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2.19.045

June 24, 2019

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Subject: Annual Radioactive Effluent Release Report for January 1 through December 31, 2018, Revision 1

Pilgrim Nuclear Power Station
NRC Docket No. 50-293
Renewed Facility Operating License No. DPR-35

Reference: 1) Entergy Nuclear Operations, Inc. (Entergy) letter to U. S. Nuclear Regulatory Commission (NRC), "Annual Radioactive Effluent Release Report for January 1 through December 31, 2018" dated May 6, 2019 (ADAMS Accession No. ML19127A216)

On May 6, 2019, in accordance with Pilgrim Nuclear Power Station Technical Specification 5.6.3, Entergy Nuclear Operations, Inc. submitted the Annual Radioactive Effluent Release Report for January 1 through December 31, 2018 (Reference 1). Subsequently, it was identified that changes to the report were necessary. Accordingly, the report is being resubmitted in its entirety and supersedes Reference 1.

If you have any questions regarding this information, please contact me at (508) 830-7127.

This letter contains no new regulatory commitments.

Respectfully,

Peter J. Miner

PJM/pm

Enclosure: Pilgrim Nuclear Power Station Annual Radioactive Effluent Release Report, Revision 1

cc: NRC Region I, Regional Administrator
NRC Senior Resident Inspector - Pilgrim
NRC Project Manager - Pilgrim
Mr. John Giarrusso, Jr. - Massachusetts Emergency Management Agency

Enclosure

2.19.045

Pilgrim Nuclear Power Station Annual Radioactive Effluent Release Report, Revision 1

PILGRIM NUCLEAR POWER STATION

Facility Operating License DPR-35

Annual Radioactive Effluent Release Report

January 1 through December 31, 2018
Rev.01

Entergy

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PILGRIM NUCLEAR POWER STATION
Facility Operating License DPR-35

ANNUAL RADIOACTIVE EFFLUENT RELEASE REPORT

JANUARY 01 THROUGH DECEMBER 31, 2018

Prepared by: _____ 6/19/19
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TABLE OF CONTENTS

LIST OF TABLES

PILGRIM NUCLEAR POWER STATION
ANNUAL RADIOACTIVE EFFLUENT RELEASE REPORT
JANUARY 01 THROUGH DECEMBER 31, 2018

1.0 EXECUTIVE SUMMARY

INTRODUCTION

This report quantifies the radioactive gaseous, liquid, and radwaste releases, and summarizes the local meteorological data for the period from January 01 through December 31, 2018. This document has been prepared in accordance with the requirements set forth in the Pilgrim Nuclear Power Station (PNPS) Technical Specifications and Revision 1 of Regulatory Guide 1.21, "Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Material in Liquid and Gaseous Effluents from Light Water Cooled Nuclear Power Plants". This document has been prepared in accordance with the requirements of PNPS Technical Specifications section 5.6.3.

The quantity of radioactive material released from PNPS was determined from sample analyses and continuous on-line monitoring of gaseous releases from the main stack, reactor building vent, turbine building, and various decontamination facilities, and liquid releases into the discharge canal.

The quantity and volume of radioactive waste shipped offsite from PNPS for processing and burial were determined from data contained on the radwaste shipping documentation. The meteorological data were obtained from monitoring instruments located on the 220-foot meteorological tower located at Pilgrim Station.

GASEOUS EFFLUENTS

Gaseous radioactive releases for the reporting period are quantified in Tables 2.2-A, 2.2-B, and 2.2-C. Radioactive noble gases released during the period totaled 7.8 Curies. Releases of radioactive iodines and particulates with half-life of greater than 8 days totaled 0.00021 Curies, tritium releases totaled 34.0 Curies, and carbon-14 totaled 6.5 Curies. No gross alpha radioactivity was detected in gaseous effluents.

Noble gases released in gaseous effluents resulted in a maximum total body dose of 0.00055 mrem, with a corresponding skin dose of 0.0030 mrem. The release of radioactive particulates, iodines, tritium, and carbon-14 in gaseous effluents from PNPS during the reporting period resulted in a total body dose to the maximum-exposed hypothetical individual of approximately 0.014 mrem. The maximum hypothetical dose to any organ from radioactive particulates, iodines, tritium, and carbon-14 was approximately 0.065 mrem. The maximum, hypothetical total body dose from the combined release of all airborne radioactivity in gaseous effluents was 0.050 mrem.

The maximum individual doses from gaseous radioactive effluents were compared to the applicable ODCM dose limits. Noble gas doses were 0.0083% of the corresponding 10CFR50 dose objectives. Maximum doses resulting from releases of particulates, iodines, tritium, and carbon-14 in gaseous effluents were less than 0.43% of corresponding 10CFR50 objectives.

LIQUID EFFLUENTS

Liquid radioactive releases for the reporting period are quantified in Tables 2.3-A and 2.3-B. Zero discharges of liquid effluents containing radioactivity occurred during the reporting period. The resulting maximum total body dose was 0.00 mrem, with a corresponding organ dose of 0.00 mrem. All doses from liquid discharges were less than 0.00% of corresponding 10CFR50 objectives.

METEOROLOGICAL DATA

Meteorological joint frequency distributions are listed in Appendix A. Data recovery for the entire annual period was 98% for the 33-ft and 96% for the 220-ft levels of the tower. The predominant wind direction was from the south-southwest, which occurred approximately 15% of the time during the reporting period. The predominant stability class was Class D, which occurred approximately 47% of the time during the reporting period

OFFSITE AMBIENT RADIATION MEASUREMENTS

Ambient radiation exposure was evaluated to complete the assessment of radiological impact on humans. A small number of thermoluminescent dosimeters (TLDs) indicated an elevation in ambient radiation exposure on Entergy property in close proximity to the station, when compared to background levels in the region. This elevation is due to nitrogen-16 contained within the plant steam system, as opposed to radioactive effluent released from the plant. The dose to the maximum-exposed member of the public at the PNPS Health Club, even though they are within the owner-controlled area, was estimated as being approximately 1.6 mrem during 2018. There was no measurable increase during 2018 in ambient radiation measurements at the location of the nearest resident 0.8 km southeast of PNPS.

COMBINED DOSE IMPACT

The collective total body dose to a maximum-exposed hypothetical member of the public from airborne radioactivity, liquid-borne radioactivity, and ambient radiation exposure resulting from PNPS operation during 2018 was calculated as being approximately 0.71 mrem. This amount is approximately 0.12% of the typical dose of 620 mrem received each year by an average person from other sources of natural and man-made radiation. Although this calculated collective dose occurs to a maximum-exposed hypothetical individual, it is also well below the NRC dose limit of 100 mrem/yr specified in 10CFR20.1301, as well as the EPA dose limit of 25 mrem/yr specified in 40CFR190. Both of these limits are to be applied to real members of the general public, so the fact that the dose to the hypothetical maximum-exposed individual is within the limits ensures that any dose received by a real member of the public would be smaller and well within any applicable limit.

RADIOACTIVE SOLID WASTE DISPOSAL

Solid radioactive wastes shipped offsite for processing and disposal during the reporting period are described in Table 7.0. A total of approximately 542 cubic meters of solid waste, containing 418 Curies of radioactivity, were shipped from the site during the reporting period.

ONSITE GROUNDWATER MONITORING PROGRAM

In response to the Nuclear Energy Institute Groundwater Protection Initiative, Pilgrim Station instituted a groundwater monitoring program during 2007. Four monitoring wells were installed onsite during the fourth quarter of 2007, and the first samples were collected in late November 2007. Additional sampling wells were added in 2010, 2011, 2012, 2013, and 2014. As of the end of 2018, samples are being collected from a total of 23 monitoring wells. Low levels of tritium, a radioactive isotope of hydrogen, were detected in several of these onsite wells. No other plant-related radioactivity was detected in the groundwater samples. The average concentration of tritium detected in these onsite monitoring wells during 2018 was well below the voluntary communications reporting level established by the EPA Drinking Water Standard of 20,000 pCi/L. Although the EPA Standard provides a standard for comparison, no drinking water sources are affected by this tritium. The maximum hypothetical dose resulting from tritium in groundwater presumed to enter Cape Cod Bay is calculated to be 0.0000000048 mrem/yr. Results of the groundwater monitoring program are presented in Appendix B.

CONCLUSION

The PNPS Offsite Dose Calculation Manual contains effluent controls to limit doses resulting from releases of radioactivity to the environment. None of the effluent controls associated with liquid or gaseous effluents were exceeded during the reporting period, as confirmed by conservative dose assessments performed at weekly and monthly intervals. Conformance to the PNPS ODCM effluent control limits ensures that releases of radioactivity in liquid and gaseous effluents are kept as low as reasonably achievable in accordance with 10 CFR Part 50, Appendix I. Compliance with the ODCM also demonstrates that requirements of the Environmental Protection Agency's nuclear fuel cycle standard, 40CFR190.10, Subpart B, have been met. Based on the dose assessment results for 2018, there was no significant radiological impact on the general public from PNPS operation.

2.0 RADIOACTIVE EFFLUENT DATA

Radioactive gaseous and liquid releases for the reporting period are given in the standard format presented in Tables 1A, 1B, 1C, 2A, 2B, and Supplemental Information table from NRC Regulatory Guide 1.21 (Reference 1) format.

2.1 Supplemental Effluent Release Data

Supplemental information related to radioactive gaseous and liquid releases for the reporting period are given in the standard NRC Regulatory Guide 1.21 format in Table 2.1.

2.2 Gaseous Effluent Data

Gaseous radioactivity is released from Pilgrim Station to the atmosphere from the main stack, reactor building vent, turbine building, and various decontamination facilities. Combined gaseous effluent releases from all release points are summarized in Table 2.2-A. No alpha activity was detected on any of the particulate filters collected during the reporting period. The total gaseous releases for various categories of radionuclides, as well as the corresponding average release rates, can be summarized as follows:

- Noble gases: 7.80 Ci , 0.247 μCi/sec
- Iodines and particulates with half-life greater than 8 days: 0.00165 Ci, 0.0000524 μCi/sec
- Tritium: 34.0 Ci, 1.08 μCi/sec
- Carbon-14: 6.52 Ci, 0.207 μCi/sec

Effluent releases from the main stack are detailed in Table 2.2-B. The main stack is 335 feet tall, and represents an elevated release point with a total height of approximately 400 feet above sea level. The main stack is located approximately 700 feet west-northwest of the reactor building.

Ground-level effluent releases are detailed in Table 2.2-C. Data in this table include releases from the reactor building vent, turbine building, and assorted equipment decontamination facilities (e.g., hot machine shop, carbon dioxide pellet decon trailer, plastic media decon trailer, etc.) used during the period. Due to the close proximity of the reactor building, all of these release points are considered to be mixed-mode/ground level release points.

Following the revision of Regulatory Guide 1.21 in 2009, the nuclear industry re-assessed their gaseous effluent releases in accordance with the new definition of "principal radionuclide". Under this new definition, any radionuclide that contributed greater than 1% of the effluent dose calculated to demonstrate compliance with 10CFR50 Appendix I, or contributed more than 1% of the total activity for that type of effluent release, would be classified as a principal radionuclide. Although Carbon-14 (C-14) had been exempted from gaseous effluent calculations in the 1970s, industry assessments in 2009 revealed that Carbon-14 would qualify as a principal radionuclide. Based on this 2009 re-assessment, licensees were required to begin reporting C-14 gaseous effluents in the Annual Radioactive Effluent Release Report beginning with calendar-year 2010. Carbon-14 releases for 2018 are summarized in Tables 2.2-A through 2.2-C, and the dose consequences from C-14 are incorporated into the dose assessments documented in Section 4.2 of this report.

Table 3.1-2 of the PNPS ODCM requires that if any of the gaseous effluent monitors are inoperable for more than 30-days, such events are to be reported in the Annual Radioactive Effluent Release Report with an explanation of why the affected monitor was not returned to operable status in a

timely manner. During 2018, there were no instances when the Turbine Building Gaseous Effluent Monitor (C-3003) or the Feed Pump Gaseous Effluent Monitor (C-3004) was out of service for more than a 30 consecutive day period. Two instances (Feb-2018 and Mar-2018) of a loss of 23kv rendered both Turbine Building Gaseous Effluent units out of service for a short duration, as an enhancement, both units power supply was changed to vital power to eliminate the threat of losing the effluent units when there was a loss of the 23kv line. There were no instances in 2018 when both channels of a dual-channel effluent monitor (Main Stack, Reactor Building Vent) were out of service at the same time during a 30 consecutive day period.

2.3 Liquid Effluent Data

Liquid radioactivity is released from PNPS to Cape Cod Bay via the circulating water discharge canal. These effluents enter Cape Cod Bay at the outfall of the canal, which is located approximately 1100 feet north of the reactor building.

Liquid effluent releases are summarized in Table 2.3-A. Detailed breakdowns for individual radionuclides are listed in Table 2.3-B. There were no discharges of liquid effluents containing radioactivity during the reporting period. Total releases for the various categories of radionuclides, as well as their corresponding mean concentrations, can be summarized as follows:

- Total Effluent Volume: 0 Liters
- Total Dilution Volume: 0 Liters
- Fission/Activation products: 0.00 Ci, 0.00 μCi/mL
- Tritium: 0.00 Ci, 0.00 μCi/mL
- Dissolved/entrained noble gases: 0.00 Ci, 0.00 μCi/mL

Table 2.1
Pilgrim Nuclear Power Station
Annual Radioactive Effluent Release Report
Supplemental Information
January-December 2018

FACILITY: PILGRIM NUCLEAR POWER STATION **LICENSE: DPR-35**

1. REGULATORY LIMITS					
a. Fission and activation gases:	500 mrem/yr total body and 3000 mrem/yr for skin at site boundary				
b,c. Iodines, particulates with half-life: >8 days, tritium	1500 mrem/yr to any organ at site boundary				
d. Liquid effluents:	0.06 mrem/month for whole body and 0.2 mrem/month for any organ (without radwaste treatment)				
2. EFFLUENT CONCENTRATION LIMITS					
a. Fission and activation gases:	10CFR20 Appendix B Table II				
b. Iodines:	10CFR20 Appendix B Table II				
c. Particulates with half-life > 8 days:	10CFR20 Appendix B Table II				
d. Liquid effluents:	2E-04 μCi/mL for entrained noble gases; 10CFR20 Appendix B Table II values for all other radionuclides				
3. AVERAGE ENERGY	Not Applicable				
4. MEASUREMENTS AND APPROXIMATIONS OF TOTAL RADIOACTIVITY					
a. Fission and activation gases: b. Iodines: c. Particulates: d. Liquid effluents:	High purity germanium gamma spectroscopy for all gamma emitters; radiochemistry analysis for H-3, Fe-55 (liquid effluents), Sr-89, and Sr-90				
5. BATCH RELEASES	Jan-Mar 2018	Apr-Jun 2018	Jul-Sep 2018	Oct-Dec 2018	Jan-Dec 2018
a. Liquid Effluents					
1. Total number of releases:	N/A	N/A	N/A	N/A	N/A
2. Total time period (minutes):	N/A	N/A	N/A	N/A	N/A
3. Maximum time period (minutes):	N/A	N/A	N/A	N/A	N/A
4. Average time period (minutes):	N/A	N/A	N/A	N/A	N/A
5. Minimum time period (minutes):	N/A	N/A	N/A	N/A	N/A
6. Average stream flow during periods of release of effluents into a flowing stream (Liters/min):	N/A	N/A	N/A	N/A	N/A
b. Gaseous Effluents	None	None	None	None	None
6. ABNORMAL RELEASES					
a. Liquid Effluents	None	None	None	None	None
b. Gaseous Effluents	None	None	None	None	None

Table 2.2-A
Pilgrim Nuclear Power Station
Annual Radioactive Effluent Release Report
Gaseous Effluents - Summation of All Releases
January-December 2018

RELEASE PERIOD	Jan-Mar 2018	Apr-Jun 2018	Jul-Sep 2018	Oct-Dec 2018	Jan-Dec 2018	Est. Total Error
A. FISSION AND ACTIVATION GASES						
Total Release: Ci	NDA	NDA	NDA	NDA	NDA	±22%
Average Release Rate: μCi/sec	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Percent of Effluent Control Limit*	*	*	*	*	*	
B. IODINE-131						
Total Iodine-131 Release: Ci	4.34E-05	4.55E-05	6.63E-05	5.60E-05	2.11E-04	±20%
Average Release Rate: μCi/sec	5.50E-06	5.77E-06	8.41E-06	7.10E-06	6.70E-06	
Percent of Effluent Control Limit*	*	*	*	*	*	
C. PARTICULATES WITH HALF-LIVES > 8 DAYS						
Total Release: Ci	7.13E-05	2.26E-05	3.79E-05	5.64E-05	1.88E-04	±21%
Average Release Rate: μCi/sec	9.05E-06	2.87E-06	4.80E-06	7.15E-06	5.97E-06	
Percent of Effluent Control Limit*	*	*	*	*	*	
Gross Alpha Radioactivity: Ci	NDA	NDA	NDA	NDA	NDA	
D. TRITIUM						
Total Release: Ci	7.66E+00	6.74E+00	7.32E+00	1.23E+01	3.40E+01	±20%
Average Release Rate: μCi/sec	9.71E-01	8.54E-01	9.28E-01	1.56E+00	1.08E+00	
Percent of Effluent Control Limit*	*	*	*	*	*	
E. CARBON-14						
Total Release: Ci	1.46E+00	1.43E+00	1.75E+00	1.88E+00	6.52E+00	N/A
Average Release Rate: μCi/sec	1.86E-01	1.81E-01	2.22E-01	2.39E-01	2.07E-01	
Percent of Effluent Control Limit*	*	*	*	*	*	

Notes for Table 2.2-A:

* Percent of Effluent Control Limit values based on dose assessments are provided in Section 6 of this report.

