGORY G

deg	0.07	0.60	MPH 3.00	7.00	12.00	18.00	24.00
0.00	0	3	10	5	0	0	0
11.25	1	3	10	3	0	0	0
33.75	0	2	8	6	1	0	0
56.25	0	2	5	3	0	0	0
78.75	0	2	2	1	0	0	0
101.25	1	1	1	0	0	0	0
123.75	0	2	4	1	1	0	0
146.25	0	3	12	10	3	0	0
168.75	1	3	11	8	3	1	0
191.25	0	4	10	8	2	0	0
213.75	0	2	11	4	1	0	0
236.25	0	2	5	2	0	0	0
258.75	0	4	4	1	1	0	0
281.25	0	2	3	3	5	2	0
303.75	0	2	5	9	11	1	0
326.25	0	2	5	12	7	0	0

NRC CATEGORY G

deg	0.07	0.60	MPH 3.00	7.00	12.00	18.00	24.00
0.00	1	11	14	0	0	0	0
11.25	0	8	13	0	0	0	0
33.75	0	4	7	1	0	0	0
56.25	0	2	1	0	0	0	0
78.75	0	2	0	0	0	0	0
101.25	0	0	0	0	0	0	0
123.75	0	3	1	1	0	0	0
146.25	1	3	7	7	0	0	0
168.75	0	6	16	6	1	0	0
191.25	0	6	8	2	0	0	0
213.75	1	6	4	1	0	0	0
236.25	0	7	5	1	0	0	0
258.75	0	6	4	1	0	0	0
281.25	1	9	8	1	0	0	0
303.75	1	10	18	4	0	0	0
326.25	1	11	25	3	0	0	0

Table 5-9 Five-Year Average, 33 Ft AGL

JOINT FREQUENCY DISTRIBUTION FOR THE TIME PERIOD 01/01-12/31
DATA AVERAGED FROM 1996-2000 HOURLY DATA

The average total hours available are 8770, 8073 hours read and 697 missing.

NRC CATEGORY A

			MPH				
deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
0.00	0	21	33	28	9	0	0
11.25	0	19	30	23	6	0	0
33.75	1	18	25	9	2	0	0
56.25	0	10	11	3	0	0	0
78.75	1	10	8	2	0	0	0
101.25	2	13	18	6	0	0	0
123.75	0	12	28	21	2	0	0
146.25	0	11	45	43	5	0	0
168.75	0	16	34	44	30	5	1
191.25	0	11	18	21	14	1	0
213.75	0	7	15	12	8	4	1
236.25	0	9	9	5	6	3	0
258.75	0	8	9	8	2	2	2
281.25	0	10	9	5	5	6	1
303.75	1	12	17	10	5	1	0
326.25	0	17	33	18	5	0	0

NRC CATEGORY B

			MPH				
deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
0.00	0	3	11	5	1	0	0
11.25	0	3	7	6	0	0	0
33.75	0	2	6	4	0	0	0
56.25	0	2	2	1	0	0	0
78.75	0	2	2	1	0	0	0
101.25	1	2	3	1	0	0	0
123.75	0	2	6	3	1	0	0
146.25	0	3	9	10	3	0	0
168.75	0	3	12	13	8	0	0
191.25	0	3	6	7	7	3	0
213.75	0	2	4	5	5	3	1
236.25	0	2	2	2	1	2	0
258.75	0	3	2	3	3	1	0
281.25	0	3	3	3	3	2	1
303.75	0	3	5	6	2	0	1
326.25	0	5	7	6	1	0	0

NRC CATEGORY C

			MPH				
deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
0.00	0	4	10	7	2	0	0
11.25	0	4	8	6	0	0	0
33.75	0	3	4	3	1	0	0
56.25	0	1	3	0	0	0	0
78.75	0	2	2	0	0	0	0
101.25	1	2	1	2	1	0	0
123.75	0	2	5	5	2	0	0
146.25	0	2	10	11	1	0	0
168.75	0	2	9	13	8	2	0
191.25	0	3	5	8	9	5	0
213.75	0	2	4	6	7	4	0
236.25	0	2	4	5	3	4	0
258.75	0	1	2	4	2	2	0
281.25	0	1	4	3	3	2	1
303.75	0	2	8	2	1	2	0
326.25	0	2	10	6	3	0	0

NRC CATEGORY D

deg	0.07	0.60	MPH 3.00	7.00	12.00	18.00	24.00
0.00	1	19	50	29	10	0	0
11.25	1	17	32	19	6	4	0
33.75	0	12	22	17	3	3	2
56.25	1	11	11	5	0	0	1
78.75	0	7	12	6	0	0	0
101.25	11	8	13	7	1	0	1
123.75	1	12	29	27	4	0	0
146.25	2	12	57	60	14	1	0
168.75	1	15	48	63	34	9	2
191.25	0	25	29	41	43	19	5
213.75	1	13	21	25	20	13	7
236.25	1	11	19	16	17	12	2
258.75	2	12	17	21	15	5	2
281.25	1	15	25	29	36	14	4
303.75	0	19	58	54	29	11	3
326.25	0	19	58	54	17	4	2

NRC CATEGORY E

deg	0.07	0.60	MPH 3.00	7.00	12.00	18.00	24.00
0.00	1	26	49	22	7	1	0
11.25	2	21	47	14	6	3	0
33.75	2	14	32	12	2	2	1
56.25	1	12	14	6	1	0	0
78.75	0	8	8	2	1	0	0
101.25	18	11	13	13	2	0	0
123.75	2	19	47	50	10	0	0
146.25	1	23	86	98	29	1	0
168.75	1	28	77	86	46	6	1
191.25	2	28	49	41	53	28	8
213.75	3	26	37	28	25	14	6
236.25	2	23	39	21	13	5	1
258.75	3	28	35	42	16	2	0
281.25	3	42	68	104	66	17	3
303.75	2	41	111	97	43	7	1
326.25	3	34	93	51	19	5	0

NRC CATEGORY F

deg	0.07	0.60	MPH 3.00	7.00	12.00	18.00	24.00
0.00	3	40	54	3	0	0	0
11.25	0	32	43	3	0	0	0
33.75	1	22	24	8	0	0	0
56.25	1	10	7	3	0	0	0
78.75	1	7	5	1	0	0	0
101.25	11	8	8	2	0	0	0
123.75	1	10	30	29	1	0	0
146.25	1	23	91	80	7	0	0
168.75	2	32	94	62	10	1	0
191.25	2	27	54	30	12	4	0
213.75	3	23	29	11	4	0	0
236.25	1	26	24	12	2	0	0
258.75	2	32	26	20	2	0	0
281.25	2	38	49	37	7	0	0
303.75	2	45	83	44	2	0	0
326.25	3	43	85	17	1	0	0

NRC CATEGORY G

deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
			MPH				
0.00	3	49	56	2	0	0	0
11.25	2	47	55	1	0	0	0
33.75	3	28	28	4	0	0	0
56.25	1	12	6	1	0	0	0
78.75	2	7	0	0	0	0	0
101.25	5	6	1	0	0	0	0
123.75	2	15	14	3	0	0	0
146.25	4	23	59	31	1	0	0
168.75	2	22	61	23	2	0	0
191.25	2	23	25	13	0	0	0
213.75	2	24	14	3	0	0	1
236.25	2	20	10	2	0	0	0
258.75	0	19	11	3	0	0	0
281.25	3	27	24	5	0	0	0
303.75	2	38	65	15	0	0	0
326.25	4	48	72	6	0	0	0

Table 5-10 Five-Year Average, 245 Ft AGL

JOINT FREQUENCY DISTRIBUTION FOR THE TIME PERIOD 01/01-12/31
DATA AVERAGED FROM 1996-2000 HOURLY DATA

The total hours are 8770, 8059 read and 711 missing.

NRC CATEGORY A

			MPH				
deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
0.00	5	12	31	22	14	1	1
11.25	3	15	25	25	11	4	0
33.75	0	7	18	13	3	1	0
56.25	0	8	12	5	1	0	0
78.75	0	8	14	3	0	0	0
101.25	0	11	14	8	1	0	0
123.75	1	11	20	15	4	0	0
146.25	1	11	38	34	6	1	0
168.75	1	10	32	54	21	4	1
191.25	0	7	22	28	36	9	4
213.75	1	6	14	16	12	7	3
236.25	0	7	10	8	5	3	3
258.75	1	5	8	7	5	2	4
281.25	1	5	12	4	6	4	1
303.75	2	10	13	6	5	3	4
326.25	0	9	26	17	10	0	0

NRC CATEGORY B

			MPH				
deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
0.00	0	2	8	7	3	0	0
11.25	0	2	6	6	2	0	0
33.75	0	1	5	5	0	0	0
56.25	0	1	3	1	0	0	0
78.75	0	0	2	2	0	0	0
101.25	0	2	2	2	0	0	0
123.75	0	1	4	2	0	0	0
146.25	0	2	6	9	2	0	0
168.75	0	1	10	15	7	1	0
191.25	0	3	8	10	9	5	0
213.75	0	1	2	4	7	5	3
236.25	0	0	3	3	4	2	2
258.75	0	1	2	2	4	2	1
281.25	0	1	2	2	4	2	1
303.75	0	3	5	6	1	2	2
326.25	0	5	6	5	3	0	0

NRC CATEGORY C

			MPH				
deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
0.00	1	2	8	8	4	0	0
11.25	0	1	5	6	2	0	0
33.75	0	2	4	3	1	0	0
56.25	0	2	4	1	0	0	0
78.75	0	2	2	1	0	0	0
101.25	0	0	1	1	0	0	0
123.75	0	1	3	2	1	0	0
146.25	0	3	7	7	1	0	0
168.75	0	4	9	13	7	2	0
191.25	0	2	6	11	13	7	1
213.75	0	2	5	6	5	6	5
236.25	1	2	4	3	5	5	3
258.75	0	2	2	3	3	2	1
281.25	0	2	2	3	3	2	2
303.75	0	1	5	3	2	2	1
326.25	0	1	7	9	4	0	0

NRC CATEGORY D

deg	0.07	0.60	MPH 3.00	7.00	12.00	18.00	24.00
0.00	0	13	38	30	18	5	1
11.25	1	9	24	25	12	2	4
33.75	1	8	21	15	7	0	3
56.25	0	5	13	9	2	0	0
78.75	0	6	9	8	1	0	0
101.25	0	6	10	8	3	0	0
123.75	1	11	16	18	7	1	0
146.25	2	8	32	40	13	1	0
168.75	2	14	44	61	29	11	2
191.25	1	24	31	51	53	32	24
213.75	1	12	21	28	27	21	31
236.25	2	13	10	20	21	14	13
258.75	0	9	15	15	14	14	8
281.25	0	9	18	27	32	21	14
303.75	1	12	36	45	36	20	18
326.25	1	12	50	52	20	8	3

NRC CATEGORY E

deg	0.07	0.60	MPH 3.00	7.00	12.00	18.00	24.00
0.00	2	14	47	36	15	2	1
11.25	0	13	33	33	7	2	2
33.75	0	7	25	20	4	2	3
56.25	0	9	18	10	2	0	1
78.75	1	9	12	9	2	0	1
101.25	1	10	13	7	4	1	0
123.75	2	11	21	25	12	2	0
146.25	1	13	38	53	34	11	2
168.75	2	18	47	68	63	31	6
191.25	1	17	37	50	69	50	39
213.75	2	19	26	30	38	43	52
236.25	2	14	25	22	19	14	13
258.75	2	11	28	29	23	14	10
281.25	1	14	40	51	78	73	38
303.75	2	13	54	94	90	60	26
326.25	2	14	55	67	33	19	5

NRC CATEGORY F

deg	0.07	0.60	MPH 3.00	7.00	12.00	18.00	24.00
0.00	4	16	44	26	6	0	0
11.25	2	11	34	20	1	0	0
33.75	1	10	29	17	5	1	0
56.25	0	9	17	11	1	1	0
78.75	1	8	12	5	0	0	0
101.25	1	9	8	3	0	0	0
123.75	1	11	18	11	6	0	0
146.25	1	12	35	43	38	5	1
168.75	2	15	44	65	45	8	2
191.25	1	13	40	52	44	18	6
213.75	3	14	34	27	20	13	6
236.25	0	12	35	18	6	3	1
258.75	2	14	27	19	17	6	1
281.25	2	10	22	29	45	28	2
303.75	2	10	30	49	63	19	1
326.25	6	10	45	49	28	4	1

NRC CATEGORY G

deg	0.07	0.60	3.00	7.00	12.00	18.00	24.00
			MPH				
0.00	1	12	41	21	2	0	0
11.25	1	12	37	13	1	0	0
33.75	0	7	30	20	5	1	0
56.25	0	7	25	10	2	1	0
78.75	0	9	11	2	1	0	0
101.25	3	6	7	0	0	0	0
123.75	1	8	14	5	3	0	0
146.25	2	15	43	33	11	1	0
168.75	3	17	53	37	11	2	0
191.25	1	12	42	34	13	2	0
213.75	1	17	34	22	4	2	0
236.25	0	10	21	9	1	0	0
258.75	0	11	13	6	3	0	0
281.25	0	7	13	10	12	5	0
303.75	2	7	19	31	35	4	0
326.25	3	11	31	46	22	0	0

6.0 DOSE ASSESSMENT -- IMPACT ON MAN

Liquid Effluents - There were no radioactive liquid discharges from Columbia Generating Station in 2001.

Gaseous Effluents - The NRC GASPAR II computer code was used to calculate doses at and beyond the site boundary using five-year average quarterly and annual meteorological data and site-specific variables as required and defined in the ODCM. Table 6-1 shows the highest calculated doses at the site boundary (1.21 miles SSE) and beyond the site boundary (1.97 miles NNW). Table 6-2 lists the annual 50-mile dose using values obtained from the ALARA annual integrated population dose summary (person-rem). Table 6-2 also provides the annual individual doses associated with each pathway. These values were obtained by dividing the ALARA integrated dose (person-rem) by the estimated 50-mile population (252,356 for year 1987) and converting to mrem.

The Columbia Generating Station Visitor Center was evaluated for assessment of radiation dose to "Members of the Public" due to their activities within the site boundary. The ODCM assumes an eight (8) hour per year occupancy by a member of the public at the Visitor Center and exposure to the plume, ground shine, and inhalation pathways. The highest organ doses calculated were in the teen age group and the organ with the highest dose was the skin. The highest dose values for this group are tabulated on the next page.

Periodically, Columbia Generating Station offers public tours of selected locations within the site boundary. Members of the public walk from the parking lot to the west entrance of the power plant. Calculations assumed an eight (8) hour per year exposure to the plume, ground shine, and inhalation pathways. The highest organ doses calculated were in the teen age group and the organ with the highest dose was the skin. The dose assessment results for this group are tabulated on the next page.

During this calendar year, U.S. Department of Energy worked within the site boundary installing ground water wells to monitor radionuclide migration from Hanford Site activities. Since this activity was not directly related to the operation of Columbia Generating Station, the individuals involved are considered 'members of the public.' The locations were mapped, hours spent at each location tabulated, and the maximum dose received at each location was determined. The individual who spent the most time at each of the locations was identified. Plume, inhalation, and ground deposition pathways were assumed for the adult and teen age groups only. The maximum doses calculated for individuals engaged in this well-drilling activity were 4.92E-02 mrem total body dose (Teen), 5.66E-03 mrem thyroid dose (Teen), and 6.47E-03 mrem highest other organ dose (Teen Skin). The Beta Air Dose was 1.39E-03 mrad and the Gamma Air Dose was 7.31E-04 mrad. Direct radiation from Columbia Generating Station to the highest exposed individual was estimated to be 1.2 mrem.

