PSEG Nuclear LLC
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PSEG
Nuclear LLC

APR 2 5 2019

TS 6.9.1.8 (Salem)
TS 6.9.1.7 (Hope Creek)

LR-N19-0042

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

Salem Generating Station, Units 1 and 2
Renewed Facility Operating License Nos. DPR-70 and DPR-75
NRC Docket Nos. 50-272 and 50-311

Hope Creek Generating Station
Renewed Facility Operating License No. NPF-57
NRC Docket No. 50-354

Subject: 2018 Annual Radioactive Effluent Release Report (ARERR)

As required with Section 6.9.1.8 of Appendix A to Renewed Facility Operating License Nos. DPR-70 (Unit 1) and DPR-75 (Unit 2) for Salem Generating Stations (SGS), and Section 6.9.1.7 of Appendix A to Renewed Facility Operating License NPF-57 for Hope Creek Generating Station (HCGS), PSEG Nuclear hereby transmits one (1) copy of the combined 2018 Annual Radioactive Effluent Release Report (Enclosure 1). Reports SGS RERR-66 and HCGS RERR-40 were combined into one (1) report that summarizes information pertaining to the releases of radioactive materials in liquid, gaseous, and solid form from the SGS and the HCGS for the period January 1, 2018 to December 31, 2018.

There are no regulatory commitments contained in this letter.

If you have any questions or require any additional information, please contact Mr. Rick Heathwaite at (856) 339-2076.

Sincerely,

Patrick A. Martino
Plant Manager
Salem Generating Stations

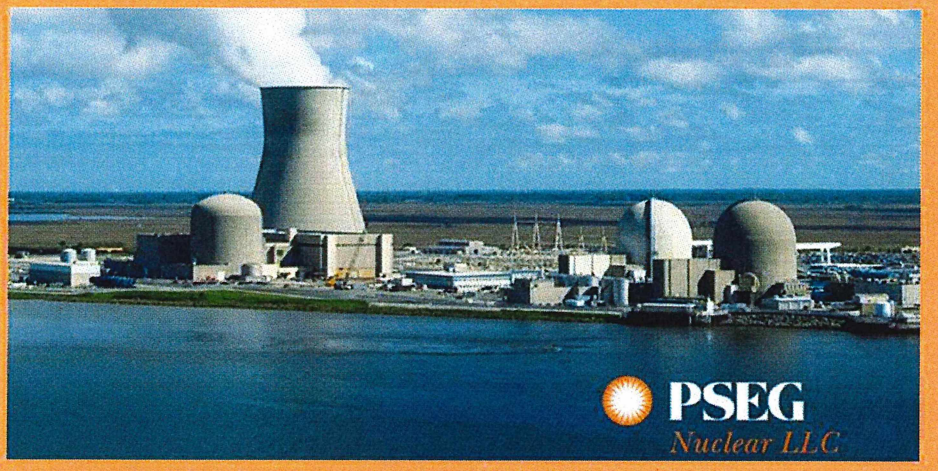
Edward T. Casulli
Plant Manager
Hope Creek Generating Station

Enclosure 1: 2018 Annual Radioactive Effluent Release Report for Salem and Hope Creek Generating Stations

APR 2 5 2019

TS 6.9.1.8 (Salem)
TS 6.9.1.7 (Hope Creek)

cc: Administrator, Region I, NRC
NRC Project Manager, Salem
NRC Project Manager, Hope Creek
NRC Senior Resident Inspector, Salem
NRC Senior Resident Inspector, Hope Creek
Mr. J. Furia, Inspector, Region I, NRC
Mr. P. Mulligan, Chief, NJ Bureau of Nuclear Engineering (NJBNE)
Mr. L. Marabella, Corporate Commitment Tracking Coordinator - w/o enclosure
Mr. T. Cachaza, Salem Commitment Tracking Coordinator - w/o enclosure
Ms. K. Stokes, Hope Creek Commitment Tracking Coordinator - w/o enclosure



2018 ANNUAL RADIOACTIVE EFFLUENT RELEASE REPORT

JANUARY 1 THROUGH DECEMBER 31, 2018

PSEG Nuclear

Salem and Hope Creek Generating Stations

Radioactive Effluent Controls

Report Prepared by: _____ **Date** 4/2/2019

Rick Heathwaite (REMP/REC ~~Program~~ Manager)

Station Reviews and Approvals

Salem

_____ Date 4/5/19
Shane Howe (R.P. Manager)

_____ Date 04/05/19
William Gropp (Chem. Manager)

_____ Date 4/5/19
Richard DeSanctis (Sr. Dir. Operations)

_____ Date 4/5/19
Patrick Martino (Plant Manager)

Hope Creek

_____ Date 4/11/19
Harold Trimble (RP Manager)

_____ Date 4/11/19
Shelly Kugler (Chem. Manager)

_____ Date 4/11/19
Thomas Agster (Sr. Dir. Operations)

_____ Date 4/11/19
Edward Casulli (Plant Manager)

SGS ARERR-67		HCGS ARERR-41
Unit 1	Unit 2	Unit 1
DOCKET No. 50-272 OPERATING LICENSE No. DPR-070	DOCKET No. 50-311 OPERATING LICENSE No. DPR-075	DOCKET No. 50-311 OPERATING LICENSE No. NPF-057

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I. Executive Summary

In 2018, the Salem Generating Station (SGS) and the Hope Creek Generating Station (HCGS) released to the environment through the radioactive liquid and gaseous effluents approximately 2.62 curies of noble gas, 0.12 curies of fission and activation products and 2,231 curies of tritium. The dose from both liquid and gaseous effluents was conservatively calculated for the Maximum Exposed Member of the Public. The results of those calculations and their comparison to the allowable limits were as follows:

Gaseous and liquid radiation doses to members of the public at the highest dose receptor

Effluent	Applicable Organ	Estimated Dose	Age Group	Receptor Location	% of Applicable Limit	Limit	Units
Noble Gas	Gamma – Air Dose	2.46E-04	All	Site Boundary	0.001%	30	mRad
	Beta – Air Dose	2.35E-04			< 0.001%	60	
Iodine, Particulate, C-14 & Tritium	Bone	3.92E-01	Child	4.6 miles SW	0.87%	45	mrem
Liquid	Total Body	7.58E-03	Adult	0.75 mi. N of Salem	0.084%	9	mrem
	Gi-Lli	2.10E-02			0.070%	30	

The calculated doses from the radiological effluents released from the three units were a very small percentage of the allowable limits.