1. NDA stands for No Detectable Activity.
2. LLD for airborne gross alpha activity listed as NDA is 1E-11 μCi/cc.
3. N/A stands for not applicable.

Table 2.2-B
Pilgrim Nuclear Power Station
Annual Radioactive Effluent Release Report
Gaseous Effluents – Elevated Release
January-December 2018

CONTINUOUS MODE RELEASES FROM ELEVATED RELEASE POINT					
Nuclide Released	Jan-Mar 2018	Apr-Jun 2018	Jul-Sep 2018	Oct-Dec 2018	Jan-Dec 2018
1. FISSION AND ACTIVATION GASES: Ci					
Ar-41	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr-85	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr-85m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr-87	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr-88	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-131m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-133	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-133m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-135	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-135m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-137	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-138	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2. IODINES: Ci					
I-131	1.59E-06	1.64E-06	1.56E-06	0.00E+00	4.79E-06
I-133	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	1.59E-06	1.64E-06	1.56E-06	0.00E+00	4.79E-06
3. PARTICULATES WITH HALF-LIVES > 8 DAYS: Ci					
Cr-51	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mn-54	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Fe-59	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Co-58	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Co-60	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Zn-65	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr-89	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr-90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ru-103	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cs-134	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cs-137	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ba/La-140	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for Period	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4. TRITIUM: Ci					
H-3	2.77E-02	1.22E-02	3.36E-02	5.41E-02	1.28E-01
5. CARBON-14: Ci					
C-14	1.42E+00	1.39E+00	1.69E+00	1.83E+00	6.33E+00

Notes for Table 2.2-B:

1. N/A stands for not applicable.
2. NDA stands for No Detectable Activity.
3. LLDs for airborne radionuclides listed as NDA are as follows:
   - Fission Gases: 1E-04 μCi/cc
   - Iodines: 1E-12 μCi/cc
   - Particulates: 1E-11 μCi/cc

Table 2.2-B (continued)
Pilgrim Nuclear Power Station
Annual Radioactive Effluent Release Report
Gaseous Effluents – Elevated Release
January-December 2018

BATCH MODE RELEASES FROM ELEVATED RELEASE POINT					
Nuclide Released	Jan-Mar 2018	Apr-Jun 2018	Jul-Sep 2018	Oct-Dec 2018	Jan-Dec 2018
1. FISSION AND ACTIVATION GASES: Ci					
Ar-41	N/A	N/A	N/A	N/A	N/A
Kr-85	N/A	N/A	N/A	N/A	N/A
Kr-85m	N/A	N/A	N/A	N/A	N/A
Kr-87	N/A	N/A	N/A	N/A	N/A
Kr-88	N/A	N/A	N/A	N/A	N/A
Xe-131m	N/A	N/A	N/A	N/A	N/A
Xe-133	N/A	N/A	N/A	N/A	N/A
Xe-133m	N/A	N/A	N/A	N/A	N/A
Xe-135	N/A	N/A	N/A	N/A	N/A
Xe-135m	N/A	N/A	N/A	N/A	N/A
Xe-137	N/A	N/A	N/A	N/A	N/A
Xe-138	N/A	N/A	N/A	N/A	N/A
Total for period	N/A	N/A	N/A	N/A	N/A
2. IODINES: Ci					
I-131	N/A	N/A	N/A	N/A	N/A
I-133	N/A	N/A	N/A	N/A	N/A
Total for period	N/A	N/A	N/A	N/A	N/A
3. PARTICULATES WITH HALF-LIVES > 8 DAYS: Ci					
Cr-51	N/A	N/A	N/A	N/A	N/A
Mn-54	N/A	N/A	N/A	N/A	N/A
Fe-59	N/A	N/A	N/A	N/A	N/A
Co-58	N/A	N/A	N/A	N/A	N/A
Co-60	N/A	N/A	N/A	N/A	N/A
Zn-65	N/A	N/A	N/A	N/A	N/A
Sr-89	N/A	N/A	N/A	N/A	N/A
Sr-90	N/A	N/A	N/A	N/A	N/A
Ru-103	N/A	N/A	N/A	N/A	N/A
Cs-134	N/A	N/A	N/A	N/A	N/A
Cs-137	N/A	N/A	N/A	N/A	N/A
Ba/La-140	N/A	N/A	N/A	N/A	N/A
Total for period	N/A	N/A	N/A	N/A	N/A
4. TRITIUM: Ci					
H-3	N/A	N/A	N/A	N/A	N/A
5. CARBON-14: Ci					
C-14	N/A	N/A	N/A	N/A	N/A

Notes for Table 2.2-B:

1. N/A stands for not applicable.
2. NDA stands for No Detectable Activity.
3. LLDs for airborne radionuclides listed as NDA are as follows:
   Fission Gases: 1E-04 μCi/cc
   Iodines: 1E-12 μCi/cc
   Particulates: 1E-11 μCi/cc

Table 2.2-C
Pilgrim Nuclear Power Station
Annual Radioactive Effluent Release Report
Gaseous Effluents – Ground-Level Release
January-December 2018

CONTINUOUS MODE RELEASES FROM GROUND-LEVEL RELEASE POINT					
Nuclide Released	Jan-Mar 2018	Apr-Jun 2018	Jul-Sep 2018	Oct-Dec 2018	Jan-Dec 2018
1. FISSION AND ACTIVATION GASES: Ci					
Ar-41	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr-85	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr-85m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr-87	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr-88	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-131m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-133	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-133m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-135	0.00E+00	2.24E+00	2.21E+00	3.35E+00	7.80E+00
Xe-135m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-137	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe-138	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total for period	0.00E+00	2.24E+00	2.21E+00	3.35E+00	7.80E+00
2. IODINES: Ci					
I-131	4.18E-05	4.39E-05	6.47E-05	5.60E-05	2.06E-04
I-133	2.41E-04	2.85E-04	3.33E-04	3.69E-04	1.23E-03
Total for period	2.83E-04	3.29E-04	3.97E-04	4.25E-04	1.43E-03
3. PARTICULATES WITH HALF-LIVES > 8 DAYS: Ci					
Cr-51	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Mn-54	1.94E-05	1.25E-05	0.00E+00	1.89E-05	5.08E-05
Fe-59	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Co-58	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Co-60	1.13E-05	0.00E+00	0.00E+00	3.87E-06	1.52E-05
Zn-65	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sr-89	0.00E+00	1.42E-05	1.91E-05	2.80E-05	6.14E-05
Sr-90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ru-103	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cs-134	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cs-137	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ba/La-140	3.62E-05	0.00E+00	3.12E-05	1.73E-05	8.47E-05
Total for period	6.69E-05	2.68E-05	5.03E-05	6.81E-05	2.12E-04
4. TRITIUM: Ci					
H-3	7.63E+00	6.72E+00	7.28E+00	1.22E+01	3.39E+01
5. CARBON-14: Ci					
C-14	4.39E-02	4.29E-02	5.18E-02	5.71E-02	1.96E-01

Notes for Table 2.2-C:

1. N/A stands for not applicable.
2. NDA stands for No Detectable Activity.
3. LLDs for airborne radionuclides listed as NDA are as follows:
   - Fission Gases: 1E-04 μCi/cc
   - Iodines: 1E-12 μCi/cc
   - Particulates: 1E-11 μCi/cc

Table 2.2-C (continued)
Pilgrim Nuclear Power Station
Annual Radioactive Effluent Release Report
Gaseous Effluents – Ground-Level Release
January-December 2018

BATCH MODE RELEASES FROM GROUND-LEVEL RELEASE POINT					
Nuclide Released	Jan-Mar 2018	Apr-Jun 2018	Jul-Sep 2018	Oct-Dec 2018	Jan-Dec 2018
1. FISSION AND ACTIVATION GASES: Ci					
Ar-41	N/A	N/A	N/A	N/A	N/A
Kr-85	N/A	N/A	N/A	N/A	N/A
Kr-85m	N/A	N/A	N/A	N/A	N/A
Kr-87	N/A	N/A	N/A	N/A	N/A
Kr-88	N/A	N/A	N/A	N/A	N/A
Xe-131m	N/A	N/A	N/A	N/A	N/A
Xe-133	N/A	N/A	N/A	N/A	N/A
Xe-133m	N/A	N/A	N/A	N/A	N/A
Xe-135	N/A	N/A	N/A	N/A	N/A
Xe-135m	N/A	N/A	N/A	N/A	N/A
Xe-137	N/A	N/A	N/A	N/A	N/A
Xe-138	N/A	N/A	N/A	N/A	N/A
Total for period	N/A	N/A	N/A	N/A	N/A
2. IODINES: Ci					
I-131	N/A	N/A	N/A	N/A	N/A
I-133	N/A	N/A	N/A	N/A	N/A
Total for period	N/A	N/A	N/A	N/A	N/A
3. PARTICULATES WITH HALF-LIVES > 8 DAYS: Ci					
Cr-51	N/A	N/A	N/A	N/A	N/A
Mn-54	N/A	N/A	N/A	N/A	N/A
Fe-59	N/A	N/A	N/A	N/A	N/A
Co-58	N/A	N/A	N/A	N/A	N/A
Co-60	N/A	N/A	N/A	N/A	N/A
Zn-65	N/A	N/A	N/A	N/A	N/A
Sr-89	N/A	N/A	N/A	N/A	N/A
Sr-90	N/A	N/A	N/A	N/A	N/A
Ru-103	N/A	N/A	N/A	N/A	N/A
Cs-134	N/A	N/A	N/A	N/A	N/A
Cs-137	N/A	N/A	N/A	N/A	N/A
Ba/La-140	N/A	N/A	N/A	N/A	N/A
Total for period	N/A	N/A	N/A	N/A	N/A
4. TRITIUM: Ci					
H-3	N/A	N/A	N/A	N/A	N/A
5. CARBON-14: Ci					
C-14	N/A	N/A	N/A	N/A	N/A

Notes for Table 2.2-C:

1. N/A stands for not applicable.
2. NDA stands for No Detectable Activity.
3. LLDs for airborne radionuclides listed as NDA are as follows:
   - Fission Gases: 1E-04 µCi/cc
   - Iodines: 1E-12 µCi/cc
   - Particulates: 1E-11 µCi/cc

Table 2.3-A
Pilgrim Nuclear Power Station
Annual Radioactive Effluent Release Report
Liquid Effluents - Summation of All Releases
January-December 2018

RELEASE PERIOD	Jan-Mar 2018	Apr-Jun 2018	Jul-Sep 2018	Oct-Dec 2018	Jan-Dec 2018	Est. Total Error
A. FISSION AND ACTIVATION PRODUCTS						
Total Release (not including tritium, gases, alpha): Ci	N/A	N/A	N/A	N/A	N/A	±12%
Average Diluted Concentration During Period: μCi/mL	N/A	N/A	N/A	N/A	N/A	
Percent of Effluent Concentration Limit*	N/A	N/A	N/A	N/A	N/A	
B. TRITIUM						
Total Release: Ci	N/A	N/A	N/A	N/A	N/A	±9.4%
Average Diluted Concentration During Period: μCi/mL	N/A	N/A	N/A	N/A	N/A	
Percent of Effluent Concentration Limit*	N/A	N/A	N/A	N/A	N/A	
C. DISSOLVED AND ENTRAINED GASES						
Total Release: Ci	N/A	N/A	N/A	N/A	N/A	±16%
Average Diluted Concentration During Period: μCi/mL	N/A	N/A	N/A	N/A	N/A	
Percent of Effluent Concentration Limit*	N/A	N/A	N/A	N/A	N/A	
D. GROSS ALPHA RADIOACTIVITY						
Total Release: Ci	N/A	N/A	N/A	N/A	N/A	±34%
E. VOLUME OF WASTE RELEASED PRIOR TO DILUTION						
Waste Volume: Liters	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	±5.7%
F. VOLUME OF DILUTION WATER USED DURING PERIOD						
Dilution Volume: Liters	1.28E+11	1.37E+11	1.55E+11	1.03E+11	5.24E+11	±10%

Notes for Table 2.3-A:

* Additional percent of Effluent Control Limit values based on dose assessments are provided in Section 6 of this report.

1. N/A stands for not applicable.
2. NDA stands for No Detectable Activity.
3. LLD for dissolved and entrained gases listed as NDA is 1E-05 μCi/mL.
4. LLD for liquid gross alpha activity listed as NDA is 1E-07 μCi/mL.

Table 2.3-B
Pilgrim Nuclear Power Station
Annual Radioactive Effluent Release Report
Liquid Effluents
January-December 2018

CONTINUOUS MODE RELEASES					
Nuclide Released	Jan-Mar 2018	Apr-Jun 2018	Jul-Sep 2018	Oct-Dec 2018	Jan-Dec 2018
1. FISSION AND ACTIVATION PRODUCTS: Ci					
Cr-51	N/A	N/A	N/A	N/A	N/A
Mn-54	N/A	N/A	N/A	N/A	N/A
Fe-55	N/A	N/A	N/A	N/A	N/A
Fe-59	N/A	N/A	N/A	N/A	N/A
Co-58	N/A	N/A	N/A	N/A	N/A
Co-60	N/A	N/A	N/A	N/A	N/A
Zn-65	N/A	N/A	N/A	N/A	N/A
Zn-69m	N/A	N/A	N/A	N/A	N/A
Sr-89	N/A	N/A	N/A	N/A	N/A
Sr-90	N/A	N/A	N/A	N/A	N/A
Zr/Nb-95	N/A	N/A	N/A	N/A	N/A
Mo/Tc-99	N/A	N/A	N/A	N/A	N/A
Ag-110m	N/A	N/A	N/A	N/A	N/A
Sb-124	N/A	N/A	N/A	N/A	N/A
I-131	N/A	N/A	N/A	N/A	N/A
I-133	N/A	N/A	N/A	N/A	N/A
Cs-134	N/A	N/A	N/A	N/A	N/A
Cs-137	N/A	N/A	N/A	N/A	N/A
Ba/La-140	N/A	N/A	N/A	N/A	N/A
Ce-141	N/A	N/A	N/A	N/A	N/A
Total for period	N/A	N/A	N/A	N/A	N/A
2. DISSOLVED AND ENTRAINED GASES: Ci					
Xe-133	N/A	N/A	N/A	N/A	N/A
Xe-135	N/A	N/A	N/A	N/A	N/A
Total for period	N/A	N/A	N/A	N/A	N/A

Notes for Table 2.3-B:

1. N/A stands for not applicable.
2. NDA stands for No Detectable Activity.
3. LLDs for liquid radionuclides listed as NDA are as follows:
   - Strontium: 5E-08 μCi/mL
   - Iodines: 1E-06 μCi/mL
   - Noble Gases: 1E-05 μCi/mL
   - All Others: 5E-07 μCi/mL

Table 2.3-B (continued)
Pilgrim Nuclear Power Station
Annual Radioactive Effluent Release Report
Liquid Effluents
January-December 2018

BATCH MODE RELEASES					
Nuclide Released	Jan-Mar 2018	Apr-Jun 2018	Jul-Sep 2018	Oct-Dec 2018	Jan-Dec 2018
1. FISSION AND ACTIVATION PRODUCTS: Ci					
Na-24	N/A	N/A	N/A	N/A	N/A
Cr-51	N/A	N/A	N/A	N/A	N/A
Mn-54	N/A	N/A	N/A	N/A	N/A
Fe-55	N/A	N/A	N/A	N/A	N/A
Fe-59	N/A	N/A	N/A	N/A	N/A
Co-58	N/A	N/A	N/A	N/A	N/A
Co-60	N/A	N/A	N/A	N/A	N/A
Zn-65	N/A	N/A	N/A	N/A	N/A
Zn-69m	N/A	N/A	N/A	N/A	N/A
Sr-89	N/A	N/A	N/A	N/A	N/A
Sr-90	N/A	N/A	N/A	N/A	N/A
Zr/Nb-95	N/A	N/A	N/A	N/A	N/A
Mo/Tc-99	N/A	N/A	N/A	N/A	N/A
Ag-110m	N/A	N/A	N/A	N/A	N/A
Sb-124	N/A	N/A	N/A	N/A	N/A
I-131	N/A	N/A	N/A	N/A	N/A
I-133	N/A	N/A	N/A	N/A	N/A
Cs-134	N/A	N/A	N/A	N/A	N/A
Cs-137	N/A	N/A	N/A	N/A	N/A
Ba/La-140	N/A	N/A	N/A	N/A	N/A
Ce-141	N/A	N/A	N/A	N/A	N/A
Ce-144	N/A	N/A	N/A	N/A	N/A
Total for period	N/A	N/A	N/A	N/A	N/A
2. DISSOLVED AND ENTRAINED GASES: Ci					
Xe-133	N/A	N/A	N/A	N/A	N/A
Xe-135	N/A	N/A	N/A	N/A	N/A
Total for period	N/A	N/A	N/A	N/A	N/A

Notes for Table 2.3-B:

1. N/A stands for not applicable.
2. NDA stands for No Detectable Activity.
3. LLDs for liquid radionuclides listed as NDA are as follows:
   - Strontium: 5E-08 μCi/mL
   - Iodines: 1E-06 μCi/mL
   - Noble Gases: 1E-05 μCi/mL
   - All Others: 5E-07 μCi/mL

3.0 METEOROLOGICAL DATA

Meteorological data are summarized for the reporting period in Appendix A, in the standard joint frequency distribution format as given in NRC Regulatory Guide 1.21.