The highest calculated dose to a child living at locations identified in the most recent land use census was 6.35E-03 mrem to the total body, 8.40E-03 mrem to the thyroid, and 7.24E-03 mrem to the skin. This location was at 4.2 miles in the ESE sector and contained a garden.

During 2001, members of the public worked at the WNP-1 industrial area. The maximum dose to these individuals was also calculated for the plume, inhalation, and ground deposition pathways. The maximum doses received by the adult and teen age groups (full-time employees) are shown below.

The following table shows dose to members of the public within the site boundary of Columbia Generating Station for the total indicated hours spent at each location.

Location	Hours Spent	Total Body Dose (mrem)	Thyroid Dose (mrem)	Highest Other Organ Dose (mrem)	Beta Air Dose (mrad)	Gamma Air Dose (mrad)
Visitor Center	8.00E+00	4.51E-04	4.78E-04	5.50E-04	2.43E-04	2.92E-06
Tour Visitors	8.00E+00	3.30E-04	3.51E-04	3.97E-04	1.83E-04	6.48E-05
Well #1	1.10E+02	1.69E-03	1.79E-03	2.06E-03	8.96E-04	3.94E-04
Well #2	4.00E+01	4.65E-04	4.93E-04	5.70E-04	2.51E-04	1.10E-04
Well #3	8.50E+01	1.17E-03	1.24E-03	1.41E-03	6.47E-04	2.23E-04
Well #4	1.12E+02	3.16E-04	3.35E-04	3.78E-04	1.71E-04	6.04E-05
Well #5	3.70E+01	8.86E-04	9.37E-04	1.08E-03	4.69E-04	2.10E-04
Well #6	4.20E+01	2.38E-04	2.52E-04	2.88E-04	1.24E-04	5.13E-05
Well Drilling Staging Area	6.60E+01	5.68E-04	6.02E-04	6.81E-04	3.12E-04	1.09E-04
WNP-1 Industrial Area	2.08E+03	2.66E-03	2.82E-03	3.30E-03	1.45E-03	7.59E-04

During the growing season, Columbia Generating Station conducts a Land Use Census to determine the nearest residents between the site boundary and five-miles in each sector.

The following table provides the results of dose calculations for each identified location.

Location	Total Body Dose (mrem)	Thyroid Dose (mrem)	Highest Other Organ Dose (mrem)	Beta Air Dose (mrad)	Gamma Air Dose (mrad)
Resident (4.30 miles NE)	7.77E-04	8.29E-04	9.53E-04	4.35E-04	1.91E-04
Resident (4.45 miles E)	1.25E-03	1.46E-03	1.84E-03	1.10E-03	9.38E-04
Resident (4.50 miles SE)	2.30E-03	2.53E-03	3.19E-03	1.51E-03	1.50E-03
Garden (4.10 miles ENE)	4.11E-03	5.24E-03	4.76E-03	1.33E-03	9.63E-04
Garden (4.20 miles ESE)	6.35E-03	8.40E-03	7.24E-03	2.00E-03	1.21E-03

The Highest 'Other Organ' in all cases was the skin. For the 'resident' locations, the group with the highest dose was the teen age group. For 'garden' locations, the group with the highest dose was the child age group.

For environmental TLD stations at or beyond the site boundary where preoperational (background) data was acquired, no increase in ambient exposure was observed in 2001 from the preoperational values. The environmental TLD station with the highest direct radiation reading was located 0.1 mi NNW (ISFSI). The annual dose at this location from direct radiation was 307 mrem after subtracting background (Station 9A at 30 miles WSW).

Dose Tables

Table 6-1 Summary of Dose from Gaseous Effluents
Year 2001

1. Location: Site Boundary

	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Cumulative*
Beta air dose (mrad)	1.68E-05	6.40E-03	1.53E-04	1.43E-04	8.34E-03
Gamma air dose (mrad)	4.77E-05	2.45E-03	4.35E-04	4.07E-04	3.55E-03

2. Location: Beyond Site Boundary

	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Cumulative*
Beta air dose (mrad)	1.22E-05	2.58E-03	3.16E-05	1.29E-04	2.62E-03
Gamma air dose (mrad)	3.46E-05	9.78E-04	8.93E-05	3.65E-04	1.32E-03

3. Location: Site Boundary (1.21 Miles SSE)

	Annual Dose
Annual Total Body Dose (mrem)	1.53E-02
Annual Skin Dose (mrem)	1.86E-02

4. Location: Beyond Site Boundary

	Annual Dose
Annual Total Body Dose (mrem)	4.83E-03
Annual Skin Dose (mrem)	5.96E-03

* Rather than the sum of the quarters, these values are based on average annual meteorological parameters and total annual effluents.

Table 6-1 Summary of Doses from Gaseous Effluents (Continued)
Year 2001

5. Location: Site Boundary

	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Cumulative*
Maximum Organ Dose (mrem)	8.81E-03	7.37E-03	2.07E-03	3.78E-03	1.86E-02

6. Location: Beyond Site Boundary

	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Cumulative*
Maximum Organ Dose (mrem)	2.64E-03	3.17E-03	8.07E-04	2.21E-03	8.40E-03

7. Location: Land Use Census; 4.2 Miles ESE

	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	Annual Cumulative*
Maximum Organ Dose (mrem)	2.53E-03	3.72E-03	6.21E-04	2.21E-03	8.40E-03

* Rather than the sum of the quarters, these values are based on average annual meteorological parameters and total annual effluents.

Table 6-2 50-Mile Population Dose from Gaseous Effluents

A. 50-mile population collective dose

Exposure Pathway	Total Body (person-rem)	Max. Organ (person-rem)
Plume	6.85E-03	2.30E-02
Ground	1.17E-03	1.38E-03
Inhalation	3.66E-02	3.66E-02
Vegetables	3.17E-02	3.17E-02
Milk	1.11E-02	1.11E-02
Meat	6.99E-03	6.96E-03
Total	9.45E-02	1.11E-01

Population: 2.52E+05

B. Average Individual*

Exposure Pathway	Total Body (mrem)	Max. Organ (mrem)
Plume	2.71E-05	9.11E-05
Ground	4.64E-06	5.47E-06
Inhalation	1.45E-04	1.45E-04
Vegetables	1.26E-04	1.26E-04
Milk	4.40E-05	4.40E-05
Meat	2.77E-05	2.76E-05
Total	3.74E-04	4.39E-04

* These values are derived by dividing the 50-mile population collective doses by the population within 50 miles of the Plant by direction and radii interval.

7.0 REVISIONS TO THE ODCM

This section completes the requirement of Technical Specification 5.5.1. As specified, a complete, legible copy of the entire Offsite Dose Calculation Manual (ODCM) is included as an enclosure to the letter transmitting this Radioactive Effluent Release Report to the Nuclear Regulatory Commission (NRC).

8.0 REVISIONS TO THE PROCESS CONTROL PROGRAM (PCP)

Minor changes were made to the PCP to ensure that procurement of transportation and disposal-related items are evaluated with regard to fit, form, and function on plant equipment (specifically to ensure that new liners and HICs will fit into pre-existing radiation shields).

9.0 NEW OR DELETED LOCATIONS FOR DOSE ASSESSMENTS AND/OR ENVIRONMENTAL MONITORING LOCATIONS

Columbia Generating Station added seven locations within the site boundary for dose assessments in 2001. These seven locations corresponded to locations where members of the public were drilling monitoring wells for the Department of Energy. The environmental monitoring program has been obtaining ISFSI preoperational data using two Thermoluminescent Dosimeter (TLD) stations. The 2000 Land Use Census (LUC) added a meat pathway to a pre-existing location (4.3 miles NE (North Ringold)). Based on the 2001 LUC, that meat pathway was not included in the calculations of this report.

Station ID	Location Relative to Columbia Generating Station
Well #1	0.24 miles N
Well #2	0.29 miles NNW
Well #3	0.22 miles WNW
Well #4	0.27 miles W
Well #5	0.14 miles NNE
Well #6	0.38 miles NE
Well Drilling Staging Area	0.32 miles WNW
121 (ISFSI)	0.10 miles NNW
122 (ISFSI)	0.30 miles NNW

10.0 MAJOR CHANGES TO RADIOACTIVE LIQUID, GASEOUS, AND SOLID WASTE TREATMENT SYSTEMS

No major changes were made to the radioactive waste systems (liquid, gaseous, or solid) during this reporting period.

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45	32	68	32
46	32	69	32
47	32	70	32
48	33	71	32
49	33	72	32
50	32	73	32
51	32	74	32
52	32	75	33
53	32	76	33
54	33	77	33
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89	32	112	32
90	32	113	32
91	33	114	32
92	33	115	32
93	33	116	32
94	32	117	32
95	32	118	32
96	33	119	32
97	32	120	32
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138	32	161	33
139	32	162	32
140	32	163	32
141	32	164	32
142	32	165	32
143	32	166	32
144	32	167	32
145	32	168	32
146	32	169	32
147	32	170	32
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1.0 INTRODUCTION

The purpose of this manual is to provide the information and methodologies to be used by Energy Northwest to satisfy the requirements of 10 CFR 20.1302, 40 CFR Part 190, 10 CFR 50.36a, and Appendix I to 10 CFR Part 50.

2.0 LIQUID EFFLUENT DOSE CALCULATION

The U.S. Nuclear Regulatory Commission's computer program LADTAP II can be used for dose analysis for liquid radioactive effluents from Columbia Generating Station into surface waters. The analyses estimate radiation dose to individuals, population groups, and biota from ingestion (aquatic foods, water, and terrestrial irrigated foods) and external exposure (shoreline, swimming, and boating) pathways. The calculated doses provide for determining compliance with Appendix I to 10 CFR Part 50.

2.1 Introduction

Liquid radwaste released from Columbia Generating Station will meet 10 CFR 20 limits at the point of discharge to the Columbia River. Actual discharges of liquid radwaste effluents will only occur on a Batch Basis, and the average concentration at the point of discharge will be only a small percentage of the allowed limits. A simplified block diagram of the liquid waste management system and effluent pathways is contained in Figure 2-1. Solid radioactive wastes are disposed of by way of an approved disposal site. A simplified block diagram of the solid radwaste system is described in Figure 2-2.

The cumulative quarterly dose contributions due to radioactive liquid effluents released to the unrestricted areas will be determined once every 31 days using the LADTAP II computer code.

The dose contributions will be calculated for all radionuclides identified in the released effluent based on guidelines provided by NUREG-0133.

The methods for calculating the doses are discussed in Section 2.4 of this manual.

2.2 Radwaste Liquid Effluent Radiation Monitoring System

This monitoring subsystem measures the radioactivity in the liquid effluent prior to its entering the cooling tower blowdown line.

All radwaste effluent passes through a four-inch line which has an off-line sodium iodide radiation monitor. The radwaste effluent flow, variable from 0 to 190 gpm, combines with the 36-inch cooling water blowdown line, variable from 0 to 7500 gpm and is discharged to the Columbia River with a total flow based on MPC_i total, and cooling water flushing needs.

The radiation monitor is located on the 437' level of the Radwaste Building and has a minimum sensitivity of 10^{-6} μCi/cc for Cs-137. The radiation indicator has seven decades of range.

2.3 10 CFR 20 Release Rate Limits

The requirements pertaining to discharge of radwaste liquid effluents to the unrestricted area are specified in Requirement for Operability 6.2.1.1.

In order to comply with this requirement, limits will be set to assure that blowdown line concentrations do not exceed 10 CFR 20, Appendix B, Table II, Column 2 at any time.

2.3.1 Pre-Release Calculation

The activity of the radionuclide mixture and the liquid effluent discharge rate will be determined in accordance with Energy Northwest procedures. The effluent concentration is determined by the following equation:

$$Conc_i = \frac{Ci \times fw}{ft} \qquad (1)$$

where:

$Conc_i$	=	Concentration of radionuclide i in the effluent at point of discharge - μCi/ml.
C_i	=	Concentration of radionuclide i in the batch to be released - μCi/ml.
fw	=	Discharge flow rate from sample tank to the blowdown line - variable from 0 to 190 gpm.
fb	=	Blowdown flow rate - variable from 0 to 7500 gpm.
ft	=	Total discharge (ft = fb + fw) flow rate - variable from 0 to 7690 gpm.

The calculated concentration in the blowdown line must be less than the concentrations listed in 10 CFR 20, Appendix B. Before releasing the batch to the environment, the following equation must hold:

$$\sum_{i=1}^{m} (Conc_i \,/\, MPC_i) \leq 1 \qquad (2)$$

where:

$Conc_i$ = The concentration of radionuclide i in the effluent at the point of discharge into the river.

MPC_i = Maximum permissible concentration of nuclide i as listed in 10 CFR 20, Appendix B, Table II.

m = Total number of radionuclides in the batch.

2.3.2 Post-Release Calculation

The concentration of each radionuclide in the unrestricted area, following the batch release, will be calculated as follows:

The average activity of radionuclide i during the time period of the release is divided by the Plant Discharge Flow/Tank Discharge Flow ratio yielding the concentration at the point of discharge:

$$Conc_{ik} = \frac{C_{ik} \times fw}{ft} \qquad (3)$$

where:

$Conc_{ik}$ = The concentration of radionuclide i in the effluent at the point of discharge during the release period k - (μCi/ml).

C_{ik} = The concentration of radionuclide i in the batch during the release period k - (μCi/ml).

fw = Discharge flow rate from sample tank to the blowdown line - variable from 0 to 190 gpm.

fb = Blowdown flow rate - variable from 0 to 7500 gpm.

ft = Total discharge ($ft = fb + fw$) flow rate - variable from 0 to 7690 gpm.

To assure compliance with 10 CFR 20, the following relationships must hold:

$$\sum_{i=1}^{m} (Conc_{ik} / MPC_i) \leq 1 \qquad (4)$$

where the terms are as defined in Equation (2).

2.3.3 Continuous Release

Continuous release of liquid radwaste effluent is not planned for Columbia Generating Station. However, should it occur, the concentrations of various radionuclides in the unrestricted area would be calculated according to Equation (3) and Equation (4). To show compliance with 10 CFR 20, the two equations must again hold.

2.4 10 CFR 50, Appendix I, Release Rate Limits

Periodic Test and Inspection 6.2.1.2.1 requires that the cumulative dose contributions be determined in accordance with the ODCM at least once per 31 days. Requirement for Operability 6.2.1.2 specifies that the dose to a member of the public from radioactive material in liquid effluents released to the unrestricted area shall be limited to:

≤1.5 mrem/Calendar Quarter - Total Body

and

≤5.0 mrem/Calendar Quarter - Any Organ.

The cumulative dose for the calendar year shall be limited to:

≤3 mrem - Total Body

and

≤10 mrem - Any Organ.

The maximum exposed individual is assumed to be an adult whose exposure pathways include potable water and fish consumption. The choice of an adult as the maximum exposed individual is based on the highest fish and water consumption rates shown by that age group and the fact that most of the dose from the liquid effluent comes from these two pathways.

The dose contribution will be calculated for all radionuclides identified in the liquid effluent released to the unrestricted area, using the following equation:

$$D\tau = \sum_{i} (A_{i\tau} \sum_{\ell=1}^{m} \Delta t_\ell C_{i\ell} F_\ell) \qquad (5)$$

where:

$D\tau$ = The cumulative dose commitment to the total body or organ, τ, from liquid effluents for the total time period $\sum_{\ell=1}^{m} \Delta t_\ell$, in mrem.

