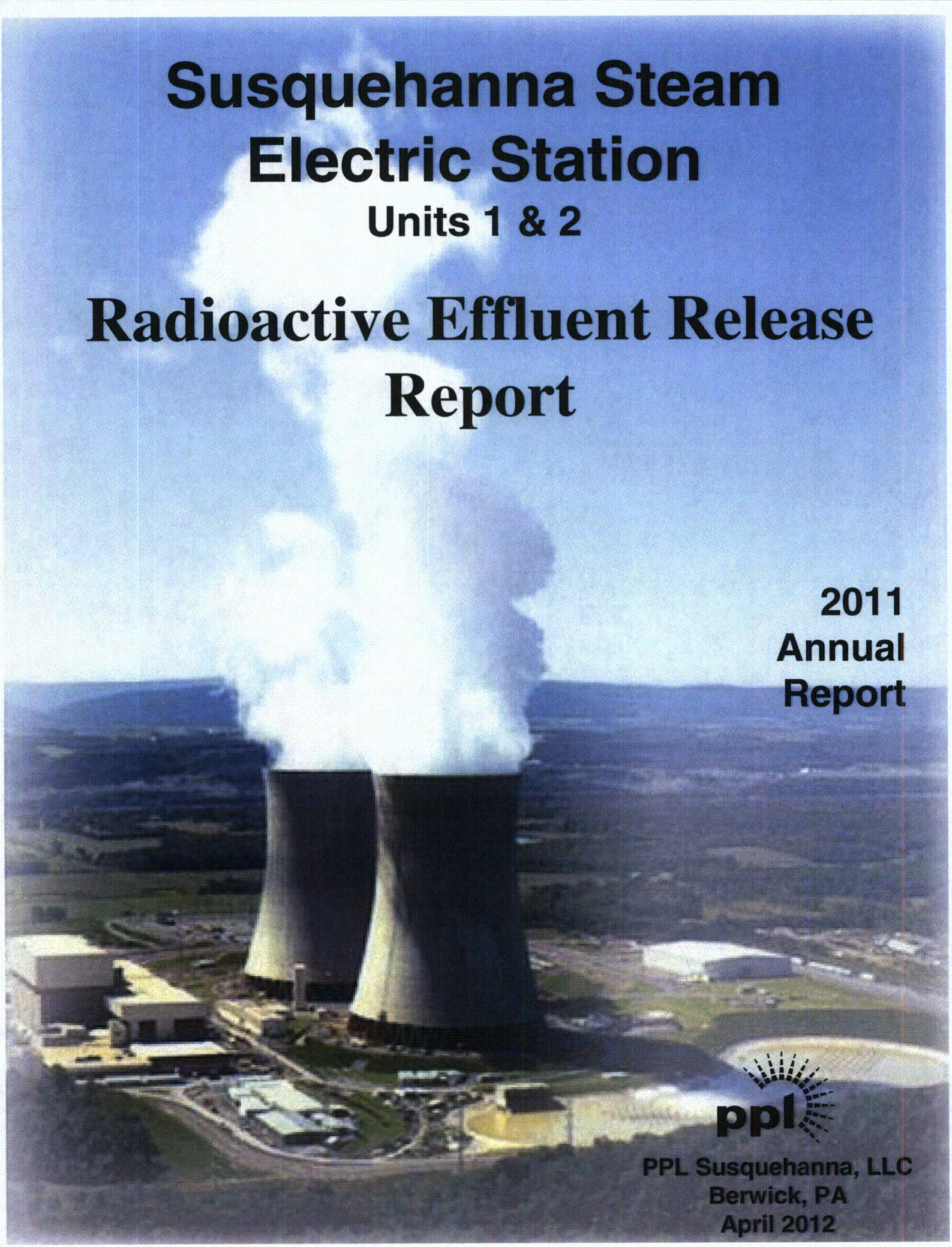
Susquehanna Steam Electric Station

Units 1 & 2

Radioactive Effluent Release Report



2011 Annual Report

PPL Susquehanna, LLC
Berwick, PA
April 2012

Attachment 1 to PLA-6833

Radioactive Effluent Release Report for SSES Units 1 and 2

RADIOACTIVE EFFLUENT RELEASE REPORT

REPORT PERIOD: 01/01/11 - 12/31/11

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INTRODUCTION, SUMMARY AND SUPPLEMENTAL INFORMATION

INTRODUCTION

The submittal of the 2011 Radioactive Effluent Release Report is in accordance with PPL Susquehanna, LLC Tech Spec. 5.6.3. The enclosed information is consistent with the objectives outlined in the Offsite Dose Calculation Manual (ODCM) and Process Control Program (PCP). The 2011 Radioactive Effluent Release Report is in conformance with 10CFR50.36a and 10CFR50, Appendix I, Section IV.B.1.

PPL Susquehanna, LLC is located in Salem Township, Luzerne County, Pennsylvania. It is on the west bank of the Susquehanna River, 8 km northeast of Berwick. The station consists of two boiling water reactor generating units. Each unit has completed an Extended Power Uprate process which has increased licensed thermal power from 3489 MWt (megawatt thermal) to 3952 MWt. Unit-1 completed the power uprate in 2010 and Unit 2 completed the power uprate in 2011. The reactor and generating units were supplied by General Electric, while the Bechtel Corporation served as architect-engineer and constructor.

Construction of the Station began in the early 1970s. Fuel load began in Unit 1 in July of 1982. Initial criticality was achieved in the Unit 1 reactor on September 10, 1982. The reactor reached 100% power for the first time on February 4, 1983. Commercial operation of Unit 1 was declared on June 8, 1983. Initial criticality of Unit 2 occurred on May 8, 1984. Unit 2 was declared commercial on February 12, 1985.

Airborne effluents are released from the Station via five rooftop vents on the reactor building (see Figure 1-1). Continuous sampling for particulates and iodines is performed at each vent as well as continuous monitoring for noble gases. A program of periodic sampling and analysis for tritium and noble gases along with periodic analysis of particulate and iodine samples is conducted as specified in the plant Technical Requirements. All waterborne effluents are released in batch mode and are sampled and analyzed prior to release. Waterborne effluents from the site are released into the cooling tower blowdown line for dilution prior to release to the Susquehanna River (see Figure 1-2). Blowdown line flow rates are at least 5,000 gpm during periods of liquid radwaste release. The diluted effluent is introduced to the river by way of a perforated diffuser pipe placed on the river bed. The diffuser serves to mix the station discharge with the main flow of the river.

This report presents a summary of the quantities of radioactive materials which were released from the Station during the period from January 1, 2011 to December 31, 2011. In addition, this report serves as a medium for notifying the US Nuclear Regulatory Commission staff of changes to the ODCM, PCP and documentation of any exceptions to the effluent monitoring program which must be reported per Technical Requirements.

Airborne and waterborne radioactive effluent releases to the environment during the report period were sampled and analyzed in accordance with the Technical

Requirements. All radioactive effluent releases were within the concentration and release limits specified in the Technical Requirements. Calculations and terms utilized in this report are those outlined in the ODCM.

Section 1 contains supplemental information pertaining to effluents from the Susquehanna plant. Included are regulatory limits (Table 1-1), sampling and analysis methods, characterization of the number and duration of batch and abnormal releases and a brief summary of the applicable year's effluents.

Section 2 contains effluent and waste disposal data for the report period. Table 2-1 contains a summation of all airborne releases, grouped into the radionuclide categories of gases, particulates, iodines, and tritium. Average release rates are presented and compared to the applicable limits. Table 2-2 presents the activity totals of specific radionuclides in airborne effluents.

Waterborne effluents are summarized in Table 2-3. Average diluted concentrations are presented and compared to the applicable limits. Table 2-4 presents the release quantities of specific radionuclides in waterborne effluents over the report period. Figures 2-1 and 2-2 present the Susquehanna River Monthly Average Flow Rates for 2011 and the Monthly Liquid Radwaste Discharge Totals for 2011, respectively.

Table 2-5 contains estimates of the errors associated with the measurements involved in quantifying effluents. Sampling errors, counting errors, and errors associated with determining effluent flow rates and volumes all contribute to the total error of effluent measurements. Error estimates are presented for each category of radionuclide detected in airborne and waterborne effluents and solid wastes during the report period (Error Analysis of the Radioactive Effluent Sampling and Analysis Program at the SSES, Hydro Nuclear Services; 1985).

Tables 2-7 through 2-15 present a characterization of the solid radioactive waste shipped offsite during the report period. An estimate of major nuclide composition is presented for each waste type. Also included are the volumes and curie contents associated with each type of solid waste. The number of waste shipments from the site transported directly for burial or disposal are listed in Table 2-6.

Section 3 presents meteorological data for 2011, including data recovery, joint frequency distribution of wind speed and direction, stability class distribution, and atmospheric dispersion estimates for selected locations.

Section 4 of this report contains an assessment of the calculated doses attributed to the reported radiological effluents for the calendar year. The Radioactive Effluent Tracking and Dose Assessment Software (RETDAS) computer code was used for calculation of doses from waterborne effluents. Site-specific parameters used in the calculations for the Danville receiver are shown in Table 4-1. The RETDAS code was also used for calculation of doses from airborne effluents. The calculated doses and direct radiation estimates can be used to estimate the doses to maximally exposed members of the

public. Table 4-2 summarizes maximum calculated doses to members of the public from airborne and waterborne effluents. Table 4-3 presents calculated collective doses to members of the public within the Riverlands/Energy Information Center Complex. Table 4-4 summarizes the calculated doses for residences and other occupied areas within the site boundary and the nearest dairy. Additionally, Section 4 includes a description of the methodology used in the calculation and resultant dose impact of carbon-14 released from the station.

Section 5 of this report documents changes to the Offsite Dose Calculation Manual, Technical Requirements Manual and the Solid Radioactive Waste Process Control Program.

Section 6 presents a listing of cases (if any) in which airborne or waterborne effluent monitoring instrumentation was declared inoperable and was not restored to operability within the time period specified in Technical Requirements 3.11.1.4, 3.11.1.5 and 3.11.2.6 Action Statements. In addition, this section presents issues (if any) with the collection of milk or fresh leafy vegetables per Technical Requirement 3.11.4.1 and changes due to the land use census per Technical Requirement 3.11.4.2. Section 6 also includes reporting associated with the Nuclear Energy Institute (NEI) Groundwater Protection Initiative.

Section 7 contains corrections (if any) to previous Radioactive Effluent Release Reports.

Section 8 contains information on effluent and offsite dose from the systems classified as insignificant effluent pathways.

SUMMARY

During 2011 there were one hundred forty eight (148) liquid batch releases resulting in a total release volume of one million four hundred eighty eight thousand (1,488,000) gallons. The total number of liquid batch releases and total volume released in 2011 was lower than the corresponding values for 2010 (206 releases resulting in 2,702,000 gallons released in 2010) due to the Unit-1 condenser area flood event (900,000 gallons of water discharged in addition to water released through liquid radwaste treatment system) which occurred in 2010. The predominant radionuclide released in liquid effluents during 2011 was tritium. Approximately fifty-two (52) curies of tritium were released in liquid effluents in 2011, compared to fifty seven (57) curies released in 2010. When compared with all radionuclides released in liquid effluents in 2011, Co-60 and Zn-65 were the main contributors to the resultant offsite dose. Consistent with previous years, the offsite dose from liquid releases in 2011 was less than one percent (1%) of the annual limits for both organ and whole body dose.

In 2010, an industry initiative (supported by EPRI and NEI) was established to evaluate and report Carbon-14 (C-14) in the Annual Radioactive Effluent Release Report. The initiative is rooted in Regulatory Guide 1.21, Revision 2, "Measuring, Evaluating, and Reporting Radioactive Material in Liquid and Gaseous Effluents and Solid Waste", in that the NRC has recommended that U.S. nuclear power plants evaluate whether C-14 is a "principal radionuclide", and if so, report the amount of C-14 released. The C-14 released from the Susquehanna station in 2011 was calculated using conservative guidance provided by the Electric Power Research Institute (EPRI Report No. 1021106). Based on the EPRI methodology, approximately 23 Curies of C-14 were released in gaseous effluents in 2011. See section 4 for additional details on the calculation of C-14 released in airborne effluents. Historically, tritium has been the predominant radionuclide (both in Curies and resultant offsite dose) released in gaseous effluents from the Susquehanna station. Approximately forty-seven (47) curies of tritium were released in gaseous effluents in 2011 compared to thirty-one (31) curies in 2010. The resultant maximum offsite organ dose due to gaseous effluents from Unit-1 for 2011 was 4.56E-1 mrem, which is three (3%) of the per unit annual limit of fifteen (15) mrem. The resultant maximum offsite organ dose due to gaseous effluents from Unit-2 for 2011 was 3.34E-1 mrem, which is two percent (2%) of the per unit annual limit of fifteen (15) mrem. The maximum offsite dose from gaseous effluents was lower in 2011 when compared with 2010 due to the dose from C-14 releases being lower.

FIGURE 1-1

AIRBORNE EFFLUENT RELEASE POINTS

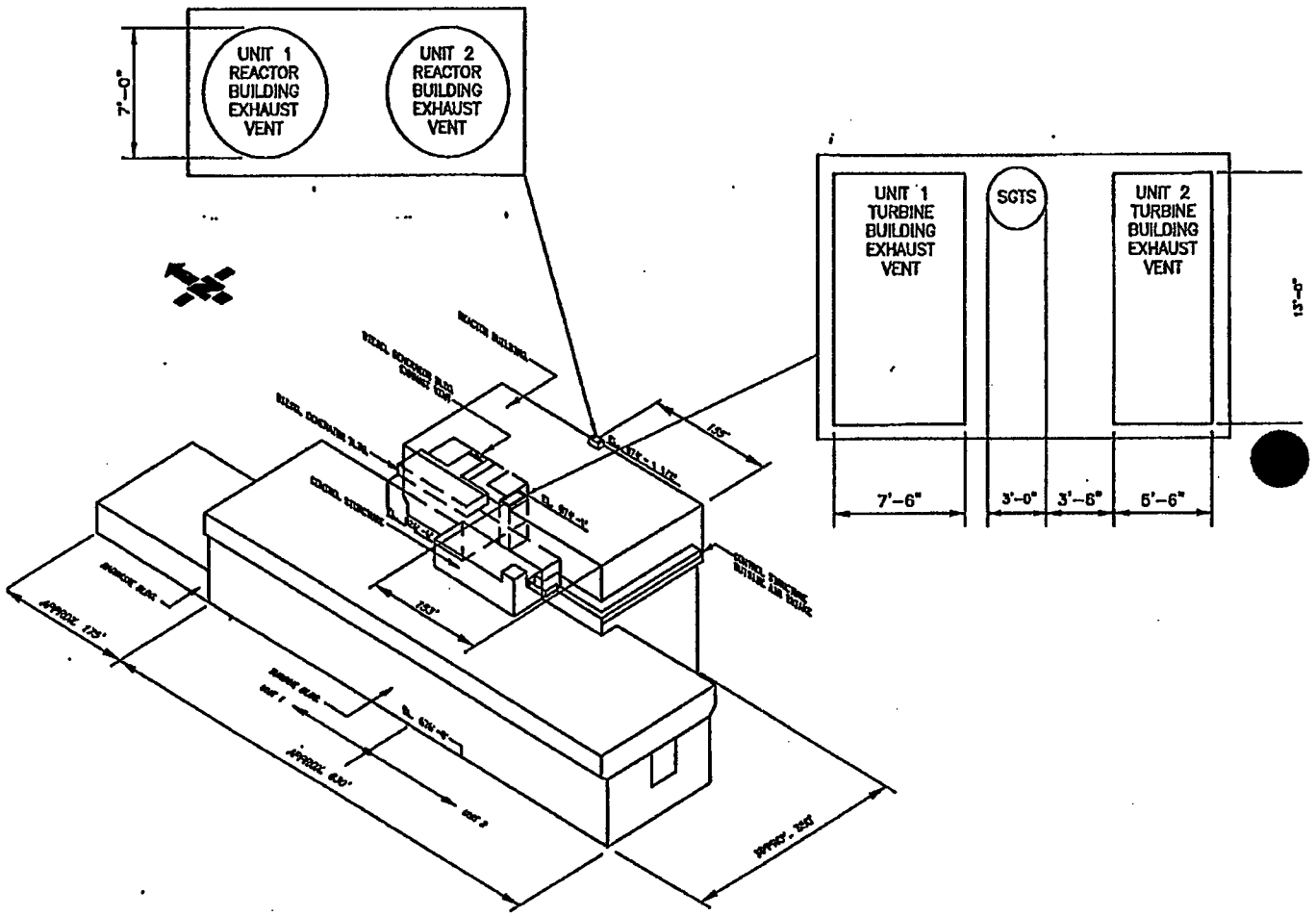
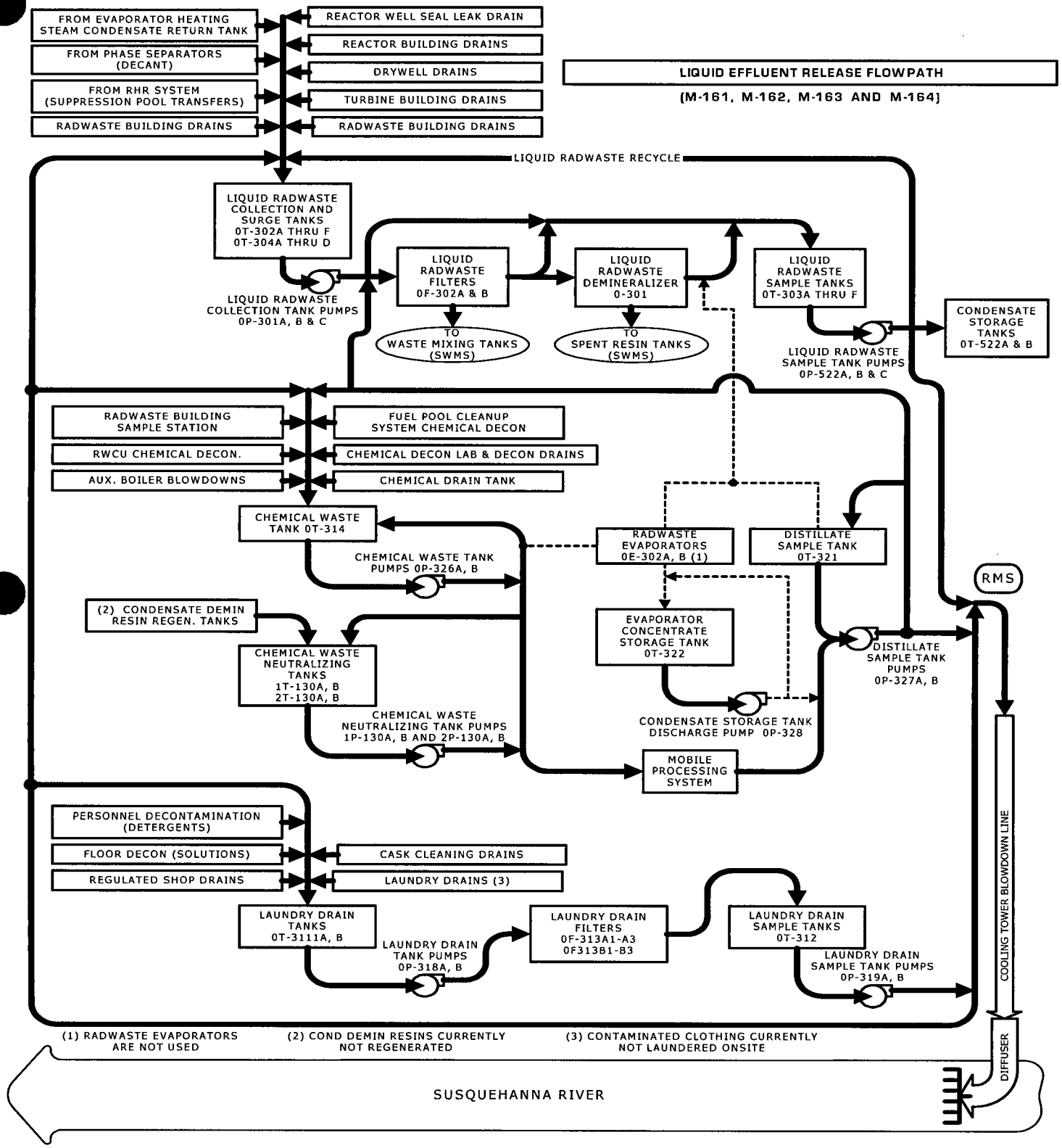


FIGURE 1-2

WATERBORNE EFFLUENT PATHWAY



SUPPLEMENTAL INFORMATION

1. Regulatory Limits

Technical Requirements 3.11.1 and 3.11.2 outline requirements for release of radioactive liquid and gaseous effluents, respectively. Concentration of radioactive materials released in liquid effluents and resulting dose are limited in unrestricted areas. Dose and dose rate due to radioactive materials released in gaseous effluents are limited in areas at or beyond the site boundary. Technical Requirement limits are listed in Table 1-1.