The Total Dose to the Critical Receptor as required by section 3.11.4 of the SGS and HCGS ODCMs was determined to be 5.16E-01 mrem. The dose calculated was below the limits of 40 CFR 190 and 10 CFR 72.104 (25 mrem) to the total body and critical organ other than the thyroid.

Maximum TEDE doses to Members of the Public and personnel not having access to the Radiologically Controlled Area (RCA) were calculated as 2.09E-02 mrem and 2.06E+00 mrem, respectively. These doses were a small fraction of the 10 CFR 20.1301 dose limit of 100 mrem.

II. Introduction

This report, SGS-RERR-67/HCGS-RERR-41, summarizes information pertaining to the releases of radioactive materials in liquid, gaseous and solid forms from SGS and HCGS for the period January 1, 2018, to December 31, 2018.

SGS Unit 1 is a Westinghouse Pressurized Water Reactor that has a licensed core thermal power rating of 3,459 MW_{th} and an approximate net electrical output of 1,180 MW_e. SGS Unit 1 achieved initial criticality on December 11, 1976, and began commercial operation on June 30, 1977.

SGS Unit 2 is a Westinghouse Pressurized Water Reactor that has a licensed core thermal power rating of 3,459 MW_{th} and an approximate net electrical output of 1,178

MW_e. SGS Unit 2 achieved initial criticality on August 2, 1980, and began commercial operation on October 13, 1981.

HCGS is a General Electric Boiling Water Reactor that has an up rated core thermal power rating of 3,902 MW_{th} and an approximate net electrical output of 1,212 MW_e. The HCGS achieved initial criticality on June 28, 1986 and began commercial operation on December 20, 1986.

This report complies with the format described in Regulatory Guide 1.21, "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", Revision 1, June, 1974, as required by Control 6.9.1.8 of the SGS Units 1 and 2 Offsite Dose Calculation Manual (ODCM) and Control 6.9.1.7 of the HCGS ODCM. Revision 2, June 2009 of this Guide permits data tables to be supplied as annual tables.

Meteorological data was obtained in the format specified in Regulatory Guide 1.23, Revision 1 "Meteorological Monitoring Programs for Nuclear Power Plants," and retained on site. Detailed meteorological data was not presented in this report.

All vendor results for samples obtained in 2018 were received and included in the report calculations. Therefore, the 2018 report is complete and no supplements to the 2018 evaluating period will be required.

III. Supplemental Information

1. Regulatory Limits

The same regulatory limits apply to SGS Unit 1, SGS Unit 2 and HCGS. The limits were as follows:

Limit		Units	Receptor	ODCM and 10 CFR 50, Appendix I Design Objective Limits
1. Noble Gases:				
a.	≤ 500	mrem/yr	Total Body	ODCM Control 3.11.2.1.a
	≤ 3000		Skin	
b.	≤ 5	mRad	Air Gamma	Quarterly air dose limits: ODCM Control 3.11.2.2.a
	≤ 10		Air Beta	
c.	≤ 10	mRad	Air Gamma	Yearly air dose limits: ODCM Control 3.11.2.2.b
	≤ 20		Air Beta	
d.	≤ 10	mrem	Total Body (Gamma)	10 CFR 50, Appendix I, Section II.B.2(b)
	≤ 30		Skin (Beta)	
2. Iodines, Tritium, Particulates with Half-Lives > 8 days:				
a.	≤ 1500	mrem/yr	Any Organ	ODCM Control 3.11.2.1.b
b.	≤ 7.5	mrem	Any Organ	Quarterly dose limits: ODCM Control 3.11.2.3.a
c.	≤ 15	mrem	Any Organ	Yearly dose limits: ODCM Control 3.11.2.3.b

Limit		Units	Receptor	ODCM and 10 CFR 50, Appendix I Design Objective Limits
3. Liquid Effluents				
a.	The concentration limits in 10 CFR 20, Appendix B, Table II Col. 2 (pre 1994). For dissolved or entrained noble gases, the concentration shall be limited to 2E-04 uCi//ml.			ODCM Control 3.11.1.1
b.	≤ 1.5	mrem	Total Body	Quarterly dose limits ODCM Control 3.11.1.2.a
	≤ 5		Any Organ	
c.	≤ 3	mrem	Total Body	Yearly dose limits ODCM Control 3.11.1.2.b
	≤ 10		Any Organ	
4. Total Dose Limits				
a.	≤ 25	mrem	Total Body or Organ	Yearly dose limits ODCM Control 3.11.4 40 CFR 190 and 10 CFR 72.104
	≤ 75		Thyroid	
b.	≤ 100	mrem	Site TEDE Dose	10 CFR 20.1301

2. Maximum Permissible Concentration (MPC) Limits

Gaseous dose rates limits rather than maximum permissible concentration limits were used to calculate permissible release rates for gaseous releases. The maximum permissible dose rates for gaseous releases were defined in ODCM Controls 3.11.2.1.a and 3.11.2.1.b.

The Maximum Permissible Concentration Limit specified in 10 CFR 20, Appendix B, Table II, Column 2 (pre 1994) for identified nuclides, were used to calculate permissible release rates and concentrations for liquid release in accordance with the SGS Unit 1 and Unit 2 and the HCGS Offsite Dose Calculation Manual Control 3.11.1.1. The total activity concentration for all dissolved or entrained gases was limited to < 2.00E-04 uCi/ml.

3. Average Energy

The SGS ODCM and the HCGS ODCM limit the instantaneous dose equivalent rates due to the release of noble gases to less than or equal to 500 mrem/year to the total body and less than or equal to 3,000 mrem/year to the skin. The average beta and gamma energies of the radionuclide mixture in releases of fission and activation gases as described in Regulatory Guide 1.21, "Measuring, Evaluation, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants," may be used to calculate doses in lieu of more sophisticated software. The SGS and HCGS radioactive effluent programs employ the methodologies presented in U.S. NRC Regulatory Guide 1.109 "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision 1, October 1977 and NUREG-0133, "Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants," October 1978. Therefore, average energies were not applicable to SGS and HCGS.

4. Measurements and Approximations of Total Radioactivity

A. Liquid Effluents:

Liquid effluents were monitored in accordance with Table 4.11-1 of the SGS ODCM and Table 4.11.1.1.1-1 of the HCGS ODCM.

During 2018, all routine batch liquid wastes were routed to sampling tanks for monitoring prior to release. The ODCMs require these tanks to be uniformly mixed for sampling and analysis before being released.