The predominant meteorological conditions observed during the annual reporting period can be summarized with their corresponding frequencies as follows:

- Stability Class: Class D, 48%
- 33-ft Wind Direction (from): South-southwest, 15%
- 33-ft Wind Speed: 3.5-7.5 mph, 55%
- 220-ft Wind Direction (from): South-southwest, 14%
- 220-ft Wind Speed: 12.5-18.5 mph, 35%

Joint data recovery for the 33-ft level was 98.1% and for the 220-ft level of the tower was 96.0%, both of which meet the 90% annual data recovery goal specified by the NRC. No major problems were encountered in 2018. There were a couple if instances in Feb-2018 and Nov-2018, where for short periods of time some anomalous wind and delta-T readings observed on the 220-ft tower, until wind sensors could be replaced. Wind speed and wind direction values from the 220-ft tower were not affected. Issues with ultrasonic wind sensor heaters were typical for the reporting period winter months. Ice and snow occasionally plugged the sensors until the low current heaters melted the ice pack, the weather subsided or the sensors

4.0 MAXIMUM INDIVIDUAL DOSES

Doses to the maximum exposed individual resulting from radionuclides in effluents released offsite were calculated using methods presented in the PNPS Offsite Dose Calculation Manual (ODCM, Reference 2), NRC Regulatory Guide 1.109 (Reference 3), NRC Regulatory Guide 1.111 (Reference 4), and the Pilgrim Station Unit 1 Appendix I Evaluation (Reference 5). Maximum individual doses are calculated separately for: (1) noble gases in gaseous effluents, (2) particulates, iodines, and tritium in gaseous effluents; and, (3) liquid effluents. Maximum consumption and use factors for various pathways from Table E-5 of the PNPS ODCM are used for calculating the doses to the maximum exposed individual.

Information related to liquid and gaseous effluent releases are summarized Section 2 of this report. These effluent release data were used as input to computer programs to calculate the resulting doses. PNPS ODCM methodologies were used to calculate the dose contributions to the various organs in each age class from major exposure pathways.

4.1 Doses From Noble Gas Releases

Gaseous effluent release data presented in Tables 2.2-A, 2.2-B, and 2.2-C from this effluent release report were used as input to a dose assessment computer program to calculate radiation doses. These data include gaseous releases from the PNPS main stack, reactor building vent, and turbine building roof exhausters. Meteorological data obtained from the PNPS 220-foot meteorological tower during the 10-year period from 2005 through 2014 were used as input to the "AEOLUS-3" computer program (Reference 6). This program was used to calculate the annual average atmospheric dispersion and deposition factors used in the dose assessment computer program to calculate maximum individual doses.

The maximum individual doses resulting from radioactive noble gases released in gaseous effluents are presented in Table 4.1 according to specific receptor locations. This table includes all noble gas doses for the individual calendar quarters and total calendar year.

Noble gases released in gaseous effluents from PNPS during 2018 resulted in a maximum total body dose of 0.000548 mrem. The maximum skin dose was 0.00297 mrem. Both of these doses occurred to a hypothetical individual, assumed to be present 24 hours per day, 365 days per year, at the site boundary location yielding the highest dose (0.63 km SSW of the Reactor Building). For the more "realistic" individuals at offsite locations, the maximum total body dose was 0.000425 mrem (nearest residence, 0.86 kilometers WNW from the Reactor Building), while the maximum skin dose was 0.000202 mrem (nearest residence, 2.39 kilometers SSW from the Reactor Building).

Table 4.1

Maximum Doses From Noble Gas Releases During 2018[a]

Release Period	Gamma Air Dose mrad/period (location)	Beta Air Dose mrad/period (location)	Total Body Dose mrem/period (location)	Skin Dose mrem/period (location)
Jan-Mar	0.00E+00 (0.52 km SSE)	0.00E+00 (0.64 km ESE)	0.00E+00 (0.52 km SSE)	0.00E+00 (0.54 km NW)
Apr-Jun	2.38E-04 (0.52 km SSE)	8.82E-04 (0.64 km ESE)	1.57E-04 (0.52 km SSE)	8.52E-04 (0.54 km NW)
Jul-Sep	2.36E-04 (0.52 km SSE)	8.72E-04 (0.64 km ESE)	1.55E-04 (0.52 km SSE)	8.42E-04 (0.54 km NW)
Oct-Dec	3.57E-04 (0.52 km SSE)	1.32E-03 (0.64 km ESE)	2.36E-04 (0.52 km SSE)	1.28E-03 (0.54 km NW)
Jan-Dec	8.31E-04 (0.52 km SSE)	3.08E-03 (0.64 km ESE)	5.48E-04 (0.52 km SSE)	2.97E-03 (0.54 km NW)

[a] All directions and distances are with respect to the reactor building vent.

4.2 Doses From Gaseous Effluent Releases

Gaseous effluent release data presented in Tables 2.2-A, 2.2-B, and 2.2-C from this effluent release report were used as input to a dose assessment computer program to calculate radiation doses. These data include gaseous releases from the PNPS main stack, reactor building vent, and turbine building roof exhausters. Meteorological data obtained from the PNPS 220-foot meteorological tower during the 10-year period from 2005 through 2014 were used as input to the NRC XOQDOQ computer program (Reference 7). This program was used to calculate the annual average atmospheric dispersion and deposition factors used in the dose assessment computer program to calculate maximum individual doses.

The maximum individual doses resulting from radioactive particulates, radioiodines, tritium and carbon-14 released in gaseous effluents are presented in Tables 4.2-A through 4.2-E. These tables cover the individual calendar quarters and the total calendar year, respectively. Doses resulting from releases of noble gases are addressed independently in the PNPS ODCM. Therefore, none of these tables for maximum individual doses include any dose contribution from noble gases. The presentation and analysis of doses resulting from noble gases are addressed in Section 4.1 of this report.

Tables 4.2-A through 4.2-E summarize the maximum total body and organ doses for the adult, teen, child, and infant age classes resulting from the major gaseous exposure pathways. These tables present the dose data according to specific receptor location and the exposure pathways assumed to occur at that location. For example, the second column of the tables presents the information for the hypothetical maximum-exposed at the most restrictive site boundary location, where only inhalation and ground deposition exposure pathways are assumed to occur. Since this is a shoreline location controlled by Entergy, the other pathways of garden vegetable production, milk production, and meat production are assumed not to occur. Doses for other offsite locations not under Entergy control, where other exposure pathways can and do occur, are presented in subsequent columns of the tables, and represent the potential maximum doses to individuals at these locations. For consistency, all distances listed in the first row of Tables 4.2-A through 4.2-E are measured from the Reactor Building Vent. However, doses at the specific receptor locations are calculated based on the actual distances from the applicable release points (PNPS main stack, reactor building vent, and turbine building roof exhausters).

Radioactivity (particulates, radioiodines, tritium, and carbon-14) released in gaseous effluents from PNPS during 2018 resulted in a maximum total body dose of 0.0136 mrem (child age class at nearest meat animal, 3.82 kilometers S from the Reactor Building), while the maximum organ dose was 0.0646 mrem (child bone at nearest meat animal, 3.82 kilometers S from the Reactor Building). Carbon-14 contributed 14% of the child total body dose and >99% of the child bone dose at the location of the nearest meat animal.

Table 4.2-A

Maximum Individual Organ Dose at Receptor Location -- mrem
From Gaseous Release Period: Jan-Mar 2018

Receptor: Direction: Distance[1]: Pathway[2]:	Bound WNW 0.24km DI	Resident S 2.22 km DI	Garden S 3.44 km DIV[3]	Cow/Goat W 3.75 km DIVCG[3]	Cow/Meat W 5.17 km DIVCM[3]	Meat S 3.82 km DIVM[3]
Age Class: Adult						
Bone	4.53E-05	1.04E-04	3.29E-03	1.91E-03	1.68E-03	4.44E-03
GI-LLI	5.04E-05	5.19E-05	7.50E-04	5.11E-04	4.23E-04	9.90E-04
Kidney	5.03E-05	5.19E-05	7.49E-04	5.10E-04	4.23E-04	9.89E-04
Liver	5.03E-05	5.18E-05	7.49E-04	5.10E-04	4.22E-04	9.89E-04
Lung	5.11E-05	5.25E-05	7.50E-04	5.11E-04	4.23E-04	9.89E-04
Thyroid	5.77E-05	5.77E-05	7.69E-04	5.96E-04	4.72E-04	1.01E-03
T.Body	5.02E-05	5.18E-05	7.49E-04	5.10E-04	4.22E-04	9.89E-04
Age Class: Teen						
Bone	6.49E-05	1.49E-04	5.31E-03	3.20E-03	2.54E-03	6.27E-03
GI-LLI	5.44E-05	6.06E-05	1.17E-03	7.90E-04	6.03E-04	1.36E-03
Kidney	5.43E-05	6.06E-05	1.16E-03	7.90E-04	6.02E-04	1.36E-03
Liver	5.43E-05	6.05E-05	1.16E-03	7.90E-04	6.02E-04	1.36E-03
Lung	5.56E-05	6.15E-05	1.16E-03	7.90E-04	6.03E-04	1.36E-03
Thyroid	6.39E-05	6.81E-05	1.18E-03	9.16E-04	6.74E-04	1.38E-03
T.Body	5.43E-05	6.05E-05	1.16E-03	7.89E-04	6.02E-04	1.36E-03
Age Class: Child						
Bone	8.96E-05	2.06E-04	1.27E-02	7.73E-03	5.96E-03	1.45E-02
GI-LLI	5.40E-05	6.74E-05	2.68E-03	1.76E-03	1.33E-03	3.04E-03
Kidney	5.41E-05	6.74E-05	2.68E-03	1.76E-03	1.33E-03	3.04E-03
Liver	5.40E-05	6.74E-05	2.68E-03	1.76E-03	1.33E-03	3.04E-03
Lung	5.50E-05	6.82E-05	2.68E-03	1.76E-03	1.33E-03	3.04E-03
Thyroid	6.57E-05	7.67E-05	2.71E-03	2.00E-03	1.46E-03	3.07E-03
T.Body	5.40E-05	6.74E-05	2.68E-03	1.76E-03	1.33E-03	3.04E-03
Age Class: Infant						
Bone	6.60E-05	1.52E-04	1.00E-04	4.85E-03	3.39E-03	9.91E-05
GI-LLI	3.46E-05	4.70E-05	3.35E-05	1.14E-03	7.82E-04	3.31E-05
Kidney	3.47E-05	4.70E-05	3.35E-05	1.14E-03	7.83E-04	3.31E-05
Liver	3.47E-05	4.70E-05	3.35E-05	1.14E-03	7.83E-04	3.31E-05
Lung	3.54E-05	4.75E-05	3.39E-05	1.14E-03	7.83E-04	3.35E-05
Thyroid	4.54E-05	5.55E-05	4.02E-05	1.68E-03	1.08E-03	3.98E-05
T.Body	3.46E-05	4.70E-05	3.35E-05	1.14E-03	7.83E-04	3.31E-05

[1] Distances are measured with respect to the reactor building vent.

[2] Pathway designations are as follows:

D = Deposition (Ground Plane) I = Inhalation V = Vegetable Garden
C = Cow Milk G = Goat Milk M = Meat

[3] Doses are conservative since it is unlikely for vegetables to be grown outside or for animals to be fed on pasture during winter months.

Table 4.2-B

Maximum Individual Organ Dose at Receptor Location -- mrem
From Gaseous Release Period: Apr-Jun 2018

Receptor: Direction: Distance[1]: Pathway[2]:	Bound WNW 0.24km DI	Resident S 2.22 km DI	Garden S 3.44 km DIV[3]	Cow/Goat W 3.75 km DIVCG[3]	Cow/Meat W 5.17 km DIVCM[3]	Meat S 3.82 km DIVM[3]
Age Class: Adult						
Bone	4.43E-05	1.02E-04	3.21E-03	1.87E-03	1.64E-03	4.35E-03
GI-LLI	4.51E-05	4.76E-05	7.24E-04	4.87E-04	4.05E-04	9.57E-04
Kidney	4.52E-05	4.76E-05	7.23E-04	4.87E-04	4.05E-04	9.57E-04
Liver	4.51E-05	4.75E-05	7.23E-04	4.86E-04	4.05E-04	9.57E-04
Lung	4.53E-05	4.77E-05	7.23E-04	4.86E-04	4.05E-04	9.57E-04
Thyroid	5.34E-05	5.41E-05	7.44E-04	5.78E-04	4.57E-04	9.81E-04
T.Body	4.51E-05	4.75E-05	7.23E-04	4.86E-04	4.05E-04	9.57E-04
Age Class: Teen						
Bone	6.35E-05	1.46E-04	5.20E-03	3.14E-03	2.48E-03	6.13E-03
GI-LLI	4.90E-05	5.60E-05	1.13E-03	7.58E-04	5.80E-04	1.32E-03
Kidney	4.91E-05	5.60E-05	1.13E-03	7.58E-04	5.80E-04	1.32E-03
Liver	4.90E-05	5.60E-05	1.13E-03	7.58E-04	5.80E-04	1.32E-03
Lung	4.94E-05	5.63E-05	1.13E-03	7.57E-04	5.80E-04	1.32E-03
Thyroid	5.98E-05	6.45E-05	1.15E-03	8.91E-04	6.56E-04	1.34E-03
T.Body	4.90E-05	5.60E-05	1.13E-03	7.57E-04	5.80E-04	1.32E-03
Age Class: Child						
Bone	8.76E-05	2.01E-04	1.24E-02	7.57E-03	5.83E-03	1.42E-02
GI-LLI	4.92E-05	6.31E-05	2.61E-03	1.70E-03	1.28E-03	2.96E-03
Kidney	4.93E-05	6.31E-05	2.61E-03	1.70E-03	1.28E-03	2.96E-03
Liver	4.92E-05	6.31E-05	2.61E-03	1.70E-03	1.28E-03	2.96E-03
Lung	4.95E-05	6.33E-05	2.61E-03	1.70E-03	1.28E-03	2.96E-03
Thyroid	6.24E-05	7.36E-05	2.64E-03	1.96E-03	1.43E-03	2.99E-03
T.Body	4.92E-05	6.31E-05	2.61E-03	1.70E-03	1.28E-03	2.96E-03
Age Class: Infant						
Bone	6.46E-05	1.48E-04	9.78E-05	4.75E-03	3.32E-03	9.69E-05
GI-LLI	3.18E-05	4.43E-05	3.14E-05	1.11E-03	7.59E-04	3.11E-05
Kidney	3.18E-05	4.44E-05	3.14E-05	1.11E-03	7.60E-04	3.11E-05
Liver	3.18E-05	4.43E-05	3.14E-05	1.11E-03	7.60E-04	3.11E-05
Lung	3.21E-05	4.45E-05	3.16E-05	1.11E-03	7.59E-04	3.13E-05
Thyroid	4.40E-05	5.40E-05	3.90E-05	1.68E-03	1.08E-03	3.86E-05
T.Body	3.18E-05	4.43E-05	3.14E-05	1.11E-03	7.60E-04	3.11E-05

[1] Distances are measured with respect to the reactor building vent.

[2] Pathway designations are as follows:

D = Deposition (Ground Plane) I = Inhalation V = Vegetable Garden
C = Cow Milk G = Goat Milk M = Meat

Table 4.2-C

Maximum Individual Organ Dose at Receptor Location -- mrem
From Gaseous Release Period: Jul-Sep 2018

Receptor: Direction: Distance[1]: Pathway[2]:	Bound WNW 0.24km DI	Resident S 2.22 km DI	Garden S 3.44 km DIV[3]	Cow/Goat W 3.75 km DIVCG[3]	Cow/Meat W 5.17 km DIVCM[3]	Meat S 3.82 km DIVM[3]
Age Class: Adult						
Bone	5.41E-05	1.24E-04	3.92E-03	2.27E-03	2.01E-03	5.30E-03
GI-LLI	5.01E-05	5.43E-05	8.72E-04	5.78E-04	4.83E-04	1.16E-03
Kidney	5.01E-05	5.42E-05	8.72E-04	5.78E-04	4.83E-04	1.16E-03
Liver	5.00E-05	5.42E-05	8.72E-04	5.78E-04	4.83E-04	1.16E-03
Lung	5.03E-05	5.44E-05	8.72E-04	5.77E-04	4.83E-04	1.16E-03
Thyroid	6.09E-05	6.27E-05	9.01E-04	7.09E-04	5.59E-04	1.19E-03
T.Body	5.00E-05	5.42E-05	8.72E-04	5.77E-04	4.83E-04	1.16E-03
Age Class: Teen						
Bone	7.74E-05	1.78E-04	6.34E-03	3.82E-03	3.03E-03	7.48E-03
GI-LLI	5.48E-05	6.46E-05	1.37E-03	9.06E-04	6.96E-04	1.60E-03
Kidney	5.48E-05	6.45E-05	1.36E-03	9.06E-04	6.96E-04	1.60E-03
Liver	5.48E-05	6.45E-05	1.36E-03	9.06E-04	6.95E-04	1.60E-03
Lung	5.53E-05	6.49E-05	1.36E-03	9.06E-04	6.95E-04	1.60E-03
Thyroid	6.87E-05	7.55E-05	1.39E-03	1.10E-03	8.05E-04	1.63E-03
T.Body	5.47E-05	6.45E-05	1.36E-03	9.06E-04	6.95E-04	1.60E-03
Age Class: Child						
Bone	1.07E-04	2.46E-04	1.52E-02	9.23E-03	7.11E-03	1.73E-02
GI-LLI	5.56E-05	7.36E-05	3.17E-03	2.05E-03	1.55E-03	3.59E-03
Kidney	5.56E-05	7.36E-05	3.17E-03	2.05E-03	1.55E-03	3.59E-03
Liver	5.56E-05	7.36E-05	3.17E-03	2.05E-03	1.55E-03	3.59E-03
Lung	5.60E-05	7.39E-05	3.17E-03	2.05E-03	1.55E-03	3.59E-03
Thyroid	7.26E-05	8.70E-05	3.20E-03	2.42E-03	1.76E-03	3.64E-03
T.Body	5.56E-05	7.36E-05	3.17E-03	2.05E-03	1.55E-03	3.59E-03
Age Class: Infant						
Bone	7.88E-05	1.81E-04	1.19E-04	5.79E-03	4.05E-03	1.18E-04
GI-LLI	3.62E-05	5.21E-05	3.67E-05	1.33E-03	9.19E-04	3.64E-05
Kidney	3.63E-05	5.22E-05	3.68E-05	1.34E-03	9.20E-04	3.64E-05
Liver	3.63E-05	5.22E-05	3.68E-05	1.34E-03	9.20E-04	3.64E-05
Lung	3.67E-05	5.25E-05	3.70E-05	1.33E-03	9.19E-04	3.66E-05
Thyroid	5.19E-05	6.45E-05	4.65E-05	2.16E-03	1.38E-03	4.60E-05
T.Body	3.62E-05	5.21E-05	3.67E-05	1.34E-03	9.19E-04	3.63E-05

[1] Distances are measured with respect to the reactor building vent.