Δt_ℓ = The length of the ℓth time period over which $C_{i\ell}$ and F_ℓ are averaged for all liquid releases, in hours.

m = The number of releases for the time period under consideration.

$C_{i\ell}$ = The average concentration of radionuclide i in undiluted liquid effluent during time period Δt_ℓ from any liquid release, in μCi/ml.

$A_{i\tau}$ = The site-related ingestion dose commitment factor to the total body or any organ τ for each identified principle gamma and beta emitter listed in Table 2-2, in mrem/hr per μCi/ml.

F_ℓ = The near field average dilution factor for $C_{i\ell}$ during any liquid waste release. This is defined as the ratio of the maximum undiluted liquid waste flow during release to the product of the average flow from the site discharge structure to unrestricted receiving waters times 500.

While the actual discharge structure exit flow is variable from 0 to 17.1 cfs (0 to 7690 gpm), a maximum flow value of 2.0 cfs will be used for dose calculation purposes in accordance with the NUREG-0133 requirement that the product of the average blowdown flow to the receiving water body, in cfs and the applicable factor (500), is 1000 cfs or less.

$$(F_\ell = \frac{\text{Liquid Radioactive Waste Flow}}{\text{Discharge Structure Exit Flow x 500}} = \frac{fw}{ft \times 500}) \qquad (6)$$

The term $A_{i\tau}$, the ingestion dose factors for the total body and critical organs, are tabulated in Table 2-2. It embodies the dose factor, fish bioaccumulation factor, pathway usage factor, and the dilution factor for the plant diffuser pipe to the Richland potable water intake. The following equation was used to calculate the ingestion dose factors:

$$A_{i\tau} = K_o (U_w/D_w + U_F \, BF_i) \, DF_i \qquad (7)$$

where:

$A_{i\tau}$ = The composite dose parameter for total body or critical organ of an adult for nuclide i (in mrem/hr per μCi/ml).

K_o = A conversion factor:

1.14E+05 = (10^6 pCi/μCi) x (10^3 ml/liter)/8760 hr/yr.

U_w = 730 liter/yr - which is the annual water consumption by the maximum adult (Table E-4 of Regulatory Guide 1.109, Revision 1).

BFi = Bioaccumulation factor for radionuclide i in fish - (pCi/Kg per pCi/liter) (Table A-1 of Regulatory Guide 1.109, Revision 1 and NUREG/CR-4013).

DFi = Adult ingestion dose conversion factor for nuclide i - Total body or critical organ, τ, in (mrem/pCi) (Table E-11 of Regulatory Guide 1.109, Revision 1 and NUREG/CR-4013).

D_w = Dilution factor from near field area (within one-quarter mile of the release point) to the Richland potable water intake - 100.

U_F = Adult fish consumption, 21 kg/yr (Table E-5 of Regulatory Guide 1.109, Revision 1).

The values of BF_i and DF_i are listed in Table 2-1. Dilution assumptions, calculations, and LADTAP II input parameters are provided in Radiological Health Calculation Log 92-2.

The quarterly limits mentioned before represent one-half of the annual design objective of Section II.A of 10 CFR 50, Appendix I. If any of the limits (either that of the calendar quarter or calendar year) are exceeded, a special report pursuant to Section IV.A of 10 CFR 50, Appendix I, shall be filed with the NRC.

2.4.1 Projection of Doses

The projected doses due to releases of radwaste liquid effluents will be calculated for each batch, using Equation (5) or LADTAP II. If the sum of the accumulated dose to date for the month and the projected dose for the remainder of the month exceeds the Requirement for Operability 6.2.1.3 limits, then the liquid radwaste treatment system shall be used. This is to ensure compliance with Requirement for Operability 6.2.1.3. This Requirement for Operability states that the liquid radwaste treatment system shall be maintained and the appropriate subsystem shall be used if the radioactive materials in liquid waste, prior to their discharge, when the dose, due to liquid effluent release to unrestricted areas when averaged over the month would exceed 0.06 mrem to total body or 0.2 mrem to any organ.

2.5 Radwaste Liquid Effluent Dilution Ratio and Alarm Setpoints Calculations

2.5.1 Introduction

The dilution alarm ratio and setpoints of the sample liquid effluent monitor are established to ensure that the limits of 10 CFR 20, Appendix B, Table II, Column 2, are not exceeded in the effluent at the discharge point (i.e., compliance with Requirement for Operability 6.2.1.1, as discussed in section 2.3.1 of this manual).

The alarm (HI) and the alarm/trip (HI-HI) setpoints for the liquid radwaste effluent monitor are calculated from the results of the radiochemical analysis of the effluent sample. The setpoints will be set into the radwaste monitor just prior to the release of each batch of radioactive liquid.

2.5.2 Methodology for Determining the Maximum Permissible Concentration (MPC) Fraction

Radwaste liquid effluents can only be discharged to the environment through the four-inch radwaste line. The maximum radwaste discharge flow rate is 190 gpm. Prior to discharge, the tank is isolated and recirculated for at least thirty minutes, and a representative sample is taken from the tank. An isotopic analysis of the batch will be made to determine the sum of the MPC fraction (MPC_f) based on 10 CFR 20 limits. From the sample analysis and the MPC values in 10 CFR 20, the MPC_f is determined using the following equation.

$$MPC_f = \sum_{i=1}^{m} \frac{c_i}{MPC_i} \quad (8)$$

where:

MPC_f = Total fraction of the Maximum Permissible Concentrations (MPCs) in the liquid effluent waste sample.

C_i = The concentration of each measured radionuclide i observed by the radiochemical analysis of the liquid waste sample (μCi/ml).

MPC_i = The limiting concentrations of the appropriate radionuclide i from 10 CFR 20, Appendix B, Table II, Column 2. For dissolved or entrained noble gases, the concentration shall be limited to 2.0E-04 μCi/ml total activity.

m = The total number of measured radionuclides in the liquid batch to be released.

If the MPC_f is less than or equal to 0.8, the liquid batch may be released at any radwaste discharge or blowdown rate. If the MPC_f exceeds 0.8, then a dilution factor (Fd) must be determined. The liquid effluent radiation monitor responds proportionally to radioactivity concentrations in the undiluted waste stream. Its setpoint must be determined for diluted releases.

2.5.3 <u>Methodology for the Determination of Minimum Dilution Factor</u>

The measured radionuclide concentrations are used to calculate the dilution factor (Fd), which is the ratio of the total discharge flow rates (RW + CBD) to the radwaste tank effluent flow rate (RW) that is required to assure that the limiting concentrations of Requirement for Operability 6.2.1.1 are met at the point of discharge.

The minimum dilution factor (Fd) is determined according to:

$$Fd = \left[\sum_{i=1}^{m} \frac{C_i}{MPC_i} \right] \times Fs \qquad (9)$$

where:

Fd = The minimum dilution factor required for compliance with 10 CFR 20, Appendix B, Table II, Column 2.

C_i = The concentration of each radionuclide i observed by radiochemical analysis of the liquid waste sample (μCi/ml).

MPC_i = The limiting concentration of the appropriate radionuclide i from 10 CFR 20, Appendix B, Table II, Column 2. For dissolved or entrained noble gases, the concentration shall be limited to 2.0E-04 μCi/ml total activity.

Fs = The safety factor; a conservative factor used to compensate for statistical fluctuations and errors in measurements. For example, a safety factor (Fs) of 1.5 corresponds to a fifty (50) percent (%) variation. The safety factor is 1.5.

m = The total number of measured radionuclides i in the liquid batch to be released.

The dilution which is required to ensure compliance with Requirement for Operability 6.2.1.1 concentration limits will be set such that discharge rates are:

$$Fd \leq \frac{RW + CBD}{RW} \qquad (10)$$

and follows that:

$$RW \leq \frac{CBD}{Fd-1} \qquad (10a)$$

or

$$CBD \geq RW(Fd-1) \qquad (10b)$$

where:

Fd = The minimum dilution factor from Equation (9).

RW = The discharge flow rate from the liquid radwaste tank to the blowdown line - variable from 0 to 190 gpm.

CBD = The cooling tower blowdown flow rate - variable from 0 to 7500 gpm.

2.5.4 Methodology for the Determination of Liquid Effluent Monitor Setpoints

Liquid effluents must meet the restrictions at the point of discharge to the river of 1 MPC or less after dilution. Therefore, the Liquid Effluent Monitor setpoint must be determined such that it will terminate a discharge at less than or equal to that point. The dilution factor must satisfy Equation (10).

$$\text{Setpoint} \leq C_M \left(\frac{CBD + RW}{RW} \right) \tag{11}$$

where:

Setpoint = the radwaste effluent monitor setpoint in μCi/ml. C_M is the maximum permissible diluted concentration, in μCi/ml, at the point of release that is in compliance with 10CFR20 Appendix B Table II column 2.

The Liquid Effluent Monitor measures the undiluted effluent, therefore the term

$$\frac{CBD + RW}{RW}$$

is used to correct for dilution.

CBD = the rate of dilution blowdown to the river in gpm.

RW = the rate of discharge from radwaste to the dilution blowdown line in gpm

The MPC fraction of the batch to be discharged, MPC_f is defined in Equation (8).

Since the final concentration must be less than or equal to one MPC:

$$C_M = \left(\frac{1}{MPC_f} \right) \sum_{i=1}^{m} C_i \tag{11a}$$

Substituting into Equation (11):

$$\text{Setpoint} \leq \left(\frac{1}{MPC_f} \right) \left(\sum_{i=1}^{m} C_i \right) \left(\frac{CBD + RW}{RW} \right) \tag{11b}$$

The Liquid Effluent Monitor reads out in counts per second (cps), therefore, it is necessary to convert the setpoint from μCi/ml to cps.

$$S_{HIHI} \leq \left(\frac{1}{MPC_f}\right)\left(\sum_{i=1}^{m} (C_i)\,(E_i)\right)\left(\frac{CBD + RW}{RW}\right) + BKG \qquad (11c)$$

where:

S_{HIHI} = the trip setpoint in cps

E_i = the monitor efficiency for nuclide i, in cps/μCi/ml

BKG = the monitor background in cps.

At low activity levels, the monitor demonstrates a normal instrument variation. In order to prevent spurious alarms and trips resulting from this variation, the setpoint can be calculated using a 1.0 MPC_f representative mixture when the MPC_f of the batch is less than 1.0 MPC_f.

The effluent monitor also has a high alarm setpoint that will be set to alarm if the batch contents exceed the concentration expected for the current discharge. This will warn the operator that the batch release is not proceeding as anticipated by the prerelease calculation, discharge should be stopped and the alarm cause investigated. The Hi alarm setpoint is determined to be at the monitor response for the current batch release multiplied by 1.25 to allow for normal variation in the monitor response. When the MPC_f of the batch is less than 1.0 MPC_f, the high setpoint will be the greater of either the calculated setpoint, or 80% of the setpoint determined from a 1.0 MPC_f mixture.

$$S_{HI} \leq BKG + 1.25\sum_{i=1}^{m} (C_i)\,(E_i) \qquad (12)$$

where:

S_{HI} is the monitor Hi setpoint in cps.

1.25 is a factor to account for normal variation in the monitor reading. It results in a maximum of a 25% greater than expected count rate before the alarm occurs.

$$S_{HI} \leq BKG + (0.8 * \text{One-MPC}) \qquad (12a)$$

Where one-MPC is the count rate corresponding to a 1.0 MPC_f representative mixture.

All other terms defined in Equation 12.

2.6 Verification of Compliance with 10 CFR 50, Appendix I, and 10 CFR 20, Appendix B

Verification of compliance with 10 CFR 50, Appendix I, and 10 CFR 20, Appendix B, limits will be achieved by following plant procedures for liquid discharge and the periodic application of the LADTAP II computer code.

2.7 Methods for Calculating Doses to Man From Liquid Effluent Pathways

Dose models presented in NRC Regulatory Guide 1.109, Revision 1, as incorporated in the LADTAP II computer code, will be used for offsite dose calculation. The details of the computer code, and user instruction, are included in NUREG/CR-4013, "LADTAP II - Technical Reference and User Guide."

2.7.1 Radiation Doses

Radiation doses from potable water, aquatic food, shoreline deposit, and irrigated food pathways will be calculated by using the following equations:

a. Potable Water

$$R_{apj} = 1100 \frac{U_{ap}M_p}{F} \sum_i Q_i D_{aipj} \exp(-\lambda_i t_p) \qquad (13)$$

b. Aquatic Foods

$$R_{apj} = 1100 \frac{U_{ap}M_P}{F} \sum_i Q_i B_{ip} D_{aipj} \exp(-\lambda_i t_p) \qquad (14)$$

c. Shoreline Deposits

$$R_{apj} = 110{,}000 \frac{U_{ap}M_p W}{F} \sum_i Q_i T_i D_{aipj} [\exp(-\lambda_i t_p)(1 - \exp(-\lambda_i t_b)] \qquad (15)$$

d. Irrigated foods

For all radionuclides except tritium:

$$R_{apj} = U_{ap}^{veg} \sum_i d_i \exp(-\lambda_i t_h) D_{aipj} \left[\frac{r\,[1 - \exp(-\lambda_{Ei} t_e]}{Y_v \lambda_{Ei}} + \frac{f_I B_{iv} [1 - \exp(-\lambda_i t_b)]}{P \lambda_i} \right]$$

$$+ U_{ap}^{animal} \sum_i F_{iA} D_{aipj} \left[Q_F d_i \exp(-\lambda_i t_h) \frac{r[1 - \exp(-\lambda_{Ei} t_e)]}{Y_v \lambda_{Ei}} \right.$$

$$\left. + \frac{f_I B_{iv} [1 - \exp(-\lambda_i t_b)]}{P \lambda_i} + C_{iAw} Q_{AW} \right] \qquad (16)$$

For tritium:

$$R_{apj} = U_{ap}^{veg} C_v D_{apj} + U_{ap}^{animal} D_{apj} F_A (C_v Q_F + C_{Aw} Q_{Aw}) \qquad (17)$$

where:

B_{ip} = The equilibrium bioaccumulation factor for nuclide i in pathway p, expressed as the ratio of the concentration in biota (in pCi/kg) to the radionuclide concentration in water (in pCi/liter), in liters/kg.

B_{iv} = The concentration factor for uptake of radionuclide i from soil by edible parts of crops, in pCi/kg (wet weight) per pCi/kg dry soil.

C_{iAw} = The concentration of radionuclide i in water consumed by animals, in pCi/liter.

C_{iv} = The concentration of radionuclide i in vegetation, in pCi/kg.

D_{aipj} = The dose factor specific to a given age group a, radionuclide i, pathway p, and organ j, which can be used to calculate the radiation dose from an intake of a radionuclide, in mrem/pCi, or from exposure to a given concentration of a radionuclide in sediment, expressed as a ratio of the dose rate (in mrem/hr) and the area radionuclide concentration (in pCi/m^2).

d_i = The deposition rate of nuclide i in pCi/m^2 per hour.

F = The flow rate of the liquid effluent, variable from 0 to 2.0 cfs, for dose calculation purposes.

f_I = The fraction of the year crops are irrigated, dimensionless.

F_{iA} = The stable element transfer coefficient that relates the daily intake rate by an animal to the concentration in an edible portion of animal product, in pCi/liter (milk) per pCi/day or pCi/kg (animal product) per pCi/day.