Batch releases were defined as:

- For SGS, releases from the Service Water Drums, which were collected and disposed via the Chemical Waste Basin, and the Chemical Volume Control System (CVCS) Monitor Tanks. During 2018, all batch liquid wastes from the Chemical Drain Tank and Laundry and Hot Shower Tanks were routed to Waste Monitor Holdup Tanks for monitoring prior to release. For flexibility in processing liquid effluents, the SGS Units 1 and 2 Liquid Radwaste Systems were cross-connected.
- For HCGS, releases from the Equipment Sample Tanks, Floor Drain Sample tanks, and Detergent Drain Tanks.

Continuous releases were defined as:

- For SGS, continuous liquid release pathways include Secondary System Leakage from the Condensate system and the Unit 1 Groundwater Recovery System through the Chemical Waste Basin.
- For HCGS, a continuous liquid effluent release path exists through the Circulating Water Dewatering Sump Discharge.

Representative samples were obtained in accordance with Table 4.11-1 of the SGS ODCM for SGS and Table 4.11.1.1.1-1 of the HCGS ODCM for HCGS. The total liquid activity discharged was determined by multiplying specific activities from the analyses by the volume of effluent discharged to the environment.

The detection requirements of Table 4.11-1 (SGS) and Table 4.11.1.1.1-1 (HCGS) of the ODCM were achieved. Radionuclides that were measured at concentrations below the ODCM-specified lower limit of detection (LLD) were considered present. A radionuclide for which no activity was detected while meeting the required LLD was considered absent.

B. Gaseous Effluents:

SGS Units 1 and 2:
Gaseous effluent streams at SGS were monitored and sampled in accordance with Table 4.11-2 of the ODCM. Each plant vent was the final release point for planned gaseous effluent releases and was continuously monitored by installed radiation monitors. The vent was also continuously sampled for iodine and particulates with fixed particulate and charcoal filters. The filter and charcoal were normally changed weekly, and analyzed on a multi-channel analyzer.

Sampling was also performed on all gas decay tanks and the containment atmosphere prior to release to the environment. The plant vent for each unit was normally sampled weekly for noble gases, particulates, iodine, and tritium.

The detection requirements of Table 4.11-2 of the ODCM were achieved or exceeded. A radionuclide detected at a concentration below the ODCM LLD was considered present. A radionuclide for which no activity was detected while meeting the required LLD was considered absent.

Continuous gaseous releases were quantified by routine sampling and isotopic analyses of the plant vent for each unit, as required by the ODCM. Specific activities for detected isotopes were multiplied by the total vent flow volume for the entire sampling period in order to determine the normal continuous release of radioactivity through each plant vent.

Batch noble gas releases were quantified by sampling each decay tank or containment atmosphere prior to release. The total activity in a batch release was determined by multiplying the specific activities for detected isotopes by the total volume of the gas discharged in that batch release.

Elevated plant vent radiation monitoring system readings while the channel was in an alarm state were treated as batch mode releases. If specific activity data from grab samples were not available, then the release was quantified by the use of the plant vent radiation monitors. The monitor response was converted to "specific activity" using historical efficiency factors. The total activity discharged was determined by multiplying the "specific activity" by the volume of effluent discharged while the channel was in an alarm state.

HCGS:

Gaseous effluent streams at HCGS were monitored and sampled in accordance with Table 4.11.2.1.2-1 of the ODCM. The North Plant Vent (NPV) and South Plant Vent (SPV) were the final release points for planned gaseous effluent releases. The NPV and SPV were continuously monitored for iodine, particulates and noble gases. These monitors have fixed particulate and charcoal filters. The particulate filters and charcoal cartridges were normally replaced and analyzed weekly. These analyses were performed on a multi-channel analyzer. The NPV and SPV were also normally sampled weekly for noble gases and tritium.

A small quantity of gaseous effluent was released via the Filtration, Recirculation, and Ventilation System (FRVS) vent during FRVS testing periods. The FRVS was continuously monitored for noble gases when in service, and has fixed particulate and charcoal filters. When the system was in vent mode for greater than two hours, samples were collected at the end of the release period. During periods of extended runs, samples were normally taken weekly.

The detection requirements of Tables 4.11.2.1.2-1 of the ODCM were achieved or exceeded. A radionuclide detected at a concentration below the ODCM LLD was considered present. A radionuclide for which no activity was detected while meeting the required LLD was considered absent.

Batch noble gas releases (i.e. primary containment purge) were quantified by pre-release sampling and isotopic analysis. The total radioactivity released was estimated by multiplying the specific activities for detected isotopes by the containment volume.

The SGS and HCGS ODCMs required LLD for airborne and liquid releases were as follows:

Liquid	**LLD** *(uCi/ml)*
Principal Gamma Emitters: Mn-54, Fe-59, Co-58, Co-60, Zn-65, Mo-99, Cs-134, Cs-137, Ce-141)	5E-07
Ce-144 – **HCGS**	5E-06
Ce-144 – **SGS**	2E-06
I-131	1E-06
Entrained Gases	1E-05
H-3	1E-05
Gross Alpha	1E-07
Sr-89, Sr-90	5E-08
Fe-55	1E-06

Airborne	**LLD** *(uCi/cc)*
Gross Alpha, Sr-89, Sr-90	1E-11
H-3	1E-06
I-131	1E-12
Principal Gamma Emitters: Mn-54, Fe-59, Co-58, Co-60, Zn-65, Mo-99, I-131, Cs-134, Cs-137,Ce-141, Ce-144	1E-11
Noble Gas: Kr-87, Kr-88, Xe-133, Xe-133m, Xe-135, Xe-138	1E-04

5. Estimated Total Error

The estimated total error reported for continuous and batch liquid releases for all three stations was within 27%. The estimated total error for continuous and batch gaseous releases, and solid waste was within 35%.

6. Non-Routine Planned Discharges and Unplanned Discharges

Regulatory Guide 1.21, Measuring, Evaluating, and Reporting Radioactive Material in Liquid and Gaseous Effluents and Solid Waste, Revision 2 defines a *non-routine, planned discharge* as an effluent release from a release point that is not defined in the ODCM, but that has been planned, monitored, and discharged in accordance with 10 CFR 20.2001. The regulatory guide defines an *unplanned discharge* as the unintended or unexpected discharge of liquid or airborne radioactive material to the unrestricted area.

SGS Unit 1

Liquid	Qtr. 1	Qtr. 2	Qtr. 3	Qtr. 4	Total
Number of Non-Routine Planned Discharges	0	0	0	0	0
Number of Unplanned Discharges	0	0	1	0	1
Total Curies Discharged	**N/A**	**N/A**	**5.87E-02**	**N/A**	**5.87E-02**
Gaseous	**Qtr. 1**	**Qtr. 2**	**Qtr. 3**	**Qtr. 4**	**Total**
Number of Non-Routine Planned Discharges	0	0	0	0	0
Number of Unplanned Discharges	0	0	0	0	0
Total Curies Discharged	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**

N/A (Not Applicable)

An unplanned discharge of a 55 gallon drum of contaminated cooling water prior to chemistry approval occurred on 09/15/2018. No limits were exceeded (Notification 20804781).