2. Maximum Permissible Concentrations in Waterborne Effluents

The concentration of radioactive material released in liquid effluents to unrestricted areas is limited to 10 times the concentrations specified in 10 CFR Part 20 Appendix B Table 2, Column 2, for radionuclides other than dissolved or entrained noble gases.

For dissolved or entrained noble gases, the concentration is limited to 2.0E-04 µCi/ml total activity (TRO 3.11.1.1).

3. Average Energy of Fission and Activation Gas

The Calculation of Noble Gas Effluent Average Energies E-Bar Beta and Gamma was not performed due to the fact that no noble gases were measured in Station Vent Air Samples above detection limits during 2011.

4. Measurements and Approximations of Total Radioactivity

Analyses of specific radionuclides in effluent samples are used to evaluate the radioactive composition and concentration of effluents.

5. Methods of Quantifying Effluents

a. **Fission and Activation Gases**: Gas samples are routinely collected monthly and analyzed with a high resolution (HPGE) detector system which incorporates a data reduction program to determine radionuclide composition in terms of specific activity. Data from the continuous vent monitors are used to determine the average concentration of noble gases. The high resolution (HPGE) isotopic scan is used to convert the continuous vent monitor activity to actual activity based on the determined nuclide mixture. The vent and sample flow rates are continuously monitored and the average flow rates for each vent are used to calculate the total activity released in a given time period. When the continuous monitors are out of service, manual grab samples are taken from each vent once every eight hours (once every four

hours for the standby gas treatment vent when standby gas treatment system is in service).

b. **Iodines**: Iodine is continuously collected on charcoal or silver zeolite cartridges via an isokinetic sampling assembly in each vent. Filters are normally exchanged once per week and analyzed on a high resolution (HPGE) system. The daily average flow rates for the vents and sample pumps are averaged for the duration of the sampling period and a ratio of vent flow rate to sample flow rate is determined. The ratio is used to determine the total activity of each isotope released during the time period in question. When the continuous samplers are out of service, iodine is continuously collected from alternate sampling ports available on the sample lines or directly from the affected rooftop vent(s).

c. **Particulates**: Particulates are continuously collected via an isokinetic sampling assembly in each vent. Filters are normally exchanged once per week and analyzed on a high resolution (HPGE) system. Flow rate corrections are performed as for iodines. When the continuous samplers are out of service, particulates are continuously collected from alternate sampling ports available on the sample lines or directly from the affected rooftop vent(s).

d. **Tritium**: Airborne tritium is collected monthly via bubbler sampler. The sample is collected for one hour at a flow rate of approximately 1000 cc/min. Tritium activity in the bubbler sample is determined by liquid scintillation counting. The liquid sample tritium concentration is then converted to air concentration by volume proportion.

e. **Waterborne Effluents**: Each tank of liquid radwaste is sampled and analyzed for principal gamma emitters prior to release. Each sample tank is recirculated for a sufficient amount of time prior to sampling to ensure that a representative sample is obtained. Samples are analyzed on a high resolution (HPGE) system and release permits are generated based on the values obtained from the isotopic analysis and the most recent values for tritium, gross alpha, iron-55, and strontium-89 and -90. An aliquot based on release volume is saved and added to monthly and quarterly composite containers. The monthly tritium analysis is done in-house. A monthly composite is sent to a vendor laboratory for gross alpha analysis. A quarterly composite is sent to a vendor laboratory for iron-55, strontium-89 and-90 analyses.

The concentration of each radionuclide in each batch is multiplied by the volume of the batch to determine the total quantity of each nuclide released in each batch. The isotopic totals for each batch are summed to determine the total source term for the report period.

TABLE 1-1

TECHNICAL REQUIREMENT LIMITS

A. NOBLE GASES:

1. ≤500 mrem/year - TOTAL BODY
   ≤3000 mrem/year - SKIN

   - dose rate limit at and beyond the site boundary
     (TRO 3.11.2.1.I)

2. ≤5 mrad - AIR GAMMA
   ≤10 mrad - AIR BETA

   - quarterly air dose limits per reactor unit at and beyond the site boundary
     (TRO 3.11.2.2a)

3. ≤10 mrad - AIR GAMMA
   ≤20 mrad - AIR BETA

   - annual air dose limits per reactor unit at and beyond the site boundary
     (TRO 3.11.2.2.b)

B. AIRBORNE I-131, I-133, TRITIUM, PARTICULATES WITH HALF-LIVES > 8 DAYS:

1. ≤1500 mrem/year - ORGAN
   (inhalation pathways only)

   - dose rate limit at and beyond the site boundary
     (TRO 3.11.2.1.II.A)

2. ≤7.5 mrem - ORGAN

   - quarterly dose limit per reactor unit at and beyond the site boundary
     (TRO 3.11.2.3.a)

3. ≤15 mrem - ORGAN

   - annual dose limit per reactor unit at and beyond the site boundary
     (TRO 3.11.2.3.b)

C. LIQUID EFFLUENTS:

1. ≤1.5 mrem - TOTAL BODY
   ≤5.0 mrem - ORGAN
   - quarterly dose limits per unit (TRO 3.11.1.2.a)

2. ≤3.0 mrem - TOTAL BODY
   ≤10.0 mrem - ORGAN
   - annual dose limits per unit (TRO 3.11.1.2.b)

D. AIRBORNE EFFLUENT: BASES FOR PERCENT OF APPLICABLE LIMIT VALUES IN TABLE 2-1

Fission and Activation Gases

Derived release rate limits based on the Technical Requirement (TRO 3.11.2.1.I.A and B) limits of 500 mrem/yr to the total body and 3000 mrem/yr to the skin were calculated (PPL calculation EC-ENVR-1041 Rev. 2) from the expected mix of noble gas radionuclides presented in Attachment A of ODCM-QA-003, Effluent Monitor Setpoints. The lower limit of 1.00E+06 μCi/min (1.67E+04 μCi/sec) based on total body dose rate is used.

Iodine-131

A derived release rate limit for I-131 based on the Technical Requirement (TRO 3.11.2.1.II.A) limit of 1500 mrem/yr from I-131, I-133, tritium and particulates with half-lives greater than 8 days was calculated (PPL calculation EC-ENVR-1041 Rev. 2) based on the ratio of the expected annual release quantities of I-131 and I-133 provided in Attachment E of ODCM-QA-004, Airborne Effluent Dose Calculations. The limit is 1.04E+02 μCi/min I-131 (1.73E+00 μCi/sec).

Particulates

A derived release rate limit for particulate activity other than iodines based on the Technical Requirement (TRO 3.11.2.1.II.A) limit of 1500 mrem/yr from I-131, I-133, tritium and particulates with half-lives greater than 8 days was calculated (PPL calculation EC-ENVR-1041 Rev. 2) based on the expected annual release quanities of particulate radionuclides provided in Attachment E of ODCM-QA-004, Airborne Effluent Dose Calculations. The limit is 3.02E+03 μCi/min (5.03E+01 μCi/sec).

Tritium

A derived release rate was calculated based on the 10 CFR 20, Appendix B, Table 2, Column 1, Effluent Concentration Limit for tritium (1.0E-07 µCi/cc) to unrestricted areas. A relative concentration of 4.1E-05 sec/m^3 was assumed (PPL calculation EC-ENVR-1040). The limit is 1.46E+05 µCi/min (2.44E+03 µCi/sec).

Radionuclide Fractional Summation

The sum of the percents of applicable limits for particulates, iodine and tritium must be less than 100%.

E. WATERBORNE EFFLUENT: BASES FOR PERCENT OF APPLICABLE LIMIT VALUES IN TABLE 2-3

Fission and Activation Products

Concentrations of fission and activation products in liquid effluent from radwaste effluent are determined for each batch prior to release. Each isotope concentration is compared to ten times the 10CFR20 Appendix B, Table 2, Column 2 Effluent Concentration Values (TRO 3.11.1.1).

Tritium

Liquid effluent quarterly tritium concentrations are compared to ten times the 10 CFR 20 Appendix B, Table 2, Column 2, Effluent Concentration value of 1.0E-03 µCi/ml to unrestricted areas.

Dissolved and Entrained Gases

Liquid effluent concentrations for dissolved and entrained gases are compared to the limiting value for total noble gas activity of 2.0E-04 µCi/ml (TRO 3.11.1.1).

Radionuclide Fractional Summation

The sum of the percents of applicable limits for fission and activation products, tritium and dissolved and entrained gases must be less than 100%.

SECTION 2

EFFLUENT AND WASTE DISPOSAL DATA

Airborne Effluents

Summaries of the radionuclide total curie activities and average release rates are included in Tables 2-1 and 2-2. Carbon-14 (C-14) activity released is not included in Tables 2-1 or 2-2. C-14 released in airborne effluents is calculated based on conservative methodology provided by the Electric Power Research Institute (EPRI Report No. 1021106). See Section 4 for additional details on the calculation of C-14 released in 2011 from the Susquehanna station. If a radionuclide was not detected, zero activity was used for that isotope in dose calculations and the activity is listed as "<MDC" (less than the minimum detectable concentration) in Tables 2-1 and 2-2. <MDC indicates that no activity was positively detected in any sample when samples were analyzed with techniques which achieved the required Lower Limits of Detection (LLD) as specified in the Technical Requirement (TRO) Table 3.11.2.1-1, Radioactive Gaseous Effluent Sampling and Analysis Program. In all cases, the measurement laboratory MDCs were at or below the LLD levels required by Technical Requirements. The following are typical measurement laboratory MDCs.

Typical MDCs

Radionuclide	MDC (µCi/cc)
Kr-87	4.3 E-08
Kr-88	4.6 E-08
Xe-133	3.0 E-08
Xe-133m	1.1 E-07
Xe-135	1.5 E-08
Xe-135m	8.0 E-08
Xe-138	1.5 E-07
Mn-54	2.9 E-13
Fe-59	2.8 E-13
Co-58	1.8 E-13
Co-60	3.8 E-13
Zn-65	1.0 E-13
Mo-99	1.0 E-12
Cs-134	2.4 E-13
Cs-137	1.1 E-13
Ce-141	1.0 E-13
Ce-144	5.0 E-13
I-131	4.4 E-14
Sr-89	1.1 E-13
Sr-90	1.3 E-14
H-3	1.5 E-08
Gross Alpha	2.3 E-14

Batch Releases

1. Number of Batch Releases:	0
2. Total Time Period for Batch Release:	NA
3. Maximum Time Period for a Batch Release:	NA
4. Average Time Period for a Batch Release:	NA
5. Minimum Time Period for a Batch Release:	NA

Abnormal Releases

1. Number of Releases	0
2. Total Activity Released	NA

TABLE 2-1

AIRBORNE EFFLUENT - SUMMATION OF ALL RELEASES

A. Fission and Activation Gas	Unit	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
Total Release	Ci	<MDC	<MDC	<MDC	<MDC
Average Release Rate for Period	µCi/sec	0	0	0	0
Percent of Applicable Limit (1.67E+04 µCi/sec)	%	0	0	0	0

B. Iodines					
Total I-131	Ci	<MDC	<MDC	<MDC	<MDC
Average Release Rate for Period	µCi/sec	0	0	0	0
Percent of Applicable Limit (1.73E+00 µCi/sec)	%	0	0	0	0

C. Particulate					
Particulate with Half-Life >8 Days	Ci	<MDC	2.24E-04	7.55E-06	<MDC
Average Release Rate for Period	µCi/sec	0	2.85E-05	9.50E-07	0
Percent of Applicable Limit (5.03E+01 µCi/sec)	%	0	5.67E-05	1.89E-06	0
Gross Alpha Radioactivity	Ci	<MDC	<MDC	<MDC	<MDC

D. Tritium					
Total Release	Ci	8.94E+00	2.91E+00	4.69E+00	3.05E+01
Average Release Rate for Period	µCi/sec	1.15E+00	3.70E-01	5.90E-01	3.84E+00
Percent of Applicable Limit (2.44E+03 µCi/sec)	%	4.71E-02	1.52E-02	2.42E-02	1.57E-01

E. Radionuclide Fractional Summation					
Sum of Percent of Applicable Limit During Period for B, C and D (Limit = 100%)	%	0.05	0.02	0.02	0.16

TABLE 2-2

AIRBORNE EFFLUENT - RADIONUCLIDES RELEASED

		Releases in Continuous Mode			
Nuclides Released	Unit	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
A. Fission and Activation Gases					
N-13	Ci	<MDC	<MDC	<MDC	<MDC
Ar-41	Ci	<MDC	<MDC	<MDC	<MDC
Kr-85	Ci	<MDC	<MDC	<MDC	<MDC
Kr-85m	Ci	<MDC	<MDC	<MDC	<MDC
Kr-87	Ci	<MDC	<MDC	<MDC	<MDC
Kr-88	Ci	<MDC	<MDC	<MDC	<MDC
Kr-89	Ci	<MDC	<MDC	<MDC	<MDC
Xe-133	Ci	<MDC	<MDC	<MDC	<MDC
Xe-135	Ci	<MDC	<MDC	<MDC	<MDC
Xe-135m	Ci	<MDC	<MDC	<MDC	<MDC
Xe-137	Ci	<MDC	<MDC	<MDC	<MDC
Xe-138	Ci	<MDC	<MDC	<MDC	<MDC
Total for Period	**Ci**	**0**	**0**	**0**	**0**
B. Iodines					
I-131	Ci	<MDC	<MDC	<MDC	<MDC
I-133	Ci	<MDC	<MDC	<MDC	<MDC
I-135	Ci	<MDC	<MDC	<MDC	<MDC
Total for Period	**Ci**	**0**	**0**	**0**	**0**
C. Particulate					
Cr-51	Ci	<MDC	1.61E-04	<MDC	<MDC
Mn-54	Ci	<MDC	<MDC	<MDC	<MDC
Fe-59	Ci	<MDC	<MDC	<MDC	<MDC
Co-57	Ci	<MDC	<MDC	<MDC	<MDC
Co-58	Ci	<MDC	<MDC	<MDC	<MDC
Co-60	Ci	<MDC	6.32E-05	7.55E-06	<MDC
Zn-65	Ci	<MDC	<MDC	<MDC	<MDC
Sr-89	Ci	<MDC	<MDC	<MDC	<MDC
Sr-90	Ci	<MDC	<MDC	<MDC	<MDC
Cs-134	Ci	<MDC	<MDC	<MDC	<MDC
Cs-137	Ci	<MDC	<MDC	<MDC	<MDC
Ce-141	Ci	<MDC	<MDC	<MDC	<MDC
Ce-144	Ci	<MDC	<MDC	<MDC	<MDC
Nb-95	Ci	<MDC	<MDC	<MDC	<MDC
Ba-La-140	Ci	<MDC	<MDC	<MDC	<MDC
Total for Period	**Ci**	**0**	**2.24E-04**	**7.55E-06**	**0**

Waterborne Effluents

Summaries of the radionuclide total curie activities, average diluted concentrations, and percent of applicable Technical Requirement limits are included in Tables 2-3 and 2-4.

	Batch Releases*	Qtr. 1	Qtr. 2	Qtr. 3	Qtr. 4	Annual
1.	Number of Batch Releases	28	48	49	23	148
2.	Total Time Period for a Batch Release	3.71E+03	6.58E+03	7.59E+03	1.74E+03	1.96E+04
3.	Maximum Time Period for a Batch Release	3.00E+02	3.08E+02	3.07E+02	2.81E+02	3.08E+02
4.	Average Time Period for a Batch Release	1.33E+02	1.37E+02	1.55E+02	7.55E+01	1.33E+02
5.	Minimum Time Period for a Batch Release	3.00E+01	2.90E+01	3.00E+01	3.20E+01	2.90E+01
6.	Average Cooling Tower Blowdown Flow Rate During Periods of Release	1.22E+04	9.47E+03	1.12E+04	1.24E+04	1.09E+04
7.	Susquehanna River Flow Rate	1.29E+07	1.76E+07	1.10E+07	1.12E+07	1.32E+07

*Units of time and flow are expressed in minutes and gallons per minute (gpm), respectively.

If a radionuclide was not detected, zero activity was used for that isotope in dose calculations and the activity is listed as "<MDC" (less than the miniumum detectable concentration) in Tables 2-3 and 2-4. <MDC indicates that no activity was positively detected in any sample when samples were analyzed with techniques which achieved the required Lower Limits of Detection (LLD) as specified in the Technical Requirement 3.11.1.1-1, Radioactive Liquid Waste Sampling and Analysis Program. In all cases, the measurement laboratory MDCs were at or below the LLD levels required by Technical Requirements. The following are typical measurement laboratory MDCs.