M_p = The mixing ratio (reciprocal of the dilution factor) at the point of exposure (or the point of withdrawal of drinking water or point of harvest of aquatic food), dimensionless.

P = The effective "surface density" for soil, in kg (dry soil)/m^2 (Table E-15, Regulatory Guide 1.109, Revision 1).

Q_{Aw} = The consumption rate of contaminated water by an animal, in liters/day.

Q_F = The consumption rate of contaminated feed or forage by an animal, in kg/day (wet weight).

Q_i = The release rate of nuclide i in Ci/yr.

r = The fraction of deposited activity retained on crops, dimensionless (Table E-15, Regulatory Guide 1.109, Revision 1).

R_{apj} = The total annual dose to organ j of individuals of age group a from all of the nuclides i in pathway p, in mrem/yr.

t_b = The period of time for which sediment or soil is exposed to the contaminated water, in hours (Table E-15, Regulatory Guide 1.109, Revision 1).

t_e = The time period that crops are exposed to contamination during the growing season, in hours (Table E-15, Regulatory Guide 1.109, Revision 1).

t_h = A holdup time that represents the time interval between harvest and consumption of the food, in hours (Table E-15, Regulatory Guide 1.109, Revision 1).

T_i = The radioactive half life of nuclide i in days.

t_p = The average transit time required for nuclides to reach the point of exposure. For internal dose, t_p is the total time elapsed between release of the nuclides and ingestion of food or water, in hours (Table E-15, Regulatory Guide 1.109, Revision 1).

U_{ap} = A usage factor that specifies the exposure time or intake rate for an individual of age group a associated with pathway p, in hr/yr, L/yr, or kg/yr (Table E-5, Regulatory Guide 1.109, Revision 1).

W = The shoreline width factor, dimensionless (Table A-2, Regulatory Guide 1.109, Revision 1).

Y_v = The agricultural productivity (yield), in kg (wet weight)/m^2 (Table E-15, Regulatory Guide 1.109, Revision 1).

λ_{Ei} = The effective removal rate constant for radionuclide i from crops, in hr^{-1}, where $\lambda_{Ei} = \lambda_i + \lambda_w$, λ_i is the radioactive decay constant, and λ_w is the removal rate constant for physical loss by weathering (Regulatory Guide 1.109, Revision 1, Table B-15).

λ_i = The radioactive decay constant of nuclide i in hr^{-1}.

1100 = The factor to convert from (Ci/yr)/(ft^3/sec) to pCi/liter.

110,000 = The factor to convert from (Ci/yr)/(ft^3/sec) to pCi/liter and to account for the proportionality constant used in the sediment radioactivity model.

These equations yield the dose rates to various organs of individuals from the exposure pathways mentioned above.

2.7.2 Plant Parameters

Columbia Generating Station is a river shoreline site with a variable effluent discharge flow rate 0 to 7690 gpm. The population center nearest the site is the city of Richland, where drinking water withdrawal takes place. The applicable dilution factor is 50,000, using average river flow. The time required for released liquids to reach Richland, approximately 12 miles downstream, is estimated at 4.0 hours. Richland is the "realistic case" location, and doses calculated for the Richland location are typically applicable to the population as a whole. Individual and population doses based on Richland parameters are calculated for all exposure pathways.

Only the population downstream of the site is affected by the liquid effluents released. There is no significant commercial fish harvest in the 50-mile radius region around Columbia Generating Station. Sportfish harvest is estimated at 14,000 kg/year.

For irrigated foods exposure pathways, it can be assumed that production within the 50-mile radius region around Columbia Generating Station is sufficient to satisfy consumption requirements.

Other relevant parameters relating to the irrigated foods pathways are defined as follows:

Food Type	Irrigation Rate (liter/m²/mo)	Annual Yield (kg/m²)	Growing Period (Days)
Vegetation	150	5.0	70
Leafy Vegetation	200	1.5	70
Feed for Milk Cows	200	1.3	30
Feed for Beef Cattle	160	2.0	130

Source terms are measured based on sampled effluent.

Table 2-3 summarizes the LADTAP II input parameters. Documentation and/or calculations of these parameters are discussed in detail in PPM 16.12.1, and Radiological Health Calculation Log 92-2.

2.8 Compliance with Technical Specification 5.5.8.b

2.8.1 Maximum Allowable Liquid Radwaste Activity in Temporary Radwaste Hold-Up Tanks

The use of temporary liquid radwaste hold-up tanks is planned for Columbia Generating Station. Technical Specification 5.5.8.b states the quantity of radioactive material contained in any outside temporary tanks shall be limited to the limits calculated in the ODCM such that a complete release of the tank contents would not result in a concentration at the nearest offsite potable water supply that would exceed the limits specified in 10 CFR Part 20 Appendix B, Table II.

Equation (18) will be used to calculate the curie limit for a temporary radwaste hold-up tank. The total tank concentration will be limited to less than or equal to ten (≤ 10) curies, excluding tritium and dissolved or entrained gases.

The quantity of radioactive material in the hold-up tanks shall be determined to be within the limit by analyzing a representative sample of the tank's contents at least once per 7 days when radioactive materials are being added to the tank.

$$A_T = \frac{k_d}{\sum_i \frac{fi}{MPC_i e^{\lambda_{it}}}} \qquad (18)$$

where:

A_T = Total allowed activity in tank (curies).

A_i = Activity of radioisotope i (curies).

MPC_i = Maximum permissible concentration of radionuclide i (10 CFR 20, Appendix B, Table II, Column 2).

λ_i = Decay constant ($years^{-1}$) radioisotope i.

t = Transit time of ground water from Columbia Generating Station to WNP-1 well (FSAR Section 2.4) = 67 years.

fi = Fraction of radioisotope fi = $\frac{A_i}{\Sigma A_i}$

i = Index for all radioisotopes in tank except tritium and noble gases.

K_d = Dispersion constant based on hydrological parameters, (2.4E+05 Ci per μCi/cc.)

The total allowed activity (A_T) is based on limiting WNP-1 well water to less than 1 MPC_i of the entire liquid content of the tank spilled to ground and then migrated via ground water to the WNP-1 well. The WNP-1 well is the location of maximum concentration since it is the nearest source of ground water and conditions are such that no spill of liquid should reach surface water. The 70-85 foot depth of the water table and the low ambient moisture of the soil requires a rather large volume of spillage for the liquid to even reach the water table in less than several hundred years. However, allowed tank activity (A_T) is conservatively based on all liquid radwaste in the tank instantaneously reaching the water table.

The hydrological analysis performed for the FSAR (Section 2.4) determined that the transit time through the ground water from Columbia Generating Station to the WNP-1 well is 67 years for Strontium and 660 years for Cesium. These two radionuclides are representative of the radionuclides found in liquid radwaste. Strontium is a moderate sorber and Cesium strongly sorbs to soil particles. This calculation conservatively treats all radionuclides as moderate sorbers with a transit time of 67 years.

The concentration of each radionuclide in the well (CW_i) is simply the concentration in the tank (CT_i) adjusted for radioactive decay during transit ($e^{-\lambda t}$) and divided by the minimum concentration reduction factor (CRF_{min}). Limiting well concentration to 1 MPC yields:

$$\sum \frac{CW_i}{MPC_i} = 1 = \sum \frac{CT_i e^{-\lambda t}}{CRF_{min} MPC_i} \tag{19}$$

(From Section 2.4 of FSAR)

$$CRF_{min} = \frac{(4 \pi L)^{3/2} (a_x a_y a_z)^{1/2}}{2V} \tag{20}$$

where:

L = Migration distance = 1 mile.

V = Volume of tank.

α_x, α_y, α_z = Dispersion constants.

Combining Equations (19) and (20) yields:

$$1 = \sum \frac{CT_i \, 2V \, e^{-\lambda_i t}}{(4 \pi L)^{3/2} (\alpha_x \alpha_y \alpha_z)^{1/2} MPC_i} \tag{21}$$

Substituting A_i for CT_i V and reorganizing terms yields:

$$\frac{(4 \pi L)^{3/2} (\alpha_x \alpha_y \alpha_z)^{1/2}}{2} = \sum \frac{A_i}{MPC_i e^{+\lambda_i t}} \tag{22}$$

Making the following substitutions

$$A_i = f_i \, A_T$$

$$K_d = \frac{(4 \pi L)^{3/2} (\alpha_x \alpha_y \alpha_z)^{1/2}}{2} \times 10^{-6} \ \text{Ci}/\mu\text{Ci} = 2.4 \times 10^5 \ \text{Ci per } \mu\frac{\text{Ci}}{\text{cc}} \qquad (23)$$

yields:

$$K_d = A_T \Sigma \frac{f_i}{MPC_i e^{+\lambda t}}$$

or

$$A_T = \frac{K_d}{\Sigma \frac{f_i}{MPC_i e^{+\lambda t}}}$$

2.8.2 Maximum Allowable Liquid Radwaste in Tanks That Are Not Surrounded by Liners, Dikes, or Walls

Although permanent outside liquid radwaste tanks which are not surrounded by liners, dikes, or walls are not planned for Columbia Generating Station, Equation (18) will be used should such tanks become necessary in the future.

2.9 Liquid Process Monitors and Alarm Setpoints Calculations

As mentioned in Section 2.2 of this manual, all liquid radwaste effluent is discharged through a four-inch line that is monitored by an off-line sodium iodide radiation monitor. This monitor is located on the 437' level of the Radwaste Building. All radwaste liquid effluent is discharged to the Columbia River through the 36-inch Cooling Water Blowdown line. In addition to the liquid effluent discharge monitor there are three liquid streams that are normally nonradioactive but have a finite possibility of having radioactive material injected into them. These liquid streams are:

- Standby Service Water (SW)
- Turbine Building Service Water (TSW)
- Turbine Building Sump Water (FD)

To prevent any discharges of radioactive liquid from these streams, radiation monitoring systems have been installed to detect any increase above the normal background concentration of radioactive material.

Alarm/setpoints are established to prevent any release of radioactive material inconcentrations greater than 10 CFR 20 limits. The maximum radiation detector setpoint calculation for the three systems is based on the MPC_i concentration of Cs-137 which is 2.OE-05 μCi/ml. The following equation is used to calculate the maximum setpoint:

Setpoint max. = [(2.0E-05 μCi/ml) (CF)] (25)
(in cpm or cps)

where:

2.0E-05 μCi/ml = MPC limit for Cs-137

CF = Monitor calibration factor - in cpm/μCi/ml or cps/μCi/ml

2.9.1 Standby Service Water (SW) Monitor

The Standby Service Water Monitors (SW) are located on the 522' level of the Reactor Building.

The meter is located in the main control room on panel P-604.

The flow rate through the monitor is variable, from zero (0) to two (2) gpm with a normal flow of 1.0-1.5 gpm.

To ensure 10 CFR 20 limits are never exceeded, the alarm setpoint shall be established at 80% or less of the maximum setpoint plus background.

If the setpoint is exceeded, an alarm will activate in the main control room. The control room operator can then terminate the discharge and mitigate any uncontrolled release of radioactive material.

2.9.2 Turbine Building Service Water (TSW) Monitor

This monitor is located on the 441' level of the Turbine Building. The readout meter and recorder is located in the main control panel BD-RAD-24.

The flow rate through that monitor is variable, from zero (0) to five (5) gpm with a normal flow of 1-2 gpm.

To ensure 10 CFR 20 limits are never exceeded, the alarm setpoint shall be established at 80% or less of the maximum setpoint plus background.

If the setpoint is exceeded, an alarm will activate in the main control room. The control room operator can then terminate the discharge and mitigate any uncontrolled release of radioactive material.

2.9.3 Turbine Building Sumps Water (FD) Monitor

There are three detectors to measure the activity of each of the three nonradioactive sumps. The monitors are located on the 441' level of the Turbine Building. The readout meters and recorder are located in the Radwaste Control Room Panel BD-RAD-41. The alarm/setpoint for these detectors is established by design at 80% of the 10 CFR Part 20, Appendix B, Table II value for Cs-137. In the event the setpoint is exceeded, the sump discharge will be automatically diverted to the Radwaste system for processing.

Turbine building sumps, T1, T2, and T3 are normally routed to the liquid radwaste system. Effluent from these turbine building sumps may be routed to the storm water system if analyses indicate no detectable radioactivity is present. Other inputs to the storm waste system, in addition to rain water, include water treatment filter backwashes, Service Building and Emergency Diesel Generator Building floor drains, HVAC air wash units, and condensed steam from plant steam leaks that collect on rooftops during cool weather. The storm water system terminates in an unlined depression or pond located 1500 feet northeast of the plant. Releases to the storm drain pond are sampled as part of the Radiological Environmental Monitoring Program. Based on past experience, it is expected that there will be some accumulation of low levels of radioactive materials, particularly tritium, in the pond.

2.10 Sanitary Waste Treatment

Sanitary wastes from Columbia Generating Station, WNP-1/4, the Kootenai Building (plant support facility), and the Department of Energy's 400 Area facilities are directed to Energy Northwest's central sanitary waste treatment facility. The facility utilizes a standard treatment process involving lined aerated lagoons and facultative stabilization ponds. The treated effluent is discharged to ground via percolation beds.

The operation of the sanitary waste treatment facility is regulated by the State of Washington. Routine monitoring of the treatment facility is performed by the Radiological Environmental Monitoring Program. Low levels of radioactive materials, particularly tritium from the 400 Area, are expected to be present in the treatment facility as a result of processing these waste streams.