SGS Unit 2

Liquid	Qtr. 1	Qtr. 2	Qtr. 3	Qtr. 4	Total
Number of Non-Routine Planned Discharges	0	0	0	0	0
Number of Unplanned Discharges	0	0	0	0	0
Total Curies Discharged	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Gaseous	**Qtr. 1**	**Qtr. 2**	**Qtr. 3**	**Qtr. 4**	**Total**
Number of Non-Routine Planned Discharges	0	0	0	0	0
Number of Unplanned Discharges	0	0	0	0	0
Total Curies Discharged	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**

N/A (Not Applicable)

HCGS:

Liquid	Qtr. 1	Qtr. 2	Qtr. 3	Qtr. 4	Total
Number of Non-Routine Planned Discharges	1	0	1	1	3
Number of Unplanned Discharges	0	0	0	0	0
Total Curies Discharged	**8.065E-03**	**N/A**	**3.33E-03**	**3.25E-04**	**1.17E-02**
Gaseous	**Qtr. 1**	**Qtr. 2**	**Qtr. 3**	**Qtr. 4**	**Total**
Number of Non-Routine Planned Discharges	3	3	3	3	12
Number of Unplanned Discharges	0	0	0	0	0
Total Curies Discharged	**1.54E+00**	**1.15E+00**	**1.25E+00**	**1.82E+00**	**5.76E+00**

N/A (Not Applicable)

1. Two planned non-routine discharges occurred from pumping the water collected in the roof containment berms in the first and third quarters of 2018. A third planned non-routine discharge occurred in the fourth quarter from discharging water from the dike for the Condensate Storage Tank, due to high organics in the water (Notification 20820792).

2. The lubricating oil ventilation system that discharges to the Turbine Building Roof had monthly (3 per quarter) release permits issued for the estimated tritium released via the airborne pathway. This is considered a non-routine planned discharge. The monthly permits were generated to account for the combined gaseous dose from the lube oil roof vents. This activity was calculated as a function of the average monthly RCS tritium concentration and the differential temperature between the lube oil system and the ambient temperature.

7. Significant Events

SGS Unit 1

None

SGS Unit 2

None

HCGS

An error in the calculation of total volume for a gaseous grab sample was discovered in the gamma spectroscopy software APEX. Although Chemistry entered the correct

dates, times and flowrate, the APEX gamma spectroscopy software used a default flowrate of 2 scfm, resulting in an incorrect total volume being calculated.

The software has been changed to allow the end flow rate to be edited and visible. In most cases, the flow rate at the start and end of the sample will be the same. The APEX software has been in use since May of 2015. This condition is believed to have occurred since that time. (Notification 20806280)

The settings of the software were changed to allow this view to be visible and therefore changeable by the user. This was verified to calculate correct sample volumes via manual calculations.

A review of all gaseous effluent permits since May of 2015 found only one permit G-20161201-127-C that was not calculated conservatively. A revision to the 2016 ARERR is contained in Section 15.

8. Changes to the Offsite Dose Calculation Manuals

There were no changes made to either the SGS or HCGS ODCMs in 2018.

9. Changes to the Process Control Program

There were no changes to RW-AA-100, Process Control Program for Radioactive Wastes, during 2018.

10. Radioactive Effluent Monitoring Instrumentation Out of Service for More than 30 Days

A. SGS Unit 1:

1. Containment Fan Coolers – Service Water Line discharge liquid radiation monitors 1R13B was declared out of service on 2/2/2018 and returned to service on 5/1/2018 (Notification 20793185, 20786403). The detector was initially declared inoperable due to an inappropriate interpretation that the RMS was functional.

2. Containment Fan Coolers – Service Water Line discharge liquid radiation monitors 1R13A was declared out of service on 2/2/2018 (Notification 20786508, 20788054, 20789469, 20744766, 20789805). Notification 20784795 was written in 2017 to document that detector 1R13A was out of service due to the 22 Circ. Water Standpipe was no longer providing adequate anti vibration support to the detector. The modification that was implemented in 2017 failed within five months. The detector failed low and remained out of service for standpipe replacement. The detector was returned to service on 7/21/2018.

B. SGS Unit 2:

None

C. HCGS:

3. Cooling Tower Blowdown liquid radiation monitor RE8817, which provides alarm only function was declared out of service on 3/30/2018 (Notification

20789606). The detector failed source check. Significant corrosion on and around the detector was observed. The cause of the corrosion was due to a degraded threaded fitting at the PIG head. The PIG head threads were cleaned and a new fitting was installed. Detector was replaced. A defective submersible pump was also replace. The radiation monitor was returned to service on 5/30/2018.

11. Elevated Gaseous Radiation Monitor Responses

During the 2018 reporting period, none of the effluent radiation monitors elicited an elevated response during the discharge of liquid and gaseous effluent from either of the SGS Units 1 and 2 or from the HCGS.

12. Independent Spent Fuel Storage Installation (ISFSI)

There have been no gaseous or liquid releases from the Independent Spent Fuel Storage Installation (ISFSI) since it was placed in service in the summer of 2006. The direct dose from the ISFSI pad to the Critical Receptor located at 4.6 miles in the SW sector, Members of the Public and personnel not having access to the Radiologically Controlled Area (RCA) was determined using the dosimetry results from the 2018 Radiological Environmental Monitoring Program (REMP) and the formula provided in ANSI/HPS N13.37-2014 as follows:

$$D_2 = OF * \left(\left(D_1 * R_1^{\,2} \right) / R_2^{\,2} \right)$$

Where:

D_1 = Net Dose that was measured from TLD Location 16S2
D_2 = Dose that will be extrapolated to Security Checkpoint, Sewage Treatment Plant (STP) and Critical Receptor
R_1 = Distance from the source to the location where D1 was obtained
R_2 = Distance to the location that dose will be extrapolated
OF = Occupancy Factor (1 = full time, 0.25 = 2000 hrs.)