[2] Pathway designations are as follows:

D = Deposition (Ground Plane) I = Inhalation V = Vegetable Garden
C = Cow Milk G = Goat Milk M = Meat

Table 4.2-D

Maximum Individual Organ Dose at Receptor Location -- mrem
From Gaseous Release Period: Oct-Dec 2018

Receptor: Direction: Distance[1]: Pathway[2]:	Bound WNW 0.24km DI	Resident S 2.22 km DI	Garden S 3.44 km DIV[3]	Cow/Goat W 3.75 km DIVCG[3]	Cow/Meat W 5.17 km DIVCM[3]	Meat S 3.82 km DIVM[3]
Age Class: Adult						
Bone	5.84E-05	1.34E-04	4.23E-03	2.46E-03	2.17E-03	5.72E-03
GI-LLI	7.80E-05	7.69E-05	9.94E-04	6.99E-04	5.72E-04	1.31E-03
Kidney	7.79E-05	7.69E-05	9.93E-04	6.98E-04	5.71E-04	1.30E-03
Liver	7.79E-05	7.69E-05	9.93E-04	6.98E-04	5.71E-04	1.30E-03
Lung	7.86E-05	7.74E-05	9.94E-04	6.98E-04	5.71E-04	1.30E-03
Thyroid	8.85E-05	8.52E-05	1.02E-03	8.12E-04	6.37E-04	1.33E-03
T.Body	7.79E-05	7.68E-05	9.93E-04	6.98E-04	5.71E-04	1.30E-03
Age Class: Teen						
Bone	8.37E-05	1.92E-04	6.84E-03	4.14E-03	3.27E-03	8.07E-03
GI-LLI	8.33E-05	8.82E-05	1.53E-03	1.06E-03	8.06E-04	1.78E-03
Kidney	8.33E-05	8.82E-05	1.53E-03	1.06E-03	8.06E-04	1.78E-03
Liver	8.32E-05	8.81E-05	1.53E-03	1.06E-03	8.06E-04	1.78E-03
Lung	8.43E-05	8.90E-05	1.53E-03	1.06E-03	8.06E-04	1.78E-03
Thyroid	9.70E-05	9.90E-05	1.56E-03	1.23E-03	9.01E-04	1.81E-03
T.Body	8.32E-05	8.81E-05	1.53E-03	1.06E-03	8.06E-04	1.78E-03
Age Class: Child						
Bone	1.15E-04	2.65E-04	1.64E-02	9.98E-03	7.69E-03	1.86E-02
GI-LLI	8.13E-05	9.58E-05	3.50E-03	2.33E-03	1.75E-03	3.96E-03
Kidney	8.13E-05	9.58E-05	3.49E-03	2.33E-03	1.75E-03	3.96E-03
Liver	8.13E-05	9.58E-05	3.50E-03	2.33E-03	1.75E-03	3.96E-03
Lung	8.22E-05	9.65E-05	3.50E-03	2.33E-03	1.75E-03	3.96E-03
Thyroid	9.82E-05	1.09E-04	3.53E-03	2.65E-03	1.93E-03	4.00E-03
T.Body	8.13E-05	9.58E-05	3.50E-03	2.33E-03	1.75E-03	3.96E-03
Age Class: Infant						
Bone	8.51E-05	1.95E-04	1.29E-04	6.25E-03	4.38E-03	1.28E-04
GI-LLI	5.14E-05	6.57E-05	4.73E-05	1.50E-03	1.03E-03	4.68E-05
Kidney	5.14E-05	6.57E-05	4.73E-05	1.51E-03	1.03E-03	4.68E-05
Liver	5.14E-05	6.57E-05	4.73E-05	1.51E-03	1.03E-03	4.68E-05
Lung	5.21E-05	6.63E-05	4.78E-05	1.50E-03	1.03E-03	4.72E-05
Thyroid	6.70E-05	7.79E-05	5.70E-05	2.22E-03	1.43E-03	5.64E-05
T.Body	5.14E-05	6.57E-05	4.73E-05	1.50E-03	1.03E-03	4.68E-05

[1] Distances are measured with respect to the reactor building vent.

[2] Pathway designations are as follows:

D = Deposition (Ground Plane) I = Inhalation V = Vegetable Garden
C = Cow Milk G = Goat Milk M = Meat

[3] Doses are conservative since it is unlikely for vegetables to be grown outside or for animals to be fed on pasture during winter months.

Table 4.2-E

Maximum Individual Organ Dose at Receptor Location -- mrem
From Gaseous Release Period: Jan-Dec 2018

Receptor:	Bound	Resident	Garden	Cow/Goat	Cow/Meat	Meat
Direction:	WNW	S	S	W	W	S
Distance[1]:	0.24km	2.22 km	3.44 km	3.75 km	5.17 km	3.82 km
Pathway[2]:	DI	DI	DIV[3]	DIVCG[3]	DIVCM[3]	DIVM[3]
Age Class: Adult						
Bone	2.02E-04	4.64E-04	1.47E-02	8.50E-03	7.50E-03	1.98E-02
GI-LLI	2.24E-04	2.31E-04	3.34E-03	2.27E-03	1.88E-03	4.41E-03
Kidney	2.23E-04	2.31E-04	3.34E-03	2.27E-03	1.88E-03	4.40E-03
Liver	2.23E-04	2.30E-04	3.34E-03	2.27E-03	1.88E-03	4.40E-03
Lung	2.25E-04	2.32E-04	3.34E-03	2.27E-03	1.88E-03	4.41E-03
Thyroid	2.60E-04	2.60E-04	3.43E-03	2.69E-03	2.13E-03	4.51E-03
T.Body	2.23E-04	2.30E-04	3.34E-03	2.27E-03	1.88E-03	4.40E-03
Age Class: Teen						
Bone	2.89E-04	6.65E-04	2.37E-02	1.43E-02	1.13E-02	2.80E-02
GI-LLI	2.42E-04	2.69E-04	5.19E-03	3.52E-03	2.68E-03	6.06E-03
Kidney	2.41E-04	2.69E-04	5.19E-03	3.52E-03	2.68E-03	6.06E-03
Liver	2.41E-04	2.69E-04	5.19E-03	3.52E-03	2.68E-03	6.06E-03
Lung	2.45E-04	2.72E-04	5.19E-03	3.52E-03	2.68E-03	6.06E-03
Thyroid	2.89E-04	3.07E-04	5.28E-03	4.14E-03	3.04E-03	6.16E-03
T.Body	2.41E-04	2.69E-04	5.19E-03	3.52E-03	2.68E-03	6.06E-03
Age Class: Child						
Bone	4.00E-04	9.18E-04	5.67E-02	3.45E-02	2.66E-02	**6.46E-02**
GI-LLI	2.40E-04	3.00E-04	1.20E-02	7.84E-03	5.91E-03	1.36E-02
Kidney	2.40E-04	3.00E-04	1.19E-02	7.84E-03	5.91E-03	1.36E-02
Liver	2.40E-04	3.00E-04	1.20E-02	7.84E-03	5.91E-03	1.36E-02
Lung	2.43E-04	3.02E-04	1.20E-02	7.84E-03	5.91E-03	1.36E-02
Thyroid	2.99E-04	3.46E-04	1.21E-02	9.03E-03	6.59E-03	1.37E-02
T.Body	2.40E-04	3.00E-04	1.20E-02	7.84E-03	5.91E-03	**1.36E-02**
Age Class: Infant						
Bone	2.95E-04	6.77E-04	4.46E-04	2.16E-02	1.51E-02	4.42E-04
GI-LLI	1.54E-04	2.09E-04	1.49E-04	5.09E-03	3.49E-03	1.47E-04
Kidney	1.54E-04	2.09E-04	1.49E-04	5.09E-03	3.49E-03	1.47E-04
Liver	1.54E-04	2.09E-04	1.49E-04	5.09E-03	3.49E-03	1.47E-04
Lung	1.56E-04	2.11E-04	1.50E-04	5.09E-03	3.49E-03	1.49E-04
Thyroid	2.08E-04	2.52E-04	1.83E-04	7.74E-03	4.97E-03	1.81E-04
T.Body	1.54E-04	2.09E-04	1.49E-04	5.09E-03	3.49E-03	1.47E-04

[1] Distances are measured with respect to the reactor building vent.

[2] Pathway designations are as follows:

D = Deposition (Ground Plane) I = Inhalation V = Vegetable Garden
C = Cow Milk G = Goat Milk M = Meat

[3] Doses are conservative since it is unlikely for vegetables to be grown outside or for animals to be fed on pasture during winter months.

4.3 Doses From Liquid Effluent Releases

Liquid effluent release data presented in Tables 2.3-A and 2.3-B were used as input to the dose assessment computer program to calculate radiation doses. The maximum individual doses resulting from radionuclides released in liquid effluents are presented in Tables 4.3-A through 4.3-E. These tables cover the individual calendar quarters and the total calendar year, respectively.

Tables 4.3-A through 4.3-E summarize the maximum total body and organ doses for the adult, teen, and child age classes resulting from the major liquid exposure pathways. NRC Regulatory Guide 1.109 does not recognize the infant age class as being exposed to the liquid effluent pathways. Therefore, doses for this age class are not included in any of the tables.

It should be noted that doses calculated for the entire year might not equal the sum of the doses for the individual quarters. Doses from liquid effluents are based on the concentration (activity divided by volume) of radionuclides released in the effluent, as prescribed by the NRC in Regulatory Guide 1.109. If a larger proportion of activity is released with a relatively smaller volume of dilution water during a given quarter, the resulting concentration for that quarter will be higher than concentrations from other quarters. This will result in a proportionally higher dose for that quarter. However, when that quarter's activity values are included in the annual sum, and divided by the total annual dilution flow, the resulting dose contribution will be smaller. In such a situation, the annual dose will actually be less than the sum of the individual quarterly doses.

There were no liquid Effluent releases from PNPS during 2018, therefore the Radioactivity released in liquid effluents from PNPS during the reporting period resulted in a maximum total body dose (teen age class) of 0.00 mrem. The maximum organ dose (teen age class, Liver) was 0.00 mrem.

Table 4.3-A

Maximum Individual Organ Doses -- mrem
From Liquid Release Period: Jan-Mar 2018

Organ	Age Class Organ Dose – mrem *		
	Adult	Teen	Child
Bone	N/A	N/A	N/A
GI-LLI	N/A	N/A	N/A
Kidney	N/A	N/A	N/A
Liver	N/A	N/A	N/A
Lung	N/A	N/A	N/A
Thyroid	N/A	N/A	N/A
T.Body	N/A	N/A	N/A

* These doses are conservative since the same usage factor was applied for each quarter. In reality, it is unlikely that anyone would be swimming or boating during the entire year. However, the resulting dose is considerably lower than those from other pathways and does not contribute much to the total dose.
- Highest total body dose and highest organ dose are bolded.

Table 4.3-B

Maximum Individual Organ Doses -- mrem
From Liquid Release Period: Apr-Jun 2018

Organ	Age Class Organ Dose – mrem		
	Adult	Teen	Child
Bone	N/A	N/A	N/A
GI-LLI	N/A	N/A	N/A
Kidney	N/A	N/A	N/A
Liver	N/A	N/A	N/A
Lung	N/A	N/A	N/A
Thyroid	N/A	N/A	N/A
T.Body	N/A	N/A	N/A

-Highest total body dose and highest organ dose are bolded.

Table 4.3-C

Maximum Individual Organ Doses -- mrem
From Liquid Release Period: Jul-Sep 2018

Organ	Age Class Organ Dose – mrem		
	Adult	Teen	Child
Bone	N/A	N/A	N/A
GI-LLI	N/A	N/A	N/A
Kidney	N/A	N/A	N/A
Liver	N/A	N/A	N/A
Lung	N/A	N/A	N/A
Thyroid	N/A	N/A	N/A
T.Body	N/A	N/A	N/A

Table 4.3-D

Maximum Individual Organ Doses -- mrem
From Liquid Release Period: Oct-Dec 2018

Organ	Age Class Organ Dose – mrem *		
	Adult	Teen	Child
Bone	N/A	N/A	N/A
GI-LLI	N/A	N/A	N/A
Kidney	N/A	N/A	N/A
Liver	N/A	N/A	N/A
Lung	N/A	N/A	N/A
Thyroid	N/A	N/A	N/A
T.Body	N/A	N/A	N/A

* These doses are conservative since the same usage factor was applied for each quarter. In reality, it is unlikely that anyone would be swimming or boating during these months. However, the resulting dose is considerably lower than those from other pathways and does not contribute much to the total dose.

Table 4.3-E

Maximum Individual Organ Doses -- mrem
From Liquid Release Period: Jan-Dec 2018

Organ	Age Class Organ Dose – mrem *		
	Adult	Teen	Child
Bone	N/A	N/A	N/A
GI-LLI	N/A	N/A	N/A
Kidney	N/A	N/A	N/A
Liver	N/A	N/A	N/A
Lung	N/A	N/A	N/A
Thyroid	N/A	N/A	N/A
T.Body	N/A	N/A	N/A

* These doses are conservative since the same usage factor was applied for each quarter. In reality, it is unlikely that anyone would be swimming or boating during the entire year. However, the resulting dose is considerably lower than those from other pathways and does not contribute much to the total dose.

-Highest total body dose and highest organ dose are bolded.

5.0 OFFSITE AMBIENT RADIATION MEASUREMENTS

The PNPS ODCM does not contain control limits related specifically to offsite ambient radiation exposure. However, Regulatory Guide 1.21 (Reference 1) recommends calculation of ambient radiation exposure as part of the overall assessment of radiological impact on man.

Thermoluminescent dosimeters (TLDs) are located at 86 sites beyond the boundary of the PNPS restricted/protected area. A number of these TLDs are located within the site boundary, on Entergy property in close proximity to the station proper. The TLDs are collected on a quarterly basis and used to calculate the ambient radiation exposure in milliRoentgen (mR) over the exposure period. These TLDs are grouped into four zones of increasing distance from the station. Average exposure values for each of these zones were calculated for each calendar quarter and the total year. The average exposure values (mR) for the four zones are presented in Table 5.0.

In addition to responding to ambient radiation exposure, TLDs will also record radiation resulting from noble gases (plume and immersion exposure), particulate materials deposited on the ground, cosmic rays from outer space, and from naturally-occurring radioactivity in the soil and air. Typically, the exposure from cosmic rays and other natural radioactivity components is approximately 40 to 70 mR/year. As calculated in Sections 4.1 and 4.2 of this report, the ambient radiation component of doses from PNPS effluent emissions are below 1 mrem/yr and would not be discernible above the natural radiation exposure levels.

The major source of ambient radiation exposure from PNPS results from high-energy gamma rays emitted from nitrogen-16 (N-16) contained in steam flowing through the turbine. Although the N-16 is enclosed in the process lines and turbine and is not released into the environment, the ambient radiation exposure and sky shine from this contained source accounts for the majority of the radiation dose, especially in close proximity to the station. Other sources of ambient radiation exposure include radiation emitted from contained radioactive materials and/or radwaste at the facility. Despite these sources of ambient radiation exposure at PNPS, increases in exposure from ambient radiation are typically not observable above background levels at locations beyond Entergy controlled property.

The average exposure values presented in Table 5.0 appear to indicate an elevation in ambient exposures in Zone 1, those TLDs within 2 miles of PNPS. Most of this elevation is due to increases in exposure levels measured at TLD locations on Entergy property in close proximity to the station proper. For example, the annual exposure at TLD location OA, located at the Overlook Area near the PNPS Health Club (I&S Building), was 195 mR for the entire year. This location is immediately adjacent to the station proper and overlooks the turbine building, therefore receiving the highest direct ambient and sky shine exposure. When the near-site TLDs (those located within 0.6 km of the Reactor Building) are removed from the calculation of averages, the mean annual exposure in Zone 1 falls from 75.5 ± 26.3 mR/yr to 57.4 ± 8.7 mR/yr. Such a corrected dose is not statistically different from the Zone 4 average of 60.1 ± 8.5 mR/yr, and is indicative of natural background radiation.

Although the annual exposure at TLD location OA was 135 mR above the average Zone 4 exposure, members of the general public do not continuously occupy this area. When adjusted for such occupancy, a hypothetical member of the public who was at this location for 40 hours per year would only receive an incremental dose of 2.7 mrem over natural background radiation levels. At the nearest residence 0.8 kilometers (0.5 miles) southeast of the PNPS Reactor Building, the annual exposure was calculated as being 61.7 ± 3.5 mR (based on continuous occupancy at this location), which compares quite well to the Zone 4 annual average background radiation level of 60.1 ± 8.5 mR. Statistically, there is no difference between these two values.

Pilgrim Station began moving spent fuel to the Independent Spent Fuel Storage Installation (ISFSI) located within the protected area immediately west of the PNPS Reactor Building. Three new TLDs were installed at the beginning of 2016 to monitor any incremental dose from this facility. TLD ISF-1 was located on Rocky Hill Road 0.35 km (0.21 mi) southwest of the reactor building. The annual exposure at this location was calculated as being 76.9 ± 2.4 mR (based on continuous occupancy at this location), or 16.8 mR above the Zone 4 average of 60.1 mR. However, the area is not continuously occupied, and when corrected for an exposure time of 365 hours/year, the estimated exposure to a person walking along this section of Rocky Hill Road would be 0.70 mR/year.