Radionuclide	MDC (µCi/ml)
Mn-54	4.5 E-08
Fe-59	5.0 E-08
Co-58	4.0 E-08
Co-60	5.4 E-08
Zn-65	4.9 E-08
Mo-99	1.7 E-07
I-131	2.0 E-08
Cs-134	2.2 E-08
Cs-137	2.6 E-08
Ce-141	3.2 E-08
Ce-144	1.3 E-07
Sr-89	4.4 E-08
Sr-90	1.6 E-08
Fe-55	8.2 E-07
H-3	3.6 E-06
Gross Alpha	3.7 E-09

Abnormal Releases

1.	Number of releases	0	0	0	0
2.	Volume Released (Gallons)	N/A	N/A	N/A	N/A
3.	Total Activity Released (Ci)	N/A	N/A	N/A	N/A

TABLE 2-3

WATERBORNE EFFLUENT - SUMMATION OF ALL RELEASES

A. Fission and Activation Products	Unit	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
1. Total Release (excluding: Tritium, Ent. Gases, Alpha)	Ci	2.30E-03	5.27E-03	1.00E-02	5.30E-03
2. Average Diluted Concentration During Period	µCi/ml	1.34E-08	2.23E-08	3.12E-08	6.52E-08
3. Sum of Average Diluted C_n/L_n Ratio During Period	Unitless	3.10E-04	5.43E-04	8.63E-04	1.90E-03
4. Percent of Applicable Limit (Ratio < 1.0)	%	0.03	0.05	0.09	0.20
B. Tritium					
1. Total Release	Ci	1.18E+01	1.78E+01	1.81E+01	4.09E+00
2. Average Diluted Concentration During Period	µCi/ml	6.89E-05	7.56E-05	5.65E-05	5.03E-05
3. Percent of Applicable Limit (1.0E-2 µCi/ml)	%	0.69	0.76	0.57	0.50
C. Dissolved and Entrained Gases					
1. Total Release	Ci	<MDC	<MDC	7.08E-06	5.74E-06
2. Average Diluted Concentration During Period	µCi/ml	0.00E+00	0.00E+00	2.21E-11	7.06E-11
3. Percent of Applicable Limit (2.0E-4 µCi/ml)	%	0.00E+00	0.00E+00	1.10E-05	3.53E-05
D. Radionuclide Fractional Summation					
1. Sum of Percent of Applicable Limit During Period for A, B and C (Limit = 100%)	%	0.72	0.81	0.66	0.70
E. Gross Alpha Radioactivity					
1. Total Release	Ci	<MDC	5.87E-06	3.91E-05	1.46E-05
F. Volume of Water Released (Prior to Dilution)	Gallons	2.79E+05	5.02E+05	5.93E+05	1.14E+05
	Liters	1.06E+06	1.90E+06	2.24E+06	4.31E+05
G. Volume of Dilution Water Used During Period of Release	Gallons	4.52E+07	6.18E+07	8.40E+07	2.14E+07
	Liters	1.71E+08	2.34E+08	3.18E+08	8.09E+07
H. Volume of Dilution Water Used Over Entire Period	Gallons	1.45E+09	1.19E+09	1.78E+09	1.58E+09
	Liters	5.49E+09	4.50E+09	6.73E+09	5.97E+09

TABLE 2-4

WATERBORNE EFFLUENT - RADIONUCLIDES RELEASED

Nuclides Released	Unit	Releases in Batch Mode			
		First Quarter	Second Quarter	Third Quarter	Fourth Quarter
A. Fission and Activation Products					
Na-24	Ci	<MDC	<MDC	<MDC	<MDC
Cr-51	Ci	2.99E-04	3.04E-04	1.04E-06	<MDC
Mn-54	Ci	1.47E-05	1.87E-05	3.92E-05	2.05E-06
Fe-55	Ci	<MDC	<MDC	<MDC	<MDC
Co-58	Ci	1.51E-04	1.13E-03	1.78E-03	5.91E-04
Fe-59	Ci	<MDC	2.06E-06	<MDC	<MDC
Co-60	Ci	1.18E-03	3.45E-03	7.78E-03	4.33E-03
Zn-65	Ci	6.57E-04	3.63E-04	4.17E-04	3.71E-04
Sr-89	Ci	<MDC	<MDC	<MDC	<MDC
Sr-90	Ci	<MDC	<MDC	<MDC	<MDC
Nb-95	Ci	<MDC	6.66E-07	<MDC	<MDC
Tc-99m	Ci	<MDC	<MDC	<MDC	<MDC
Sb-124	Ci	<MDC	<MDC	<MDC	<MDC
Cs-137	Ci	<MDC	<MDC	<MDC	<MDC
Sb-125	Ci	<MDC	<MDC	<MDC	<MDC
Ta-182	Ci	<MDC	2.75E-06	<MDC	<MDC
Total for Period	**Ci**	**2.30E-03**	**5.27E-03**	**1.00E-02**	**5.30E-03**
B. Tritium					
Total for Period	**Ci**	**1.18E+01**	**1.78E+01**	**1.81E+01**	**4.09E+00**
C. Dissolved and Entrained Gases					
Ar-41	Ci	<MDC	<MDC	<MDC	<MDC
Kr-85	Ci	<MDC	<MDC	<MDC	<MDC
Kr-85m	Ci	<MDC	<MDC	<MDC	<MDC
Kr-87	Ci	<MDC	<MDC	<MDC	<MDC
Kr-88	Ci	<MDC	<MDC	<MDC	5.74E-06
Xe-131m	Ci	<MDC	<MDC	<MDC	<MDC
Xe-133m	Ci	<MDC	<MDC	<MDC	<MDC
Xe-133	Ci	<MDC	<MDC	4.98E-06	<MDC
Xe-135m	Ci	<MDC	<MDC	<MDC	<MDC
Xe-135	Ci	<MDC	<MDC	2.10E-06	<MDC
Total for Period	**Ci**	**0**	**0**	**7.08E-06**	**5.74E-06**

Figure 2-1

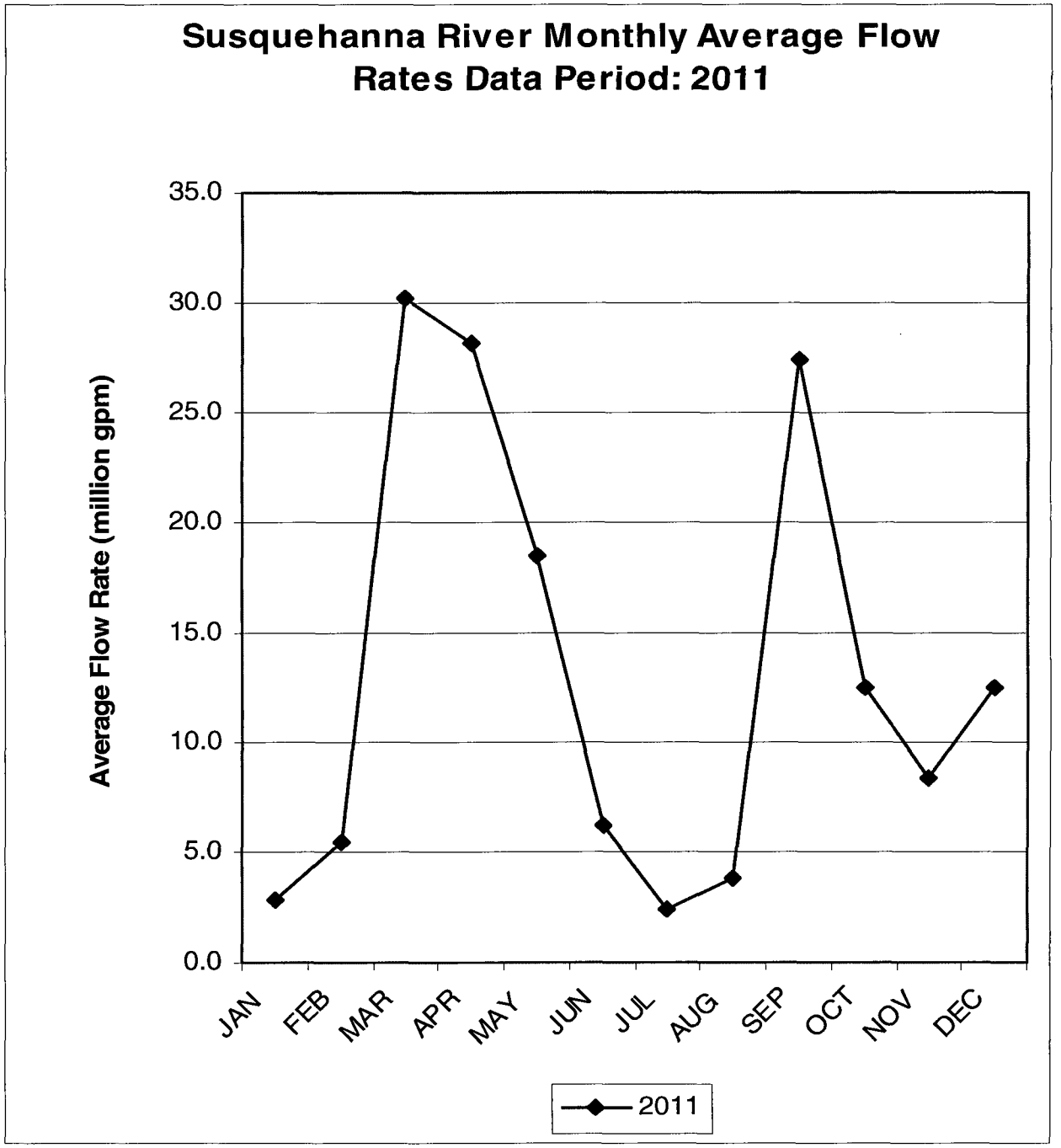

Susquehanna River Monthly Average Flow Rates Data Period: 2011
Average Flow Rate (million gpm)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
2011

Figure 2-2

Monthly Liquid Radwaste Discharge Totals

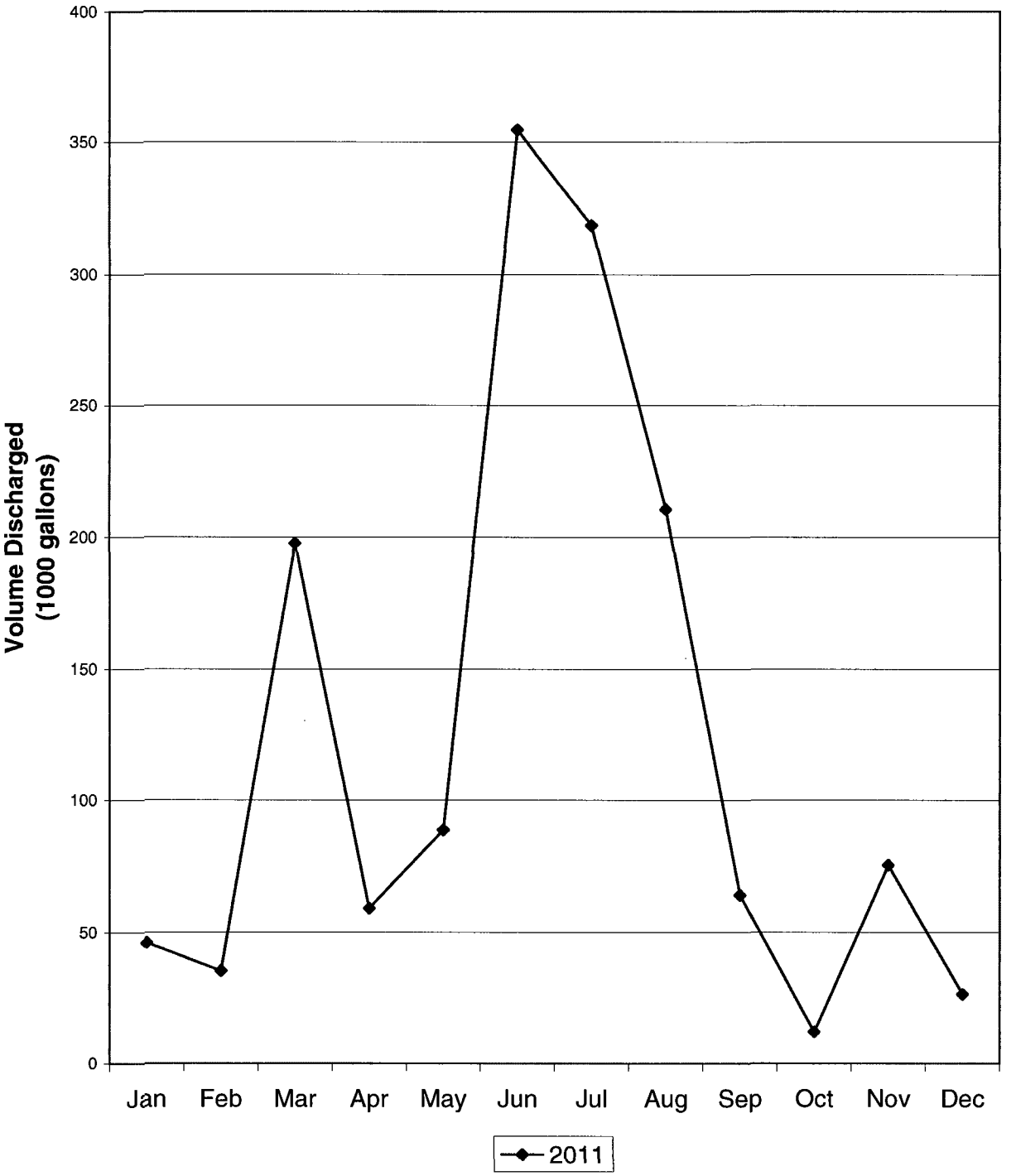


TABLE 2-5

ESTIMATED TOTAL ERRORS ASSOCIATED WITH EFFLUENTS MEASUREMENTS

	MEASUREMENT	ESTIMATED TOTAL ERROR
1.	**Airborne Effluents**	
a.	Fission and Activation Gases	15.9%
b.	I-131	13.3%
c.	Particulates (incl. Gross Alpha)	15.8%
d.	Tritium	13.6%
2.	**Waterborne Effluents**	
a.	Fission and Activation Products	5.0%
b.	Tritium	3.3%
c.	Dissolved and Entrained Gases	8.4%
d.	Gross Alpha Activity	6.0%
e.	Volume of Waste Released (Prior to Dilution)	5.0%
f.	Volume of Dilution Water Used During Period	15.0%
		ESTIMATED MAXIMUM MEASUREMENT ERROR
3.	**Solid Wastes**	
a.	Bead Resin / Charcoal – Class A HIC (Pyrolysis)	±25%
b.	CFS Backwash Media – Class A HIC (Pyrolysis)	±25%
c.	CFS Filters - Class A HIC (Pyrolysis)	±25%
d.	Condensate Demineralizer / Radwaste Demineralizer - Class A HIC (Pyrolysis)	±25%
e.	Contaminated Waste Oil – Class A Fuel Blending for Co-Generation	±25%
f.	Liquid Radwaste Filter Media – Class A HIC (Pyrolysis)	±25%
g.	Processed DAW – Class A HIC (Compacted)	±25%
h.	Processed DAW – Class A Strong Tight Container (Compacted)	±25%
i.	Sump Sludge – Class A HIC (Pyrolysis)	±25%

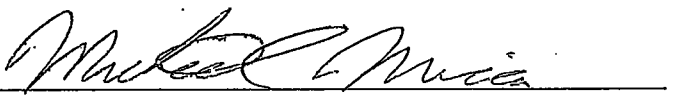
SUSQUEHANNA STEAM ELECTRIC STATION

RADIOACTIVE WASTE REPORT

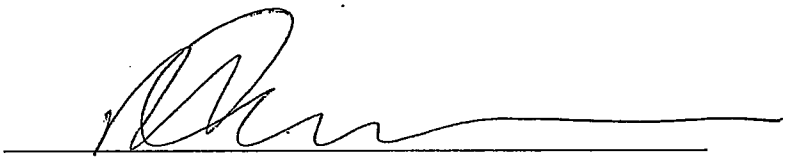
RADIOACTIVE EFFLUENT RELEASE REPORT

SOLID RADIOACTIVE WASTE

DATA PERIOD: JANUARY 1, 2011 - DECEMBER 31, 2011

PREPARED BY: 

MICHAEL C. MICCA
HEALTH PHYSICIST

APPROVED BY: 

RICK KESSLER
RADIOLOGICAL OPERATIONS SUPERVISOR

REPORT NOTES

1. All activities reported in Milli-Curies (mCi) unless otherwise noted.

2. Reported activities, as indicated with the (<) sign, are comprised in whole or part of MDL values.

3. Estimated maximum measurement error is ±25%.

TABLE 2-6

WASTE DISPOSITION

Data Period: January 1, 2011 - December 31, 2011

A. SOLID WASTE SHIPPED OFF-SITE FOR BURIAL OR DISPOSAL

Number of Shipments	Mode of Transportation	Destination
NONE		

B. IRRADIATED FUEL SHIPMENTS

Number of Shipments	Mode of Transportation	Destination
NONE		

NOTE: The number of shipments listed in A include only the shipments from PPL Susquehanna, LLC to a disposal site. It does not include shipments made to or from volume reduction vendors.

Table 2-7

Annual Waste Release Summary Report

Year: 2011
Class: A Volume Reduction Vendor: Yes
Source: Bead Resin/Charcoal
Container: HIC (High Integrity Container)
Process: Pyrolysis

Nuclides	Activity (mCi)	% of Total
C-14	7.810E-03	0.02 %
CO-58	5.110E-03	0.01 %
CO-60	1.200E+01	30.44 %
CS-137	7.170E-01	1.82 %
FE-55	1.250E+01	31.71 %
H-3	5.570E+00	14.13 %
I-129	6.970E-03	0.02 %
MN-54	6.320E+00	16.03 %
NI-63	1.040E+00	2.64 %
SR-90	1.530E-02	0.04 %
TC-99	6.180E-02	0.16 %
ZN-65	1.180E+00	2.99 %
Total Activity (Ci)	0.039	100.00 %
Container Volume	25.390 ft3	0.719 m3

Table 2-8

Annual Waste Release Summary Report

Year: 2011
Class: A Volume Reduction Vendor: Yes
Source: CFS Backwash Media
Container: HIC (High Integrity Container)
Process: Pyrolysis

Nuclides	Activity (mCi)	% of Total
C-14	1.800E+00	0.01 %
CO-58	7.720E+01	0.62 %
CO-60	2.690E+03	21.59 %
CR-51	3.560E+01	0.29 %
CS-137	5.310E-01	0.00 %
FE-55	9.080E+03	72.87 %
FE-59	7.370E+00	0.06 %
H-3	2.720E+01	0.22 %
I-129	7.100E-02	0.00 %
MN-54	3.460E+02	2.78 %
NB-95	4.960E+00	0.04 %
NI-63	7.480E+01	0.60 %
SR-90	6.520E-01	0.01 %
TA-182	6.200E+00	0.05 %
TC-99	6.470E-01	0.01 %
ZN-65	1.040E+02	0.83 %
ZR-95	4.170E+00	0.03 %
Total Activity (Ci)	12.461	100.00 %
Container Volume	17.260 ft3	0.489 m3

Table 2-9

Annual Waste Release Summary Report

Year: 2011
Class: A Volume Reduction Vendor: Yes
Source: CFS Filters
Container: HIC (High Integrity Container)
Process: Pyrolysis

Nuclides	Activity (mCi)	% of Total
C-14	3.970E+00	0.01 %
CO-58	1.220E+02	0.43 %
CO-60	5.990E+03	21.21 %
CR-51	1.290E+02	0.46 %
CS-137	1.180E+00	0.00 %
FE-55	2.020E+04	71.52 %
FE-59	3.170E+01	0.11 %
H-3	1.660E+01	0.06 %
I-129	1.170E-01	0.00 %
MN-54	1.190E+03	4.21 %
NB-95	1.680E+01	0.06 %
NI-63	1.660E+02	0.59 %
SR-90	1.440E+00	0.01 %
TC-99	1.070E+00	0.00 %
ZN-65	3.720E+02	1.32 %
Total Activity (Ci)	28.242	100.00 %
Container Volume	53.720 ft3	1.521 m3

Table 2-10

Annual Waste Release Summary Report

Year: 2011
Class: A
Volume Reduction Vendor: Yes
Source: Condensate Demineralizer / Radwaste Demineralizer
Container: HIC (High Integrity Container)
Process: Pyrolysis

Nuclides	Activity (mCi)	% of Total
C-14	1.940E+03	18.34 %
CO-58	7.150E+02	6.76 %
CO-60	4.470E+03	42.25 %
CR-51	4.050E+01	0.38 %
CS-137	7.130E+00	0.07 %
FE-55	1.110E+03	10.49 %
FE-59	3.740E+00	0.04 %
H-3	3.810E+02	3.60 %
I-129	2.180E-01	0.00 %
I-131	9.920E-02	0.00 %
MN-54	1.370E+03	12.95 %
NB-95	2.990E+01	0.28 %
NI-63	1.110E+02	1.05 %
SB-124	2.730E-01	0.00 %
SB-125	1.470E+00	0.01 %
SN-113	2.020E+00	0.02 %
SR-90	1.730E+00	0.02 %
TC-99	1.660E+00	0.02 %
ZN-65	3.700E+02	3.50 %
ZR-95	2.460E+01	0.23 %
Total Activity (Ci)	10.580	100.00 %
Container Volume	157.100 ft3	4.449 m3