Location Of Extrapolated Dose	**R_1** *(ft.)* ***Distance from ISFSI to TLD 16S2***	**R_2** *(ft.)* ***Distance from ISFSI to Location***	**D_1** *(mrem)* ***Net Dose of TLD 16S2*** D_1 = A - B	A **Gross Annual Dose at 16S2** *(mrem)*	B **Background Dose at 16S2** *(mrem)*	**OF** Occupancy Factor	**D_2** *(mrem)* **Extrapolated Dose for Location**
Security Checkpoint	203	6,275	59.7	114.3	54.6	0.25	**1.56E-02**
STP	203	575	59.7	114.3	54.6	0.25	**1.86E+00**
Critical Receptor	203	24,288	59.7	114.3	54.6	1.00	**4.17E-03**
Nearest Resident	203	19,536	59.7	114.3	54.6	1.00	**6.45E-03**

13. Effluent Trends

The following trend graphs displays the total curies of liquid and gaseous effluents released for SGS and HCGS from 2005 through 2018.

Figure 1
Fision and Activation Gases Released in Gaseous Effluents, Salem Unit 1, Salem Unit 2 and Hope Creek Unit 1, 2005 - 2018

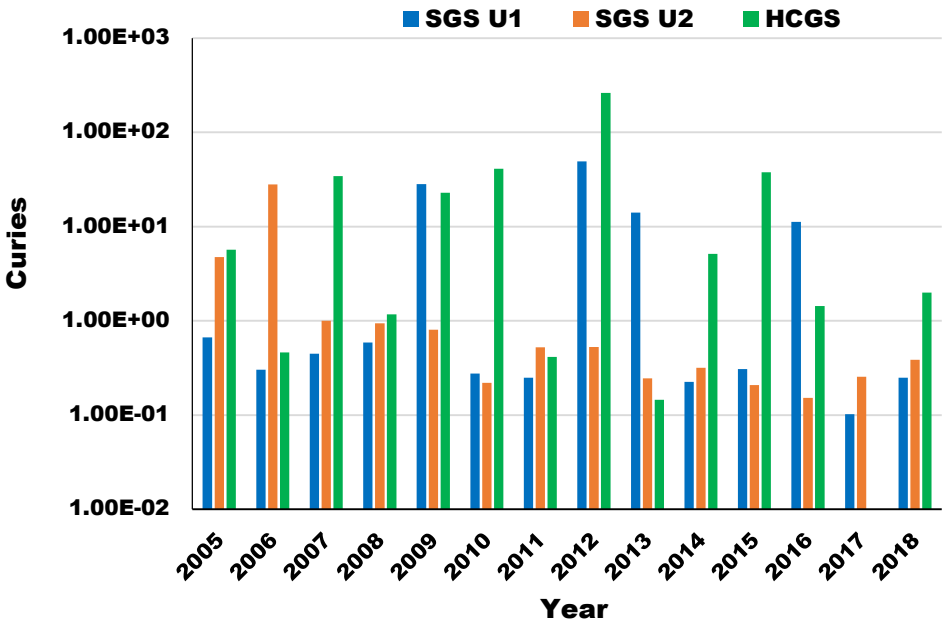


Figure 2
Iodines Released in Gaseous Effluents, Salem Unit 1, Salem Unit 2 and Hope Creek Unit 1, 2005 - 2018

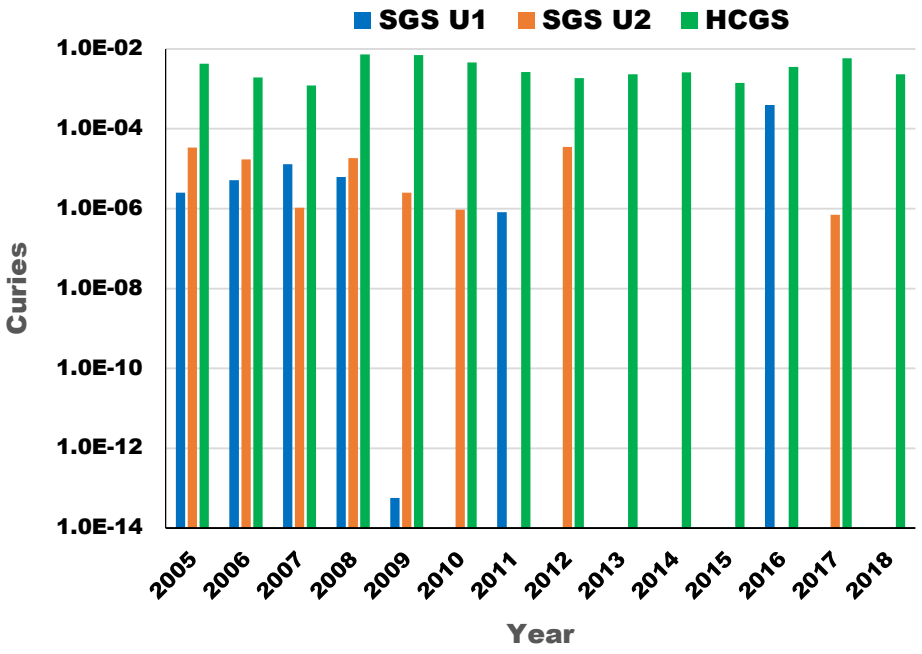


Figure 3
Particulates Released in Gaseous Effluents, Salem Unit 1, Salem Unit 2 and Hope Creek Unit 1, 2005 - 2018

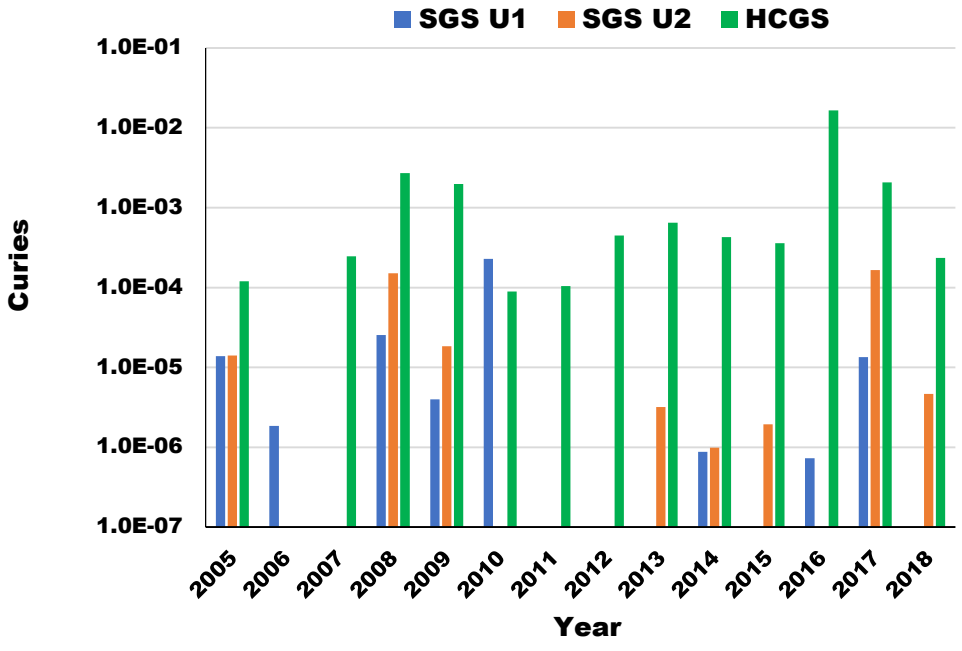


Figure 4
Tritium Released in Gaseous Effluents, Salem Unit 1, Salem Unit 2 and Hope Creek Unit 1, 2005 - 2018