Table 2-1

FISH BIOACCUMULATION FACTORS (BF_i)[1]
AND ADULT INGESTION DOSE CONVERSION FACTORS (DF_i)[2]

Nuclide	Fish Bioaccumulation Factor (BF_i) (pCi/kg per pCi/liter)	Dose Conversion Factor (DF_i) (mRem per pCi Ingested) Total Body	Bone	Thyroid	Liver	GI Tract
H-3	9.0E-01	6.0E-08	__(3)	6.0E-08	6.0E-08	6.0E-08
Na-24	1.0E+02	1.7E-06	1.7E-06	1.7E-06	1.7E-06	1.7E-06
P-32	1.0E+05	7.5E-06	1.9E-04	__(3)	1.2E-05	2.2E-05
Cr-51	2.0E+02	2.7E-09	__(3)	1.6E-09	__(3)	6.7E-07
Mn-54	4.0E+02	8.7E-07	__(3)	__(3)	4.6E-06	1.4E-05
Mn-56	4.0E+02	2.0E-08	__(3)	__(3)	1.2E-07	3.7E-06
Fe-55	1.0E+02	4.4E-07	2.8E-06	__(3)	1.9E-06	1.1E-06
Fe-59	1.0E+02	3.9E-06	4.3E-06	__(3)	1.0E-05	3.4E-05
Co-58	5.0E+01	1.7E-06	__(3)	__(3)	7.5E-07	1.5E-05
Co-60	5.0E+01	4.7E-06	__(3)	__(3)	2.1E-06	4.0E-05
Ni-65	1.0E+02	3.1E-08	5.3E-07	__(3)	6.9E-08	1.7E-06
Cu-64	5.0E+01	3.9E-08	__(3)	__(3)	8.3E-08	7.1E-06
Zn-65	2.0E+03	7.0E-06	4.8E-06	__(3)	1.5E-05	9.7E-06
Zn-69m	2.0E+03	3.7E-08	1.7E-07	__(3)	4.1E-07	2.5E-05
As-76	1.0E+02	4.8E-06	__(3)	__(3)	__(3)	4.4E-05
Br-82	4.2E+02	2.3E-06	__(3)	__(3)	__(3)	2.6E-06
Br-83	4.2E+02	4.0E-08	__(3)	__(3)	__(3)	5.8E-08
Br-84	4.2E+02	5.2E-08	__(3)	__(3)	__(3)	4.1E-13
Rb-89	2.0E+03	2.8E-08	__(3)	__(3)	4.0E-08	2.3E-21
Sr-89	3.0E+01	8.8E-06	3.1E-04	__(3)	__(3)	4.9E-05
Sr-90	3.0E+01	1.8E-04	8.7E-03	__(3)	__(3)	2.2E-04
Sr-91	3.0E+01	2.3E-07	5.7E-06	__(3)	__(3)	2.7E-05
Sr-92	3.0E+01	9.3E-08	2.2E-06	__(3)	__(3)	4.3E-05
Y-90	2.5E+01	2.6E-10	9.7E-09	__(3)	__(3)	1.0E-04
Y-91m	2.5E+01	3.5E-12	9.1E-11	__(3)	__(3)	2.7E-10
Y-91	2.5E+01	3.8E-09	1.4E-07	__(3)	__(3)	7.8E-05

Table 2-1

FISH BIOACCUMULATION FACTORS (BF_i)(1)
AND ADULT INGESTION DOSE CONVERSION FACTORS (DF_i)(2)

Nuclide	Fish Bioaccumulation Factor (BF_i)	Dose Conversion Factor (DF_i) Total Body	Bone	Thyroid	Liver	GI Tract
	(pCi/kg per pCi/liter)	(mRem per pCi Ingested)				
Y-92	2.5E+01	2.5E-11	8.5E-10	__(3)	__(3)	1.5E-05
Y-93	2.5E+01	7.4E-11	2.7E-09	__(3)	__(3)	8.5E-05
Zr-95	3.3E+00	6.6E-09	3.1E-08	__(3)	9.8E-09	3.1E-05
Nb-95	3.0E+04	1.9E-09	6.2E-09	__(3)	3.5E-09	2.1E-05
Zr-97	3.3E+00	1.6E-10	1.7E-09	__(3)	3.4E-10	1.1E-04
Nb-97	3.0E+04	4.8E-12	5.2E-11	__(3)	1.3E-11	4.9E-08
Mo-99	1.0E+01	8.2E-07	__(3)	__(3)	4.3E-06	1.0E-05
Tc-99m	1.5E+01	8.9E-09	2.5E-10	__(3)	7.0E-10	4.1E-07
Tc-101	1.5E+01	3.6E-09	2.5E-10	__(3)	3.7E-10	1.1E-21
Ru-103	1.0E+01	8.0E-08	1.9E-07	__(3)	__(3)	2.2E-05
Ru-105	1.0E+01	6.1E-09	1.5E-08	__(3)	__(3)	9.4E-06
Rh-105	1.0E+01	5.8E-08	1.2E-07	__(3)	8.9E-08	1.4E-05
Ru-106	1.0E+01	3.5E-07	2.8E-06	__(3)	__(3)	1.8E-04
Ag-110m	2.3E+00	8.8E-08	1.6E-07	__(3)	1.5E-07	6.0E-05
Sb-124	1.0E+00	1.1E-06	2.8E-06	6.8E-09	5.3E-08	8.0E-05
Sb-125	1.0E+00	4.3E-07	1.8E-06	1.8E-09	2.0E-08	2.0E-05
Sb-126	1.0E+00	4.2E-07	1.2E-06	7.0E-09	2.3E-08	9.4E-05
Sb-127	1.0E+00	9.9E-08	2.6E-07	3.1E-09	5.7E-09	5.9E-05
Te-127	4.0E+02	2.4E-08	1.1E-07	8.2E-08	4.0E-08	8.7E-06
Te-129m	4.0E+02	1.8E-06	1.2E-05	4.0E-06	4.3E-06	5.8E-05
Te-129	4.0E+02	7.7E-09	3.1E-08	2.4E-08	1.2E-08	2.4E-08
Te-131m	4.0E+02	7.1E-07	1.7E-06	1.3E-06	8.5E-07	8.4E-05
Te-131	4.0E+02	6.2E-09	2.0E-08	1.6E-08	8.2E-09	2.8E-09
Te-132	4.0E+02	1.5E-06	2.5E-06	1.8E-06	1.6E-06	7.7E-05
I-131	1.5E+01	3.4E-06	4.2E-06	2.0E-03	6.0E-06	1.6E-06
I-132	1.5E+01	1.9E-07	2.0E-07	1.9E-05	5.4E-07	1.0E-07
I-133	1.5E+01	7.5E-07	1.4E-06	3.6E-04	2.5E-06	2.2E-06
I-134	1.5E+01	1.0E-07	1.1E-07	5.0E-06	2.9E-07	2.5E-10

Table 2-1

FISH BIOACCUMULATION FACTORS (BF_i)(1)
AND ADULT INGESTION DOSE CONVERSION FACTORS (DF_i)(2)

Nuclide	Fish Bioaccumulation Factor (BF_i) (pCi/kg per pCi/liter)	Dose Conversion Factor (DF_i) (mRem per pCi Ingested): Total Body	Bone	Thyroid	Liver	GI Tract
I-135	1.5E+01	4.3E-07	4.4E-07	7.7E-05	1.2E-06	1.3E-06
Cs-134	2.0E+03	1.2E-04	6.2E-05	__(3)	1.5E-04	2.6E-06
Cs-136	2.0E+03	1.9E-05	6.5E-06	__(3)	2.6E-05	2.9E-06
Cs-137	2.0E+03	7.1E-05	8.0E-05	__(3)	1.1E-04	2.1E-06
Cs-138	2.0E+03	5.4E-08	5.5E-08	__(3)	1.1E-07	4.7E-13
Ba-139	4.0E+00	2.8E-09	9.7E-08	__(3)	6.9E-11	1.7E-07
Ba-140	4.0E+00	1.3E-06	2.0E-05	__(3)	2.6E-08	4.2E-05
La-140	2.5E+01	3.3E-10	2.5E-09	__(3)	1.3E-09	9.3E-05
La-141	2.5E+01	1.6E-11	3.2E-10	__(3)	9.9E-11	1.2E-05
La-142	2.5E+01	1.5E-11	1.3E-10	__(3)	5.8E-11	4.3E-07
Ce-141	1.0E+00	7.2E-10	9.4E-09	__(3)	6.3E-09	2.4E-05
Ce-143	1.0E+00	1.4E-10	1.7E-09	__(3)	1.2E-06	4.6E-05
Ce-144	1.0E+00	2.6E-08	4.9E-07	__(3)	2.0E-07	1.7E-04
Pr-143	2.5E+01	4.6E-10	9.2E-09	__(3)	3.7E-09	4.0E-05
Nd-147	2.5E+01	4.4E-10	6.2E-09	__(3)	7.3E-09	3.5E-05
Hf-179m	3.3E+00	4.8E-06	__(3)	__(3)	__(3)	4.1E-05
Hf-181	3.3E+00	4.3E-06	__(3)	__(3)	__(3)	4.1E-05
W-185	1.2E+03	1.4E-08	4.1E-07	__(3)	1.4E-07	1.6E-05
W-187	1.2E+03	3.0E-08	1.0E-07	__(3)	8.6E-08	2.8E-05
Np-239	1.0E+01	6.5E-11	1.2E-09	__(3)	1.2E-10	2.4E-05

(1)NRC NUREG/CR-4013.

(2)NRC NUREG/CR-4013.

(3)No data listed in NUREG/CR-4013.
(Use total body dose conversion factor as an approximation.)

Table 2-2

INGESTION DOSE FACTORS ($A_{i\tau}$) FOR TOTAL BODY AND CRITICAL ORGAN
(in mrem/hr per μCi/ml)

Liquid Effluent

Nuclide	Total Body	Bone	Thyroid	Liver	GI Tract
H-3	1.8E-01	**	1.8E-01	1.8E-01	1.8E-01
Na-24	4.1E+02	4.1E+02	4.1E+02	4.1E+02	4.1E+02
P-32	1.8E+06	4.6E+07	**	2.9E+06	5.3E+06
Cr-51	1.3E+00	**	7.7E-01	**	3.2E+02
Mn-54	8.3E+02	**	**	4.4E+03	1.3E+04
Mn-56	1.9E+01	**	**	1.6E+02	3.6E+03
Fe-55	1.1E+02	6.7E+02	**	4.6E+02	2.6E+02
Fe-59	9.4E+02	1.0E+03	**	2.4E+03	8.2E+03
Co-58	2.1E+02	**	**	9.0E+01	1.8E+03
Co-60	5.7E+02	**	**	2.5E+02	4.8E+03
Ni-65	7.5E+00	1.3E+02	**	1.7E+01	4.1E+02
Cu-64	4.7E+00	**	**	1.0E+01	8.6E+02
Zn-65	3.4E+04	2.3E+04	**	7.2E+04	4.7E+04
Zn-69m	1.8E+02	8.1E+02	**	2.0E+03	1.2E+05
As-76	1.2E+03	**	**	**	1.1E+04
Br-82	2.3E+03	**	**	**	2.6E+03
Br-83	4.0E+01	**	**	**	5.8E+01
Br-84	5.2E+01	**	**	**	4.1E-04
Rb-89	1.3E+02	**	**	1.9E+02	1.1E-11
Sr-89	6.4E+02	2.3E+04	**	**	3.6E+03
Sr-90	1.3E+04	6.3E+05	**	**	1.6E+04
Sr-91	1.7E+01	4.1E+02	**	**	2.0E+03
Sr-92	6.8E+00	1.6E+02	**	**	3.1E+03
Y-90	1.6E-02	5.9E-01	**	**	6.1E+03
Y-91m	2.1E-04	5.5E-03	**	**	1.6E-02
Y-91	2.3E-01	8.5E+00	**	**	4.7E+03
Y-92	1.5E-03	5.2E-02	**	**	9.1E+02
Y-93	4.5E-03	1.6E-01	**	**	5.2E+03

Table 2-2

INGESTION DOSE FACTORS ($A_{i\tau}$) FOR TOTAL BODY AND CRITICAL ORGAN
(in mrem/hr per μCi/ml)

Liquid Effluent

Nuclide	Total Body	Bone	Thyroid	Liver	GI Tract
Zr-95	5.3E-02	2.5E-01	**	7.9E-02	2.5E+02
Nb-95	1.4E+02	4.5E+02	**	2.5E+02	1.5E+06
Zr-97	1.3E-03	1.4E-02	**	2.7E-03	8.8E+02
Nb-97	3.5E-01	3.7E+00	**	9.3E-01	3.5E+03
Mo-99	2.0E+01	**	**	1.1E+02	2.5E+02
Tc-99m	3.3E-01	9.2E-03	**	2.6E-02	1.5E+01
Tc-101	1.3E-01	9.2E-03	**	1.4E-02	4.0E-14
Ru-103	2.0E+00	4.7E+00	**	**	5.5E+02
Ru-105	1.5E-01	3.7E-01	**	**	2.3E+02
Rh-105	1.4E+00	3.0E+00	**	2.2E+00	3.5E+02
Ru-106	8.7E+00	6.9E+01	**	**	4.5E+03
Ag-110m	5.6E-01	1.0E-00	**	9.5E-01	3.8E+02
Sb-124	3.6E+00	9.0E+00	2.2E-02	1.7E-01	2.6E+02
Sb-125	1.4E+00	5.8E+00	5.8E-03	6.5E-02	6.5E+01
Sb-126	1.4E+00	3.9E+00	2.3E-02	7.4E-02	3.0E+02
Sb-127	3.2E-01	8.4E-01	1.0E-02	1.8E-02	1.9E+02
Te-127	2.3E+01	1.1E+02	7.9E+01	3.8E+01	8.3E+03
Te-129m	1.7E+03	1.2E+04	3.8E+03	4.1E+03	5.6E+04
Te-129	7.4E+00	3.0E+01	2.3E+01	1.2E+01	2.3E+01
Te-131m	6.8E+02	1.6E+03	1.3E+03	8.2E+02	8.1E+04
Te-131	5.9E+00	1.9E+01	1.5E+01	7.9E+00	2.7E+00
Te-132	1.4E+03	2.4E+03	1.7E+03	1.5E+03	7.4E-04
I-131	1.3E+02	1.5E+02	7.4E+04	2.2E+02	5.9E+01
I-132	7.0E+00	7.4E+00	7.0E+02	2.0E+01	3.7E+00
I-133	2.8E+01	5.1E+01	1.3E+04	9.2E+01	8.1E+01
I-134	3.7E+00	4.0E+00	1.8E+02	1.1E+01	9.2E-03
I-135	1.6E+01	1.6E+01	2.8E+03	4.4E+01	4.8E+01
Cs-134	5.8E+05	3.0E+05	**	7.2E+05	1.3E+04
Cs-136	9.1E+04	3.1E+04	**	1.3E+05	1.4E+04
Cs-137	3.4E+05	3.8E+05	**	5.3E+05	1.0E+04
Cs-138	2.6E+02	2.6E+02	**	5.3E+02	2.3E-03

Table 2-2

INGESTION DOSE FACTORS ($A_{i\tau}$) FOR TOTAL BODY AND CRITICAL ORGAN
(in mrem/hr per μCi/ml)

Liquid Effluent

Nuclide	Total Body	Bone	Thyroid	Liver	GI Tract
Ba-139	2.9E-02	1.0E-00	**	7.2E-04	1.8E+00
Ba-140	1.4E+01	2.1E+02	**	2.7E-01	4.4E+02
La-140	2.0E-02	1.5E-01	**	7.9E-02	5.6E+03
La-141	9.7E-04	1.9E-02	**	6.0E-03	7.3E+02
La-142	9.1E-04	7.9E-03	**	3.5E-03	2.6E+01
Ce-141	2.3E-03	3.0E-02	**	2.0E-02	7.7E+01
Ce-143	4.5E-04	5.5E-03	**	3.9E+00	1.5E+02
Ce-144	8.4E-02	1.6E+00	**	6.5E-01	5.5E+02
Pr-143	2.8E-02	5.6E-01	**	2.3E-01	2.4E+03
Nd-147	2.7E-02	3.8E-01	**	4.4E-01	2.1E+03
Hf-179m	4.2E+01	**	**	**	3.6E+02
Hf-181	3.8E+01	**	**	**	3.6E+02
W-185	4.0E+01	1.2E+03	**	4.0E+02	4.6E+04
W-187	8.6E+01	2.9E+02	**	2.5E+02	8.1E+04
Np-239	1.6E-03	3.0E-02	**	3.0E-03	6.0E+02

**No Ingestion Dose Factor (DF_i) is listed in NUREG/CR-4013. (Total body dose factor value will be used as an approximation.)