It must be emphasized that the projected ambient exposures discussed above and on the previous page are calculated to occur to a maximum-exposed hypothetical individual. Even though conservative assumptions are made in the projection of these dose consequences, all of the projected doses are well below the NRC dose limit of 100 mrem/yr specified in 10CFR20.1301, as well as the EPA dose limit of 25 mrem/yr specified in 40CFR190. Both of these limits are to be applied to real members of the general public, so the fact that the dose to the hypothetical maximum-exposed individual is within the limits ensures that any dose received by a real member of the public would be smaller and well within any applicable limit.

In 1994, Pilgrim Station opened the old training facility (I&S Building) overlooking the plant as a health club for its employees. This site is immediately adjacent to the protected area boundary near monitoring location OA and receives appreciable amounts of direct ambient and sky shine exposure from the turbine building. Although personnel using this facility are employees of Entergy, they are considered to be members of the public. Due to their extended presence in the facility (500 hr/yr, assuming utilization of the facility for 2 hr/day, 5 days a week, for 50 weeks/yr), these personnel represent the most conservative case in regards to ambient radiation exposure to a member of the public within the PNPS owner controlled area. Their annual incremental radiation dose above background during 2018 is estimated as being approximately 1.6 mrem, based on the average exposure measured by the TLD in the building.

The exposures measured by the TLD located in the health club would also include any increase in ambient radiation resulting from noble gases and/or particulate activity deposited on the ground from gaseous releases. However, they would not indicate any internal dose received by personnel in this facility from inhalation of small amounts of PNPS-related radioactivity contained in the air. An environmental air sampler located immediately adjacent to the health club did not indicate any PNPS-related activity during 2018. Dose calculations performed in the same manner as those outlined in Section 4.2 for airborne effluent releases yielded a projected total body dose to the maximum-exposed individual (500 hr/yr exposure) of approximately 0.0378 mrem, resulting from inhalation.

Again, it must be emphasized that the above-described exposures were received by personnel who are employees or contractors of Entergy, accessing areas or facilities on property under the ownership and control of Entergy. Since this exposure was received within the owner-controlled area, it is not used for comparison to the annual dose limit of 25 mrem/yr specified in 40CFR190. This regulation explicitly applies to areas at or beyond the owner-controlled property, and is not applicable in this situation. As stated earlier, TLDs at and beyond the site boundary do not indicate elevated ambient radiation levels resulting from the operation of Pilgrim Station.

Although some of the TLDs in close proximity to PNPS indicate increases in exposure levels from ambient radiation, such increases are localized to areas under Entergy control. For members of the general public who are not employed or contracted with Entergy and are accessing Entergy controlled areas (e.g., parking lots, etc.), such increases in dose from ambient radiation exposure are estimated as being less than 0.6 mrem/year.

Table 5.0

Average TLD Exposures By Distance Zone During 2018

Exposure Period	Average Exposure ± Standard Deviation: mR/period			
	Zone 1* 0-3 km	Zone 2 3-8 km	Zone 3 8-15 km	Zone 4 >15 km
Jan-Mar	18.9 ± 6.1	14.2 ± 3.4	14.4 ± 1.2	15.1 ± 2.4
Apr-Jun	18.7 ± 7.0	13.8 ± 2.0	13.1 ± 1.6	14.3 ± 2.0
Jul-Sep	18.8 ± 7.3	14.0 ± 2.0	13.7 ± 1.3	14.8 ± 2.1
Oct-Dec	18.9 ± 6.1	15.2 ± 2.0	14.9 ± 1.4	15.9 ± 2.2
Jan-Dec	75.3 ± 26.3	57.2 ± 9.7	56.0 ± 6.0	60.1 ± 8.5

* Zone 1 extends from the PNPS restricted/protected area boundary outward to 3 kilometers (2 miles), and includes several TLDs located within the site boundary.

** When corrected for TLDs located within the site boundary, the Zone 1 annual average is calculated to be 62.1 ± 8.0 mR/yr.

6.0 PERCENT OF ODCM EFFLUENT CONTROL LIMITS

The PNPS ODCM contains dose and concentration limits for radioactive effluents. In addition, the effluent controls specified ensure that radioactive releases are maintained as low as reasonably achievable. The percentage of the PNPS ODCM Control limit values were determined from doses calculated in Section 4, the effluent releases summarized in Section 2, and the ODCM Control limits/objectives listed in Tables 6.1 and 6.2.

The percent of applicable control limit values are provided to supplement the information provided in the Section 2 of this report. The format for the percent of applicable limits is modified from that prescribed in Regulatory Guide 1.21 (Reference 1) to accommodate the Radioactive Effluents Technical Specifications (RETS) that became effective March 01, 1986. The percentages have been grouped according to whether the releases were via liquid or gaseous effluent pathways.

6.1 Gaseous Effluent Releases

Dose-based effluent controls related to exposures arising from gaseous effluent releases are presented in Table 6.1. The maximum quarterly air doses and annual whole body doses listed in Table 4.1 were used to calculate the percentage values shown in Table 6.1. All doses resulting from noble gas exposure were a small percentage of the applicable effluent control.

Organ dose limits for the maximum-exposed individual from radioactive particulates, iodines, and tritium from the PNPS ODCM are also shown in Table 6.1. The maximum quarterly and annual organ doses from Tables 4.2-A through 4.2-E were used to calculate the percentages shown in Table 6.1. The resulting organ doses from Pilgrim Station's gaseous releases during 2018 were a small percentage of the corresponding effluent control.

Table 6.1

Percent of ODCM Effluent Control Limits
for Gaseous Effluent Releases During 2018

A. Instantaneous Dose Rate Limit - Noble Gases
PNPS ODCM Control 3.3.1.a
Limit: 500 mrem/yr Total Body Dose

Period	Value - mrem/yr	Fraction of Limit
Jan-Dec	5.48E-04	1.10E-04%

B. Instantaneous Dose Rate Limit - Noble Gases
PNPS ODCM Control 3.3.1.a
Limit: 3000 mrem/yr Skin Dose

Period	Value - mrem/yr	Fraction of Limit
Jan-Dec	2.97E-03	9.91E-05%

C. Instantaneous Dose Rate Limit - Particulates, Iodines, & Tritium
PNPS ODCM Control 3.3.1.b
Limit: 1500 mrem/yr Organ Dose

Period	Value - mrem/yr	Fraction of Limit
Jan-Dec	6.46E-02	4.31E-01%

D. Quarterly Dose Objective - Noble Gas Gamma Air Dose
PNPS ODCM Control 3.3.2.a
Objective: 5 mrad Gamma Air Dose

Period	Value – mrad	Fraction of Limit
Jan-Mar	0.00E+00	0.00E+00%
Apr-Jun	2.38E-04	4.77E-03%
Jul-Sep	2.36E-04	4.71E-03%
Oct-Dec	3.57E-04	7.14E-03%

E. Annual Dose Objective - Noble Gas Gamma Air Dose
PNPS ODCM Control 3.3.2.b
Objective: 10 mrad Gamma Air Dose

Period	Value - mrad/yr	Fraction of Limit
Jan-Dec	8.31E-04	8.31E-03%

Table 6.1 (continued)

Percent of ODCM Effluent Control Limits
for Gaseous Effluent Releases During 2018

F. Quarterly Dose Objective - Noble Gas Beta Air Dose
PNPS ODCM Control 3.3.2.a
Objective: 10 mrad Beta Air Dose

Period	Value - mrad	Fraction of Limit
Jan-Mar	0.00E+00	0.00E+00%
Apr-Jun	8.82E-04	8.82E-03%
Jul-Sep	8.72E-04	8.72E-03%
Oct-Dec	1.32E-03	1.32E-02%

G. Annual Dose Objective - Noble Gas Beta Air Dose
PNPS ODCM Control 3.3.2.b
Objective: 20 mrad Beta Air Dose

Period	Value - mrad/yr	Fraction of Limit
Jan-Dec	3.08E-03	1.54E-02%

H. Quarterly Dose Objective - Particulates, Iodines, Tritium, and Carbon-14
PNPS ODCM Control 3.3.3.a
Objective: 7.5 mrem Organ Dose

Period	Value - mrem	Fraction of Limit
Jan-Mar	1.45E-02	1.93E-01%
Apr-Jun	1.42E-02	1.89E-01%
Jul-Sep	1.73E-02	2.30E-01%
Oct-Dec	1.86E-02	2.49E-01%

I. Annual Dose Objective - Particulates, Iodines, Tritium, and Carbon-14
PNPS ODCM Control 3.3.3.b
Objective: 15 mrem Organ Dose

Period	Value - mrem/yr	Fraction of Limit
Jan-Dec	6.46E-02	4.31E-01%

6.2 Liquid Effluent Releases

Liquid effluent concentration limits and dose objectives from the PNPS ODCM are shown in Table 6.2. The quarterly average concentrations from Table 2.3-A were used to calculate the percent concentration limits. The maximum quarterly and annual whole body and organ doses from Tables 4.3-A through 4.3-E were used to calculate the percentages shown in Table 6.2. The resulting concentrations, as well as organ and total body doses from Pilgrim Station's liquid releases during the reporting period were a small percentage of the corresponding effluent controls.

Table 6.2

Percent of ODCM Effluent Control Limits
for Liquid Effluent Releases During 2018

A. Fission and Activation Product Effluent Concentration Limit
PNPS ODCM Control 3.2.1
Limit: 10CFR20 Appendix B, Table 2, Column 2 Value

Period	Value - μCi/mL	Fraction of Limit
Jan-Mar	N/A	N/A
Apr-Jun	N/A	N/A
Jul-Sep	N/A	N/A
Oct-Dec	N/A	N/A
Jan-Dec	N/A	N/A

B. Tritium Average Concentration Limit
PNPS ODCM Control 3.2.1
Limit: 1.0E-03 μCi/mL

Period	Value - μCi/mL	Fraction of Limit
Jan-Mar	N/A	N/A
Apr-Jun	N/A	N/A
Jul-Sep	N/A	N/A
Oct-Dec	N/A	N/A
Jan-Dec	N/A	N/A

C. Dissolved and Entrained Noble Gases Concentration Limit
PNPS ODCM Control 3.2.1
Limit: 2.0E-04 μCi/mL

Period	Value - μCi/mL	Fraction of Limit
Jan-Mar	N/A	N/A
Apr-Jun	N/A	N/A
Jul-Sep	N/A	N/A
Oct-Dec	N/A	N/A
Jan-Dec	N/A	N/A

Table 6.2 (continued)

Percent of ODCM Effluent Control Limits
for Liquid Effluent Releases During 2018

D. Quarterly Total Body Dose Objective
PNPS ODCM Control 3.2.2.a
Objective: 1.5 mrem Total Body Dose

Period	Value - mrem	Fraction of Limit
Jan-Mar	N/A	N/A
Apr-Jun	N/A	N/A
Jul-Sep	N/A	N/A
Oct-Dec	N/A	N/A

E. Annual Total Body Dose Objective
PNPS ODCM Control 3.2.2.b
Objective: 3 mrem Total Body Dose

Period	Value - mrem	Fraction of Limit
Jan-Dec	N/A	N/A

F. Quarterly Organ Dose Objective
PNPS ODCM Control 3.2.2.a
Objective: 5 mrem Organ Dose

Period	Value - mrem	Fraction of Limit
Jan-Mar	N/A	N/A
Apr-Jun	N/A	N/A
Jul-Sep	N/A	N/A
Oct-Dec	N/A	N/A

G. Annual Organ Dose Objective
PNPS ODCM Control 3.2.2.b
Objective: 10 mrem Organ Dose

Period	Value - mrem	Fraction of Limit
Jan-Dec	N/A	N/A

7.0 RADIOACTIVE WASTE DISPOSAL DATA

Radioactive wastes that were shipped offsite for processing and disposal during the reporting period are described in Table 7.0, in the standard NRC Regulatory Guide 1.21 format.

The total quantity of radioactivity in Curies and the total volume in cubic meters are summarized in Table 7.0 for the following waste categories:

- Spent resins, filter sludges, and evaporator bottoms;
- Dry activated wastes, contaminated equipment, etc.;
- Irradiated components, control rods, etc.; and,
- Other.

During the reporting period approximately 91.8 cubic meters of spent resins, filter sludges, etc., containing a total activity of approximately 416 Curies were shipped from PNPS for processing and disposal. Dry activated wastes and contaminated equipment shipped during the period totaled 451 cubic meters and contained 1.88 Curies of radioactivity. There were no shipments of irradiated components during the reporting period. There were no shipments of "Other wastes" during the reporting period. There were no shipments of irradiated fuel during the reporting period.

Estimates of principal radionuclides, those comprising greater than 1% of the total activity in each waste category shipped, are listed in Table 7.0. There were 27 shipments to Energy Solutions' Bear Creek Facility in Oak Ridge, TN and 1 shipments to Energy Solutions Erwin Resin Solutions' Facility in Erwin, TN.

Table 7.0
Pilgrim Nuclear Power Station
Annual Radioactive Effluent Release Report
Solid Waste and Irradiated Fuel Shipments
January-December 2018

A. SOLID WASTE SHIPPED OFFSITE FOR BURIAL OR DISPOSAL (Not irradiated fuel)

1. Estimate of volume and activity content by type of waste

Type of waste	Jan-Dec 2018		
	Volume - m^3	Curies	Total Error
a. Spent resins, filters, filter sludges, evaporator bottoms, etc.	9.18E+01	4.16E+02	± 25%
b. Dry activated waste, contaminated equipment, etc.	4.51E+02	1.88E+00	± 25%
c. Irradiated components, control rods, etc.	0.00E+00	0.00E+00	N/A
d. Other (describe):	0.00E+00	0.00E+00	N/A

2. Estimate of major nuclide composition by type of waste[1]

Type of waste	Radionuclide	Abundance	Total Error
a. Spent resins, filters, filter sludge's, evaporator bottoms, etc.	Mn-54	19.26%	± 25%
	Fe-55	27.69%	± 25%
	Co-60	21.20%	± 25%
	Zn-65	25.8%	± 25%
	Cs-137	3.33%	± 25%
b. Dry activated waste, contaminated equipment, etc.	Mn-54	1.51%	± 25%
	Fe-55	72.90%	± 25%
	Co-60	22.95%	± 25%
	Ni-63	1.90%	± 25%
c. Irradiated components, control rods, etc.	N/A	N/A	N/A
d. Other (describe): Contaminated oil and water	N/A	N/A	N/A

[1] *"Major" is defined as any radionuclide comprising >1% of the total activity in the waste category.*

3. Solid Waste Disposition

Number of Shipments	Mode of Transportation	Destination
27	Tractor-trailer (Hittman Transport)	Energy Solutions, Bear Creek Facility[2] Oak Ridge, TN
1	Tractor-trailer (Hittman Transport)	Energy Solutions, Erwin Resin Solutions[2] Erwin, TN

[2] *This processor provides volume reduction services for dry compressible waste, contaminated equipment, etc. Remaining radioactive wastes will be shipped to Envirocare, Inc. in Clive, UT for final disposal.*

B. IRRADIATED FUEL SHIPMENTS & DISPOSITION

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

8.0 OFFSITE DOSE CALCULATION MANUAL REVISIONS

The PNPS Offsite Dose Calculation Manual (ODCM) was not revised during the calendar year of 2018.

9.0 PROCESS CONTROL PROGRAM REVISIONS

The following list summarizes changes made during 2018 to various procedures related to the Process Control Program (PCP):

EN-RW-102, "Radioactive Shipping Procedure", Rev. 15 &16:

Rev 15:

The purpose of this revision is to add instruction for contacting ANI in the event of off-normal shipment of Radioactive Materials (CR-HQN-2016-00874) and to add an option for use of type B(U) and B(M) packaging (CR-HQN-2016-00869).

- Step 2.0[16]: added reference to ANI Guideline 15-02
- Step 3.0[5]: added definition for Special Shipment (from ANI 15-02)
- Step 5.1[14] and preceding Note: added step for advance notification of ANI of Special Shipments
- Step 5.2[16]: revised Flow Chart 1 and Flow Chart 2 to reflect contacting ANI for Special Shipments
- Section 8.0: updated commitment number per GGNS Commitment Review.

Attachment 9.2, step 4: added item for Type B(U) or B(M) packaging; added "Excl Use SCO" to 5th bullet item.

Rev 16:

The purpose of this revision is remove GGNS section 8.0 items that are not commitments. This revision is non-editorial for GGNS and editorial for the rest of the fleet.

- Deleted GGNS line items from section 8.0 that are not actually commitments.
- Updated coversheet

10.0 REFERENCES

1. U.S. Nuclear Regulatory Commission, "Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water Cooled Nuclear Power Plants", Regulatory Guide 1.21, Revision 1, June 1974.

2. "Pilgrim Nuclear Power Station Offsite Dose Calculation Manual", Revision 10, May 2009.

3. U.S. Nuclear Regulatory Commission, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10CFR50 Appendix I", Regulatory Guide 1.109, Revision 1, October 1977.

4. U.S. Nuclear Regulatory Commission, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors", Regulatory Guide 1.111, July 1977.

5. Boston Edison Company, "Pilgrim Station Unit 1 Appendix I Evaluation", April 1977.

6. Entech Engineering Inc., P100-R19, "AEOLUS-3 - A Computer Code for the Determination of Atmospheric Dispersion and Deposition of Nuclear Power Plant Effluents During Continuous, Intermittent and Accident Conditions in Open-Terrain Sites, Coastal Sites and Deep-River Valleys".

7. U.S. Nuclear Regulatory Commission, "XOQDOQ: Computer Program for the Meteorological Evaluation of Routine Effluent Releases at Nuclear Power Stations", NUREG/CR2919, September 1982.