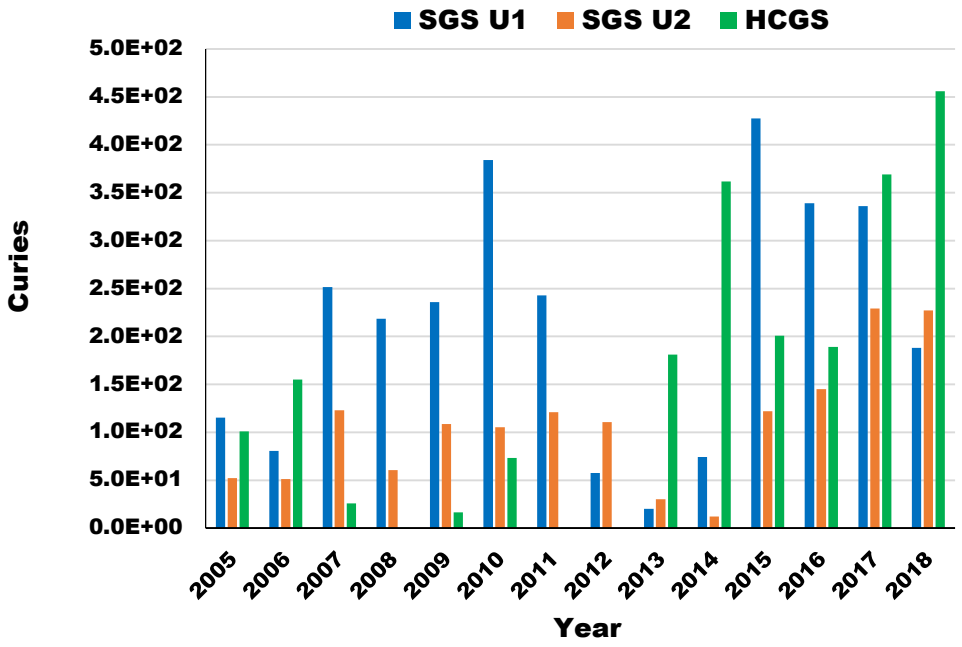


Figure 5
Fission and Activation Products Released in Liquid Effluents, Salem Unit 1, Salem Unit 2 and Hope Creek Unit 1, 2005 - 2018

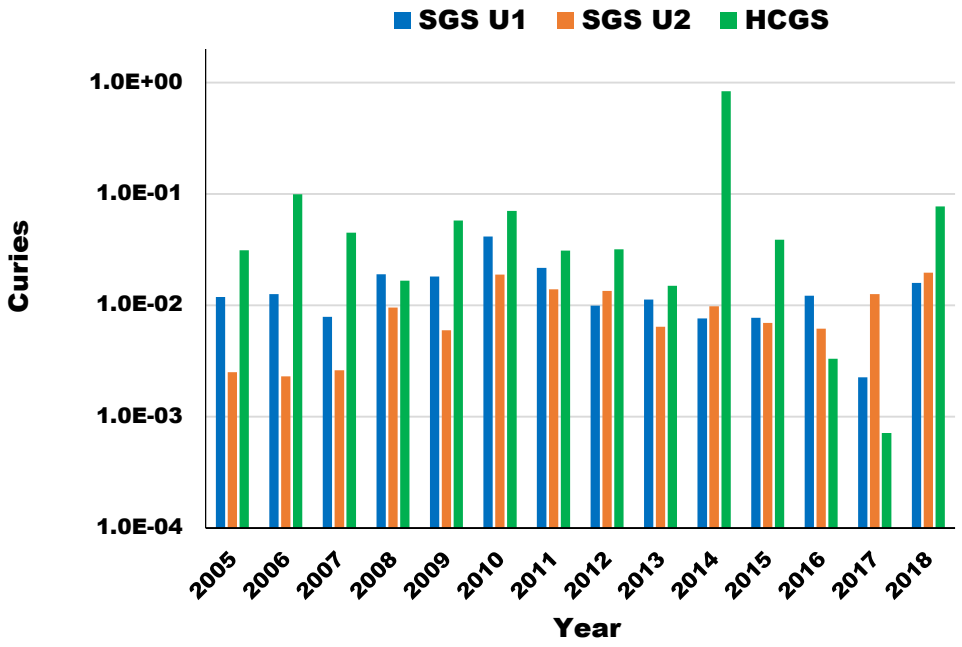
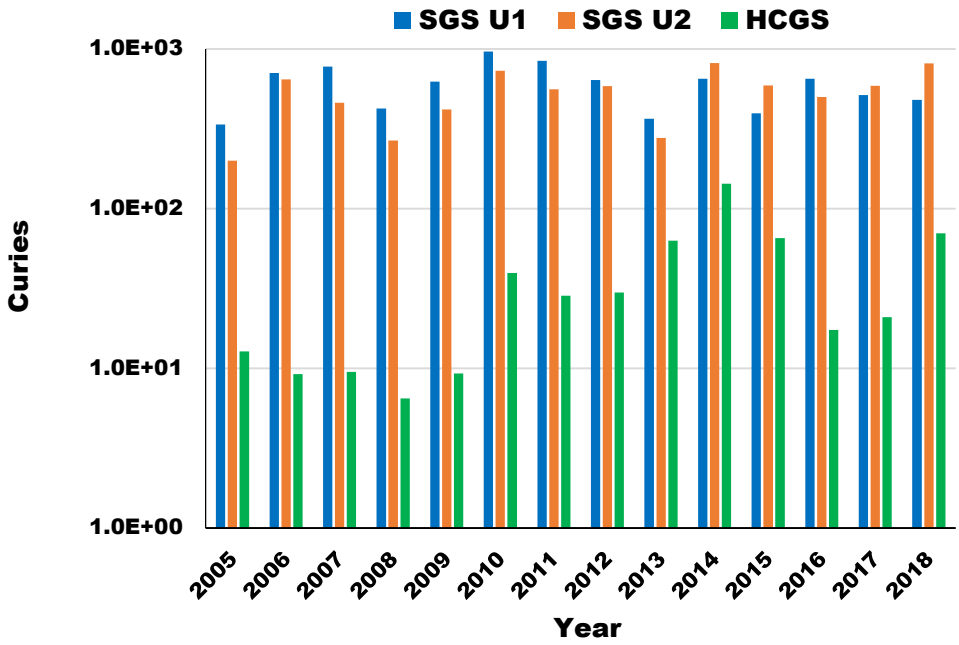