Table 2-11

Annual Waste Release Summary Report

Year: 2011
Class: A Volume Reduction Vendor: Yes
Source: Contaminated Waste Oil
Container: None
Process: Fuel Blending for Co-Generation

Nuclides	Activity (mCi)	% of Total
C-14	< 1.080E-03	0.01 %
CO-60	1.150E+00	9.63 %
CS-137	1.840E-03	0.02 %
FE-55	9.170E-01	7.68 %
H-3	9.820E+00	82.22 %
I-129	< 2.380E-04	0.00 %
MN-54	3.960E-02	0.33 %
NI-63	8.140E-03	0.07 %
TC-99	< 5.840E-03	0.05 %
Total Activity (Ci)	0.012	100.00 %
Container Volume	0.000 ft3	0.000 m3

Table 2-12

Annual Waste Release Summary Report

Year: 2011
Class: A Volume Reduction Vendor: Yes
Source: Liquid Radwaste Filter Media
Container: HIC (High Integrity Container)
Process: Pyrolysis

Nuclides	Activity (mCi)	% of Total
C-14	5.690E-02	0.00 %
CO-58	3.240E+01	0.37 %
CO-60	1.530E+03	17.29 %
CR-51	1.410E+01	0.16 %
CS-137	4.120E-01	0.00 %
FE-55	6.790E+03	76.74 %
H-3	2.520E+01	0.28 %
I-129	1.360E-02	0.00 %
MN-54	2.420E+02	2.74 %
NB-95	1.320E+00	0.01 %
NI-63	1.020E+02	1.15 %
SR-90	4.340E-02	0.00 %
TA-182	7.130E+00	0.08 %
TC-99	1.780E-01	0.00 %
ZN-65	1.030E+02	1.16 %
Total Activity (Ci)	8.848	100.00 %
Container Volume	16.280 ft3	0.461 m3

Table 2-13

Annual Waste Release Summary Report

Year: 2011
Class: A Volume Reduction Vendor: Yes
Source: Processed DAW
Container: HIC (High Integrity Container)
Process: Compacted

Nuclides	Activity (mCi)	% of Total
C-14	4.200E-01	0.01 %
CO-58	1.150E+02	2.70 %
CO-60	1.070E+03	25.11 %
CS-137	3.700E+00	0.09 %
FE-55	2.430E+03	57.04 %
H-3	2.170E-01	0.01 %
I-129	1.240E-03	0.00 %
MN-54	1.370E+02	3.22 %
NB-95	5.570E+00	0.13 %
NI-63	4.950E+01	1.16 %
SR-89	3.970E+00	0.09 %
SR-90	2.940E-02	0.00 %
TC-99	1.070E-02	0.00 %
ZN-65	4.450E+02	10.44 %
Total Activity (Ci)	4.260	100.00 %
Container Volume	22.200 ft3	0.629 m3

Table 2-14

Annual Waste Release Summary Report

Year: 2011
Class: A Volume Reduction Vendor: Yes
Source: Processed DAW
Container: Strong Tight Container
Process: Compacted

Nuclides	Activity (mCi)	% of Total
C-14	3.592E-01	0.00 %
CO-58	7.354E+00	0.07 %
CO-60	2.709E+03	25.27 %
CR-51	4.106E-01	0.00 %
CS-137	2.364E+00	0.02 %
FE-55	7.445E+03	69.47 %
FE-59	2.098E-02	0.00 %
H-3	1.383E+02	1.29 %
HF-181	3.820E-04	0.00 %
I-129	2.710E-02	0.00 %
MN-54	2.229E+02	2.08 %
NB-94	3.160E-03	0.00 %
NB-95	6.260E-02	0.00 %
NI-59	7.560E-01	0.01 %
NI-63	1.563E+02	1.46 %
SB-124	8.780E-05	0.00 %
SB-125	3.210E-04	0.00 %
SR-90	1.577E-02	0.00 %
TA-182	8.890E-02	0.00 %
TC-99	1.058E-01	0.00 %
ZN-65	3.489E+01	0.33 %
ZR-95	2.230E-02	0.00 %
Total Activity (Ci)	10.718	100.00 %
Container Volume	4601.350 ft3	130.298 m3

Table 2-15

Annual Waste Release Summary Report

Year: 2011
Class: A Volume Reduction Vendor: Yes
Source: Sump Sludge
Container: HIC (High Integrity Container)
Process: Pyrolysis

Nuclides	Activity (mCi)	% of Total
C-14	9.900E+00	0.96 %
CO-58	2.770E-01	0.03 %
CO-60	2.150E+02	20.84 %
CS-137	1.450E+00	0.14 %
FE-55	7.480E+02	72.52 %
H-3	1.320E+01	1.28 %
HF-181	1.590E-01	0.02 %
I-129	1.570E-01	0.02 %
MN-54	1.760E+01	1.71 %
NB-95	5.150E-01	0.05 %
NI-63	2.150E+01	2.08 %
TC-99	4.800E-01	0.05 %
ZN-65	2.540E+00	0.25 %
ZR-95	6.570E-01	0.06 %
Total Activity (Ci)	1.031	100.00 %
Container Volume	19.150 ft3	0.542 m3

SECTION 3

METEOROLOGICAL DATA AND DISPERSION ESTIMATES

METEOROLOGY AND DISPERSION DATA

Meteorological data have been collected at the PPL Susquehanna, LLC site since the early 1970s. At the present time, the meteorological system is based on a 300-foot high tower located approximately 1,000 feet to the southeast of the plant. Wind sensors are mounted at the 10m and 60m elevations on this tower. Vertical temperature differential is measured with redundant sensor pairs between the 10m and 60m levels. Sigma theta (the standard deviation of horizontal wind direction) is calculated from wind direction at both levels. Dew point and ambient temperature sensors are present at the 10m level. Precipitation is measured at ground level.

A back-up meteorological tower was erected in 1982. It is a 10m tower providing alternate measurements of wind speed, wind direction, and sigma theta. A 10m supplemental downriver meteorological tower is also available. This tower measures wind speed, wind direction, sigma theta, temperature and dew point.

Meteorological data are transmitted to the plant Control Room, Technical Support Center, Emergency Operations Facility for emergency response availability, and ABSG Consulting, Inc. ABSG Consulting, Inc., located in Rockville, Maryland, provides meteorological consulting services to PPL Susquehanna, LLC.

Regulatory Guide 1.23 (Safety Guide 23) requires at least 90% data recovery for meteorological instrumentation. During 2011, all meteorological instrumentation met the 90% data recovery requirement. Table 3-1 lists the percent valid data recovery values for the parameters monitored as part of the PPL Susquehanna Meteorological Monitoring Program.

Dispersion modeling for effluents from normal operation is done using the MIDAS system XDCALC program, a straight-line Gaussian plume model designed to estimate average relative concentration. The model was developed in accordance with Regulatory Guide 1.111. For periods when the wind speed is calm, the actual wind direction that last occurred is used.

XDCALC and the XQINTR program that interpolates X/Q values to exact locations both use terrain correction factors to account for the temporal and spatial variations in the airflow in the region. A straight-line trajectory model assumes that a constant mean wind transports and diffuses effluents in the direction of airflow at the release point within the entire region of interest. The terrain correction factors were taken from FSAR Table 2.3-128.

Tables 3-2 and 3-3 provide the joint frequency distribution of wind speed and direction (as a function of delta temperature) at the 10 and 60 meter elevations of the primary meteorological tower. Table 3-4 lists no decay, undepleted X/Q values at various distances from the site. Table 3-5 lists 2.26 day decay, undepleted X/Q values at various distances from the site. Table 3-6 lists 8-day decay, depleted X/Q values at various distances from the site and Table 3-7 is a listing of D/Q (relative deposition) values at various distances from the site.

TABLE 3-1

METEOROLOGICAL DATA RECOVERY FOR 2011

Parameter	Percent Valid Data Recovery
Wind Speed 10m - Primary (1) Wind Speed 60m – Primary Wind Speed 10m – Backup (2) Wind Speed 10m – Downriver (3)	99.3 99.3 99.5 100.0
Wind Direction 10m - Primary Wind Direction 60m – Primary Wind Direction 10m – Backup Wind Direction 10m – Downriver	98.4 98.4 99.6 100.0
Temperature 10m – Primary Dew Point 10m – Primary	99.4 100.0
Delta Temperature 60m – Primary	99.0
Sigma Theta 10m – Primary Sigma Theta 60m – Primary Sigma Theta 10m – Backup Sigma Theta 10m – Downriver	98.4 98.4 99.6 100.0
Precipitation – Primary	100.0
Composite Parameters	
Wind Speed and Direction 10m, Delta Temperature 60-10m	98.1
Wind Speed and Direction 60m, Delta Temperature 60-10m	98.1

(1) SSES "Primary" meteorological tower

(2) SSES "Backup" meteorological tower

(3) SSES "Downriver" meteorological tower

TABLE 3-2

SSES JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND WIND DIRECTION 10m VERSUS DELTA TEMPERATURE 60-10m FOR THE PERIOD OF JANUARY 1, 2011 THROUGH DECEMBER 31, 2011

Joint Frequency Distribution

Hours at Each Wind Speed and Direction

Total Period

Period of Record = 1/1/2011 00:00 - 12/31/2011 23:00

Elevation: **Speed:** 10_SPD **Direction:** 10_WD **Lapse:** DT60-10A

Stability Class A Delta Temperature Extremely Unstable

Wind Speed (mph)

Wind Direction	1 - 4	4 - 8	8 - 13	13 - 19	19 - 25	≥ 25	Total
N	0	0	0	0	0	0	0
NNE	0	0	3	0	0	0	3
NE	2	5	0	0	0	0	7
ENE	3	0	0	0	0	0	3
E	3	0	0	0	0	0	3
ESE	3	0	0	0	0	0	3
SE	3	0	0	0	0	0	3
SSE	1	1	0	0	0	0	2
S	1	0	2	0	0	0	3
SSW	2	4	2	0	0	0	8
SW	3	8	6	0	0	0	17
WSW	2	2	1	0	0	0	5
W	0	0	0	0	0	0	0
WNW	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0
Total	23	20	14	0	0	0	57

Calm Hours not Included above for :	**Total Period**	0
Variable Direction Hours for:	**Total Period**	0
Invalid Hours for:	**Total Period**	167
Valid Hours for this Stability Class for:	**Total Period**	57
Total Hours for Period		8760

TABLE 3-2
(continued)

SSES JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND WIND DIRECTION 10m VERSUS DELTA TEMPERATURE 60-10m FOR THE PERIOD OF JANUARY 1, 2011 THROUGH DECEMBER 31, 2011 (Continued)

Joint Frequency Distribution

Hours at Each Wind Speed and Direction

Total Period

Period of Record = 1/1/2011 00:00 - 12/31/2011 23:00

Elevation: **Speed:** 10_SPD **Direction:** 10_WD **Lapse:** DT60-10A

Stability Class B Delta Temperature Moderately Unstable

Wind Speed (mph)

Wind Direction	1 - 4	4 - 8	8 - 13	13 - 19	19 - 25	≥ 25	Total
N	0	1	2	0	0	0	3
NNE	0	3	1	0	0	0	4
NE	1	6	0	0	0	0	7
ENE	0	0	0	0	0	0	0
E	1	0	0	0	0	0	1
ESE	0	1	0	0	0	0	1
SE	0	0	0	0	0	0	0
SSE	1	0	0	0	0	0	1
S	1	2	5	0	0	0	8
SSW	0	11	4	0	0	0	15
SW	1	16	22	0	0	0	39
WSW	0	3	8	1	0	0	12
W	0	1	2	0	0	0	3
WNW	0	1	0	0	0	0	1
NW	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0
Total	5	45	44	1	0	0	95

Calm Hours not Included above for :	**Total Period**	0
Variable Direction Hours for:	**Total Period**	0
Invalid Hours for:	**Total Period**	167
Valid Hours for this Stability Class for:	**Total Period**	95
Total Hours for Period		8760

TABLE 3-2
(continued)

SSES JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND WIND DIRECTION 10m VERSUS DELTA TEMPERATURE 60-10m FOR THE PERIOD OF JANUARY 1, 2011 THROUGH DECEMBER 31, 2011 (Continued)

Joint Frequency Distribution

Hours at Each Wind Speed and Direction

Total Period

Period of Record = 1/1/2011 00:00 - 12/31/2011 23:00

Elevation: **Speed:** 10_SPD **Direction:** 10_WD **Lapse:** DT60-10A

Stability Class C Delta Temperature Slightly Unstable

Wind Speed (mph)

Wind Direction	1 - 4	4 - 8	8 - 13	13 - 19	19 - 25	≥ 25	Total
N	1	6	6	0	0	0	13
NNE	1	10	9	1	0	0	21
NE	0	31	1	0	0	0	32
ENE	2	13	1	0	0	0	16
E	7	4	1	0	0	0	12
ESE	1	1	2	0	0	0	4
SE	0	1	0	0	0	0	1
SSE	0	1	5	0	0	0	6
S	1	5	13	0	0	0	19
SSW	3	22	7	1	0	0	33
SW	0	43	30	4	0	0	77
WSW	0	14	28	4	0	0	46
W	0	3	9	0	0	0	12
WNW	0	1	0	0	0	0	1
NW	0	6	4	5	0	0	15
NNW	0	1	11	3	0	0	15
Total	16	162	127	18	0	0	323

Calm Hours not Included above for :	**Total Period**	0
Variable Direction Hours for:	**Total Period**	0
Invalid Hours for:	**Total Period**	167
Valid Hours for this Stability Class for:	**Total Period**	323
Total Hours for Period		8760

TABLE 3-2
(continued)

SSES JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND WIND DIRECTION 10m VERSUS DELTA TEMPERATURE 60-10m FOR THE PERIOD OF JANUARY 1, 2011 THROUGH DECEMBER 31, 2011 (Continued)

Joint Frequency Distribution

Hours at Each Wind Speed and Direction

Total Period

Period of Record = 1/1/2011 00:00 - 12/31/2011 23:00
Elevation: **Speed:** 10_SPD **Direction:** 10_WD **Lapse:** DT60-10A
Stability Class D Delta Temperature Neutral

Wind Speed (mph)

Wind Direction	1 - 4	4 - 8	8 - 13	13 - 19	19 - 25	≥ 25	Total
N	26	168	143	4	0	0	341
NNE	77	212	43	0	0	0	332
NE	141	203	10	0	0	0	354
ENE	132	98	22	1	0	0	253
E	117	49	10	0	0	0	176
ESE	86	25	28	17	2	0	158
SE	105	44	15	1	0	0	165
SSE	81	103	12	1	0	0	197
S	91	166	49	6	0	0	312
SSW	81	209	39	1	0	0	330
SW	63	301	163	15	0	0	542
WSW	28	147	139	41	0	0	355
W	17	77	87	42	0	0	223
WNW	10	57	65	14	0	0	146
NW	12	74	127	35	3	0	251
NNW	7	90	139	11	0	0	247
Total	1074	2023	1091	189	5	0	4382

Calm Hours not Included above for :	**Total Period**	0
Variable Direction Hours for:	**Total Period**	0
Invalid Hours for:	**Total Period**	167
Valid Hours for this Stability Class for:	**Total Period**	4382
Total Hours for Period		8760

TABLE 3-2
(continued)

SSES JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND WIND DIRECTION 10m VERSUS DELTA TEMPERATURE 60-10m FOR THE PERIOD OF JANUARY 1, 2011 THROUGH DECEMBER 31, 2011 (Continued)

Joint Frequency Distribution

Hours at Each Wind Speed and Direction

Total Period

Period of Record = 1/1/2011 00:00 - 12/31/2011 23:00
Elevation: **Speed:** 10_SPD **Direction:** 10_WD **Lapse:** DT60-10A
Stability Class E Delta Temperature Slightly Stable

Wind Speed (mph)

Wind Direction	1 - 4	4 - 8	8 - 13	13 - 19	19 - 25	≥ 25	Total
N	27	46	2	1	0	0	76
NNE	92	99	0	4	3	0	198
NE	160	63	3	0	0	0	226
ENE	330	24	1	0	0	0	355
E	195	8	0	0	0	0	203
ESE	113	5	2	0	0	0	120
SE	125	9	2	0	0	0	136
SSE	94	22	5	0	0	0	121
S	137	94	11	1	0	0	243
SSW	89	142	11	1	0	0	243
SW	48	105	12	1	0	0	166
WSW	16	46	4	1	0	0	67
W	12	17	3	0	0	0	32
WNW	6	7	0	0	0	0	13
NW	8	14	3	0	0	0	25
NNW	9	29	0	0	0	0	38
Total	1461	730	59	9	3	0	2262

Calm Hours not Included above for :	**Total Period**	0
Variable Direction Hours for:	**Total Period**	0
Invalid Hours for:	**Total Period**	167
Valid Hours for this Stability Class for:	**Total Period**	2262
Total Hours for Period		8760

TABLE 3-2
(continued)

SSES JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND WIND DIRECTION 10m VERSUS DELTA TEMPERATURE 60-10m FOR THE PERIOD OF JANUARY 1, 2011 THROUGH DECEMBER 31, 2011 (Continued)

Joint Frequency Distribution

Hours at Each Wind Speed and Direction

Total Period

Period of Record = 1/1/2011 00:00 - 12/31/2011 23:00
Elevation: **Speed:** 10_SPD **Direction:** 10_WD **Lapse:** DT60-10A
Stability Class F Delta Temperature Moderately Stable

Wind Speed (mph)

Wind Direction	1 - 4	4 - 8	8 - 13	13 - 19	19 - 25	≥ 25	Total
N	2	3	0	0	0	0	5
NNE	26	7	0	0	0	0	33
NE	106	7	0	0	0	0	113
ENE	391	11	0	0	0	0	402
E	171	0	0	0	0	0	171
ESE	48	0	0	0	0	0	48
SE	36	0	0	0	0	0	36
SSE	30	0	0	0	0	0	30
S	27	4	0	0	0	0	31
SSW	21	14	0	0	0	0	35
SW	3	7	0	0	0	0	10
WSW	3	1	0	0	0	0	4
W	0	0	0	0	0	0	0
WNW	1	0	0	0	0	0	1
NW	2	0	0	0	0	0	2
NNW	1	1	0	0	0	0	2
Total	868	55	0	0	0	0	923

Calm Hours not Included above for :	Total Period	0
Variable Direction Hours for:	Total Period	0
Invalid Hours for:	Total Period	167
Valid Hours for this Stability Class for:	Total Period	923
Total Hours for Period		8760

TABLE 3-2
(continued)

SSES JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND WIND DIRECTION 10m VERSUS DELTA TEMPERATURE 60-10m FOR THE PERIOD OF JANUARY 1, 2011 THROUGH DECEMBER 31, 2011 (Continued)

Joint Frequency Distribution

Hours at Each Wind Speed and Direction

Total Period

Period of Record = 1/1/2011 00:00 - 12/31/2011 23:00
Elevation: **Speed:** 10_SPD **Direction:** 10_WD **Lapse:** DT60-10A
Stability Class G Delta Temperature Extremely Stable

Wind Speed (mph)

Wind Direction	1 - 4	4 - 8	8 - 13	13 - 19	19 - 25	≥ 25	Total
N	2	0	0	0	0	0	2
NNE	2	1	0	0	0	0	3
NE	67	2	0	0	0	0	69
ENE	319	13	0	0	0	0	332
E	85	0	0	0	0	0	85
ESE	23	0	0	0	0	0	23
SE	21	0	0	0	0	0	21
SSE	8	0	0	0	0	0	8
S	4	1	0	0	0	0	5
SSW	1	0	0	0	0	0	1
SW	0	0	0	0	0	0	0
WSW	0	0	0	0	0	0	0
W	1	0	0	0	0	0	1
WNW	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0
NNW	1	0	0	0	0	0	1
Total	534	17	0	0	0	0	551