APPENDIX A

Meteorological Joint Frequency Distributions

Table A-1
Joint Frequency Distribution of Wind Directions and Speeds
For the 33-ft level of the 220-ft Tower

Jan-Mar 2018

Class A Freq: 0.113

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	1	0	3	2	1	0	0	0	0	0	0	0	0	0	0	5	12
3.5-7.5	21	30	3	17	7	0	1	2	4	5	0	2	9	31	12	5	149
7.5-12.5	0	23	0	0	0	0	1	0	0	6	5	7	23	15	1	0	81
12.5-18.5	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	22	53	6	19	8	0	2	2	4	12	5	9	32	46	13	10	243

Class B Freq: 0.065

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	2	1	0	0	0	0	0	2	0	0	0	0	1	6
3.5-7.5	6	6	3	2	1	0	0	0	2	3	1	3	10	15	19	8	79
7.5-12.5	1	10	0	0	0	0	0	2	5	11	2	2	13	6	0	0	52
12.5-18.5	0	0	1	0	0	0	0	2	1	0	0	0	0	0	0	0	4
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	7	16	4	4	2	0	0	4	8	14	5	5	23	21	19	9	141

Class C Freq: 0.078

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	1	3	5	1	0	0	1	0	1	1	0	1	0	1	0	15
3.5-7.5	2	13	0	2	1	3	1	0	4	11	4	8	18	9	6	6	88
7.5-12.5	0	17	1	2	0	0	0	2	8	8	3	2	15	0	2	4	64
12.5-18.5	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	2	32	4	9	2	3	1	3	13	20	8	10	34	9	9	10	169

Class D Freq: 0.558

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	7	8	6	13	2	2	2	7	6	8	12	9	15	19	10	9	135
3.5-7.5	8	35	38	19	6	9	23	26	61	53	59	109	78	82	48	18	672
7.5-12.5	22	77	17	5	2	1	6	6	32	74	21	13	34	12	8	8	338
12.5-18.5	6	19	3	2	0	0	0	0	21	6	0	0	0	0	0	0	57
18.5-24	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	43	141	64	39	10	12	31	39	120	141	92	131	127	113	66	35	1204

Table A-1 (continued)

Jan-Mar 2018

Class E Freq: 0.164

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
0.95-3.5	13	9	2	6	3	1	3	1	6	4	2	12	19	8	10	6	105
3.5-7.5	3	17	7	0	0	0	4	8	17	23	33	27	24	8	4	5	180
7.5-12.5	0	7	2	0	0	0	0	3	2	35	3	3	2	1	0	0	58
12.5-18.5	0	9	1	0	0	0	0	0	0	0	0	0	0	0	0	0	10
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	16	42	12	6	3	1	7	12	25	62	38	43	45	17	14	11	354

Class F Freq: 0.021

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	1	0	0	0	0	2	2	1	5	5	2	5	0	0	23
3.5-7.5	0	0	0	0	0	0	2	1	0	5	1	4	0	1	1	1	16
7.5-12.5	0	0	0	0	0	0	0	0	0	2	4	0	0	0	0	0	6
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	1	0	0	0	2	3	2	8	10	9	2	6	1	1	45

Class G Freq: 0.001

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	2
3.5-7.5	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
7.5-12.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	0	3

Class All Freq: 1.000

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
0.95-3.5	21	18	15	28	8	3	6	11	14	14	22	27	37	32	21	21	298
3.5-7.5	40	101	51	40	15	12	31	37	88	100	98	154	139	146	90	43	1185
7.5-12.5	23	134	20	7	2	1	7	13	47	136	38	27	87	34	11	12	599
12.5-18.5	6	29	5	2	0	0	0	2	23	7	0	0	0	0	0	0	74
18.5-24	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	90	284	91	77	25	16	44	63	172	257	158	209	263	212	122	76	2159

Table A-1 (continued)

Apr-Jun 2018

Class A Freq: 0.110

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	5	1	2	5	7	0	0	0	0	0	0	0	0	0	1	3	24
3.5-7.5	7	23	37	19	15	14	4	1	1	0	1	5	10	12	14	4	167
7.5-12.5	0	3	5	0	0	0	4	0	9	14	1	3	11	0	0	0	50
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	12	27	44	24	22	14	8	1	10	14	2	8	21	12	15	7	241

Class B Freq: 0.043

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	3	1	4	2	1	0	0	0	0	0	0	0	2	1	0	1	15
3.5-7.5	3	1	4	2	4	2	3	0	0	3	2	13	2	3	0	0	42
7.5-12.5	0	0	5	6	0	0	1	2	4	9	7	1	1	0	0	0	36
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	6	2	13	10	5	2	4	2	4	12	9	14	5	4	0	1	93

Class C Freq: 0.062

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	2	5	3	5	4	2	0	0	0	0	0	0	0	1	0	4	26
3.5-7.5	1	2	11	6	11	3	10	3	1	12	7	10	3	2	0	0	82
7.5-12.5	0	0	2	2	0	0	1	3	12	5	1	0	1	0	0	0	27
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	3	7	16	13	15	5	11	6	13	17	8	10	4	3	0	4	135

Class D Freq: 0.404

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	3
0.95-3.5	23	26	24	26	17	9	12	9	16	13	5	12	3	9	17	22	243
3.5-7.5	10	15	11	15	31	32	28	19	67	91	40	30	49	10	7	8	463
7.5-12.5	0	0	7	2	3	4	14	15	28	80	5	1	11	0	0	0	170
12.5-18.5	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	3
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	33	41	42	43	51	45	57	44	111	184	50	44	64	19	24	30	882

Table A-1 (continued)

Apr-Jun 2018

Class E Freq: 0.279

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	4	8	18	20	18	7	7	11	10	7	8	22	24	20	10	10	204
3.5-7.5	0	1	3	11	8	6	10	24	34	88	53	19	30	5	3	3	298
7.5-12.5	0	0	0	0	0	1	1	2	6	73	20	0	3	0	0	0	106
12.5-18.5	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	2
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	4	9	21	31	26	14	19	37	50	169	81	41	57	25	13	13	610

Class F Freq: 0.079

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	1	3	8	11	5	1	2	1	2	2	5	13	18	13	1	9	95
3.5-7.5	0	0	1	2	2	0	0	0	4	11	29	7	1	3	1	0	61
7.5-12.5	0	0	0	0	0	0	0	0	0	5	12	0	0	0	0	0	17
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1	3	9	13	7	1	2	1	6	18	46	20	19	16	2	9	173

Class G Freq: 0.023

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	1	0	1	1	0	0	1	0	2	1	5	0	0	1	0	13
3.5-7.5	0	0	0	0	0	0	0	0	0	1	13	1	0	0	0	0	15
7.5-12.5	0	0	0	0	0	0	0	0	0	5	16	0	0	0	0	0	21
12.5-18.5	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	1	0	1	1	0	0	1	0	9	30	6	0	0	1	0	50

Class All Freq: 1.000

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	3
0.95-3.5	38	45	59	70	53	19	21	22	28	24	19	52	47	44	30	49	620
3.5-7.5	21	42	67	55	71	57	55	47	107	206	145	85	95	35	25	15	1128
7.5-12.5	0	3	19	10	3	5	21	22	59	191	62	5	27	0	0	0	427
12.5-18.5	0	0	0	0	0	0	3	1	0	2	0	0	0	0	0	0	6
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	59	90	145	135	127	81	101	92	194	423	226	143	170	79	55	64	2184

Table A-1 (continued)

Jul-Sep 2018

Class A Freq: 0.011

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	3	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	7
3.5-7.5	0	5	4	1	0	2	0	1	0	0	1	0	0	0	0	0	14
7.5-12.5	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	3	5	7	2	0	2	0	1	2	0	1	0	0	0	0	0	23

Class B Freq: 0.014

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	3	2	0	0	0	0	0	0	0	0	0	1	0	0	6
3.5-7.5	0	10	7	0	0	2	1	1	0	0	0	0	0	0	0	0	21
7.5-12.5	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	2
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	10	10	2	0	2	1	2	1	0	0	0	0	1	0	0	29

Class C Freq: 0.012

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	1	4
3.5-7.5	0	9	5	1	1	0	0	0	2	2	1	0	0	0	0	0	21
7.5-12.5	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	9	6	1	2	0	0	0	3	2	1	0	0	1	0	1	26

Class D Freq: 0.360

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	9	31	53	23	17	12	9	3	10	8	4	6	6	1	6	6	204
3.5-7.5	5	81	22	5	12	40	35	33	67	140	30	1	0	1	0	2	474
7.5-12.5	0	0	0	0	0	3	10	21	22	29	5	0	0	0	0	0	90
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	14	112	75	28	29	55	54	57	99	177	39	7	6	2	6	8	768

Table A-1 (continued)

Jul-Sep 2018

Class E Freq: 0.434

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	1	0	0	0	0	2	1	2	0	0	6
0.95-3.5	12	23	20	23	44	14	23	20	21	9	21	29	35	28	22	30	374
3.5-7.5	3	17	4	4	10	14	38	21	81	111	107	25	6	3	2	4	450
7.5-12.5	0	0	0	0	0	0	3	20	35	24	14	0	0	0	0	0	96
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	15	40	24	27	54	28	65	61	137	144	142	56	42	33	24	34	926

Class F Freq: 0.147

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1	0	3
0.95-3.5	3	4	16	41	17	5	1	8	8	17	21	44	15	3	4	11	218
3.5-7.5	0	0	0	5	2	0	1	0	4	14	55	2	0	0	2	0	85
7.5-12.5	0	0	0	0	0	0	0	0	0	2	6	0	0	0	0	0	8
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	3	4	16	46	19	5	2	8	12	33	82	48	15	3	7	11	314

Class G Freq: 0.023

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	2	2	2	9	4	0	0	0	1	1	7	10	1	0	1	0	40
3.5-7.5	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	9
7.5-12.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	2	2	2	9	4	0	0	0	1	1	16	10	1	0	1	0	49

Class All Freq: 1.000

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	1	0	0	0	0	4	1	2	1	0	9
0.95-3.5	29	60	98	99	83	31	33	31	40	35	53	89	57	34	33	48	853
3.5-7.5	8	122	42	16	25	58	75	56	154	267	203	28	6	4	4	6	1074
7.5-12.5	0	0	0	0	0	3	13	42	61	55	25	0	0	0	0	0	199
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	37	182	140	115	108	92	122	129	255	357	281	121	64	40	38	54	2135

Oct-Dec 2018

Class A Freq: 0.014

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	1	2	0	0	0	0	0	0	0	0	0	1	2	1	0	0	7
3.5-7.5	0	1	0	0	0	0	0	0	1	0	0	2	1	1	2	1	9
7.5-12.5	0	0	0	1	0	0	0	0	0	2	2	1	2	4	1	0	13
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1	3	0	1	0	0	0	0	1	2	2	4	5	6	3	1	29

Class B Freq: 0.012

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
3.5-7.5	0	1	0	0	1	1	0	0	0	0	0	0	2	3	4	1	13
7.5-12.5	0	0	0	0	0	0	0	0	1	4	2	0	1	2	1	0	11
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	1	0	0	1	1	0	0	1	4	2	0	4	5	5	1	25

Class C Freq: 0.023

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	3
3.5-7.5	2	1	0	0	4	1	0	0	0	1	3	1	4	8	5	4	34
7.5-12.5	0	0	0	0	1	0	0	0	1	3	0	0	1	6	0	0	12
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	2	1	1	0	5	1	0	0	1	4	3	2	6	14	5	4	49

Class D Freq: 0.605

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	28	12	16	9	11	1	3	8	8	6	17	33	14	15	18	15	214
3.5-7.5	19	25	21	18	21	39	18	18	30	93	81	157	140	119	77	23	899
7.5-12.5	2	7	10	7	7	5	14	7	17	19	5	6	15	32	10	3	166
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	49	44	47	34	39	45	35	33	55	118	103	196	169	166	105	41	1279

Table A-1 (continued)

Oct-Dec 2018

Class E Freq: 0.305

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	12	21	4	4	5	7	8	13	20	22	45	38	36	10	7	6	258
3.5-7.5	1	3	5	1	6	6	22	31	31	38	99	52	31	6	5	2	339
7.5-12.5	0	0	2	0	2	0	6	5	11	10	3	0	0	0	0	0	39
12.5-18.5	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	8
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	13	24	11	5	13	13	36	57	62	70	147	90	67	16	12	8	644

Class F Freq: 0.039

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	1	0	2	1	0	2	1	2	1	6	18	7	1	0	3	1	46
3.5-7.5	0	0	0	0	0	0	0	0	2	6	27	0	0	0	0	0	35
7.5-12.5	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1	0	2	1	0	2	1	2	3	12	46	7	1	0	3	1	82

Class G Freq: 0.002

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	1	0	1	0	1	0	0	0	0	1	1	0	0	0	0	0	5
3.5-7.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7.5-12.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1	0	1	0	1	0	0	0	0	1	1	0	0	0	0	0	5

Class All Freq: 1.000

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	43	35	24	14	17	10	12	23	29	35	81	80	55	26	28	22	534
3.5-7.5	22	31	26	19	32	47	40	49	64	138	210	212	178	137	93	31	1329
7.5-12.5	2	7	12	8	10	5	20	12	30	38	13	7	19	44	12	3	242
12.5-18.5	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	8
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	67	73	62	41	59	62	72	92	123	211	304	299	252	207	133	56	2113

Table A-1 (continued)

Jan-Dec 2018

Class A Freq: 0.062

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	10	3	8	8	8	0	0	0	0	0	0	1	2	1	1	8	50
3.5-7.5	28	59	44	37	22	16	5	4	6	5	2	9	20	44	28	10	339
7.5-12.5	0	26	5	1	0	0	5	0	11	22	8	11	36	19	2	0	146
12.5-18.5	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	38	88	57	46	30	16	10	4	17	28	10	21	58	64	31	18	536

Class B Freq: 0.034

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	3	1	7	6	2	0	0	0	0	0	2	0	3	2	0	2	28
3.5-7.5	9	18	14	4	6	5	4	1	2	6	3	16	14	21	23	9	155
7.5-12.5	1	10	5	6	0	0	1	5	11	24	11	3	15	8	1	0	101
12.5-18.5	0	0	1	0	0	0	0	2	1	0	0	0	0	0	0	0	4
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	13	29	27	16	8	5	5	8	14	30	16	19	32	31	24	11	288

Class C Freq: 0.044

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	2	6	8	10	6	2	0	1	0	1	1	1	2	2	1	5	48
3.5-7.5	5	25	16	9	17	7	11	3	7	26	15	19	25	19	11	10	225
7.5-12.5	0	17	3	4	1	0	1	5	22	16	4	2	17	6	2	4	104
12.5-18.5	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	7	49	27	23	24	9	12	9	30	43	20	22	44	27	14	19	379

Class D Freq: 0.481

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	0	3
0.95-3.5	67	77	99	71	47	24	26	27	40	35	38	60	38	44	51	52	796
3.5-7.5	42	156	92	57	70	120	104	96	225	377	210	297	267	212	132	51	2508
7.5-12.5	24	84	34	14	12	13	44	49	99	202	36	20	60	44	18	11	764
12.5-18.5	6	19	3	2	0	0	2	1	21	6	0	0	0	0	0	0	60
18.5-24	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	139	338	228	144	129	157	177	173	385	620	284	378	366	300	201	114	4133

Table A-1 (continued)

Jan-Dec 2018

Class E Freq: 0.295

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	1	0	0	0	0	3	1	2	0	0	7
0.95-3.5	41	61	44	53	70	29	41	45	57	42	76	101	114	66	49	52	941
3.5-7.5	7	38	19	16	24	26	74	84	163	260	292	123	91	22	14	14	1267
7.5-12.5	0	7	4	0	2	1	10	30	54	142	40	3	5	1	0	0	299
12.5-18.5	0	9	1	0	0	0	1	8	0	1	0	0	0	0	0	0	20
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	48	115	68	69	96	56	127	167	274	445	408	230	211	91	63	66	2534

Class F Freq: 0.071

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1	0	3
0.95-3.5	5	7	27	53	22	8	4	13	13	26	49	69	36	21	8	21	382
3.5-7.5	0	0	1	7	4	0	3	1	10	36	112	13	1	4	4	1	197
7.5-12.5	0	0	0	0	0	0	0	0	0	9	23	0	0	0	0	0	32
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	5	7	28	60	26	8	7	14	23	71	184	84	37	25	13	22	614

Class G Freq: 0.012

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	3	3	3	10	6	0	1	1	1	4	9	16	1	0	2	0	60
3.5-7.5	0	0	0	0	0	0	0	0	0	1	22	2	0	0	0	0	25
7.5-12.5	0	0	0	0	0	0	0	0	0	5	16	0	0	0	0	0	21
12.5-18.5	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	3	3	3	10	6	0	1	1	1	11	47	18	1	0	2	0	107

Class All Freq: 1.000

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	2	0	0	0	0	6	2	2	1	0	13
0.95-3.5	131	158	196	211	161	63	72	87	111	108	175	248	196	136	112	140	2305
3.5-7.5	91	296	186	130	143	174	201	189	413	711	656	479	418	322	212	95	4716
7.5-12.5	25	144	51	25	15	14	61	89	197	420	138	39	133	78	23	15	1467
12.5-18.5	6	29	5	2	0	0	3	11	23	9	0	0	0	0	0	0	88
18.5-24	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	253	629	438	368	319	251	339	376	744	1248	969	772	749	538	348	250	8591

Table A-2
Joint Frequency Distribution of Wind Directions and Speeds
For the 220-ft level of the 220-ft Tower

Jan-Mar 2018

Class A Freq: 0.121

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5-7.5	3	2	4	4	1	1	1	0	0	0	0	0	0	1	2	2	21
7.5-12.5	4	4	3	4	8	1	0	3	1	3	2	0	0	3	2	2	40
12.5-18.5	13	4	2	2	1	2	0	0	0	4	3	2	5	9	8	8	63
18.5-24	7	11	0	0	0	0	0	0	0	1	5	1	8	13	15	2	63
>24	5	12	0	0	0	0	0	0	0	0	2	0	12	12	10	3	56
TOTAL	32	33	9	10	10	4	1	3	1	8	12	3	25	38	37	17	243