Figure 6
Tritium Released in Liquid Effluents, Salem Unit 1, Salem Unit 2 and Hope Creek Unit 1, 2005 - 2018



14. Carbon-14 in Gaseous Effluents

The NRC has identified Carbon-14 (C-14) as a potential principal radionuclide for gaseous effluent (refer to Regulatory Position 1.9 in Revision 2 of Regulatory Guide 1.21). Since the publication of Regulatory Guide 1.21, "*Measuring, Evaluating, and Reporting Radioactive Material in Liquid and Gaseous Effluents and Solid Waste"*, Revision 1, June 1974, the radioactive effluents from commercial nuclear power plants have decreased to the point that C-14 was likely to be a principal radionuclide in gaseous effluents. Gaseous effluent releases from a boiling water reactor (BWR), such as the HCGS, and pressurized water reactor (PWR), such as the SGS Units 1 and 2, can contain significant quantities of C-14, the NRC has recommended that licensees evaluate C-14 as a potential principal radionuclide for gaseous releases from their facility. Those evaluations have determined that C-14 was a "principal radionuclide" in gaseous effluent from each of the three stations.

The assessment methodology used to estimate the quantity of C-14 discharged in gaseous effluent from the SGS and HCGS involved the use of a normalized C-14 source term and scaling factors based on power generation from EPRI Technical Report 1021106, "*Estimation of Carbon-14 in Nuclear Power Plant Gaseous Effluents*", December 2010. This method was selected based on guidance offered in Regulatory Guide 1.21, and incorporates dose models described in Regulatory Guide 1.109, "*Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I*", Revision 1, October 1977.

The following assumptions were incorporated into the method:

- Only C-14 in the form of CO_2 was incorporated into vegetation through photosynthesis, which causes dose via the ingestion exposure pathways.
- The concentration of C-14 in vegetation was proportional to the concentration of C-14 in air (per equation C-8 in Regulatory Guide 1.109).
- 95% of C-14 released from a BWR (i.e., HCGS) and 30% of C-14 released from a PWR (i.e., SGS Units 1 and 2) was in the form of CO_2 (EPRI Technical Report 1021106).
- The total MW h_e electrical output by unit for 2018 was as follows:

SGS Unit 1	10,177,507	MW^*h_e
SGS Unit 2	8,717,600	MW^*h_e
HCGS	9,546,675	MW^*h_e

Using scaling factors and the 2018 power generation data, the estimated total C-14 released in 2018 was 11.61 Ci from SGS Unit 1, 9.94 Ci from SGS Unit 2, and 16.34 Ci from the HCGS.

The calculated dose contribution of C-14 was determined using the methodology detailed in the HCGS's and SGS's ODCMs. The calculated maximum total body and organ (bone) doses from C-14 occurred for a child receptor at 4.6 miles SW (Table 1) using the pathways of inhalation, meat and vegetation. The calculated doses from the estimated C-14 in gaseous effluents represent about 100% of the total bone dose from both SGS and HCGS.

Table 1
Quarterly and Annual Bone Doses from Radioactive Gaseous Effluent Releases from the Site to the Critical Receptor (Child) and Pathway (Inhalation, Meat, Food Products and Ground Shine) 2018.

Bone Dose from Other Radionuclides (mrem)	**Qtr. 1**	**Qtr. 2**	**Qtr. 3**	**Qtr. 4**	**Total**
SGS Unit 1	0.00E+00	0.00E+00	0.00E+00	5.24E-09	5.24E-09
SGS Unit 2	0.00E+00	0.00E+00	0.00E+00	1.83E-07	1.83E-07
HCGS	4.05E-04	8.32E-07	2.60E-05	1.05E-05	4.42E-04
Total Bone Dose from Other Radionuclides (mrem)	4.05E-04	8.32E-07	2.60E-05	1.07E-05	4.42E-04
Bone Dose from C-14 (mrem)	**Qtr. 1**	**Qtr. 2**	**Qtr. 3**	**Qtr. 4**	**Total**
SGS Unit 1	2.95E-02	2.98E-02	3.02E-02	3.02E-02	1.20E-01
SGS Unit 2	2.53E-02	2.56E-02	2.58E-02	2.58E-02	1.03E-01
HCGS	4.15E-02	4.20E-02	4.24E-02	4.24E-02	1.68E-01
Total Dose from C-14 (mrem)	9.63E-02	9.74E-02	9.84E-02	9.84E-02	3.91E-01
Total Dose From All Nuclides (mrem)	9.67E-02	9.74E-02	9.85E-02	9.85E-02	3.91E-01
Percent of dose from C-14	99.58%	100.00%	99.97%	99.99%	99.89%

15. Errata Data Section: Modifications or Revisions Made to Previous Radioactive Effluent Release Reports

A. PSEG's 2016 ARERR Tables 2A-3 and Table 2C-3 were revised to correct the curies released from one gaseous effluent permit that had underestimated the total curies due to a gamma spectroscopy software issue that was discussed in Section 7 of this report. The values that changed are bracketed in **[red]**.