Calm Hours not Included above for :	Total Period	0
Variable Direction Hours for:	Total Period	0
Invalid Hours for:	Total Period	167
Valid Hours for this Stability Class for:	Total Period	551
Total Hours for Period		8760

TABLE 3-2
(continued)

SSES JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND WIND DIRECTION 10m VERSUS DELTA TEMPERATURE 60-10m FOR THE PERIOD OF JANUARY 1, 2011 THROUGH DECEMBER 31, 2011 (Continued)

Joint Frequency Distribution

Hours at Each Wind Speed and Direction

Summary of All Stability Classes

Total Period

Period of Record = 1/1/2011 00:00 - 12/31/2011 23:00

Elevation: **Speed:** 10_SPD **Direction:** 10_WD **Lapse:** DT60-10A

Delta Temperature

Wind Speed (mph)

Wind Direction	1 - 4	4 - 8	8 - 13	13 - 19	19 - 25	> 25	Total
N	58	224	153	5	0	0	440
NNE	198	332	56	5	3	0	594
NE	477	317	14	0	0	0	808
ENE	1177	159	24	1	0	0	1361
E	579	61	11	0	0	0	651
ESE	274	32	32	17	2	0	357
SE	290	54	17	1	0	0	362
SSE	215	127	22	1	0	0	365
S	262	272	80	7	0	0	621
SSW	197	402	63	3	0	0	665
SW	118	480	233	20	0	0	851
WSW	49	213	180	47	0	0	489
W	30	98	101	42	0	0	271
WNW	17	66	65	14	0	0	162
NW	22	94	134	40	3	0	293
NNW	18	121	150	14	0	0	303
Total	3981	3052	1335	217	8	0	8593

Calm Hours not Included above for :	**Total Period**	0
Variable Direction Hours for:	**Total Period**	0
Invalid Hours for:	**Total Period**	167
Valid Hours for this Stability Class for:	**Total Period**	8593
Total Hours for Period		8760

TABLE 3-3

SSES JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND WIND DIRECTION 60m VERSUS DELTA TEMPERATURE 60-10m FOR THE PERIOD OF JANUARY 1, 2011 THROUGH DECEMBER 31, 2011

Joint Frequency Distribution

Hours at Each Wind Speed and Direction

Total Period

Period of Record = 1/1/2011 00:00 - 12/31/2011 23:00

Elevation: **Speed:** 60_SPD **Direction:** 60_WD **Lapse:** DT60-10A

Stability Class A Delta Temperature Extremely Unstable

Wind Speed (mph)

Wind Direction	1 - 4	4 - 8	8 - 13	13 - 19	19 - 25	≥ 25	Total
N	1	0	0	0	0	0	1
NNE	1	2	4	1	0	0	8
NE	2	3	0	0	0	0	5
ENE	2	0	0	0	0	0	2
E	1	0	0	0	0	0	1
ESE	1	0	0	0	0	0	1
SE	2	1	0	0	0	0	3
SSE	0	1	0	0	0	0	1
S	1	0	0	2	1	0	4
SSW	2	2	3	1	0	0	8
SW	3	2	7	4	0	0	16
WSW	0	5	0	1	0	0	6
W	0	0	0	0	0	0	0
WNW	1	0	0	0	0	0	1
NW	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0
Total	17	16	14	9	1	0	57

Calm Hours not Included above for :	**Total Period**	1
Variable Direction Hours for:	**Total Period**	0
Invalid Hours for:	**Total Period**	165
Valid Hours for this Stability Class for:	**Total Period**	57

Total Hours for Period 8760

TABLE 3-3
(continued)

SSES JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND WIND DIRECTION 60m VERSUS DELTA TEMPERATURE 60-10m FOR THE PERIOD OF JANUARY 1, 2011 THROUGH DECEMBER 31, 2011 (Continued)

Joint Frequency Distribution

Hours at Each Wind Speed and Direction

Total Period

Period of Record = 1/1/2011 00:00 - 12/31/2011 23:00
Elevation: **Speed:** 60_SPD **Direction:** 60_WD **Lapse:** DT60-10A
Stability Class B Delta Temperature Moderately Unstable

Wind Speed (mph)

Wind Direction	1 - 4	4 - 8	8 - 13	13 - 19	19 - 25	≥ 25	Total
N	1	0	5	0	0	0	6
NNE	0	2	5	0	0	0	7
NE	1	0	1	0	0	0	2
ENE	1	0	0	0	0	0	1
E	0	0	1	0	0	0	1
ESE	0	0	0	0	0	0	0
SE	1	0	0	0	0	0	1
SSE	0	0	0	0	0	0	0
S	0	0	1	2	0	0	3
SSW	0	1	9	5	0	0	15
SW	0	5	29	12	0	0	46
WSW	0	1	5	6	0	0	12
W	0	0	1	0	0	0	1
WNW	0	0	0	0	0	0	0
NW	0	0	0	0	0	0	0
NNW	0	0	0	0	0	0	0
Total	4	9	57	25	0	0	95

Calm Hours not Included above for :	**Total Period**	1
Variable Direction Hours for:	**Total Period**	0
Invalid Hours for:	**Total Period**	165
Valid Hours for this Stability Class for:	**Total Period**	95
Total Hours for Period		8760

TABLE 3-3
(continued)

SSES JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND WIND DIRECTION 60m VERSUS DELTA TEMPERATURE 60-10m FOR THE PERIOD OF JANUARY 1, 2011 THROUGH DECEMBER 31, 2011 (Continued)

Joint Frequency Distribution

Hours at Each Wind Speed and Direction

Total Period

Period of Record = 1/1/2011 00:00 - 12/31/2011 23:00
Elevation: **Speed:** 60_SPD **Direction:** 60_WD **Lapse:** DT60-10A
Stability Class C Delta Temperature Slightly Unstable

Wind Speed (mph)

Wind Direction	1 - 4	4 - 8	8 - 13	13 - 19	19 - 25	≥ 25	Total
N	0	4	13	3	0	0	20
NNE	2	17	13	5	0	0	37
NE	4	12	10	0	0	0	26
ENE	3	2	1	0	0	0	6
E	0	1	1	1	0	0	3
ESE	0	0	1	0	0	0	1
SE	0	1	3	0	0	0	4
SSE	0	1	2	2	0	0	5
S	1	1	7	8	1	0	18
SSW	1	11	15	5	1	0	33
SW	0	7	54	20	4	0	85
WSW	0	2	19	15	3	0	39
W	0	2	9	0	0	0	11
WNW	0	1	4	3	0	0	8
NW	0	1	4	11	1	0	17
NNW	0	0	4	3	0	0	7
Total	11	63	160	76	10	0	320

Calm Hours not Included above for :	**Total Period**	1
Variable Direction Hours for:	**Total Period**	0
Invalid Hours for:	**Total Period**	165
Valid Hours for this Stability Class for:	**Total Period**	320
Total Hours for Period		8760

TABLE 3-3
(continued)

SSES JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND WIND DIRECTION 60m VERSUS DELTA TEMPERATURE 60-10m FOR THE PERIOD OF JANUARY 1, 2011 THROUGH DECEMBER 31, 2011 (Continued)

Joint Frequency Distribution

Hours at Each Wind Speed and Direction

Total Period

Period of Record = 1/1/2011 00:00 - 12/31/2011 23:00
Elevation: **Speed:** 60_SPD **Direction:** 60_WD **Lapse:** DT60-10A
Stability Class D Delta Temperature Neutral

Wind Speed (mph)

Wind Direction	1 - 4	4 - 8	8 - 13	13 - 19	19 - 25	≥ 25	Total
N	23	116	148	22	1	0	310
NNE	51	164	150	34	0	0	399
NE	74	155	72	10	0	0	311
ENE	58	56	34	9	0	0	157
E	41	30	31	13	7	2	124
ESE	31	35	18	17	9	6	116
SE	43	52	32	10	0	1	138
SSE	41	53	59	9	3	0	165
S	46	65	118	31	18	0	278
SSW	47	135	98	42	7	1	330
SW	44	226	242	133	26	3	674
WSW	19	84	169	127	41	1	441
W	11	33	95	55	24	0	218
WNW	10	23	89	52	14	1	189
NW	3	33	133	64	10	0	243
NNW	12	34	158	54	2	0	260
Total	554	1294	1646	682	162	15	4353

Calm Hours not Included above for :	**Total Period**	1
Variable Direction Hours for:	**Total Period**	0
Invalid Hours for:	**Total Period**	165
Valid Hours for this Stability Class for:	**Total Period**	4353
Total Hours for Period		8760

TABLE 3-3

SSES JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND WIND DIRECTION 60m VERSUS DELTA TEMPERATURE 60-10m FOR THE PERIOD OF JANUARY 1, 2011 THROUGH DECEMBER 31, 2011 (Continued)

Joint Frequency Distribution

Hours at Each Wind Speed and Direction

Total Period

Period of Record = 1/1/2011 00:00 - 12/31/2011 23:00

Elevation: **Speed:** 60_SPD **Direction:** 60_WD **Lapse:** DT60-10A

Stability Class E Delta Temperature Slightly Stable

Wind Speed (mph)

Wind Direction	1 - 4	4 - 8	8 - 13	13 - 19	19 - 25	≥ 25	Total
N	36	136	19	2	0	3	196
NNE	110	206	71	3	3	2	395
NE	118	75	21	3	0	0	217
ENE	65	21	9	1	0	0	96
E	46	27	9	0	0	0	82
ESE	39	17	2	1	0	0	59
SE	59	27	7	2	1	0	96
SSE	36	32	25	5	0	0	98
S	42	62	52	15	8	1	180
SSW	34	76	104	20	3	0	237
SW	24	121	134	23	2	0	304
WSW	16	39	79	29	1	0	164
W	7	17	14	0	0	0	38
WNW	5	15	10	0	0	0	30
NW	9	19	25	2	0	0	55
NNW	6	21	10	1	0	0	38
Total	652	911	591	107	18	6	2285

Calm Hours not Included above for :	**Total Period**	1
Variable Direction Hours for:	**Total Period**	0
Invalid Hours for:	**Total Period**	165
Valid Hours for this Stability Class for:	**Total Period**	2285
Total Hours for Period		8760

TABLE 3-3
(continued)

SSES JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND WIND DIRECTION 60m VERSUS DELTA TEMPERATURE 60-10m FOR THE PERIOD OF JANUARY 1, 2011 THROUGH DECEMBER 31, 2011 (Continued)

Joint Frequency Distribution

Hours at Each Wind Speed and Direction

Total Period

Period of Record = 1/1/2011 00:00 - 12/31/2011 23:00

Elevation: **Speed:** 60_SPD **Direction:** 60_WD **Lapse:** DT60-10A

Stability Class F Delta Temperature Moderately Stable

Wind Speed (mph)

Wind Direction	1 - 4	4 - 8	8 - 13	13 - 19	19 - 25	> 25	Total
N	20	92	6	0	0	0	118
NNE	76	201	1	0	0	0	278
NE	74	60	5	0	0	0	139
ENE	45	9	0	0	0	0	54
E	40	3	0	0	0	0	43
ESE	22	6	0	0	0	0	28
SE	33	7	0	0	0	0	40
SSE	26	14	0	0	0	0	40
S	14	25	1	1	0	0	41
SSW	11	28	12	1	0	0	52
SW	6	26	21	1	0	0	54
WSW	2	7	10	6	0	0	25
W	3	5	1	0	0	0	9
WNW	0	1	0	0	0	0	1
NW	2	3	0	0	0	0	5
NNW	1	3	1	0	0	0	5
Total	375	490	58	9	0	0	932

Calm Hours not Included above for :	Total Period	1
Variable Direction Hours for:	Total Period	0
Invalid Hours for:	Total Period	165
Valid Hours for this Stability Class for:	Total Period	932
Total Hours for Period		8760

TABLE 3-3
(continued)

SSES JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND WIND DIRECTION 60m VERSUS DELTA TEMPERATURE 60-10m FOR THE PERIOD OF JANUARY 1, 2011 THROUGH DECEMBER 31, 2011 (Continued)

Joint Frequency Distribution

Hours at Each Wind Speed and Direction

Total Period

Period of Record = 1/1/2011 00:00 - 12/31/2011 23:00

Elevation: **Speed:** 60_SPD **Direction:** 60_WD **Lapse:** DT60-10A

Stability Class G Delta Temperature Extremely Stable

Wind Speed (mph)

Wind Direction	1 - 4	4 - 8	8 - 13	13 - 19	19 - 25	≥ 25	Total
N	8	46	3	0	0	0	57
NNE	26	116	4	0	0	0	146
NE	47	34	0	0	0	0	81
ENE	29	5	0	0	0	0	34
E	17	3	0	0	0	0	20
ESE	19	4	0	0	0	0	23
SE	14	3	0	0	0	0	17
SSE	10	6	0	0	0	0	16
S	13	34	0	0	0	0	47
SSW	7	31	9	1	0	0	48
SW	1	24	15	0	0	0	40
WSW	1	1	2	0	0	0	4
W	2	2	0	0	0	0	4
WNW	0	0	0	0	0	0	0
NW	3	3	2	0	0	0	8
NNW	1	4	2	0	0	0	7
Total	198	316	37	1	0	0	552

Calm Hours not Included above for :	**Total Period**	1
Variable Direction Hours for:	**Total Period**	0
Invalid Hours for:	**Total Period**	165
Valid Hours for this Stability Class for:	**Total Period**	552
Total Hours for Period		8760

TABLE 3-3
(continued)

SSES JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND WIND DIRECTION 60m VERSUS DELTA TEMPERATURE 60-10m FOR THE PERIOD OF JANUARY 1, 2011 THROUGH DECEMBER 31, 2011 (Continued)

Joint Frequency Distribution

Hours at Each Wind Speed and Direction

Summary of All Stability Classes

Total Period

Period of Record = 1/1/2011 00:00 - 12/31/2011 23:00

Elevation: **Speed:** 60_SPD **Direction:** 60_WD **Lapse:** DT60-10A

Delta Temperature

Wind Speed (mph)

Wind Direction	1 - 4	4 - 8	8 - 13	13 - 19	19 - 25	> 25	Total
N	89	394	194	27	1	3	708
NNE	266	708	248	43	3	2	1270
NE	320	339	109	13	0	0	781
ENE	203	93	44	10	0	0	350
E	145	64	42	14	7	2	274
ESE	112	62	21	18	9	6	228
SE	152	91	42	12	1	1	299
SSE	113	107	86	16	3	0	325
S	117	187	179	59	28	1	571
SSW	102	284	250	75	11	1	723
SW	78	411	502	193	32	3	1219
WSW	38	139	284	184	45	1	691
W	23	59	120	55	24	0	281
WNW	16	40	103	55	14	1	229
NW	17	59	164	77	11	0	328
NNW	20	62	175	58	2	0	317
Total	1811	3099	2563	909	191	21	8594

Calm Hours not Included above for :	Total Period	1
Variable Direction Hours for:	Total Period	0
Invalid Hours for:	Total Period	165
Valid Hours for this Stability Class for:	Total Period	8594
Total Hours for Period		8760

TABLE 3-4

2011 SSES Annual Relative Concentrations - No Decay, Undepleted X/Q (sec/m^3)

	Miles									
Direction From	0 - 1	1 - 2	2 - 3	3 - 4	4 - 5	5 - 10	10 - 20	20 - 30	30 - 40	40 - 50
N	4.39E-06	8.30E-07	3.43E-07	1.80E-07	1.16E-07	4.26E-08	1.16E-08	5.55E-09	3.47E-09	2.44E-09
NNE	8.08E-06	1.65E-06	7.35E-07	3.92E-07	2.52E-07	9.29E-08	2.53E-08	1.23E-08	7.82E-09	5.56E-09
NE	1.59E-05	2.98E-06	1.35E-06	7.63E-07	5.03E-07	1.97E-07	5.92E-08	2.96E-08	1.90E-08	1.38E-08
ENE	4.34E-05	8.13E-06	3.94E-06	2.32E-06	1.54E-06	6.10E-07	1.76E-07	8.53E-08	5.52E-08	4.05E-08
E	2.02E-05	3.69E-06	1.62E-06	9.16E-07	6.11E-07	2.48E-07	7.82E-08	3.95E-08	2.55E-08	1.86E-08
ESE	1.03E-05	1.99E-06	8.97E-07	5.00E-07	3.32E-07	1.34E-07	3.70E-08	1.62E-08	1.04E-08	7.49E-09
SE	1.16E-05	2.28E-06	1.04E-06	5.88E-07	3.91E-07	1.59E-07	3.99E-08	1.47E-08	9.38E-09	6.75E-09
SSE	8.37E-06	1.63E-06	7.19E-07	4.01E-07	2.69E-07	1.15E-07	2.97E-08	1.05E-08	6.68E-09	4.78E-09
S	7.63E-06	1.62E-06	7.82E-07	4.49E-07	3.06E-07	1.41E-07	3.84E-08	1.31E-08	8.28E-09	5.90E-09
SSW	8.40E-06	1.69E-06	7.75E-07	4.37E-07	2.88E-07	1.19E-07	3.04E-08	1.15E-08	7.26E-09	5.16E-09
SW	6.59E-06	1.33E-06	6.25E-07	3.55E-07	2.36E-07	1.02E-07	2.56E-08	8.46E-09	5.27E-09	3.69E-09
WSW	3.76E-06	7.32E-07	3.40E-07	1.99E-07	1.36E-07	6.39E-08	1.98E-08	7.37E-09	3.75E-09	2.04E-09
W	1.86E-06	3.54E-07	1.52E-07	8.31E-08	5.44E-08	2.23E-08	5.99E-09	2.41E-09	1.49E-09	1.03E-09
WNW	1.19E-06	2.17E-07	8.67E-08	4.53E-08	2.88E-08	1.05E-08	2.81E-09	1.31E-09	8.06E-10	5.54E-10
NW	2.11E-06	3.91E-07	1.56E-07	7.99E-08	5.06E-08	1.82E-08	4.80E-09	2.27E-09	1.40E-09	9.71E-10
NNW	2.28E-06	4.32E-07	1.82E-07	9.65E-08	6.08E-08	2.12E-08	5.27E-09	2.49E-09	1.54E-09	1.07E-09