Class B Freq: 0.069

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5-7.5	1	0	2	0	3	0	0	0	0	0	0	0	0	0	0	0	6
7.5-12.5	0	0	0	1	0	0	0	0	1	0	3	1	2	0	2	0	10
12.5-18.5	2	2	4	0	0	0	0	1	3	12	1	1	7	7	6	6	52
18.5-24	2	2	1	1	1	0	0	1	2	1	2	2	7	5	9	7	43
>24	5	4	1	0	0	0	0	0	0	1	1	0	3	10	3	0	28
TOTAL	10	8	8	2	4	0	0	2	6	14	7	4	19	22	20	13	139

Class C Freq: 0.077

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5-7.5	0	0	4	2	0	0	1	0	0	0	0	1	0	2	0	0	10
7.5-12.5	1	2	1	1	0	1	0	0	1	3	3	3	4	2	1	0	23
12.5-18.5	0	10	0	1	0	1	1	1	5	8	4	0	12	4	3	1	51
18.5-24	1	1	1	0	1	1	0	1	2	3	3	1	4	5	2	5	31
>24	3	9	2	2	1	0	0	0	1	1	0	0	6	8	4	4	41
TOTAL	5	22	8	6	2	3	2	2	9	15	10	5	26	21	10	10	156

Class D Freq: 0.549

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	1	0	1	0	1	1	0	0	0	0	0	0	0	1	1	0	6
3.5-7.5	1	7	4	5	1	3	1	4	4	3	2	4	4	2	6	2	53
7.5-12.5	6	5	21	12	5	5	10	13	16	26	34	23	13	18	7	6	220
12.5-18.5	1	9	28	8	2	2	8	7	21	74	51	58	62	29	28	11	399
18.5-24	2	12	14	11	2	5	0	0	8	32	42	9	28	29	34	12	240
>24	49	39	5	13	0	0	0	0	14	11	3	0	7	10	26	11	188
TOTAL	60	72	73	49	11	16	19	24	63	146	132	94	114	89	102	42	1106

Jan-Mar 2018

Class E Freq: 0.163

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	2	1	2	1	0	0	0	2	0	0	1	0	0	0	0	9
3.5-7.5	4	6	3	1	2	4	0	2	3	4	3	3	2	6	2	2	47
7.5-12.5	6	3	5	1	0	1	2	4	7	8	7	10	7	14	7	3	85
12.5-18.5	5	6	11	0	0	0	1	1	14	11	1	13	11	15	7	4	100
18.5-24	3	4	2	0	0	0	0	1	1	4	17	3	2	7	3	5	52
>24	1	12	3	0	0	0	0	0	0	10	2	0	0	4	2	2	36
TOTAL	19	33	25	4	3	5	3	8	27	37	30	30	22	46	21	16	329

Class F Freq: 0.019

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	4
3.5-7.5	0	0	0	0	1	1	1	0	0	0	2	1	1	1	0	1	9
7.5-12.5	0	0	0	0	0	0	1	1	2	0	1	2	0	1	2	0	10
12.5-18.5	0	0	0	0	0	0	0	1	1	0	1	0	1	2	1	0	7
18.5-24	0	0	0	0	0	0	0	0	0	0	4	2	0	0	0	0	6
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3
TOTAL	1	0	0	0	1	1	2	2	3	0	8	5	3	5	3	5	39

Class G Freq: 0.001

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5-7.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7.5-12.5	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	2
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	3

Class All Freq: 1.000

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	2	2	2	2	2	1	0	0	2	0	0	1	1	2	1	1	19
3.5-7.5	9	15	17	12	8	9	4	6	7	7	7	9	7	12	10	7	146
7.5-12.5	17	14	30	19	13	8	13	22	28	40	50	40	26	38	21	11	390
12.5-18.5	21	31	45	11	3	5	10	11	44	109	61	74	98	67	53	30	673
18.5-24	15	30	18	12	4	6	0	3	13	41	73	18	49	59	63	31	435
>24	63	76	11	15	1	0	0	0	15	23	8	0	28	44	45	23	352
TOTAL	127	168	123	71	31	29	27	42	109	220	199	142	209	222	193	103	2015

Apr-Jun 2018

Class A Freq: 0.111

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5-7.5	2	5	13	4	2	0	0	0	1	0	0	0	0	0	0	2	29
7.5-12.5	5	8	4	3	21	18	4	0	3	0	1	2	3	9	2	5	88
12.5-18.5	4	5	10	6	2	3	5	1	1	12	4	5	8	7	4	1	78
18.5-24	6	3	2	2	0	0	0	0	1	3	1	0	6	3	5	2	34
>24	3	1	3	2	1	0	0	0	0	0	0	0	2	0	0	0	12
TOTAL	20	22	32	17	26	21	9	1	6	15	6	7	19	19	11	10	241

Class B Freq: 0.043

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5-7.5	2	2	2	1	1	1	0	0	0	0	0	0	0	1	0	1	11
7.5-12.5	3	0	2	1	2	2	3	0	2	4	5	3	4	1	1	0	33
12.5-18.5	0	1	0	1	1	0	1	2	2	3	6	11	0	1	0	0	29
18.5-24	0	0	1	0	1	0	0	0	0	0	1	0	0	1	0	1	5
>24	1	0	3	6	3	0	0	0	0	1	0	0	1	0	0	0	15
TOTAL	6	3	8	9	8	3	4	2	4	8	12	14	5	4	1	2	93

Class C Freq: 0.062

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5-7.5	3	3	2	5	1	3	1	1	1	1	1	0	0	1	0	2	25
7.5-12.5	0	1	2	0	4	3	7	3	2	7	5	8	3	1	0	2	48
12.5-18.5	0	0	4	3	3	5	1	1	7	6	3	3	1	1	0	2	40
18.5-24	0	1	5	2	4	0	0	0	0	2	1	0	0	1	0	0	16
>24	0	0	1	3	1	0	0	0	0	0	0	0	1	0	0	0	6
TOTAL	3	5	14	13	13	11	9	5	10	16	10	11	5	4	0	6	135

Class D Freq: 0.404

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	6	2	2	0	1	2	1	5	1	4	0	0	0	1	0	0	25
3.5-7.5	6	9	19	11	8	12	9	7	7	14	10	2	2	2	4	8	130
7.5-12.5	13	12	9	15	12	24	15	6	19	38	19	10	7	4	9	13	225
12.5-18.5	5	10	0	7	13	16	11	18	32	84	28	22	26	8	9	12	301
18.5-24	9	3	7	6	6	5	5	4	1	46	39	2	7	17	5	5	167
>24	1	0	1	2	7	3	2	0	0	6	2	0	5	2	0	0	31
TOTAL	40	36	38	41	47	62	43	40	60	192	98	36	47	34	27	38	879

Apr-Jun 2018

Class E Freq: 0.280

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	1	1	0	5	2	4	2	3	3	2	0	1	1	0	3	28
3.5-7.5	2	7	8	9	5	12	7	2	5	7	4	4	1	4	7	7	91
7.5-12.5	4	3	2	5	7	15	12	10	17	27	10	10	10	7	10	9	158
12.5-18.5	3	1	1	2	2	1	4	12	10	58	39	12	20	12	7	9	193
18.5-24	2	0	1	0	1	0	0	0	0	40	48	4	2	8	2	2	110
>24	0	0	0	0	0	0	2	0	0	14	6	0	2	3	3	0	30
TOTAL	11	12	13	16	20	30	29	26	35	149	109	30	36	35	29	30	610

Class F Freq: 0.078

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	1	2	0	0	0	3	1	0	1	0	0	0	0	1	9
3.5-7.5	8	2	4	3	2	2	1	2	3	4	1	0	4	0	5	3	44
7.5-12.5	2	1	0	0	0	3	1	1	0	4	3	1	3	3	1	8	31
12.5-18.5	1	0	0	0	0	0	0	4	0	3	9	9	9	3	5	8	51
18.5-24	2	0	0	0	0	0	0	1	0	5	11	1	1	1	3	6	31
>24	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	3
TOTAL	13	3	5	5	2	5	2	11	4	16	28	11	17	7	14	26	169

Class G Freq: 0.023

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	2
0.95-3.5	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	4
3.5-7.5	1	0	0	0	0	0	0	0	1	0	0	1	1	1	0	0	5
7.5-12.5	0	0	0	0	0	0	0	0	0	1	1	1	4	1	1	0	9
12.5-18.5	1	0	0	0	0	0	0	0	0	1	6	10	2	1	0	0	21
18.5-24	0	0	0	0	0	0	0	0	0	2	1	3	0	0	0	0	6
>24	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	3
TOTAL	3	1	1	0	0	0	0	0	3	7	9	15	7	3	1	0	50

Class All Freq: 1.000

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	2
0.95-3.5	7	4	4	2	6	4	5	10	6	8	3	0	1	2	0	4	66
3.5-7.5	24	28	48	33	19	30	18	12	18	26	16	7	8	9	16	23	335
7.5-12.5	27	25	19	24	46	65	42	20	43	81	44	35	34	26	24	37	592
12.5-18.5	14	17	15	19	21	25	22	38	52	167	95	72	66	33	25	32	713
18.5-24	19	7	16	10	12	5	5	5	2	98	102	10	16	31	15	16	369
>24	5	1	8	13	12	3	4	0	0	23	12	0	11	5	3	0	100
TOTAL	96	82	111	101	116	132	96	85	122	403	272	124	136	106	83	112	2177

Table A-2 (continued)

Jul-Sep 2018

Class A Freq: 0.011

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5-7.5	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2
7.5-12.5	0	0	2	2	0	1	0	1	0	0	0	1	0	0	0	1	8
12.5-18.5	0	1	7	1	0	0	0	0	1	0	0	0	0	0	0	1	11
18.5-24	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
>24	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
TOTAL	1	1	10	3	1	1	0	1	2	0	0	1	0	0	0	2	23

Class B Freq: 0.013

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5-7.5	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2
7.5-12.5	0	0	1	2	0	1	0	0	1	0	0	0	0	0	1	0	6
12.5-18.5	0	3	5	1	0	1	0	1	1	0	0	0	0	0	0	0	12
18.5-24	0	3	4	0	0	0	0	0	0	0	0	0	0	0	0	0	7
>24	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
TOTAL	0	6	12	3	1	2	0	1	2	0	0	0	0	0	1	0	28

Class C Freq: 0.011

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5-7.5	0	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	3
7.5-12.5	0	0	2	1	0	1	0	0	0	2	1	0	0	0	0	0	7
12.5-18.5	0	0	2	1	0	0	0	0	1	1	0	0	0	0	0	0	5
18.5-24	0	4	2	1	0	0	0	0	0	0	0	0	0	0	0	1	8
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	4	6	4	0	1	0	0	1	4	1	0	0	1	0	1	23

Class D Freq: 0.358

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	2
3.5-7.5	2	3	15	6	3	3	3	1	4	6	3	1	0	0	1	0	51
7.5-12.5	5	9	40	25	15	10	17	13	15	43	23	2	1	3	3	8	232
12.5-18.5	8	20	44	9	10	13	9	24	20	121	54	1	1	1	1	2	338
18.5-24	3	25	6	11	5	13	5	3	1	21	18	0	0	0	0	2	113
>24	0	0	2	2	12	0	0	0	0	6	0	0	0	0	0	0	22
TOTAL	18	57	108	53	46	39	34	41	40	197	98	4	2	4	5	12	758

Jul-Sep 2018

Class E Freq: 0.435

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	2
0.95-3.5	4	2	7	2	1	3	2	0	2	2	1	0	1	1	2	2	32
3.5-7.5	15	12	10	17	20	10	5	15	5	8	5	6	10	7	7	7	159
7.5-12.5	9	10	5	14	15	48	28	19	33	53	44	18	13	18	16	11	354
12.5-18.5	9	13	4	2	3	0	7	15	35	97	53	27	18	6	8	7	304
18.5-24	3	3	0	0	0	0	0	3	1	19	26	2	0	1	1	5	64
>24	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	3	6
TOTAL	41	40	26	35	39	62	42	52	76	179	130	53	42	34	34	36	921

Class F Freq: 0.148

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
0.95-3.5	2	5	8	4	6	1	1	1	2	4	2	2	1	1	1	0	41
3.5-7.5	6	7	3	13	11	17	8	5	6	7	3	5	8	4	2	3	108
7.5-12.5	6	2	3	0	5	4	6	6	7	1	4	7	11	5	10	3	80
12.5-18.5	1	1	0	0	0	0	0	1	1	4	14	16	15	5	3	1	62
18.5-24	1	0	0	0	0	0	0	0	0	1	15	2	0	0	0	0	19
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3
TOTAL	16	15	15	17	22	22	15	13	16	17	38	32	35	15	16	10	314

Class G Freq: 0.023

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	2	0	5	3	2	0	3	0	0	1	0	0	0	0	2	0	18
3.5-7.5	0	3	3	0	0	0	3	1	1	0	0	2	1	0	1	0	15
7.5-12.5	0	0	0	0	0	1	0	1	1	0	2	1	1	3	0	0	10
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	2	1	3	0	0	6
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	2	3	8	3	2	1	6	2	2	1	2	5	3	6	3	0	49

Class All Freq: 1.000

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	3
0.95-3.5	8	7	21	9	10	4	6	1	4	7	3	2	2	2	5	2	93
3.5-7.5	24	25	34	37	34	30	19	22	16	22	11	14	19	12	11	10	340
7.5-12.5	20	21	53	44	35	66	51	40	57	99	74	29	26	29	30	23	697
12.5-18.5	18	38	62	14	13	14	16	41	59	223	121	46	35	15	12	11	738
18.5-24	7	35	12	12	5	13	5	6	3	41	59	4	0	1	1	8	212
>24	1	0	2	2	14	0	0	0	0	6	1	0	0	1	0	6	33
TOTAL	78	126	185	118	111	128	97	110	139	398	269	95	82	60	59	61	2116

Table A-2 (continued)

Oct-Dec 2018

Class A Freq: 0.014

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5-7.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7.5-12.5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
12.5-18.5	2	1	0	0	0	0	0	0	1	0	1	2	0	2	3	0	12
18.5-24	0	1	0	0	0	0	0	0	0	1	2	0	1	0	0	1	6
>24	0	0	0	1	0	0	0	0	0	0	0	0	2	2	4	1	10
TOTAL	2	2	0	1	0	0	0	0	1	1	3	2	3	5	7	2	29

Class B Freq: 0.012

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5-7.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7.5-12.5	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	1	6
18.5-24	0	1	0	0	1	0	0	0	0	3	3	0	0	0	4	0	12
>24	0	0	0	0	1	0	0	0	0	1	0	0	0	2	2	0	6
TOTAL	0	1	0	0	2	0	0	0	0	4	3	0	1	4	9	1	25

Class C Freq: 0.022

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5-7.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7.5-12.5	0	0	0	0	0	0	0	0	0	0	1	0	0	1	3	0	5
12.5-18.5	0	0	0	1	0	0	0	0	0	0	2	2	1	3	1	0	10
18.5-24	0	1	0	0	2	0	0	0	0	4	0	0	0	3	1	3	14
>24	0	0	0	0	1	0	0	0	0	0	0	0	0	5	6	5	17
TOTAL	0	1	0	1	3	0	0	0	0	4	3	2	1	12	11	8	46

Class D Freq: 0.606

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
3.5-7.5	4	6	4	7	6	2	1	2	2	2	1	5	3	6	5	3	59
7.5-12.5	14	7	11	6	7	4	7	4	9	27	48	28	29	22	12	11	246
12.5-18.5	8	9	19	7	15	10	11	10	8	37	94	48	87	87	66	22	538
18.5-24	7	11	14	12	14	8	8	8	2	17	10	2	31	48	53	24	269
>24	12	9	2	13	18	2	3	1	0	0	0	0	5	41	44	12	162
TOTAL	46	42	50	45	60	26	30	25	21	83	153	83	155	204	180	72	1275

Table A-2 (continued)

Oct-Dec 2018

Class E Freq: 0.306

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	2	0	1	1	0	0	1	0	0	0	0	0	0	0	1	2	8
3.5-7.5	6	6	6	2	3	2	8	2	11	6	3	8	10	9	5	6	93
7.5-12.5	5	2	10	3	6	3	14	22	17	13	32	38	35	32	15	6	253
12.5-18.5	3	0	5	2	3	3	13	19	12	29	35	24	34	17	5	1	205
18.5-24	1	0	2	2	6	2	3	5	5	5	13	2	3	8	2	2	61
>24	2	0	0	2	8	0	0	8	1	0	0	0	0	1	1	1	24
TOTAL	19	8	24	12	26	10	39	56	46	53	83	72	82	67	29	18	644

Class F Freq: 0.039

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	3	0	0	0	0	0	1	0	0	0	0	0	0	0	4
3.5-7.5	3	0	0	0	0	0	1	0	0	2	0	2	1	2	0	0	11
7.5-12.5	0	0	1	0	0	0	0	1	1	5	4	4	8	10	1	0	35
12.5-18.5	0	0	0	0	0	0	0	0	1	0	11	8	6	1	0	0	27
18.5-24	0	0	0	0	0	1	2	0	0	0	1	0	0	0	0	0	4
>24	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
TOTAL	3	0	4	0	0	1	3	1	3	7	17	14	15	13	1	0	82

Class G Freq: 0.002

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5-7.5	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	2
7.5-12.5	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	2
12.5-18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.5-24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL	0	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	4