TABLE 2-3

INPUT PARAMETERS USED TO CALCULATE MAXIMUM INDIVIDUAL DOSE FROM LIQUID EFFLUENTS

Drinking Water

River Dilution:	50,000	
River Transit Time:	4 hours	
Usage Factors:	Adult = 730 1/yr	Teenager = 510 1/yr
	Child = 510 1/yr	Infant = 330 1/yr

Boating and Aquatic Food

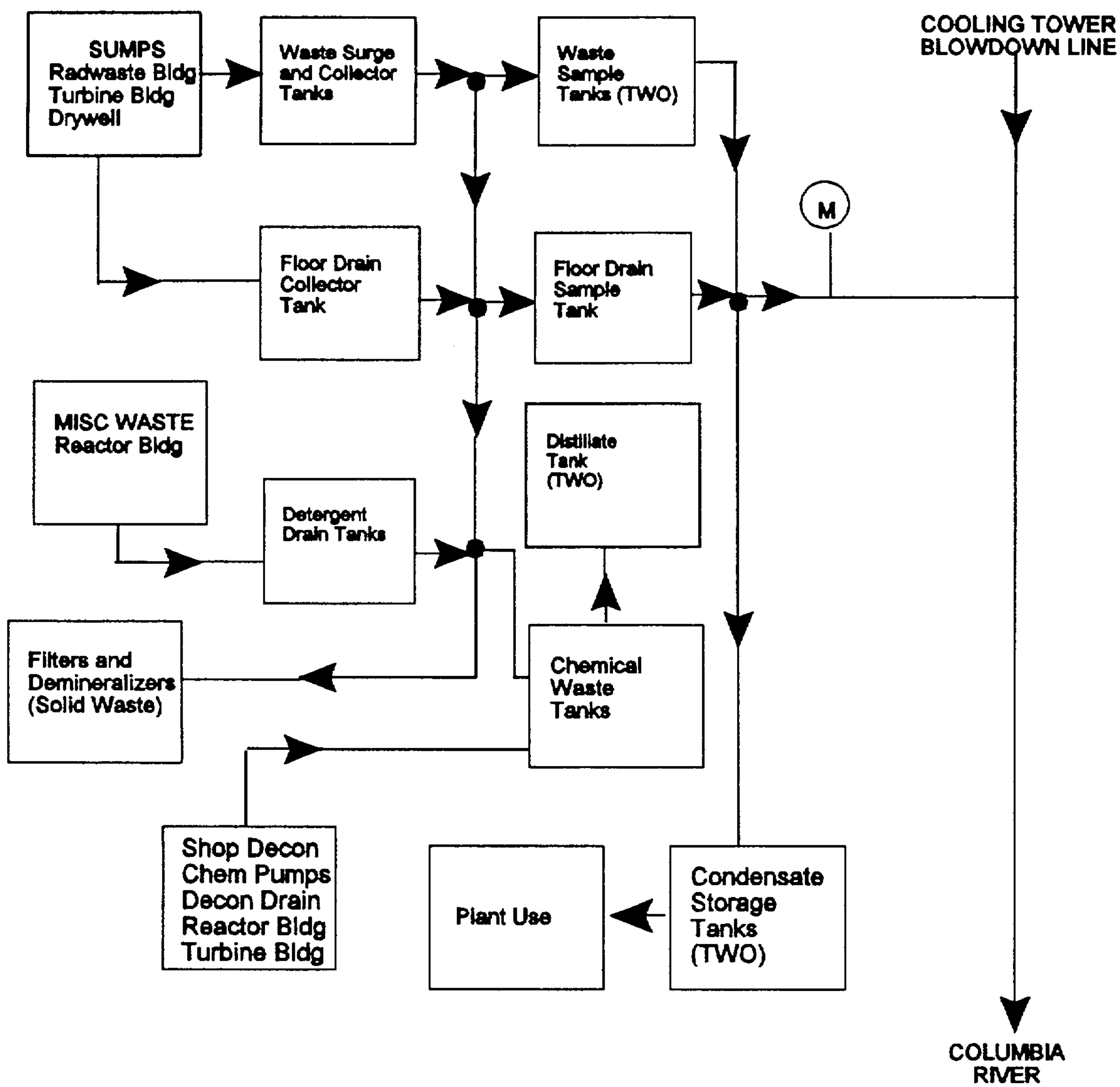
River Dilution:	500	
Transit Time:	2 hours	
Usage Factors: (Aquatic Food)	Adult = 21 kg/yr	Teenager = 16 kg/yr
	Child = 6.9 kg/yr	Infant = 0
(Boating)	Adult = 100 hr/yr	Teenager = 100 hr/yr
	Child = 85 hr/yr	Infant = 0

Recreation

River Dilution:	20,000	
Shoreline Width Factor:	0.2	
Usage Factors:	Shoreline Activities:	Adult = 90 hr/yr
		Teenager = 500 hr/yr
		Child = 105 hr/yr
		Infant = 0
	Swimming:	Adult = 18 hr/yr
		Teenager = 100 hr/yr
		Child = 21 hr/yr

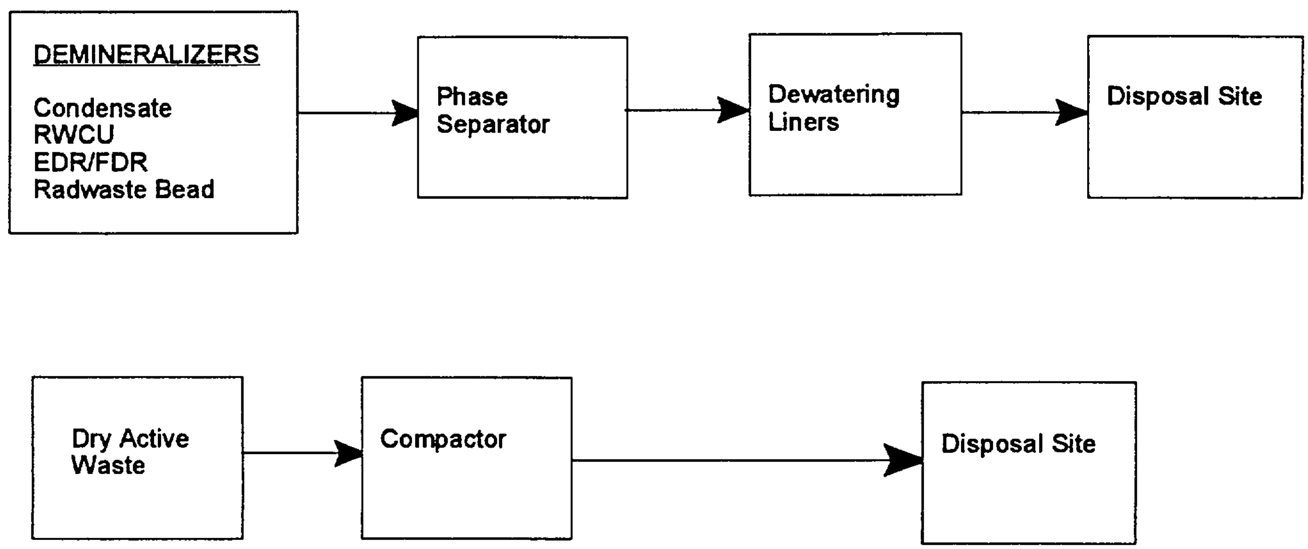
Irrigated Foodstuffs

River Dilution:	50,000			
River Transit Time:	4 hours			
	Vegetables	Milk	Meat	Leafy Vegetables
Food Delivery Time:	14 days	48 hours	20 days	24 hours
Usage Factors:				
Adult	520 kg/yr	310 1/yr	110 kg/yr	64 kg/yr
Teenager	630 kg/yr	400 1/yr	65 kg/yr	42 kg/yr
Child	520 kg/yr	330 1/yr	41 kg/yr	26 kg/yr
Monthly Irrigation Rate:	180 $1/m^2$	200 $1/m^2$	160 $1/m^2$	200 $1/m^2$
Annual Yield:	5.0 kg/m^2	1.3 $1/m^2$	2.0 kg/m^2	1.5 kg/m^2
Annual Growing Period:	70 days	30 days	130 days	70 days
Annual 50-Mile Production:	3.5E+09 kg	2.8E+08 L	2.3E+07 kg	1.9E+06 kg



SIMPLIFIED BLOCK DIAGRAM OF
LIQUID WASTE SYSTEM

Figure 2-1



SIMPLIFIED BLOCK DIAGRAM OF
SOLID RADWASTE SYSTEM

Figure 2-2

3.0 GASEOUS EFFLUENTS DOSE CALCULATIONS

The U.S. Nuclear Regulatory Commission's computer program GASPAR II can be used to perform environmental dose analyses for releases of radioactive effluents from Columbia Generating Station into the atmosphere. The analyses estimate radiation dose to individuals and population groups from inhalation, ingestion (terrestrial foods), and external exposure (ground and plume) pathways. The calculated doses provide information for determining compliance with Appendix I of 10 CFR Part 50. This computer code has the subroutine "PARTS" which can be used for calculating dose factors.

The NRC computer program GASPAR II supplements the ODCM in monthly, quarterly and annual dose equivalent determinations from gaseous effluents. The method which is normally employed to calculate the annual dose to the maximally exposed organ sums the dose to the maximally exposed organ for each quarter. As a result, the maximum annual organ dose may not represent the maximum dose to any one particular organ for that particular year. Actual specific organ doses will be less than or equal to this calculated value.

Both the ODCM equations and the NRC GASPAR II computer program for estimating the highest dose to any organ for a particular age group provides conservatism in calculating maximum organ doses. This conservatism is recognized and is intentional.

3.1 Introduction

Gaseous effluents are released on a continuous basis; in addition, batch releases also occur when containment and mechanical vacuum pump purges are performed and when the off-gas treatment system operates in the charcoal bypass mode. The gaseous effluents released will meet Requirement for Operability at the site boundary.

Figure 3-1 delineates the Site boundary, which for dose calculation purposes, is considered circular with a radius of 1.2 miles. There are several low occupancy unrestricted locations within the site boundary. These locations, with the exception of the visitor center, are not continuously controlled by Energy Northwest. The locations are:

1. Wye burial site - normally controlled by DOE.

2. DOE train - two railroad lines pass through the site (approximately 3 miles of line). According to DOE, the train makes one round trip a day, through the site at an average speed of 20 mph, 5 days a week, 52 weeks/year.

3. BPA Ashe Substation - occupied 2080 hours/year. These people are not normally controlled by Energy Northwest but are involved in activities directly in support of Columbia Generating Station.

4. Energy Northwest Visitor Center - assumed occupied 8 hrs/yr by non-Energy Northwest individuals.

5. WNP-1 - occupied 2080 hrs/yr. This location is controlled by Energy Northwest. However, activities are not in direct support of Columbia Generating Station.

6. WNP-4 - occupied 2080 hrs/yr. This location is controlled by Energy Northwest. However, activities are not in direct support of Columbia Generating Station.

All other locations listed in Figure 3-1 support Columbia Generating Station activities and are controlled by Energy Northwest. Figure 3-2 provides a simplified block diagram of the gaseous radwaste system for the reactor, turbine and radwaste buildings. Figure 3-3 provides a simplified block diagram for the off-gas treatment system.

Air doses and doses to individuals at these locations were calculated based on the NRC GALE code design base mixture, location specific estimated occupancy, and X/Qs from XOQDOQ. (Note: Desert Sigmas were used in calculating X/Q and D/Q values, and are listed in Table 3-10 and 3-11). These doses are listed in Tables 3-16 and 3-17 along with the doses to the maximum exposed individual.

The most likely exposed member of the public is considered to be residing in Taylor Flats (4.2 miles ESE of Columbia Generating Station). This is the closest residential area with the highest X/Q and D/Q values.

The Auxiliary Boiler supplies heating steam to the Reactor, Radwaste, Turbine and Service buildings when Seal Steam Evaporator B is not in operation. The Auxiliary Boiler and associated heating steam system vents to the atmosphere and provides a possible unmonitored source of radioactive effluent when in operation. Samples have shown 2.0 E+06 picocuries per liter of tritium activity to be present within the Auxiliary Boiler system. Using NRC Regulatory Guide 1.109 methodology with FSAR Low Population Zone (LPZ) X/Q values and assuming one gallon per minute (1 gpm) makeup flowrate for 180 days plus a one time complete boil-off of the total water inventory, the dose contribution from tritium would be less than one tenth of a millirem per year (<0.1 mrem/yr). Figure 3-4 provides a simplified diagram for the Auxiliary Boiler.

Tritium in the form of tritiated water vapor is released to the environment through monitored/sampled effluent pathways. Under certain meteorological conditions, the tritiated water vapor may condense onto surfaces such as rooftops and parking lots. Subsequently, this condensed, recaptured tritiated water may be carried with precipitation into the Storm Drain Pond (SDP) which serves as a collection point for storm drainage. In addition, tritiated water vapor released onto site buildings may condense on cold metal exterior walls and run onto adjacent rooftops, to be carried with precipitation to the SDP. Influent to the SDP is continuously sampled and periodically analyzed for tritium content.

3.2 Gaseous Effluent Radiation Monitoring System

3.2.1 Main Plant Release Point

The Main Plant Release is instrument monitored for gaseous radioactivity prior to discharge to the environment via the main plant vent release point. Particulates and iodine activity are accumulated in filters which will be changed and analyzed as per Periodic Test and Inspection 6.2.2.1.2 and Table 6.2.2.1.2-1. The effluent is supplied from: the gland seal exhauster, mechanical vacuum pumps, treated off gas, standby gas treatment, and exhaust air from the entire reactor building's ventilation.

Two 100-percent capacity vanaxial fans supply 80,000 CFM ventilation air. One is normally operating, the other is in standby. The radiation monitors are located on the ventilation exhaust plenum.

Effluent monitoring consists of a gamma spectroscopy system which provides an isotopic analysis of the Elevated Release effluents. The low range (PRM-RE-1A) is a high efficiency, cryogenically cooled, high purity germanium detector located inside the duct at elevation 611' to monitor low level normal operation radioactivity. Low range response is approximately 8.0×10^8 cps/ μCi/cc. PRM-RE-1A has a gross gamma Log Count Rate Meter range of 10 to 10^6 cps, located on Radwaste Building elevation 525' in PRM-CP-1, and is recorded on PRM-RR-3 on BD-RAD-24 in the Main Control Room. Power is from battery-backed, reliable 120 VAC buses. This monitor has no control function but annunciates in the Main Control Room. The alarm will initiate proper action as defined in plant procedures.

3.2.2 Radwaste Building Ventilation Exhaust Monitor

The radwaste building ventilation exhaust monitoring system monitors the radioactivity in the exhaust air prior to discharge. Radioactivity can originate from: radwaste tank vents, laboratory hoods, and various cubicles housing liquid process treatment equipment and systems.

The radwaste building exhaust system has three 50-percent capacity exhaust filter units of 42,000 cfm capacity. Each exhaust unit has a medium-efficiency prefilter, a high efficiency particulate air filter (HEPA) and two centrifugal fans. Total exhaust flow will vary as the combined exhaust unit maintains a radwaste building differential pressure of -0.25 inches H_20 to the environment.

Particulate and iodine air sample filters are changed weekly for laboratory analysis. After the particulate and iodine filters, the air sample streams are combined in a manifold prior to being monitored by a beta scintillator.

The beta scintillators, on the 487' level are mounted in lead shielded chambers. The low range beta scintillator has an approximate response of 80 cpm/pCi/cc to Kr-85, and 50 cpm/pCi/cc to Xe-133 and a meter range of 10 - 10^7 cpm. The intermediate range has a response from 10^{-2} - 10^3 μCi/cc Xe-133 equivalent, and reads in panel meter units (PMU) with a meter range of 10^0 - 10^5 PMU. The readouts and recorder are located in the main control room panel BD-RAD-24. Power is provided from 125 VDC divisional buses. This monitor has no control functions but annunciates in the main control room. The alarm will initiate proper action as defined in plant procedures.

3.2.3 Turbine Building Ventilation Exhaust Monitor

This monitoring system detects fission and the activation products from the turbine building air which may be present due to leaks from the turbine and other primary components in the building.

The turbine building main exhaust system consists of four roof-mounted centrifugal fans which draw air from a central exhaust plenum. Three fans operate, with one in standby to provide a flow of 360,000 cfm during summer months, and two fans operate with two in standby to provide a flow of 240,000 cfm during winter months.