TABLE 3-5

2011 SSES Annual Relative Concentrations - 2.26-Day Decay, Undepleted X/Q (sec/m^3)

	Miles									
Direction From	0 - 1	1 - 2	2 - 3	3 - 4	4 - 5	5 - 10	10 - 20	20 - 30	30 - 40	40 - 50
N	4.38E-06	8.25E-07	3.40E-07	1.78E-07	1.13E-07	4.13E-08	1.09E-08	5.01E-09	3.00E-09	2.02E-09
NNE	8.07E-06	1.64E-06	7.27E-07	3.86E-07	2.47E-07	8.98E-08	2.36E-08	1.10E-08	6.65E-09	4.52E-09
NE	1.59E-05	2.96E-06	1.33E-06	7.48E-07	4.91E-07	1.89E-07	5.44E-08	2.57E-08	1.55E-08	1.06E-08
ENE	4.32E-05	8.06E-06	3.89E-06	2.27E-06	1.50E-06	5.83E-07	1.61E-07	7.37E-08	4.50E-08	3.11E-08
E	2.02E-05	3.65E-06	1.60E-06	8.94E-07	5.93E-07	2.35E-07	7.05E-08	3.32E-08	2.00E-08	1.36E-08
ESE	1.03E-05	1.97E-06	8.81E-07	4.88E-07	3.21E-07	1.27E-07	3.32E-08	1.35E-08	8.05E-09	5.41E-09
SE	1.16E-05	2.26E-06	1.03E-06	5.75E-07	3.79E-07	1.52E-07	3.61E-08	1.25E-08	7.43E-09	5.01E-09
SSE	8.35E-06	1.62E-06	7.09E-07	3.93E-07	2.62E-07	1.10E-07	2.72E-08	9.12E-09	5.46E-09	3.69E-09
S	7.62E-06	1.61E-06	7.73E-07	4.42E-07	3.00E-07	1.36E-07	3.57E-08	1.16E-08	7.00E-09	4.75E-09
SSW	8.39E-06	1.68E-06	7.68E-07	4.31E-07	2.83E-07	1.15E-07	2.87E-08	1.04E-08	6.31E-09	4.30E-09
SW	6.58E-06	1.33E-06	6.20E-07	3.51E-07	2.33E-07	9.95E-08	2.44E-08	7.80E-09	4.71E-09	3.19E-09
WSW	3.75E-06	7.29E-07	3.38E-07	1.97E-07	1.34E-07	6.26E-08	1.90E-08	6.85E-09	3.39E-09	1.79E-09
W	1.85E-06	3.52E-07	1.51E-07	8.21E-08	5.36E-08	2.17E-08	5.68E-09	2.20E-09	1.31E-09	8.81E-10
WNW	1.19E-06	2.16E-07	8.61E-08	4.49E-08	2.84E-08	1.03E-08	2.69E-09	1.22E-09	7.24E-10	4.83E-10
NW	2.11E-06	3.90E-07	1.55E-07	7.91E-08	5.00E-08	1.78E-08	4.59E-09	2.10E-09	1.26E-09	8.46E-10
NNW	2.28E-06	4.30E-07	1.81E-07	9.56E-08	6.00E-08	2.07E-08	5.05E-09	2.32E-09	1.39E-09	9.41E-10

TABLE 3-6

2011 SSES Annual Relative Concentrations - 8-Day Decay, Depleted X/Q (sec/m^3)

	Miles									
Direction From	0 - 1	1 - 2	2 - 3	3 - 4	4 - 5	5 - 10	10 - 20	20 - 30	30 - 40	40 - 50
N	4.01E-06	7.03E-07	2.77E-07	1.40E-07	8.65E-08	2.96E-08	7.11E-09	2.98E-09	1.67E-09	1.06E-09
NNE	7.39E-06	1.40E-06	5.94E-07	3.03E-07	1.89E-07	6.45E-08	1.55E-08	6.61E-09	3.74E-09	2.41E-09
NE	1.45E-05	2.53E-06	1.09E-06	5.90E-07	3.76E-07	1.37E-07	3.62E-08	1.57E-08	8.99E-09	5.88E-09
ENE	3.96E-05	6.88E-06	3.19E-06	1.79E-06	1.15E-06	4.22E-07	1.08E-07	4.52E-08	2.61E-08	1.73E-08
E	1.85E-05	3.12E-06	1.31E-06	7.07E-07	4.56E-07	1.71E-07	4.75E-08	2.08E-08	1.19E-08	7.81E-09
ESE	9.41E-06	1.69E-06	7.24E-07	3.86E-07	2.48E-07	9.23E-08	2.24E-08	8.50E-09	4.83E-09	3.14E-09
SE	1.06E-05	1.93E-06	8.41E-07	4.55E-07	2.92E-07	1.10E-07	2.43E-08	7.75E-09	4.40E-09	2.85E-09
SSE	7.64E-06	1.38E-06	5.81E-07	3.10E-07	2.01E-07	7.94E-08	1.81E-08	5.59E-09	3.16E-09	2.04E-09
S	6.97E-06	1.37E-06	6.32E-07	3.48E-07	2.29E-07	9.77E-08	2.36E-08	6.99E-09	3.95E-09	2.55E-09
SSW	7.68E-06	1.43E-06	6.27E-07	3.38E-07	2.16E-07	8.24E-08	1.87E-08	6.17E-09	3.49E-09	2.25E-09
SW	6.02E-06	1.13E-06	5.06E-07	2.75E-07	1.77E-07	7.10E-08	1.58E-08	4.57E-09	2.56E-09	1.63E-09
WSW	3.43E-06	6.20E-07	2.75E-07	1.55E-07	1.02E-07	4.46E-08	1.23E-08	3.99E-09	1.82E-09	9.02E-10
W	1.70E-06	3.00E-07	1.23E-07	6.44E-08	4.08E-08	1.55E-08	3.69E-09	1.30E-09	7.19E-10	4.53E-10
WNW	1.09E-06	1.84E-07	7.02E-08	3.51E-08	2.16E-08	7.32E-09	1.74E-09	7.11E-10	3.91E-10	2.45E-10
NW	1.93E-06	3.31E-07	1.27E-07	6.19E-08	3.80E-08	1.27E-08	2.97E-09	1.23E-09	6.80E-10	4.29E-10
NNW	2.08E-06	3.66E-07	1.47E-07	7.48E-08	4.56E-08	1.48E-08	3.26E-09	1.35E-09	7.51E-10	4.75E-10

TABLE 3-7

2011 SSES Annual Relative Concentrations - D/Q (m^{-2})

	Miles									
Direction From	0 - 1	1 - 2	2 - 3	3 - 4	4 - 5	5 - 10	10 - 20	20 - 30	30 - 40	40 - 50
N	2.59E-08	3.82E-09	1.57E-09	7.43E-10	4.39E-10	1.39E-10	3.33E-11	1.23E-11	6.54E-12	4.11E-12
NNE	3.35E-08	5.18E-09	2.25E-09	1.07E-09	6.30E-10	1.96E-10	4.57E-11	1.68E-11	8.99E-12	5.65E-12
NE	4.15E-08	6.26E-09	2.68E-09	1.30E-09	7.69E-10	2.48E-10	6.07E-11	2.23E-11	1.19E-11	7.49E-12
ENE	7.38E-08	1.15E-08	5.10E-09	2.50E-09	1.48E-09	4.67E-10	1.06E-10	3.73E-11	1.99E-11	1.25E-11
E	3.42E-08	4.99E-09	2.03E-09	9.71E-10	5.80E-10	1.91E-10	4.84E-11	1.78E-11	9.51E-12	5.97E-12
ESE	2.16E-08	3.27E-09	1.39E-09	6.73E-10	4.02E-10	1.33E-10	3.03E-11	9.78E-12	5.22E-12	3.28E-12
SE	2.64E-08	4.01E-09	1.75E-09	8.65E-10	5.20E-10	1.76E-10	3.65E-11	1.00E-11	5.34E-12	3.35E-12
SSE	2.53E-08	3.78E-09	1.61E-09	7.95E-10	4.84E-10	1.73E-10	3.80E-11	1.01E-11	5.40E-12	3.39E-12
S	3.04E-08	4.87E-09	2.29E-09	1.18E-09	7.32E-10	2.84E-10	6.62E-11	1.70E-11	9.06E-12	5.69E-12
SSW	3.90E-08	5.96E-09	2.67E-09	1.35E-09	8.19E-10	2.86E-10	6.35E-11	1.81E-11	9.67E-12	6.08E-12
SW	4.49E-08	7.13E-09	3.36E-09	1.74E-09	1.07E-09	4.03E-10	9.11E-11	2.32E-11	1.24E-11	7.78E-12
WSW	2.95E-08	4.55E-09	2.12E-09	1.14E-09	7.23E-10	2.98E-10	8.39E-11	2.43E-11	1.06E-11	5.21E-12
W	1.38E-08	2.07E-09	8.94E-10	4.46E-10	2.72E-10	9.73E-11	2.37E-11	7.44E-12	3.97E-12	2.49E-12
WNW	9.08E-09	1.31E-09	5.28E-10	2.52E-10	1.50E-10	4.85E-11	1.20E-11	4.41E-12	2.36E-12	1.48E-12
NW	1.79E-08	2.62E-09	1.05E-09	4.88E-10	2.89E-10	9.16E-11	2.20E-11	8.09E-12	4.32E-12	2.71E-12
NNW	1.85E-08	2.74E-09	1.16E-09	5.60E-10	3.28E-10	1.00E-10	2.25E-11	8.28E-12	4.42E-12	2.78E-12

TABLE 3-8

2011 ATMOSPHERIC DISPERSION ESTIMATES FOR RETDAS INPUT AT SELECTED LOCATIONS

AFFECTED SECTOR	LOCATION	MILES	X/Q [1]	X/Q DEC [2]	X/Q DEC+ DEP [3]	DEPOSITION [4]
11/SW	Maximum (X/Q) Site Boundary	0.61	1.18E-05	1.17E-05	1.06E-05	2.95E-08
9/S	Closest (X/Q) Site Boundary	0.38	6.66E-06	6.65E-06	6.20 E-06	4.18E-08
12 / WSW	Maximum (X/Q) Residence	1.3	1.01E-05	1.00E-05	8.65E-06	1.46E-08
16 / NNW	Maximum (D/Q) Residence	0.6	6.37E-06	6.35E-06	5.75E-06	1.84E-08
12 / WSW	Maximum (D/Q) Garden	1.3	1.01E-05	1.00E-05	8.65E-06	1.46E-08
12 / WSW	Maximum (D/Q) Dairy	1.7	6.82E-06	6.75E-06	5.70E-06	9.41E-09
12 / WSW	Maximum (D/Q) Meat Producer	1.7	6.82E-06	6.75E-06	5.70E-06	9.41E-09
3 / NE	Riverlands / EIC	0.7	4.04E-06	4.03E-06	3.60E-06	2.56E-08
12 / WSW	Tower's Club	0.5	4.33E-05	4.32E-05	3.95E-05	7.37E-08

NEAREST RESIDENCE WITHIN A 5-MILE RADIUS BY SECTOR

SECTOR NUMBER	AFFECTED SECTOR	NAME	MILES	X/Q	X/Q DEC	X/Q DEC +DEP	DEPOSITION
1	N	H. Burd	1.3	1.99E-06	1.97E-06	1.70E-06	6.18E-09
2	NNE	E. Ashbridge III	1	3.06E-06	3.05E-06	2.67E-06	1.19E-08
3	NE	W. Tuggle	0.9	2.80E-06	2.79E-06	2.46E-06	1.68E-08
4	ENE	R. Dickosky	2.1	4.42E-07	4.39E-07	3.63E-07	2.76E-09
5	E	L.Kozlowski/M. Witts	1.4	3.93E-07	3.91E-07	3.34E-07	2.33E-09
6	ESE	R. Panetta	0.5	1.19E-06	1.19E-06	1.08E-06	9.06E-09
7	SE	J. Futoma	0.5	2.11E-06	2.10E-06	1.92E-06	1.79E-08
8	SSE	M. Naunczek	0.6	1.73E-06	1.72E-06	1.56E-06	1.34E-08
9	S	S. Slusser	1	1.54E-06	1.53E-06	1.34E-06	7.75E-09
10	SSW	S. Molnar	0.9	3.45E-06	3.44E-06	3.03E-06	1.23E-08
11	SW	F. Michael	1.5	2.99E-06	2.96E-06	2.53E-06	6.27E-09
12	WSW	F. Michael	1.3	1.01E-06	1.00E-06	8.65E-06	1.46E-08
13	W	F. Hummel	1.2	5.22E-06	5.17E-06	4.48E-06	7.38E-09
14	WNW	R. Orlando	0.8	5.10E-06	5.06E-06	4.51E-06	9.63E-09
15	NW	B. Kramer	0.7	7.06E-06	7.02E-06	6.30E-06	1.48E-08
16	NNW	G. John	0.6	6.37E-06	6.35E-06	5.75E-06	1.84E-08

NEAREST GARDEN WITHIN A 5-MILE RADIUS BY SECTOR

SECTOR NUMBER	AFFECTED SECTOR	NAME	MILES	X/Q	X/Q DEC	X/Q DEC +DEP	DEPOSITION
1	N	B. J. Wojcik	3.2	5.20E-07	5.12E-07	4.07E-07	1.40E-09
2	NNE	R. Chapin	2.3	8.80E-07	8.72E-07	7.17E-07	3.05E-09
3	NE	M. Welch	2.7	5.49E-07	5.44E-07	4.40E-07	2.89E-09
4	ENE	G. Dennis	2.4	3.62E-07	3.59E-07	2.94E-07	2.26E-09
5	E	W. Daily	1.8	2.62E-07	2.60E-07	2.18E-07	1.53E-09
6	ESE	B. Smith	3.1	5.72E-08	5.67E-08	4.51E-08	3.29E-10
7	SE	T. Scholl	0.6	1.59E-06	1.59E-06	1.44E-06	1.30E-08
8	SSE	H. Roinick	2.9	1.38E-07	1.36E-07	1.09E-07	8.40E-10
9	S	T. Stemrich	2.7	2.96E-07	2.93E-07	2.37E-07	1.32E-09
10	SSW	S. Bodnar	1.2	2.28E-06	2.26E-06	1.96E-06	7.58E-09
11	SW	R. Broody	1.9	2.07E-06	2.05E-06	1.71E-06	4.23E-09
12	WSW	F. Michael	1.3	1.01E-05	1.00E-05	8.65E-06	1.46E-08
13	W	F. Hummel	1.2	5.22E-06	5.17E-06	4.48E-06	7.38E-09
14	WNW	P. Moskaluk	1.3	2.47E-06	2.45E-06	2.11E-06	4.18E-09
15	NW	D. Goff	1.8	1.73E-06	1.71E-06	1.44E-06	2.99E-09
16	NNW	P. Culver	4	3.24E-07	3.17E-07	2.46E-07	6.10E-10

TABLE 3-8
(continued)

NEAREST ANIMAL RAISED FOR MEAT CONSUMPTION WITHIN A 5-MILE RADIUS BY SECTOR

SECTOR NUMBER	AFFECTED SECTOR	NAME	MILES	X/Q	X/Q DEC	X/Q DEC+DEP	DEPOSITION
2	NNE	R.Chapin	2.3	8.80E-07	8.72E-07	7.17E-07	3.05E-09
4	ENE	G.Dennis	2.4	3.62E-07	3.59E-07	2.94E-07	2.26E-09
5	E	W. Daily	1.8	2.62E-07	2.60E-07	2.18E-07	1.53E-09
6	ESE	B. Smith	3.1	5.72E-08	5.67E-08	4.51E-08	3.29E-10
10	SSW	K. & C. Drasher	3.5	3.92E-07	3.85E-07	3.03E-07	1.07E-09
12	WSW	T. & M Berger	1.7	6.82E-06	6.75E-06	5.70E-06	9.41E-09

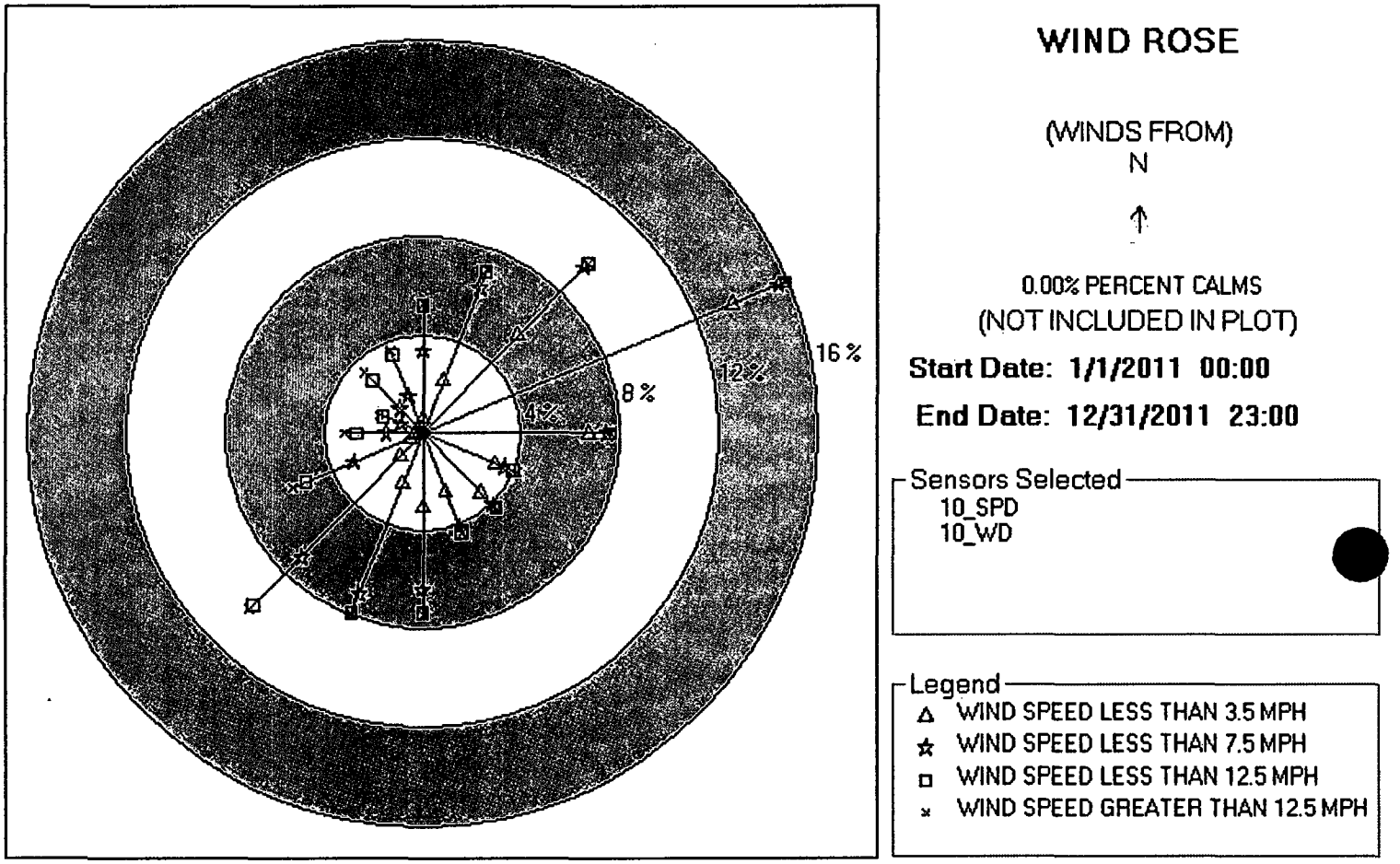
ALL DAIRY LOCATIONS

SECTOR NUMBER	AFFECTED SECTOR	NAME	MILES	X/Q	X/Q DEC	X/Q DEC+DEP	DEPOSITION
5	E	W.Bloss	4.5	5.44E-08	5.85E-08	4.08E-08	2.72E-10
10	SSW	K. & C. Drasher	3.5	3.92E-07	3.85E-07	3.03E-07	1.07E-09
10	SSW	K.Davis	14.01	2.87E-08	2.69E-08	1.79E-08	5.28E-11
12	WSW	T. & M. Berger	1.7	6.82E-06	6.75E-06	5.70E-06	9.41E-09
13	W	J. Dent	5	5.07E-07	4.90E-07	3.72E-07	4.61E-10

1	X/Q	RELATIVE CONCENTRATION (SEC/M^3)
2	X/Q DEC	DECAYED AND UNDEPLETED, HALF-LIFE 2.26 DAYS (SEC/M^3)
3	X/Q DEC+DEP	DECAYED AND DEPLETED, HALF-LIFE 8 DAYS (SEC/M^3)
4	DEPOSITION	RELATIVE DEPOSITION RATE (1/M^2)