Class All Freq: 1.000

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	3	0	4	1	0	0	1	0	1	0	0	0	0	0	1	2	13
3.5-7.5	13	12	10	9	9	4	10	4	13	11	5	15	14	17	10	9	165
7.5-12.5	19	9	22	9	13	7	21	27	27	45	85	71	74	66	31	17	543
12.5-18.5	13	10	24	10	18	13	24	29	22	66	143	84	128	112	78	24	798
18.5-24	8	14	16	14	23	11	13	13	7	30	29	4	35	59	60	30	366
>24	14	9	2	16	28	2	3	9	1	1	1	0	7	51	57	19	220
TOTAL	70	54	78	59	91	37	72	82	71	153	263	174	258	305	237	101	2105

Table A-2 (continued)

Jan-Dec 2018

Class A Freq: 0.064

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5-7.5	6	7	18	8	3	1	1	0	1	0	0	0	0	1	2	4	52
7.5-12.5	9	12	9	9	29	20	4	4	4	3	3	3	3	13	4	8	137
12.5-18.5	19	11	19	9	3	5	5	1	3	16	8	9	13	18	15	10	164
18.5-24	13	15	2	2	0	0	0	0	2	5	8	1	15	16	20	5	104
>24	8	13	3	3	2	0	0	0	0	0	2	0	16	14	14	4	79
TOTAL	55	58	51	31	37	26	10	5	10	24	21	13	47	62	55	31	536

Class B Freq: 0.034

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5-7.5	3	2	6	1	4	1	0	0	0	0	0	0	0	1	0	1	19
7.5-12.5	3	0	3	4	2	3	3	0	4	4	8	4	7	1	4	0	50
12.5-18.5	2	6	9	2	1	1	1	4	6	15	7	12	7	10	9	7	99
18.5-24	2	6	6	1	3	0	0	1	2	4	6	2	7	6	13	8	67
>24	6	4	4	6	5	0	0	0	0	3	1	0	4	12	5	0	50
TOTAL	16	18	28	14	15	5	4	5	12	26	22	18	25	30	31	16	285

Class C Freq: 0.043

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5-7.5	3	3	6	8	1	3	2	1	1	2	1	1	0	4	0	2	38
7.5-12.5	1	3	5	2	4	5	7	3	3	12	10	11	7	4	4	2	83
12.5-18.5	0	10	6	6	3	6	2	2	13	15	9	5	14	8	4	3	106
18.5-24	1	7	8	3	7	1	0	1	2	9	4	1	4	9	3	9	69
>24	3	9	3	5	3	0	0	0	1	1	0	0	7	13	10	9	64
TOTAL	8	32	28	24	18	15	11	7	20	39	24	18	32	38	21	25	360

Class D Freq: 0.478

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.95-3.5	8	2	4	0	3	3	1	5	1	4	0	0	0	2	1	0	34
3.5-7.5	13	25	42	29	18	20	14	14	17	25	16	12	9	10	16	13	293
7.5-12.5	38	33	81	58	39	43	49	36	59	134	124	63	50	47	31	38	923
12.5-18.5	22	48	91	31	40	41	39	59	81	316	227	129	176	125	104	47	1576
18.5-24	21	51	41	40	27	31	18	15	12	116	109	13	66	94	92	43	789
>24	62	48	10	30	37	5	5	1	14	23	5	0	17	53	70	23	403
TOTAL	164	207	269	188	164	143	126	130	184	618	481	217	318	331	314	164	4018

Jan-Dec 2018

Class E Freq: 0.298

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	2
0.95-3.5	6	5	10	5	7	5	7	2	7	5	3	1	2	2	3	7	77
3.5-7.5	27	31	27	29	30	28	20	21	24	25	15	21	23	26	21	22	390
7.5-12.5	24	18	22	23	28	67	56	55	74	101	93	76	65	71	48	29	850
12.5-18.5	20	20	21	6	8	4	25	47	71	195	128	76	83	50	27	21	802
18.5-24	9	7	5	2	7	2	3	9	7	68	104	11	7	24	8	14	287
>24	4	12	3	2	8	0	2	8	1	24	9	0	2	9	6	6	96
TOTAL	90	93	88	67	88	107	113	142	184	418	352	185	182	182	113	100	2504

Class F Freq: 0.072

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
0.95-3.5	3	5	12	6	6	1	1	4	4	4	3	2	2	2	1	2	58
3.5-7.5	17	9	7	16	14	20	11	7	9	13	6	8	14	7	7	7	172
7.5-12.5	8	3	4	0	5	7	8	9	10	10	12	14	22	19	14	11	156
12.5-18.5	2	1	0	0	0	0	0	6	3	7	35	33	31	11	9	9	147
18.5-24	3	0	0	0	0	1	2	1	0	6	31	5	1	1	3	6	60
>24	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	6	10
TOTAL	33	18	24	22	25	29	22	27	26	40	91	62	70	40	34	41	604

Class G Freq: 0.013

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	2
0.95-3.5	3	1	5	3	2	0	3	0	1	2	0	0	0	0	2	0	22
3.5-7.5	1	3	3	0	0	0	3	1	2	1	1	3	2	1	1	0	22
7.5-12.5	0	0	0	0	0	1	0	2	1	1	3	4	6	4	1	0	23
12.5-18.5	1	0	0	0	0	0	0	0	0	1	6	12	3	5	0	0	28
18.5-24	0	0	0	0	0	0	0	0	0	2	1	3	0	0	0	0	6
>24	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	3
TOTAL	5	4	9	3	2	1	6	3	5	9	12	22	11	10	4	0	106

Class All Freq: 1.000

mph	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL
Calm-0.95	0	0	2	0	0	1	0	0	1	0	0	0	0	0	0	1	5
0.95-3.5	20	13	31	14	18	9	12	11	13	15	6	3	4	6	7	9	191
3.5-7.5	70	80	109	91	70	73	51	44	54	66	39	45	48	50	47	49	986
7.5-12.5	83	69	124	96	107	146	127	109	155	265	253	175	160	159	106	88	2222
12.5-18.5	66	96	146	54	55	57	72	119	177	565	420	276	327	227	168	97	2922
18.5-24	49	86	62	48	44	35	23	27	25	210	263	36	100	150	139	85	1382
>24	83	86	23	46	55	5	7	9	16	53	22	0	46	101	105	48	705
TOTAL	371	430	497	349	349	326	292	319	441	1174	1003	535	685	693	572	377	8413

APPENDIX B

Results of Onsite Groundwater Monitoring Program

In response to the Nuclear Energy Institute (NEI) Groundwater Protection Initiative, Pilgrim Station instituted a groundwater monitoring program during 2007. Four monitoring wells were installed inside the protected area fence during the fourth quarter of 2007. The first samples were collected in November 2007. Since these are onsite wells, they are not considered part of the Radiological Environmental Monitoring Program (REMP), and data from these wells are being reported in the annual Radiological Effluent Release Report. Two pre-existing wells were incorporated into the groundwater monitoring program in early 2008. Additional wells were added to the program in 2010 (12 wells), 2011 (2 wells), 2012 (1 well), 2013 (3 wells), and 2014 (1 well). A total of 23 wells are being sampled on a routine basis.

In addition to sampling the onsite monitoring wells, samples of surface water are collected from a location in the PNPS Intake Canal. These locations are along the shoreline in the same direction as the groundwater flow gradient.

All samples collected are analyzed for tritium, a radioactive isotope of hydrogen, and also for gamma emitting radionuclides. In accordance with industry practice established under the NEI initiative, lower limits of detection (LLDs) used for analysis of REMP samples were used when assessing these samples for the presence of radioactivity. Low levels of tritium were detected in many of the onsite wells. Although gamma spectroscopy indicated the presence of naturally-occurring radioactivity, such as Potassium-40 and radon daughters from the uranium/thorium decay chains, there was no indication of any plant-related radioactivity in the groundwater samples, other than tritium. Such levels of natural radioactivity are expected as these radionuclides are dissolved into the groundwater from the rocks and soil. The fact that these low levels of naturally-occurring radioactivity can be detected demonstrates the ability of the gamma spectroscopy analyses to detect radioactivity in groundwater. Analyses are also performed for hard-to-detect radionuclides, including Iron-55, Nickel-63, Strontium-89, and Strontium-90 on a less frequent basis. These hard-to-detect radionuclides were also non-detectable in all of the wells sampled and analyzed during 2018.

A summary of the results of the tritium analyses conducted in 2018 are presented in the following table. In this table, a value of "NDA < xx" in the columns indicates that no activity was detected in the sample when analyzed to the minimum-detectable level following the "<" sign. For example, the sample collected from MW201 on 28-Mar-2018 contained no detectable tritium, and a minimum detectable concentration of 295 pCi/L was achieved on that sample. The achieved sensitivity of 295 pCi/L is well below the required REMP LLD of 3000 pCi/L, and no tritium was detected even when counted to this more sensitive level of detection. No plant-related radioactivity (other than tritium) was detected in any of the monitoring wells, and no tritium or plant-related radioactivity was detected in surface water samples collected from the intake canal.

Monitoring Well ID	Installation Date	Number of Samples	Number of Positive Results	Minimum Concentration pCi/L	Maximum Concentration pCi/L
MW201	Nov-2007	4	0	NDA < 295	NDA<325
MW202	Nov-2007	4	1	NDA<303	314
MW202-I	Apr-2010	4	3	NDA < 290	879
MW203	Nov-2007	Well decommissioned in 2013 during construction of ISFSI pad			
MW204	Nov-2007	4	3	NDA<326	470
MW205	Apr-2010	4	0	NDA<292	NDA<337
MW206	Apr-2010	18	4	NDA < 290	1570
MW207	Apr-2010	4	2	NDA < 317	410
MW208-S	Apr-2010	4	0	NDA < 290	NDA < 327
MW208-I	Apr-2010	4	0	NDA < 288	NDA < 325
MW209	Aug-2010	4	2	NDA<300	631
MW210	Aug-2010	4	1	NDA<302	478
MW211	Aug-2010	24	24	1140	4020
MW212	Aug-2010	4	3	NDA<326	790
MW213	Aug-2010	4	1	NDA<299	431
MW214	Aug-2010	4	0	NDA<294	NDA<327
MW215	Dec-2011	18	14	NDA<287	3350
MW216	Sep-2012	18	18	575	3000
MW217	Dec-2011	4	3	NDA<312	791
MW218	Nov-2013	18	18	1080	2200
MW219	Dec-2013	47	47	747	40500
MW220	Dec-2014	7	4	NDA<276	1130
MW3	Jul-1987	4	0	NDA<300	NDA<332
MW4	Jul-1997	Well decommissioned in 2013 during installation of MW4R			
MW4-R	Nov-2013	4	0	NDA<295	NDA<328
All Wells	--	214	148	NDA < 276	40500
Intake Canal West	--	49	0	NDA < 270	NDA < 337
Intake Canal East	--	Discontinued sampling in 2016 for sampling safety concerns			

Concentrations of tritium detected in the onsite wells ranged from non-detectable at less than 276 pCi/L, up to a maximum concentration of 40,500 pCi/L. The average quarterly concentrations from these onsite wells are well below the voluntary communication reporting level of 20,000 pCi/L as established by the EPA Drinking Water Standard. MW219 was the outlier in 2018 due to a leak found within the Feedwater system that was located above an expansion joint leading to the ground onsite. This leak was mitigated and there was no increase seen in downstream shoreline wells. By the end of 2018 the levels in MW219 had returned to normal. Although the EPA Standard provides a baseline for comparison, no drinking water sources are affected by this tritium. All of the affected wells are onsite, and the general groundwater flow pathway is under Pilgrim Station and out into the salt water of Cape Cod Bay. As such, there is no potential to influence any off-site drinking water wells. Even if worst-case assumptions were made and the water from monitoring well MW219 (average concentration = 11,414 pCi/L) was consumed as drinking water for an entire year, the maximum dose consequence would be less than 0.86 mrem/yr. In actuality, any dose consequence would be much less than this, as any tritium-laden water potentially leaving the site would be diluted into the seawater of Cape Cod Bay before being incorporated into any ingestion pathways. No drinking water ingestion pathway exists at the Pilgrim Station site.

Although there are no indications that the groundwater containing detectable tritium is actually migrating offsite, a bounding calculation was performed to assess the potential dose impact of such a scenario. Based on the tritium concentrations detected during 2018, the annual average concentrations of tritium in groundwater in the four monitoring wells most closely adjacent to the shoreline (MW204, MW205, MW202, and MW201) were used to estimate potential tritium migration into the intake bay. Hydrological characteristics of the compacted backfill in the vicinity of these wells were measured in 2010 and indicate the hydraulic conductivity ranges from 0.002 cm/sec to approximately 0.006 cm/sec. When coupled with the hydraulic slope of 0.014 and average porosity of 0.3, the flow velocity was calculated as being between 0.08 and 0.23 meters per day. Using an assumed horizontal shoreline interface area 236 meters long by 3 meters deep that could potentially transmit groundwater into the intake bay, the annual discharge of groundwater would be approximately 12.5 million Liters of water per year. Assuming this volume of 12.5 million liters contained the segment-weighted average concentration of 468 pCi/L, the annual discharge of tritium into the intake bay under this hypothetical scenario would be 0.00585 Curies. This activity represents less than 0.0004% of the annual airborne effluent of tritium released from the reactor building vent (see Table 2.2-C). Such airborne effluents can be washed down to the ground surface during precipitation events and infiltrate into the ground, thereby introducing tritium into the groundwater.

In the hypothetical scenario described above, the 0.00585 Curies of tritium entering the intake bay would be further diluted into the circulating water flow of the plant. As documented in Table 2.3-A, the total volume of circulating water flow during 2018 was 524 billion Liters, yielding an effective concentration of tritium in the intake bay of approximately 0.0091 pCi/L. Such a concentration would be well below the detection sensitivity of approximately 450 pCi/L used to analyze water collected from the discharge canal as part of the radiological environmental monitoring program (REMP). The calculated dose to the maximum-exposed member of the public from such a hypothetical release would be 0.0000000052 millirem, resulting from ingestion of tritium incorporated into fish and shellfish. Since the tritium would be incorporated into seawater, there is no drinking water ingestion pathway in the described scenario.

The following table lists the hydrological characteristics in the vicinity of each of the monitoring wells used to estimate tritium migration. Predicted flow velocities, annual discharge volumes, average tritium concentrations, and hypothetical tritium discharges are listed for each shoreline segment represented by each monitoring well.

Shoreline Segment Number	1	2	3	4
Monitoring Well Number	MW204	MW205	MW202	MW201
Hydraulic Conductivity - cm/sec	1.99E-03	4.27E-03	3.13E-03	5.64E-03
Hydraulic Slope	0.014	0.014	0.014	0.014
Porosity	0.300	0.300	0.300	0.300
Flow Velocity - m/day	8.02E-02	1.72E-01	1.26E-01	2.27E-01
Flow Velocity - ft/yr	9.61E+01	2.06E+02	1.51E+02	2.72E+02
Length of Shoreline Segment – m	61.0	38.1	45.7	91.4
Thickness of Water Layer – m	3.0	3.0	3.0	3.0
Volumetric Discharge - m^3/day	4.40E+00	5.90E+00	5.19E+00	1.87E+01
Volumetric Discharge - Liter/yr	1.61E+06	2.16E+06	1.90E+06	6.84E+06
Annual Average H-3 Concentration - pCi/L	3.11E+02	3.16E+02	7.68E+02	3.11E+02
Annual Segment Tritium Discharge - Ci/yr	5.00E-04	6.81E-04	1.46E-03	2.13E-03
Total Volumetric Discharge - L/yr	1.25E+07			
Total H-3 Discharge - Ci/yr	4.76E-03			
Annual Circulating Water Flow - Liter/yr	5.24E+11			
Discharge Canal H-3 Concentration - Ci/L	9.09E-15			
Discharge Canal H-3 Concentration - pCi/L	9.09E-03			
Max. Indiv. Dose Factor - mrem/yr per Ci/L	5.73E+05			
Maximum Individual Dose - mrem/yr	5.21E-09			

In conclusion, the only radionuclide detected in groundwater during the 2018 monitoring effort that is attributable to Pilgrim Station operations is tritium. Although some soil samples near the separation in the underground discharge line from the neutralizing sump indicated the presence of low-level gamma radioactivity, such activity has not been detected in the groundwater and indicates the radioactivity is immobile and confined to the soil. Even in the case of the three reportable events that occurred in 2013 and subsequent sample results in 2016, the total dose impact to a maximally-exposed member of the public would have been much less than 1 mrem/yr.

APPENDIX C

CORRECTIONS TO PREVIOUS EFFLUENT REPORTS

There were no corrections made to previous effluent reports during calendar-year 2018. Corrections found through the process of creating this report are as follows:

-One typo found in the 2017 Annual Radiological Effluent Release Report (ARERR): Table 2.3-A section A. "Fission and Activation Products" reported the annual percent of effluent concentration limit to be 3.14E-0% instead of the indented result of 3.14E-07%. Table 6.2 "Percent of ODCM Effluent Control Limits" section A. "Fission and Activation Product Effluent Concentration Limit" accurately reported the fraction of the limit as 3.14E-07%.

- One issue found in the 2017 Annual Radiological Effluent Release Report (ARERR): Table 6.1 section C "Instantaneous Dose Rate Limit - Particulates, Iodines, & Tritium, PNPS ODCM Control 3.3.1.b, Limit: 1500 mrem/yr Organ Dose" reported the Fraction of the Limit as 4.76E-03%. This value actually represents the fraction of the limit and not the fraction of the limit as a percent, which should be reported as 4.76E-01%. Looking at previous reports, this error was reported as such since the 2008 ARERR.

APPENDIX D

CHANGES TO PNPS
OFFSITE DOSE CALCULATION MANUAL

No revision was made to the PNPS Offsite Dose Calculation Manual (ODCM) during calendar year 2018. A signature cover page was added to ODCM revision 11 on 9-May-2018 to include the site GMPO signature. This addition was not considered a revision of the ODCM.