A representative sample is extracted from the exhaust vent and passed through a particulate and charcoal filter. The air sample then passes to a beta scintillator.

The beta scintillators are mounted in lead shielded chambers. The low range beta scintillator has an approximate response of 80 cpm/pCi/cc to Kr-85, and 50 cpm/pCi/cc to Xe-133 and a meter range of 10 - 10^7 cpm. The intermediate range has a response from 10^{-2} - 10^3 μCi/cc Xe-133 equivalent, and reads in panel meter units (PMU) with a meter range of 10^0 - 10^5 PMU. The monitors are on the 525' level of the radwaste building and the readouts and the recorder are located in the main control room panel BD-RAD-24. Power is provided from the 125 VDC divisional buses. This monitor has no control functions but annunciates in the main control room. The alarm will initiate proper action as defined in plant procedures.

3.3 10 CFR 20 Release Rate Limits

Limits for release of gaseous effluents from the site to areas at and beyond the site boundary are stated in Requirement for Operability 6.2.2.1. The dose rate at these areas due to radioactive materials released in gaseous effluents from the site shall be limited to the following values:

(a) "The dose rate limit for noble gases shall be ≤500 mrem/yr to the total body and ≤3000 mrem/yr to the skin."

(b) "The dose rate limit for all radioiodines and for all radioactive materials in particulate form and radionuclides other than noble gases with half-lives greater than eight days shall be ≤1500 mrem/yr to any organ."

3.3.1 Noble Gases

In order to comply with Requirement for Operability 6.2.2.1, the following equations must hold:

Whole body:

$$\sum_i Ki \left[(\overline{X/Q})_m \; \dot{Q}_{im} + (\overline{X/Q})_g \; \dot{Q}_{ig} \right] \leq 500 \text{ mrem/yr} \qquad (1)$$

Skin:

$$\sum_i \left[(L_i + 1.1M_i) \left((\overline{X/Q})_m \; \dot{Q}_{im} + (\overline{X/Q})_g \; \dot{Q}_{ig} \right) \right] \leq 3000 \text{ mrem/yr} \qquad (2)$$

3.3.2 Radioiodines and Particulates

Part "b" of Requirement for Operability 6.2.2.1 requires that the release rate limit for all radioiodines and radioactive materials in particulate form and radionuclides other than noble gases must meet the following relationship:

Any organ:

$$\sum_i P_i \left[W_M \; \dot{Q}_{im} + W_g \; \dot{Q}_{ig} \right] \leq 1500 \text{ mrem/yr} \qquad (3)$$

The terms used in Equations (1) through (3) are defined as follows:

K_i = The total body dose factor due to gamma emissions for each identified noble gas radionuclide i (mrem/yr per $\mu Ci/m^3$).

L_i = The skin dose factor due to beta emissions for each identified noble gas radionuclide i (mrem/yr per $\mu Ci/m^3$).

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

P_i = The dose parameter for all radionuclides other than noble gases for the inhalation pathway, (mrem/yr per μCi/m^3) and for food and ground plane pathways, m^2(mrem/yr per μCi/sec). The dose factors are based on the critical individual organ and the most restrictive age group.

$\dot{Q}_{im}$ = The release rate of radionuclide i in gaseous effluent from mixed mode release. The main plant release point is a partially elevated mixed mode release (μCi/sec).

$\dot{Q}_{ig}$ = The release rate of radionuclide i in gaseous effluent from all ground level releases (μCi/sec).

$(\overline{X/Q})_m$ = (sec/m^3). For partially elevated mixed mode releases from the main plant vent release point. The highest calculated partially elevated annual average relative concentration for any area at and beyond the site boundary.

$(\overline{X/Q})_g$ = (sec/m^3). For all Turbine Building and Radwaste releases. The highest calculated ground level annual average relative concentration for any area at and beyond the site boundary.

W_g = The highest calculated annual average dispersion parameter for estimating the dose to an individual at the controlling location due to all ground level releases.

> W_g = (sec/m^3). For the inhalation pathway. The location is at and beyond the site boundary in the sector of maximum concentration.
>
> W_g = m^{-2}. For ground plane pathways. The location is at and beyond the site boundary in the sector of maximum concentration.

W_M = The highest calculated annual average dispersion parameter for estimating the dose to an individual at the controlling location due to partially elevated releases:

> W_M = sec/m^3. For inhalation pathway. The location is at and beyond the site boundary in the sector of maximum concentration.
>
> W_M = m^{-2}. For ground plane pathways. The location is at and beyond the site boundary in the sector of maximum concentration.

The factors, L_i and M_i, relate the radionuclide airborne concentrations to various dose rates assuming a semi-infinite cloud. These factors are listed in Table B-1 of Regulatory Guide 1.109, Revision 1, and in Table 3-1 of this manual.

The values used in the equations for the implementation of Requirement for Operability 6.2.2.1 are based upon the maximum long-term annual average X/Q at and beyond the site boundary. Table 3-2 provides typical locations based on the current Land Use Census with pathways for use in dose determinations. Table 3-3 provides these typical locations with long term X/Q and D/Q values which may be used if current annual averages are not available.

The X/Q and D/Q values listed in Tables 3-10 and 3-11 reflecting correctly acquired meteorological data, January 1, 1984 - January 1, 1990 may be utilized in GASPAR II Computer runs.

3.3.2.1 Dose Parameter for Radionuclide i (P_i)

The dose parameters used in Equation (3) are based on:

1. Inhalation and ground plane. (Note: Food pathway is not applicable since no food is grown at or near the restricted area boundary.)
2. The annual average continuous release meteorology at the site boundary.
3. The critical organ for each radionuclide (thyroid for radioiodine).
4. The most restrictive age group.

Calculation of P_i^I (Inhalation): The following equation will be used to calculate P_i^I (Inhalation).

$$P_i^I \text{ (Inhalation)} = K^A(BR)\ DFA_i \text{ (mrem/yr per } \mu\text{Ci/m}^3) \quad (5)$$

where:

K^A = A constant of conversion, 10^6 pCi/μCi.

BR = The breathing rate of the child age group, 3700 m^3/yr.

DFA_i = The critical organ inhalation dose factor for the child age group for the ith radionuclide in mrem/pCi. The total body is considered as an organ in the selection of DFA_i.

The inhalation dose factor for DFA_i for the child age group is listed in Table E-9 of Regulatory Guide 1.109, Revision 1, and Table 3-4 of this manual. Resolving the units yields:

$$P_i^I = \text{(Inhalation)} = (3.7 \times 10^9)\ (DFA_i)\ (\text{mrem/yr per } \mu\text{Ci/m}^3) \qquad (6)$$

The P_i^I (Inhalation) values for the child age group are tabulated in Table 3-4 of this manual.

3.4 <u>10 CFR 50 Release Rate Limits</u>

The requirements pertaining to 10 CFR 50 release rate limits are specified in Requirement for Operability 6.2.2.2 and 6.2.2.3.

Requirement for Operability 6.2.2.2 deals with the air dose from noble gases and requires that the air dose at and beyond the site boundary due to noble gases released in gaseous effluents shall be limited to the following:

(a) "During any calendar quarter, to ≤5 mrad for gamma radiation and to ≤10 mrad for beta radiation."

(b) "During any calendar year, to ≤10 mrad for gamma radiation and ≤20 mrad for beta radiation."

Requirement for Operability 6.2.2.3 deals with radioiodines, tritium, and radioactive materials in particulate form, and requires that the dose to an individual from radioiodines, tritium and radioactive materials in particulate form with half-lives greater than eight days in gaseous effluents released to unrestricted areas shall be limited to the following:

(a) "During any calendar quarter, to ≤7.5 mrem."

(b) "During any calendar year, to ≤15 mrem."

3.4.1 <u>Noble Gases (Requirement for Operability 6.2.2.2)</u>

The air dose at and beyond the site boundary due to noble gases released in the gaseous effluent will be determined by using the following equations.

a. During any calendar quarter, for gamma radiation:

$$3.17 \times 10^{-8} \sum_i \left[M_i (\overline{X/Q})_g Q_{ig} + (X/q)_g q_{ig} + (\overline{X/Q})_m Q_{im} + (X/q)_m q_{im}\right] \leq 5 \text{ mrad} \qquad (8)$$

During any calendar quarter, for beta radiation:

$$3.17 \times 10^{-8} \sum_i N_i \left[(\overline{X/Q})_g Q_{ig} + (X/q)_g q_{ig} + (\overline{X/Q})_m Q_{im} + (X/q)_m q_{im}\right] \leq 10 \text{ mrad} \qquad (9)$$

b. During any calendar year, for gamma radiation:

$$3.17 \times 10^{-8} \sum_i M_i \left[(\overline{X/Q})_g Q_{ig} + (X/q)_g q_{ig} + (\overline{X/Q})_m Q_{im} + (X/q)_m q_{im}\right] \leq 10 \text{ mrad} \qquad (10)$$

During any calendar year, for beta radiation:

$$3.17 \times 10^{-8} \sum_i N_i \left[(\overline{X/Q})_g Q_{ig} + (X/q)_q q_{ig} + (\overline{X/Q})_m Q_{im} + (X/q)_m q_{im}\right] \leq 20 \text{ mrad} \qquad (11)$$

where:

M_i = The air dose factor due to gamma emissions for each identified noble gas radionuclide, in mrad/yr per $\mu Ci/m^3$ (M_i values are listed in Table 3-1).

N_i = The air dose factor due to beta emissions for each identified noble gas radionuclide, in mrad/yr per $\mu Ci/m^3$ (N_i values are listed in Table 3-1).

$(\overline{X/Q})_g$ = For ground level release points. The highest calculated annual average relative concentration for area at and beyond the site area boundary for long-term releases (greater than 500 hr/yr). (Sec/m^3)

$(X/q)_g$ = For ground level release points. The relative concentration for areas at and beyond the site area boundary for short-term releases (equal to or less than 500 hr/yr). (Sec/m^3)

$(\overline{X/Q})_m$ = For partially elevated release points. The highest calculated annual average relative concentration for areas at and beyond the site boundary for long-term releases (greater than 500 hr/yr). (Sec/m^3)

$(X/q)_m$ = For partially elevated release points. The relative concentration for areas at and beyond the site boundary for short-term releases (equal to or less than 500 hr/yr). (Sec/m^3)

q_{im} = The average release of noble gas radionuclides in gaseous effluents, i, for short-term releases (equal to or less than 500 hr/yr) from the main plant release point, in μCi. Releases shall be cumulative over the calendar quarter or year, as appropriate.

q_{ig} = The average release of noble gas radionuclides in gaseous effluents, i, for short-term releases (equal to or less than 500 hr/yr) from Radwaste and Turbine Building, in μCi. Releases shall be cumulative over the calendar quarter or year, as appropriate.

Q_{im} = The average release of noble gas radionuclides in gaseous releases, i, for long-term releases (greater than 500 hr/yr) from the main plant release point, in μCi. Release shall be cumulative over the calendar quarter or year, as appropriate.

Q_{ig} = The average release of noble gas radionuclides in gaseous effluents, i, for long-term releases (greater than 500 hr/yr) from Radwaste and Turbine Building, in μCi. Releases shall be cumulative over the calendar quarter or year, as appropriate.

3.17×10^{-8} = The inverse of the number of seconds in a year.

3.4.2 Radioiodines, Tritium and Particulates Requirement for Operability 6.2.2.3

The following equation calculates the dose to an individual from radioiodines, tritium, and radioactive material in particulate form with half-lives greater than eight days in gaseous effluents released to the unrestricted areas:

a. During any calendar quarter:

$$3.17 \times 10^{-8} \sum_i R_i \left[W_m Q_{im} + w_m q_{im} + W_g Q_{ig} + w_g q_{ig} \right] \leq 7.5 \text{ mrem} \qquad (12)$$

b. During any calendar year:

$$3.17 \times 10^{-8} \sum_i R_i \left[W_m Q_{im} + w_m q_{im} + W_g Q_{ig} + w_g q_{ig} \right] \leq 15 \text{ mrem} \qquad (13)$$

where:

Q_{im}, Q_{ig} = The releases of radionuclides, radioactive materials in particulate form, and radionuclides other than noble gases in gaseous effluents, i, for long-term releases greater than 500 hr/yr, in μCi. Releases shall be cumulative over the calendar quarter or year, as appropriate (m is for mixed mode releases, g is for ground level releases).

q_{im}, q_{ig} = The releases of radionuclides, radioactive materials in particulate form, and radionuclides other than noble gases in gaseous effluents, i, for short-term releases equal to or less than 500 hr/yr, in μCi. Releases shall be cumulative over the calendar quarter or year as appropriate (m is for mixed mode releases, g is for ground level releases).

W_m,W_g = The dispersion parameter for estimating the dose to an individual at the controlling location for long-term (greater than 500 hr.) releases (m is for mixed mode releases, g is for ground level releases).

W_m = $(\overline{X/Q})_m$ for the inhalation pathway, in sec/m^3.

W_g = $(\overline{D/Q})_g$ for the food and ground plane pathways in meters^{-2}.

w_m,w_g = The dispersion parameter for estimating the dose to an individual at the controlling location for short-term (less than 500 hr.) releases (m is for mixed mode releases, g is for ground level releases).

w_m = $(\overline{X/q})_m$ for the inhalation pathway, in sec/m^3.

w_g = $(\overline{D/q})_g$ for the food and ground plane pathways in meters^{-2}.

3.17×10^{-8} = The inverse of the number of seconds in a year.

R_i = The dose factor for each identified radionuclide, i, in m^2(mrem/yr per μCi/sec) or mrem/yr per μCi/m^3.

3.4.2.1 Dose Parameter for Radionuclide i (R_i)

The R_i values used in Equations (12) and (13) of this section are calculated separately for each of the following potential exposure pathways:

- Inhalation
- Ground plane contamination
- Grass-cow/goat-milk pathway
- Grass-cow-meat pathway
- Vegetation pathway

Monthly dose assessments for gaseous effluent will be done for all age groups.

Calculation of R_i^I (Inhalation Pathway Factor)

$$R_i^I \text{ (Inhalation)} = K' (BR)_a (DFA_i)_a \text{ (mrem/yr per } \mu\text{Ci/m}^3) \qquad (14)$$

where:

R_i^I	=	The inhalation pathway factor (mrem/yr per μCi/m^3).
K'	=	A constant of unit conversion, 10^6 pCi/μCi.
$(BR)_a$	=	The breathing rate of the receptor of age group (a) in meter^3/yr. (Infant = 1400, child = 3,700, teen = 8,000, adult = 8,000. From P.32 NUREG-0133).
$(DFA_i)_a$	=	The maximum organ inhalation dose factor for receptor of age group a for the ith radionuclide (mrem/pCi). The total body is considered as an organ in the selection of $(DFA_i)_a$. $(DFA_i)_a$ values are listed in Tables E-7 through E-10 of Regulatory Guide 1.109 manual, Revision 1 and NUREG/CR-4013. Values of R_i^I are listed in Table 3-5.

Calculation of R_i^G (Ground Plane Pathway Factor)

$$R_i^G \text{ (Ground Plane)} = K^A K^B (SF)(DFG_i)(1 - e^{-\lambda_i t})/\lambda_i \text{ (m}^2 \text{ x mrem/yr per } \mu\text{Ci/sec)} \qquad (15)$$

where:

R_i^G = Ground plane pathway factor (m^2 x mrem/yr per μCi/sec).