FIGURE 3-1

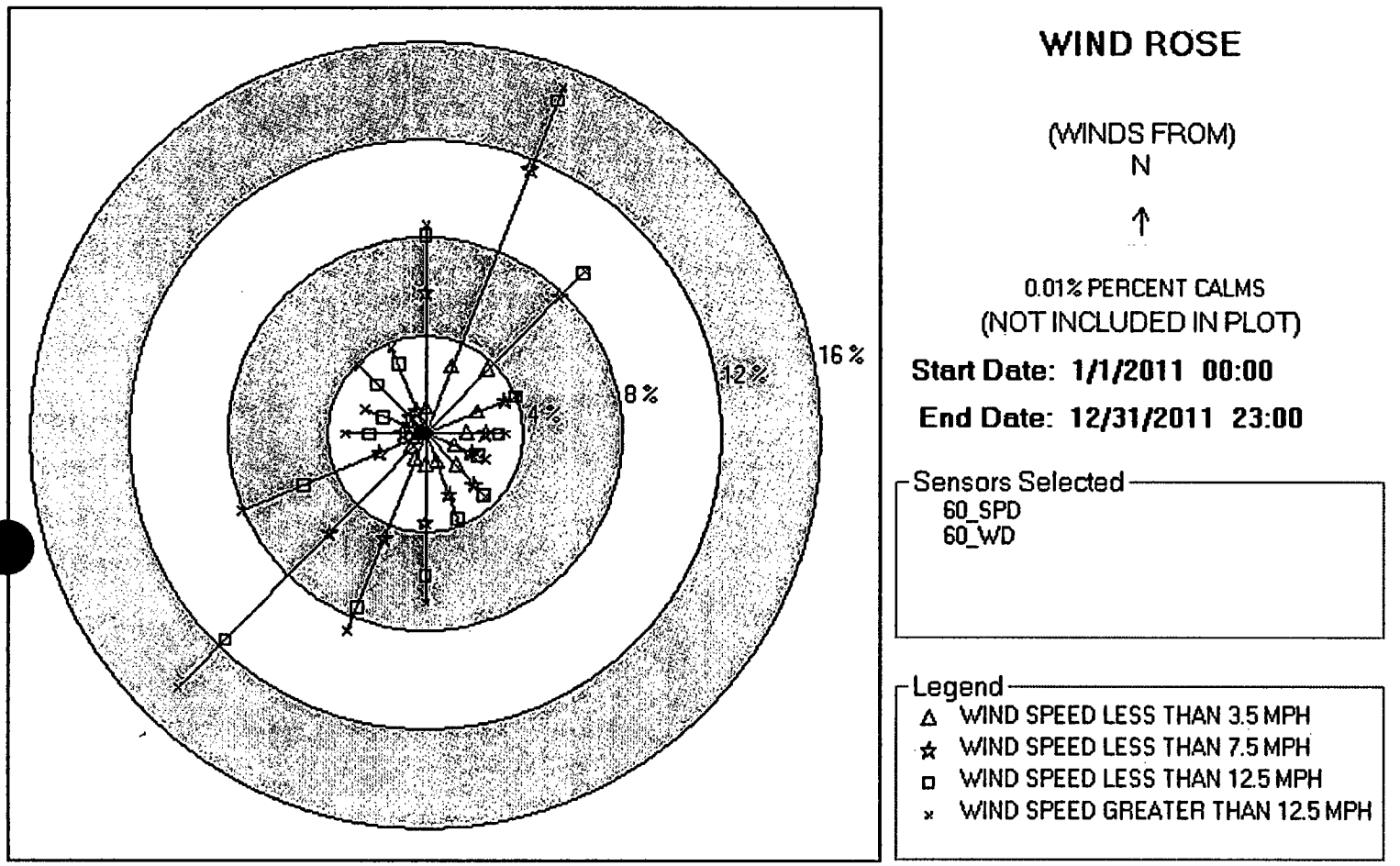
2011 ANNUAL WIND ROSE 10M LEVEL – PRIMARY TOWER



This wind rose displays the frequency of hourly average wind direction from a given sector. In 2011, the predominant wind direction occurred 15.8 % of the time from the ENE sector. The average wind speed was 4.8 mph and the average wind speed for the predominant sector (ENE) was 2.8 mph. The sector with the highest average wind speed was NW (8.7 mph).

FIGURE 3-2

2011 ANNUAL WIND ROSE 60M LEVEL – PRIMARY TOWER

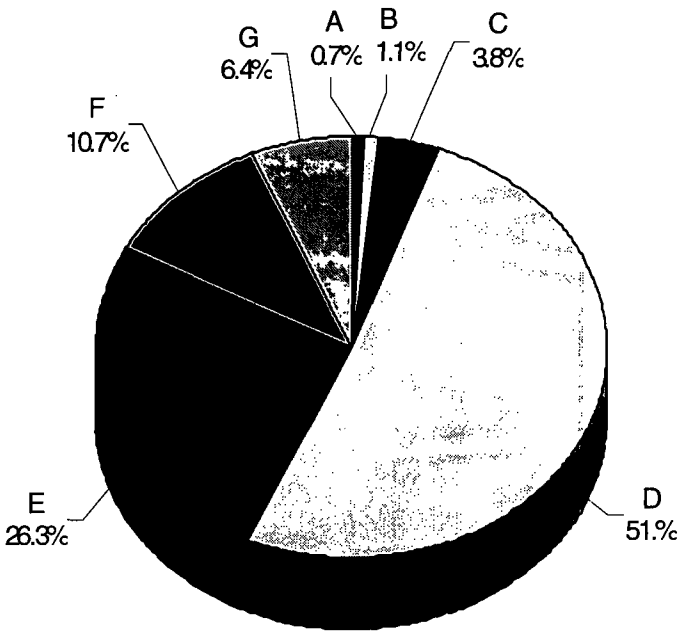


This wind rose displays the frequency of hourly average wind direction from a given sector. In 2011, the predominant wind direction occurred 14.8 % of the time from the NNE sector. The average wind speed was 7.5 mph and the average wind speed for the predominant sector (NNE) was 5.9 mph. The sector with the highest average wind speed was WSW (10.8 mph.).

FIGURE 3-3

PASQUIL STABILITY CLASS PREVALENCES DATA
Period: 2011

Joint Frequency Distributions at 10 Meters
Wind Speed and Direction 10M vs. Delta Temperature 60-10M
(Based on 8,593 Valid Hours)



SECTION 4

DOSE MEASUREMENTS AND ASSESSMENTS

Radiological Impact on Man

Sampling and analysis of airborne and waterborne effluents were performed in accordance with the frequencies, types of analysis, and Lower Limit of Detection (LLD) outlined in the PPL Susquehanna, LLC Technical Requirements Manual.

Radioactive material was detected in some of the airborne and waterborne effluent samples analyzed. Dose calculations using measured and calculated effluent activity levels, meteorological data from the current reporting period and average river flow dilution factors resulted in estimated doses to individuals at levels below 10 CFR 20 and 10 CFR 50, Appendix I limits. Direct radiation resulting from plant operation (reported in the 2011 Annual Radiological Environmental Operating Report) contributed a maximum of 6.68E-1 mrem (measured at TLD Location 9S2 and based on an occupancy time by a member of the public of 20 hours per quarter) at the Protected Area Boundary south of the plant. Based on airborne effluent sample data, the maximum organ (including thyroid)/total body dose is 4.52E-1 mrem (CHILD, LUNG Table 4-4). The maximum organ/total body dose from all liquid effluent is 6.00E-3 mrem (TEEN, LIVER Table 4-2). Conservatively adding the maximum organ/total body dose from liquid and gaseous effluent and the maximum total body dose determined from direct radiation results in a dose of 1.13 mrem, which is 4.5% of the 40CFR190 limit of 25 mrem to total body/organ (except thyroid) and 1.5% of the 40CFR190 limit of 75 mrem to the thyroid.

Doses to a maximally exposed member of the public from waterborne effluents are calculated for fish ingestion and shoreline exposure at the plant outfall, and drinking water ingestion at Danville, PA. Site specific parameters used in the calculations for the Danville receiver, specific for actual average blowdown and river level for the entire year are shown in Table 4-1.

TABLE 4-1

SITE-SPECIFIC PARAMETERS USED FOR RETDAS CALCULATIONS (DANVILLE RECEIVER) FOR 2011

PARAMETER	ENTIRE YEAR
Cooling Tower Blowdown (CFS)	25.4
Average Net River Level (ft.)	9.0
Dilution Factor at Danville[1]	1071.8
Transit time to Danville (hr.)[1]	14.7

[1]From ODCM-QA-005, Att. E

Summaries of maximum individual doses resulting from airborne and waterborne radioactive effluent releases from each unit are given in Table 4-2. Meteorological data from Section 3 were used to calculate the dose from airborne effluents.

The Radioactive Effluent Release Report includes an assessment of the radiation dose from radioactive effluents to members of the public within the site boundary. Within the Site Boundary there are several areas frequented by members of the public. There are no significant exposure pathways from waterborne effluents in these areas. Doses from airborne effluent are calculated for members of the public for the following locations: Riverlands Energy Information Center, the Towers Club, and residence with the maximum X/Q value; the garden, dairy and meat producing farm with the maximum D/Q value; and the site boundary with the maximum X/Q value. Summaries of the calculated maximum doses within the site boundary and selected locations beyond the site boundary resulting from airborne effluents are presented in Table 4-4. The above referenced locations are shown on Figure 4-1.

In the area comprising the Riverlands recreation area, which surrounds the Energy Information Center, three pathways of radiation exposure can be identified: plume, ground, and inhalation. There are no significant exposure pathways from waterborne effluents in this area. There are approximately 100,000 visitors to the Riverlands/Energy Information Center complex each year. For dose calculations, it is assumed the visitor stays in the area for one hour. The calculated dose rate and collective dose for visitors to the Riverlands/Energy Information Center during 2011 are shown on Table 4-3.

Use of the RETDAS code yields calculated doses for the Riverlands area for the report period. These doses assume an occupancy factor of 100% for a member of the public during 2011. These calculated dose values are shown on Table 4-4.

In Regulatory Guide 1.21, Revision 2, "Measuring, Evaluating, and Reporting Radioactive Material in Liquid and Gaseous Effluents and Solid Waste", the NRC has recommended that U.S. nuclear power plants evaluate whether Carbon-14 (C-14) is a "principal radionuclide", and if so, report the amount of C-14 released. Radioactive effluent releases of C-14 have not increased but the decline in releases of other radionuclides has resulted in C-14 possibly becoming more prominent, specifically in airborne effluents. This regulatory guidance has led to an industry initiative to evaluate and report C-14 in the Annual Radioactive Effluent Release Report.

Information for C-14 dose impact is included as supplemental information in this report. Reportable values for dose impact do not include C-14 contribution. C-14, with a half-life of 5730 years, is a naturally occurring isotope of carbon produced by cosmic ray interactions in the atmosphere. Nuclear weapons testing in the 1950s and 1960s significantly increased the amount of C-14 in the atmosphere. C-14 is

also produced in commercial nuclear reactors, but the amounts produced are much less than those produced naturally or from weapons testing.

In December 2010 the Electric Power Research Institute (EPRI) published Report 1021106, "Estimation of Carbon-14 in Nuclear Power Plant Gaseous Effluents", which provides conservative technical guidance to support the calculation of C-14 released in radioactive effluents. The calculation of C-14 discharged from the Susquehanna station and resultant offsite dose during 2011 is based upon the methodology outlined in the referenced EPRI report. In a BWR the majority of C-14 is generated in the reactor core by neutron activation of reactor coolant, specifically $^{17}O(n,\alpha)\ ^{14}C$. Thus C-14 generation is directly proportional to reactor power. As documented in the EPRI report, approximately 99% of the C-14 produced in the reactor core is discharged as gaseous effluent (primarily as CO_2) through the offgas system and released from the Turbine Building vents. The remaining 1% is released in the form of solid radwaste. There is minimal (<1%) C-14 released in the liquid effluent pathway. Based on the EPRI methodology, approximately 23 Curies of C-14 were released in gaseous effluents in 2011.

The airborne effluent pathway with the highest offsite dose potential (for C-14 releases) is the vegetation ingestion pathway. The maximum expected annual dose from C-14 released from Susquehanna Unit-1 (1.83E-1 mrem) and Unit-2 (1.55E-1 mrem) has been calculated based on methodology in Regulatory Guide 1.109 and includes site specific parameters (e.g., nearest garden with highest X/Q value, producing both broad leaf and non-broad leaf vegetation). The maximum organ dose from airborne effluent C-14 released from the Susquehanna station in 2011 is well below the 10CFR50, Appendix I, ALARA design objective (i.e., 15 mrem/yr per unit). The annual dose to the maximally exposed individual from all gaseous releases of C-14 (calculated by the above referenced methodology) is 3.38E-1 mrem to the critical organ (bone) and 6.74E-2 mrem to the total body.

Conservatively adding the maximum dose (calculated based on liquid and gaseous effluent sample results combined with direct radiation results) referenced on page 4-2 to the maximum dose due to the calculated release of C-14 (3.38E-1 mrem, CHILD, BONE) bounds the dose that any member of the public receives from station operations to 1.47 mrem, which is 6% of the 40CFR190 limit of 25 mrem to total body/organ (except thyroid) and 2% of the 40CFR190 limit of 75 mrem to the thyroid.

TABLE 4-2

SUMMARY OF MAXIMUM INDIVIDUAL DOSES TO MEMBERS OF THE PUBLIC [4]

DATA PERIOD: 1/1/11 TO 12/31/11

UNIT	EFFLUENT	AGE GROUP	APPLICABLE ORGAN	ESTIMATED MAXIMUM DOSE (MREM/MRAD)	LOCATION		PERCENT OF LIMIT	LIMIT (MREM/ MRAD)[2]
					DIST (MILES)	AFFECTED SECTOR		
1	Liquid[1]	Teen	Total Body	2.12E-03	(3)		0.07	3
1	Liquid[1]	Teen	Liver	3.00E-03	(3)		0.03	10
1	Noble Gas	N/A	Air Dose (Gamma-MRAD)	0	0.5	WSW	0	10
1	Noble Gas	N/A	Air Dose (Beta-MRAD)	0	0.5	WSW	0	20
1	Airborne Iodine, Tritium and Particulates	Child	Liver	2.73E-01	0.5	WSW	1.8	15
2	Liquid[1]	Teen	Total Body	2.12E-03	(3)		0.07	3
2	Liquid[1]	Teen	Liver	3.00E-03	(3)		0.03	10
2	Noble Gas	N/A	Air Dose (Gamma-MRAD)	0	0.5	WSW	0	10
2	Noble Gas	N/A	Air Dose (Beta-MRAD)	0	0.5	WSW	0	20
2	Airborne Iodine, Tritium and Particulates	Child	Lung	1.79E-01	0.5	WSW	1.2	15

[1]Estimated dose is based on a site total activity release equally divided between Unit 1 and Unit 2.

[2]10 CFR 50, Appendix I limits are in terms of mrad or mrem/reactor-year for airborne and waterborne effluent from each unit.

[3]Doses from liquid effluent are estimated from fish ingestion and shoreline exposure at the site outfall and from the drinking water pathway at Danville, PA.

[4]Dose due to calculated release of C-14 not included.

TABLE 4-3

CALCULATED COLLECTIVE DOSES TO MEMBERS OF THE PUBLIC WITHIN THE RIVERLANDS/ENERGY INFORMATION CENTER COMPLEX
DATA PERIOD: 1/1/11 TO 12/31/11

EFFLUENT	AGE GROUP	APPLICABLE ORGAN	DOSE RATE[1] (MREM/HR)	COLLECTIVE DOSE[2] (PERSON-REM)
Noble Gas	N/A	Total Body	0	0
Noble Gas	N/A	Skin	0	0
Iodine, Tritium and Particulates[3]	Child	GI-LLI	4.93E-06	4.93E-04

[1]Estimated dose and dose rate is based on annual site total activity release.

[2]Collective dose is based on 100,000 person-hours.

[3] Dose due to calculated release of C-14 not included.

TABLE 4-4

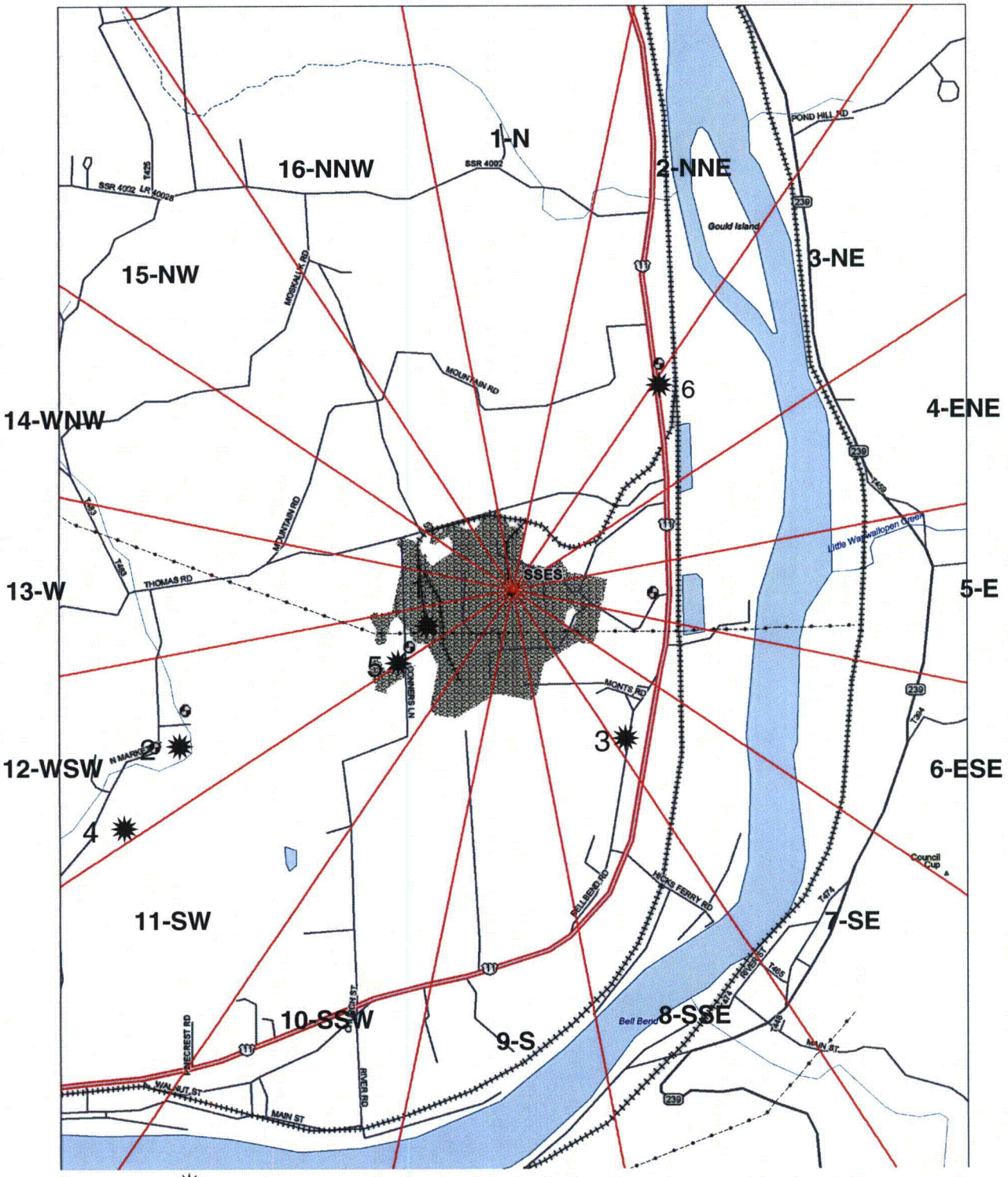
SUMMARY OF MAXIMUM INDIVIDUAL DOSES FROM AIRBORNE EFFLUENT

LOCATION	PATHWAY	MAXIMUM TOTAL BODY DOSE (MREM)		MAXIMUM ORGAN DOSE (MREM)		MAXIMUM THYROID DOSE (MREM)	
1. Maximum site boundary X/Q	Total (All)	1.24E-01	(CHILD)	1.24E-01	(CHILD, LUNG)	1.23E-01	(CHILD)
2. Maximum X/Q Residence Maximum D/Q Garden	Total (All)	1.05E-01	(CHILD)	1.05E-01	(CHILD, LUNG)	1.05E-01	(CHILD)
3. Maximum D/Q Dairy + Maximum D/Q Meat	Total (All)	7.10E-02	(CHILD)	7.11E-02	(CHILD, LUNG)	7.10E-02	(CHILD)
4. Tower's Club	Total (All)	4.52E-01	(CHILD)	4.52E-01	(CHILD, LUNG)	4.51E-01	(CHILD)
5. Riverland/EIC	Total (All)	4.31E-02	(CHILD)	4.32E-02	(CHILD, GI-LLI)	4.30E-02	(CHILD)

Note: The doses shown above are based on 100% occupancy at the indicated locations. They are based on a composite of all pathways resulting in a total dose to the maximally exposed individual due to airborne effluents from both Unit-1 and Unit-2 operations. Dose due to calculated release of C-14 not included.