K^A = A conversion constant of (10^6 pCi/μCi).

K^B = A conversion constant - (8760 hr/yr).

λ_i = The decay constant for the ith radionuclide (sec^{-1}).

t = Exposure time, 6.31 x 10^8 sec (20 years).

DFG_i = The ground plane dose conversion factor for the ith radionuclide, as listed in Table E-6 of Regulatory Guide 1.109, Revision 1 and NUREG/CR-4013 (mrem/hr per pCi/m^2).

SF = Shielding Factor (dimensionless)--0.7 if building is present, as suggested in Table E-15 of Regulatory Guide 1.109, Revision 1.

The values of R_i^G are listed in Table 3-5 of this manual.

<u>Calculation of R_i^C (Grass-Cow/Goat-Milk Pathway Factor)</u>

R_i^C (Grass-Cow/Goat-Milk Factor) =

$$K' \frac{Q_F(U_{ap})}{\lambda_i + \lambda_w} F_m(r)(DFL_i)_a \left[\frac{f_p f_s}{Y_p} + \frac{(1-f_p f_s)e^{-\lambda_i t_h}}{Y_s}\right] e^{-\lambda_i t_f} \quad (16)$$

(m^2 x mrem/yr per μCi/sec)

where:

K' = A constant of unit conversion, 10^6 pCi/μCi.

Q_F = The cow/goat consumption rate, in kg/day (wet weight).

U_{ap} = The receptor's milk consumption rate for age a, in liters/yr.

Y_p = The agricultural productivity by unit area of pasture feed grass, in kg/m^2.

Y_s = The agricultural productivity by unit area of stored feed, in kg/m^2.

F_m = The stable element transfer coefficients, in days/liter.

r = Fraction of deposited activity retained on feed grass.

$(DFL_i)_a$ = The maximum organ ingestion dose factor for the ith radionuclide for the receptor in age group a, in mrem/pCi (Tables E-11 to E-14 of Regulatory Guide 1.109, Revision 1 and NUREG/CR-4013).

λ_i = The decay constant for the ith radionuclide, in sec^{-1}.

λ_w = The decay constant for removal of activity on leaf and plant surfaces by weathering, 5.73 x 10^{-7} sec^{-1} (corresponding to a 14-day half-life).

t_f = The transport time from pasture to animal, to milk, to receptor, in sec.

t_h = The transport time from pasture, to harvest, to animal, to milk, to receptor, in sec.

f_p = Fraction of the year that the cow/goat is on pasture (dimensionless).

f_s = Fraction of the cow/goat feed that is pasture grass while the cow is on pasture (dimensionless).

NOTE: For radioiodines, multiply R_i^C value by 0.5 to account for the fraction of elemental iodine available for deposition.

The input parameters used for calculating R_i^C are listed in Table 3-6. The individual pathway dose parameters for R_i^C are tabulated in Tables 3-5a through 3-5d.

For Tritium:

In calculating R_T^C pertaining to tritium in milk, the airborne concentration rather than the deposition will be used:

R_T^C(Grass-Cow/Goat-Milk Factor) =

$$K^A K^C F_m Q_F U_{ap} (DFL_i)_a [0.75(0.5/H)] \text{ (mrem/yr per } \mu\text{Ci/m}^3) \quad (17)$$

where:

K^A	=	A constant unit conversion, 10^6 pCi/μCi.
K^C	=	A constant of unit conversion, 10^3 gm/kg.
H	=	Absolute humidity of the atmosphere, in gm/m^3.
0.75	=	The fraction of total feed that is water.
0.5	=	The ratio of the specific activity of the feed grass water to the atmospheric water.

<u>Calculation of R_i^M (Grass-Cow-Meat Pathway Factor)</u>

R_i^M (Grass-Cow-Meat Factor) =

$$K' \frac{Q_F(U_{ap})}{\lambda_i + \lambda_w} F_f(r)(DFL_i)_a \left[\frac{f_p f_s}{Y_p} + \frac{(1-f_p f_s)e^{-\lambda_i t_h}}{Y_s}\right] e^{-\lambda_i t_f} \qquad (18)$$

(m^2 x mrem/yr per μCi/sec)

where:

K'	=	A constant unit conversion, 10^6pCi/μCi.
F_f	=	The stable element transfer coefficients, in days/kg.
U_{ap}	=	The receptor's meat consumption rate for age a, in kg/yr.
t_f	=	The transport time from pasture to receptor, in sec.
t_h	=	The transport time from crop field to receptor, in sec.

All other parameters are as defined in Equation 16.

<u>NOTE</u>: For radioiodines, multiply R_i^M value by 0.5 to account for the fraction of elemental iodine available for deposition.

The input parameters used for calculation R_i^M (18) are listed in Table 3-7. The individual pathway dose parameters for R_i^M are tabulated in Tables 3-5a through 3-5d.

For Tritium:

In calculating the R^M_T for tritium in meat, the airborne concentration is used rather than the deposition rate. The following equation is used to calculate the R^M_T values for tritium:

R^M_T (Grass-Cow-Meat Pathway) =

$$K^A K^C \left[F_f Q_F U_{ap} \, (DFL_i)_a \right] \left[0.75(0.5/H) \right] \text{ (mrem/yr per } \mu\text{Ci/m}^3\text{)} \qquad (19)$$

Where the terms are as defined in Equations (16) through (18), R^M_i values for tritium pertaining to the infant age group is zero since there is no meat consumption by this age group.

Calculation of R^V_i (Vegetation Pathway Factor)

R^V_i (Vegetation Pathway Factor) =

$$K' \left[\frac{(r)}{Y_v(\lambda_i + \lambda_w)} (DFL_i)_a \right] \left[U^L_a f_L e^{-\lambda_i t_L} + U^S_a f_g e^{-\lambda_i t_h} \right] \qquad (20)$$

(m^2 x mrem/yr per μCi/sec)

where:

K'	=	A constant of unit conversion, 10^6pCi/μCi.
U^L_a	=	The consumption rate of fresh leafy vegetation by the receptor in age group a, in kg/yr.
U^S_a	=	The consumption rate of stored vegetation by the receptor in age group a, in kg/yr.
f_L	=	The fraction of the annual intake of fresh leafy vegetation grown locally.
f_g	=	The fraction of the annual intake of stored vegetation grown locally.

t_L = The average time between harvest of leafy vegetation and its consumption, in seconds.

t_h = The average time between harvest of stored vegetation and its consumption, in seconds.

Y_v = The vegetation area density, in kg/m^2.

NOTE: For radioiodines, multiply R_i^V value by 0.5 to account for the fraction of elemental iodine available for deposition.

All other items are as defined in Equations (16) through (18).

The input parameters for calculation R_i^V are listed in Table 3-8. The individual pathway dose parameters for R_i^V are tabulated in Tables 3-5a through 3-5d.

For Tritium:

In calculating the R_T^V for tritium, the concentration of tritium in vegetation is based on airborne concentration rather than the deposition rate. The following equation is used to calculate R_T^V for tritium:

R_T^V (Vegetation Pathway Factor) =

$$K^A K^C \left[(U_a^L f_L + U_a^s f_g)(DFL_i)_a \right] [0.75(0.5/H)] \text{ (mrem/yr per } \mu\text{Ci/m}^3) \tag{21}$$

Where all terms have been defined above and in Equations (16) through (18), the R_T^V value for tritium is zero for the infant age group due to zero vegetation consumption rate by that age group. The input parameters needed for solving Equations (20) and (21) are listed in Table 3-8.

3.4.3 Annual Doses At Special Locations

The Radioactive Effluent Release Report submitted within 60 days after January 1 of each year shall include an assessment of the radiation doses from radioactive gaseous effluents to "Members of the Public," due to their activities inside the site boundary during the report period.

Annual doses within the site boundary have been determined for several locations using the NRC GASPARII computer code and source term data from Table 11.3-7 of the FSAR. These values are listed in Tables 3-16 and 3-17. Of the locations listed within the site boundary, only two, the DOE Train and Visitor Center are considered as being occupied by a "Member of the Public." Annual doses to the maximum exposed "Member of the Public" shall be determined for an individual at the Visitor Center based on occupancy of 8 hours per year due to it being the higher of the two locations.

3.5 Compliance with Requirement for Operability 6.2.2.4

Requirement for Operability 6.2.2.4 states:

"The GASEOUS RADWASTE TREATMENT SYSTEM shall be in operation in either the normal or charcoal bypass mode. The charcoal bypass mode shall not be used unless the offgas post-treatment radiation monitor is OPERABLE as specified in Table 6.1.2.1-1."

"RELEVANT CONDITIONS: Whenever the main condenser steam jet air ejector (evacuation) system is in operation."

Prior to placing the gaseous radwaste treatment system in the charcoal bypass mode, the alarm setpoints on the main plant vent release monitor shall be set to account for the increased percentages of short-lived noble gases. Noble gas percentages shall be based either on actual measured values or on primary coolant design base noble gas concentration percentages adjusted for 30-minute decay. Table 3-15 lists the percentage values for 30-minute decay.

3.5.1 Projection of Doses

The projected doses due to gaseous effluent releases will be determined at least once per 31 days as stated in Requirement for Operability 6.2.2.5. The projected dose when averaged over 31 days is not to exceed 0.3 mrem to any organ in a 31 day period to areas at and beyond the site boundary. Dose projection values will be determined by using a previous 31 day "GasparII Output" (NRC Computer Code) for the site boundary and/or an area beyond the site boundary. Based on operating data, the projected dose should be adjusted accordingly to compensate for those anticipated changes in operations and/or source term values.

3.6 Calculation of Gaseous Effluent Monitor Alarm Setpoints

3.6.1 Introduction

The following procedure is used to ensure that the dose rate in the unrestricted areas due to noble gases in the gaseous effluent do not exceed 500 mrem/yr to the whole body or 3000 mrem/yr to the skin. The initial setpoints determination was calculated using a conservative radionuclide mix obtained from the GALE code. While the plant is operating and sufficient measurable process fission gases are in the effluent, then the actual radionuclide mix will be used to calculate the alarm setpoint.

3.6.2 Setpoint Determination for all Gaseous Release Paths

The setpoints for gaseous effluent are based on instantaneous noble gas dose rates. Sampling and analysis of radioiodines and radionuclides in particulate form will be performed in accordance with Requirement for Operability to ensure compliance with 10 CFR 20 and 10 CFR 50 Appendix I limits. The three release points will be partitioned such that their sum does not exceed 100 percent of the limit. Originally, the setpoints will be set at 40 percent for the Reactor Building, 40 percent for the Turbine Building and 20 percent for the Radwaste Building. These percentages could vary at the plant discretion, should the operational conditions warrant such change. However, the combined releases due to variations in the setpoints will not result in doses which exceed the limit stated in Requirement for Operability. Both skin dose and whole body setpoints will be calculated and the lower limit will be used.

3.6.2.1 Setpoints Calculations Based on Whole Body Dose Limits

The fraction (π_j) of the total gaseous radioactivity in each gaseous effluent release path j for each noble gas radionuclide i will be determined by using the following equation:

$$\pi_{ij} = \frac{M_{ij}}{M_{Tj}} \quad \text{(dimensionless)} \qquad (22)$$

where:

M_{ij} = The measured individual concentration of radionuclide i in the gaseous effluent release path j (μCi/cc).

M_{Tj} = The measured total concentration of all noble gases identified in the gaseous effluent release path j (μCi/cc).

Based on Requirement for Operability 6.2.2.1, the maximum acceptable release rate of all noble gases in the gaseous effluent release path j is calculated by using the following equation:

$$Q_{TJ} = \frac{F_j \; 500}{X/Q_j \sum_{i=1}^{m} (K_i)(\pi_{ij})} \; (\mu\text{Ci/sec}) \qquad (23)$$

where:

Q_{TJ} = The maximum acceptable release rate (μCi/sec) of all noble gases in the gaseous effluent release path j (μCi/cc).

F_j = Fraction of total dose allocated to release path j.

500 = Whole body dose rate limit of 500 mrem/yr as specified in Requirement for Operability 6.2.2.1.a.

X/Q_j = Maximum normalized diffusion coefficient of effluent release path j at and beyond the site boundary (sec/m^3). Turbine Building and Radwaste Building values are based on average annual ground level values. Main plant vent release values are for mixed mode and may be either short term or average annual value dependent upon type of release.

K_i = The total whole body dose factor due to gamma emission from noble gas nuclide i (mrem/yr per μCi/m^3) (as listed in Table B-1 of Regulatory Guide 1.109, Revision 1).

π_{ij} = As defined in Equation (22).

m = Total number of radionuclides in the gaseous effluent.

j = Different release pathways.

The total maximum acceptable concentration (C_{Tj}) of noble gas radionuclides in the gaseous effluent release path j (μCi/cc) will be calculated by using the following equation:

$$C_{Tj} = \frac{Q_{Tj}}{R_j} \; (\mu\text{Ci/cc}) \qquad (24)$$

where:

C_{Tj} = The total allowed concentration of all noble gas radionuclides in the gaseous effluent release path j (μCi/cc).

Q_{Tj} = The maximum acceptable release rate (μCi/sec) of all noble gases in the gaseous effluent release path j.

R_j = The effluent release rate (cc/sec) at the point of release.

To determine the maximum acceptable concentration (C_{ij}) of noble gas radionuclide i in the gaseous effluent for each individual noble gas in the gaseous effluent (μCi/cc), the following equation will be used:

$$C_{ij} = \pi_{ij} C_{Tj} \ (\mu Ci/cc) \qquad (25)$$

where:

π_{ij} and C_{TJ} are as defined in Equations (22) and (24) respectively, the gaseous effluent monitor alarm setpoint will then be calculated as follows:

$$C.R.j. = \sum_{i=1}^{m} C_{ij} E_{ij} (cpm) \qquad (26)$$

where:

C.R.j = Count rate above background (cpm) for gaseous release path j.

C_{ij} = The maximum acceptable concentration of noble gas nuclide i in the gaseous effluent release path j μCi/cc.

E_{ij} = Detection efficiency of the gaseous effluent monitor j for noble gas i (cpm/μCi/cc).

3.6.2.2 Setpoints Calculations Based on Skin Dose Limits

The method for calculating the setpoints to ensure compliance with the skin dose limits specified in Requirement for Operability 6.2.2.1.a is similar to the one described for whole body dose limits (Section 3.6.2.1 of this manual), except Equation (27) will be used instead of Equation (23) for determining maximum acceptable release rate (Q_{Tj}).

$$Q_{TJ} = \frac{F_j \; 3000}{(X/Q_j) \sum_{i=1}^{m} (L_i + 1.1M_i)(\pi_{ij})} \quad (\mu Ci/sec) \tag{27}$$

where:

Q_{TJ} = The maximum acceptable release rate of all noble gases in the gaseous effluent release path j in μCi/sec.

X/Q_j = The maximum annual normalized diffusion coefficient for release path j at and beyond the site boundary (sec/m^3).

F_j = Fraction of total allowed dose.

L_i = The skin dose factor due to beta emission for each identified noble gas radionuclide i in mrem/yr per $\mu Ci/m^3$ (L_i values are listed in Table 3-1).

M_i = The air dose factor due to gamma emissions for each identified noble gas radionuclide, in mrad/yr per $\mu Ci/m^3$ (M_i values are listed in Table 3-1).

1.1 = A conversion factor to convert dose in mrad to dose equivalent in mrem.

3000 = Skin dose rate limit of 3000 mrem/yr as specified in Requirement for Operability 6.2.2.1.