FIGURE 4-1

AIRBORNE-DOSE CALCULATION LOCATIONS



✸ Indicates airborne-dose calculation location per Table 4-4

SECTION 5

CHANGES TO THE OFFSITE DOSE CALCULATION MANUAL (ODCM), TECHNICAL REQUIREMENTS MANUAL (TRM) AND THE SOLID RADIOACTIVE WASTE PROCESS CONTROL PROGRAM

CHANGES TO THE OFFSITE DOSE CALCULATION MANUAL

The PPL Susquehanna, LLC ODCM consists of nine (9) individual procedures.

ODCM-QA-003, Effluent Monitor Setpoints, was revised in 2011. Revision 7 was issued on March 24, 2011. The revision incorporated setpoint guidance to support the current airborne effluent SPING (System Particulate, Iodine and Noble Gas) units as well as the VERMS (Vent Effluent Radiation Monitoring System) units.

ODCM-QA-008, Radiological Environmental Monitoring Program, was revised in 2011. Revision 14 was issued October 21, 2011. The revision: a) added a new groundwater sampling location; b) deleted three dairy farm locations which were no longer in operation and c) updated a note to clarify that some dairy farms may not participate in the REMP milk sampling program but are still listed in the ODCM since the exposure pathway exists.

CHANGES TO THE TECHNICAL REQUIREMENTS MANUAL

Section 3.11 and 3.6.1 of the Unit-1 and Unit-2 Technical Requirements Manual (TRM) by reference are part of the ODCM. The following limits and requirements are contained in Section 3.11: liquid and gaseous effluent dose limits, liquid and gaseous effluent treatment system operability criteria (based on effluent dose), liquid and gaseous effluent treatment system operability criteria and the conduct of the Radiological Environmental Monitoring Program. Section 3.6.1 contains requirements for venting or purging of primary containment.

There were no changes to TRM Sections 3.6.1 or 3.11 during 2011.

PROCESS CONTROL PROGRAM CHANGES

The following changes were made to the Process Control Program and implementing procedures during 2011. None of the changes reduce the overall conformance of the solidified waste product to existing criteria for solid wastes. All changes were reviewed and approved (as necessary) by the Plant Operations Review Committee (PORC) as documented on the attached summary of procedure changes. The following procedures were changed:

1. WM-RP-107, Transfer and Dewater A (B) RWCU Phase Separator

2. WM-RP-113, Transfer and Dewatering of Waste Mix Tanks

3. WM-RP-106, Transfer and Dewatering Bead Resin

4. MT-EO-051, Fuel Pool Cleanout – Operation of EnergySolutions Shielded Transfer Bell and Verification of No Free-Standing Water in FEXM High Integrity Container

5. CH-TP-055, Solid Radwaste 10CFR61 Correlation Factor Determination – Sample Collection and Preparation

6. WM-RP-104, Gross Dewatering

7. WM-RP-112, Dewatering to Waste Disposal Criteria

8. ME-0RF-172, Fuel Pool Cleanout – EnergySolutions Operating Guidelines for Use of Polyethlyene High Integrity Containers

NDAP-QA-0646 continues to fully implement the requirements and intent of the following:

1. Sections 11.4 and 13.5 of the FSAR
2. Section 3.7.4 of the Technical Requirements Manual
3. 10 CFR 20, 10 CFR 61, 10 CFR 71, 49 CFR 100-177, and 40 CFR 261

Compliance with all applicable regulatory requirements listed above continues to be met as the result of these changes to the program. These changes to the Process Control Program will not reduce the overall conformance of the solidified waste product to existing criteria for solid wastes.

PROCEDURE REVISION SUMMARY
WM-RP-107, TRANSFER AND DEWATER A (B) RWCU PHASE SEPARATOR

1. Change in Step 7.5.4.a to incorporate change in vendors procedure.

PROCEDURE REVISION SUMMARY
WM-RP-113, TRANSFER AND DEWATERING OF WASTE MIX TANKS

1. Change in Step 7.5.4.a to incorporate change in vendors procedure.

PROCEDURE REVISION SUMMARY
WM-RP-106, TRANSFER AND DEWATERING BEAD RESIN

1. Change in Step 7.5.4.a to incorporate change in vendors procedure.

PROCEDURE REVISION SUMMARY
MT-EO-051, FUEL POOL CLEANOUT-OPERATION OF ENERGYSOLUTIONS SHIELDED TRANSFER BELL AND VERIFICATION OF NO FREE STANDING WATER IN FEXM HIGH INTERGRITY CONTAINER

1. Changes reflect revisions made to EnergySolutions FP-OP-023, Rev. 9.
2. Made various administrative changes.
3. Added CAUTION before Step 8.2.1
4. Added checkboxes at Notes and Cautions

PROCEDURE REVISION SUMMARY
CH-TP-055, SOLID RADWASTE 10CFR61 CORRELATION FACTOR DETERMINATION – SAMPLE COLLECTION AND PREPARATION

1. Deleted PCAF 2007-1223 (Admin change). Reincorporated pertinent changes as below.
2. Change procedure format, owner and adherence level.
3. Minor typographical changes
4. Deleted specific waste type information and Reference NDAP-QA-0646 for information.
5. Changed volume to Grams on FORM CH-TP-055-1, and updated Waste Stream information.

6. Added clarification about performing isotopic analyses based on deadtime criteria in Section 7.1. Updated sample frequency and quantity requirements in Section 7.1

7. Updated requirement for saving remaining original composite until vendor results are evaluated.

8. Move multiple notes to above the step they expand and made others procedure steps as appropriate.

9. Add Radwaste Health Physicist to Recommended Reviews

10. Adjust sampling frequency from 9 months to 1 year per Health Physicist-Radwaste and added provision for Health Physicist-Radwaste to be able to change frequency.

11. Added step in records section allowing the continued use of previous revisions of the FORM that are in use.

12. Update references.

PROCEDURE REVISION SUMMARY
WM-RP-104, GROSS DEWATERING

1. Added note to clarify how to proceed following completion of Step 6.4.4.

PROCEDURE REVISION SUMMARY
WM-RP -112, DEWATERING TO WASTE DISPOSAL CRITERIA

1. Added note to clarify how to proceed following completion of Step 6.6.8.

PROCEDURE REVISION SUMMARY
ME-0RF -172, FUEL POOL CLEANOUT - ENERGYSOLUTIONS OPERATING GUIDELINES FOR USE OF POLYETHYLENE HIGH INTEGRITY CONTAINERS

1. Revise vendor name throughout procedure.

2. Revisions in accordance with EnergySolutions FO-AD-002, Revision 35 changes.

3. Add checkboxes to Notes and Cautions.

SECTION 6

MISCELLANEOUS TECHNICAL REQUIREMENTS MANUAL (TRM), FSAR, 40CFR190 AND NEI GROUNDWATER PROTECTION INITIATIVE REPORTING

1. TRM Action 3.11.1.4.F.2 requires the reporting of Liquid Radwaste Effluent Monitoring Instrumentation inoperability not corrected in a timely manner.

   The liquid radwaste discharge radiation monitor was declared inoperable at 0815 on 1/13/11 (requiring entry into TRO 3.11.1.4 Condition B) due to a leak in the detector canister assembly. Replacement parts were ordered to repair the leaking canister. The replacement parts were not available onsite until 1/26/11. TRO 3.11.1.4 Condition F was entered at 0815 on 1/27/11 due to exceeding the 14 day return to service requirement of TRO 3.11.1.4 Condition B. The liquid radwaste discharge radiation monitor detector canister leak was repaired and the monitor was declared operable at 1227 on 1/27/11.

   The liquid radwaste discharge radiation monitor was declared inoperable at 0543 on 10/15/11 (requiring entry into TRO 3.11.1.4 Condition B) due to a problem with circuit boards related to detector response. Multiple attempts were made to repair/replace the failed circuit boards. TRO 3.11.1.4 Condition F was entered at 0543 on 10/29/11 due to exceeding the 14 day return to service requirement of TRO 3.11.1.4 Condition B. The liquid radwaste discharge radiation monitor circuit board problem was corrected and the monitor was declared operable at 1411 on 11/5/11.

2. TRM Action 3.11.1.5.C.1 requires the reporting of Radioactive Liquid Process Effluent Monitoring Instrumentation inoperability not corrected in a timely manner.

   None to report for 2011.

3. TRM Action 3.11.2.6.K requires an explanation for Radioactive Gaseous Effluent Monitoring Instrumentation required actions and completion times not met.

   None to report for 2011.

4. TRM Action 3.11.4.1.F.2 requires reporting the cause of the unavailability of milk or fresh leafy vegetable samples and identify the new locations for obtaining replacements.

   None to report for 2011.

5. TRM Action 3.11.4.2.A requires reporting when land use census identifies a new location which yields a calculated dose or dose commitment greater than the values currently being calculated in Requirement 3.11.2.3 (Gaseous Effluent Dose due to Iodine, Tritium, and Radionuclides in Particulate Form).

   None to report for 2011.

6. TRM Action 3.11.4.2.B requires reporting when land use census identifies locations that yield a calculated dose or dose commitment (via the same exposure pathway) 20 percent greater than at a location from which samples are currently being obtained in accordance with Requirement 3.11.4.1 (Radiological Environmental Monitoring Program).

   None to report for 2011.

7. The limits outlined in 40CFR190.10 (Environmental Standards for the Uranium Fuel Cycle-Standards for Normal Operations) were not exceeded by station operations during 2011. Refer to Section 2 and Section 4 for specific values.

8. FSAR Section 11.6.11 requires the reporting of airborne radioactivity detected in the Low Level Radwaste Holding Facility.

   Only naturally occurring airborne radioactivity was detected above analysis MDC's in air samples from the Low Level Radwaste Holding Facility during 2011.

9. The PPL Susquehanna station has implemented an Action Plan in response to the NEI Initiative on Groundwater Protection. Part of the Action Plan includes the assessment of the current groundwater monitoring program. Groundwater is sampled and analyzed quarterly as part of the Radiological Environmental Monitoring Program (REMP). REMP groundwater sampling locations are defined in ODCM-QA-008 Attachment G. In August 2006, additional groundwater sampling was initiated at locations which are not listed in the ODCM. The additional locations are three manholes which collect water from a perimeter drain system. The perimeter drain system consists of perforated piping installed just above the footing along the exterior base of the vertical walls of the reactor, turbine and radwaste buildings. Outlined in Table 6-1 are the tritium analysis results from sampling of the perimeter drain system. No nuclear by-product gamma emitting radionuclides were identified above analysis MDC's for the perimeter drain samples in 2011. The tritium results reported in Table 6-1 did not exceed any Reporting Level thresholds in the PPL Susquehanna Technical Requirements Manual or any reporting criteria established in response to the NEI Groundwater Protection Initiative. Figure 6-1 is a trend graph of airborne and waterborne effluent tritium releases from the PPL Susquehanna Station starting in 1982.

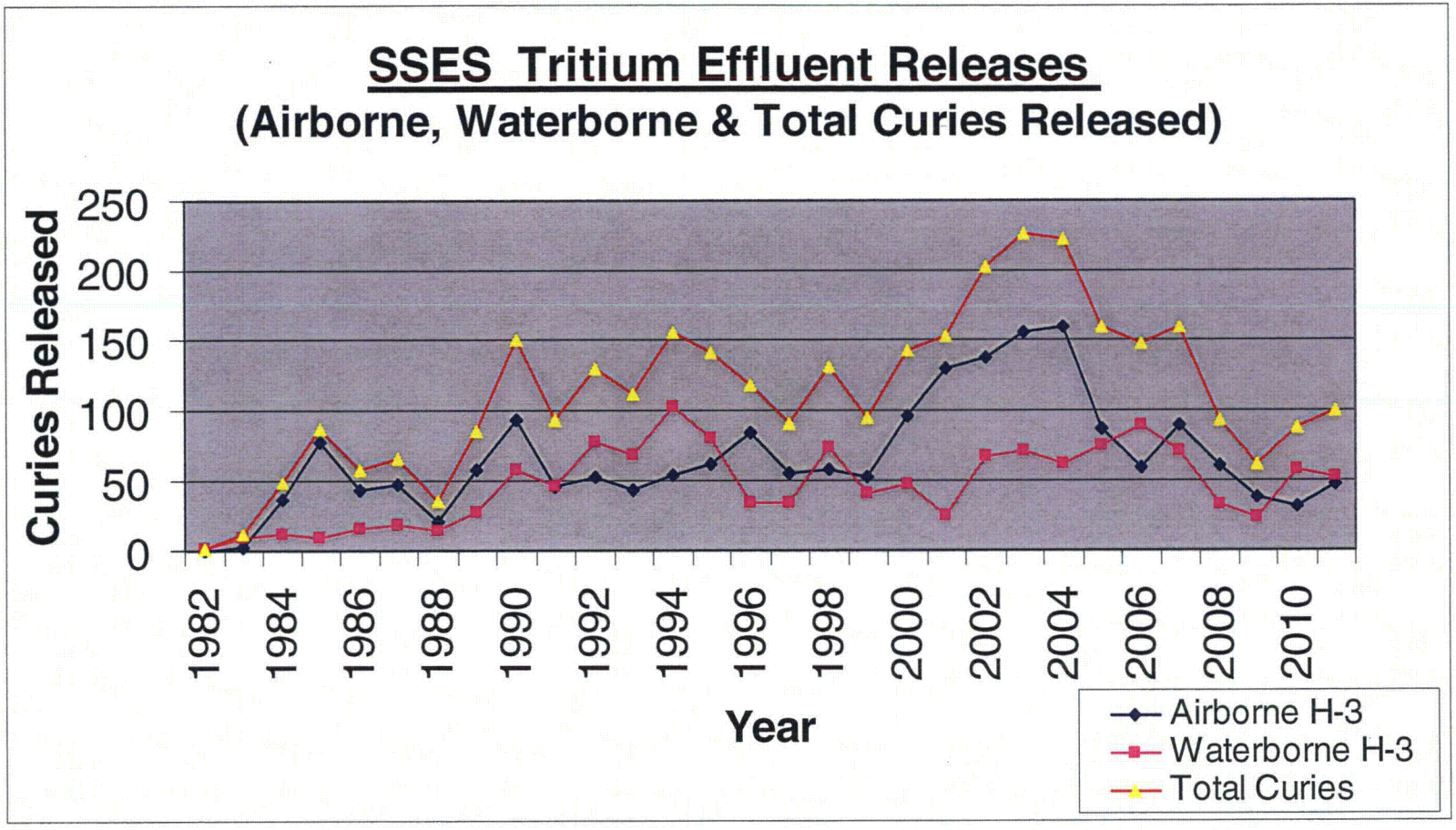
TABLE 6-1

NEI Ground Water Protection Initiative Reporting

Perimeter Drain Sampling Results: 2011

	Manhole FD-1 (7S9 - E of U2 CST)	Manhole FD-2 (16S3- NW corner of RW Bldg.)	Manhole FD-3 (9S3 - I/S RCA @ U2 HP Cont. Pt. Closet)
Date	Tritium (pCi/liter)	Tritium (pCi/liter)	Tritium (pCi/liter)
2/7/2011	223	318	417
5/16/2011	215	237	195
8/16/2011	152	261	210
11/14/2011	153	216	234

Figure 6-1


SSES Tritium Effluent Releases
(Airborne, Waterborne & Total Curies Released)
Curies Released
250
200
150
100
50
0
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year
Airborne H-3
Waterborne H-3
Total Curies

SECTION 7

CORRECTIONS TO PREVIOUS RADIOACTIVE EFFLUENT RELEASE REPORTS

CORRECTIONS TO PREVIOUS
RADIOACTIVE EFFLUENT RELEASE REPORTS

No corrections to previous Radioactive Effluent Release Reports are submitted for this report period.

SECTION 8

EFFLUENT FROM SYSTEMS CLASSIFIED AS INSIGNIFICANT EFFLUENT PATHWAYS

EFFLUENT FROM SYSTEMS CLASSIFIED AS INSIGNIFICANT EFFLUENT PATHWAYS

Insignificant Effluent Pathways are: 1) evaporation from the Unit 1 and Unit 2 Condensate Storage Tanks (CST's); 2) evaporation from the common Refueling Water Storage Tank (RWST); 3) gaseous effluent from the Hydrogen Seal Oil, Main Turbine and RFPT lubrication oil mist eliminators which vent to the turbine building roofs.

These pathways are not continuously monitored. The CSTs and RWST are sampled monthly to determine the concentration of radionuclides present in these tanks. Tritium analysis on these samples is performed quarterly. Airborne release to the environment from the tanks is estimated based on conservative estimates of the evaporation rates from each of the tanks using a modified method established within Chapter 7 of EPA AP-42. A conservative carry-over fraction of radionuclides from the water to the evaporated liquid is then assumed. Airborne release to the environment from the demisters conservatively assumes the maximum moisture (condensate) concentration of the lubrication oil as measured via sampling during 2011. The calculation also assumes immediate removal of 100% of the water by the oil mist eliminators as it passes through the turbines.

The annual release of tritium, iodines and particulates with half-lives greater than 8 days was calculated based on the conservative assumptions outlined above. The calculated releases are shown in Table 8-1. All nuclides, except for tritium, released from insignificant effluent pathways are negligible compared to the airborne release data shown in Tables 2-1 and 2-2. The maximum dose to the public from a release of 4.50 Ci of tritium is calculated to be 4.34E-2 mrem (child). This is a small fraction of the maximum dose from airborne effluent reported in Section 4.

TABLE 8-1

ANNUAL RELEASE FROM SYSTEMS CLASSIFIED AS INSIGNIFICANT EFFLUENT PATHWAYS

Nuclide	RWST (Ci)	U1-CST and Main Turbine/RFPT Lube Oil Systems (Ci)	U2-CST and Main Turbine/RFPT Lube Oil Systems (Ci)	Total (Ci)
H-3	4.66E-02	2.25E+00	2.20E+00	4.50E+00
Mn-54	6.74E-09	2.58E-06	2.80E-07	2.86E-06
Co-60	4.06E-08	7.21E-06	8.96E-07	8.14E-06
Co-58	6.17E-09	5.28E-06	7.38E-07	6.02E-06
Zn-65	1.54E-09	9.67E-07	1.49E-07	1.12E-06