TABLE 2A-3

GASEOUS EFFLUENTS – SUMMATION OF ALL RELEASES

Facility: Hope Creek Unit 1 Period: **[2016]**

A. Fission & Activation Gases	Unit	Qtr. 1	Qtr. 2	Qtr. 3	Qtr. 4	Total	Est. Total Error %
Total Release	Ci	4.53E-01	9.89E-01	0.00E+00	0.00E+00	1.44E+00	3.400E+01
Average release rate for the period	µCi/sec	5.76E-02	1.26E-01	0.00E+00	0.00E+00	4.56E-02	
Percent of limit (ODCM 3.11.2.2(a))	Gamma Air %	See Table 3 on page 21					
	Beta Air %						
B. Iodines and Halogens							
Total Release	Ci	9.05E-04	1.05E-03	1.08E-03	4.87E-04	3.52E-03	3.00E+01
Average release rate for the period	µCi/sec	1.15E-04	1.34E-04	1.35E-04	6.12E-05	1.11E-04	
Percent of limit (ODCM 3.11.2.3(a))	%	*	*	*	*	*	
C. Particulates							
Particulates with half-lives > 8 days	Ci	1.80E-03	9.25E-03	5.53E-03	**[6.69E-06]**	1.66E-02	3.00E+01
Average release rate for the period	µCi/sec	2.29E-04	1.18E-03	6.95E-04	**[8.41E-07]**	5.24E-04	
Percent of limit (ODCM 3.11.2.3(a))	%	*	*	*	*	*	
Gross alpha radioactivity	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	
D. Tritium							
Total Release	Ci	3.68E+01	3.67E+01	7.57E+01	3.94E+01	1.89E+02	3.10E+01
Average release rate for the period	µCi/sec	4.68E+00	4.67E+00	9.52E+00	4.95E+00	5.96E+00	
Percent of limit (ODCM 3.11.2.3(a))	%	*	*	*	*	*	
E. Carbon-14							
Total Release	Ci	4.09E+00	4.09E+00	4.13E+00	4.13E+00	1.64E+01	N/A[a]
Average release rate for the period	µCi/sec	5.19E-01	5.21E-01	5.16E-01	5.19E-01	5.18E-01	
Percent of limit (ODCM 3.11.2.3(a))	%	*	*	*	*	*	
F. I-131, I-133, H-3 & Particulates > 8 day half-life							
Percent of limit (ODCM 3.11.2.3(a))	%	See Table 3 on page 21					
G. I-131, I-133, H-3, Particulates > 8 day half-life & C-14							
Percent of limit (ODCM 3.11.2.3(a))	%	See Table 3 on page 21					

TABLE 2C-3

GASEOUS EFFLUENTS – GROUND LEVEL RELEASES

Facility: Hope Creek Unit 1 Period: [2016]

Nuclides Released		Continuous Mode					Batch Mode				
1. Fission gases	**Unit**	**Qtr. 1**	**Qtr. 2**	**Qtr. 3**	**Qtr. 4**	**Total**	**Qtr. 1**	**Qtr. 2**	**Qtr. 3**	**Qtr. 4**	**Total**
Xe-133	Ci	< LLD	9.89E-01	< LLD	< LLD	9.89E-01	< LLD	< LLD	< LLD	< LLD	< LLD
Xe-135	Ci	4.53E-01	< LLD	< LLD	< LLD	4.53E-01	< LLD	< LLD	< LLD	< LLD	< LLD
Total	Ci	4.53E-01	9.89E-01	< LLD	< LLD	1.44E+00	< LLD	< LLD	< LLD	< LLD	< LLD
2. Iodines and Halogens											
Br-82	Ci	9.82E-06	< LLD	< LLD	< LLD	9.82E-06	< LLD	< LLD	< LLD	< LLD	< LLD
I-131	Ci	1.55E-04	2.10E-04	1.94E-04	1.07E-04	6.66E-04	< LLD	< LLD	< LLD	< LLD	< LLD
I-133	Ci	7.40E-04	8.43E-04	8.81E-04	3.80E-04	2.84E-03	< LLD	< LLD	< LLD	< LLD	< LLD
Total	Ci	9.05E-04	1.05E-03	1.08E-03	4.87E-04	3.52E-03	< LLD	< LLD	< LLD	< LLD	< LLD
3. Particulates											
Na-24	Ci	9.67E-05	2.43E-04	7.98E-05	< LLD	4.20E-04	< LLD	< LLD	< LLD	< LLD	< LLD
Co-58	Ci	< LLD	< LLD	1.20E-06	< LLD	1.20E-06	< LLD	< LLD	< LLD	< LLD	< LLD
Co-60	Ci	4.36E-05	1.62E-05	9.39E-06	6.62E-06	[7.60E-05]	< LLD	< LLD	< LLD	< LLD	< LLD
Y-91m	Ci	1.65E-03	8.95E-03	5.44E-03	< LLD	1.60E-02	< LLD	< LLD	< LLD	< LLD	< LLD
Ce-141	Ci	< LLD	3.46E-05	< LLD	< LLD	3.46E-05	< LLD	< LLD	< LLD	< LLD	< LLD
Other	Ci	1.12E-05	< LLD	< LLD	< LLD	1.12E-05	< LLD	< LLD	< LLD	< LLD	< LLD
Total	Ci	1.80E-03	9.25E-03	5.53E-03	6.62E-06	1.66E-02	< LLD	< LLD	< LLD	< LLD	< LLD
4. Tritium	Ci	3.68E+01	3.67E+01	7.57E+01	3.94E+01	1.89E+02	< LLD	< LLD	< LLD	1.88E-03	1.88E-03
5. Carbon-14	Ci	4.05E+00	4.10E+00	4.14E+00	4.14E+00	1.64E+01	< LLD	< LLD	< LLD	< LLD	< LLD

Note: Only radionuclides with positive activity reported in this table.

IV. Radiological Impact on Man

1. Effluent Doses

The doses from gaseous and liquid effluent represent the maximum potential radiation dose for a member of the general public following the methodology in the station's ODCM and reported by the SGS's EMS database program and HCGS's OpenEMS database program.

The annual doses presented in the tables below represent calculations for the four quarters of 2018. The radiological impacts from gaseous and liquid effluent discharges from SGS Units 1 and 2 and HCGS are presented in Tables 2 and 3, respectively, and demonstrate compliance with applicable regulatory limits. Dose limit values presented in bold font are regulatory limits. The quarterly doses must not

exceed the quarterly limit in any quarter and the summation of two or more quarterly doses must not exceed the annual dose limit.

A. Doses from Gaseous Effluent using Default Conservative Meteorology:

Quarterly doses from gaseous effluent were calculated using the methodology described in the SGS and HCGS ODCMs. Usage factors and dose conversion factors used in the gaseous dose calculations were those presented in the SGS and HCGS ODCMs.

The individual doses from radioactive gaseous effluents (presented in Table 3) were calculated for the controlling locations described in the SGS and HCGS ODCMs using the methodology in the ODCMs by the SGS's EMS and the HCGS OpenEMS database programs. The dose contribution from C-14 was determined by manual calculations for SGS 1 and 2 and OpenEMS for HCGS using the methodology listed in the stations' ODCMs and added to the appropriate organ from the EMS or OpenEMS printouts.

Table 2
2018 Doses and Percent of the Limits from Gaseous Effluents by Operating Unit

SGS Unit 1							
Gaseous Effluent Parameter			**Qtr. 1**	**Qtr. 2**	**Qtr. 3**	**Qtr. 4**	**Annual**
Gaseous Dose From Noble Gas	Gamma Air	**Dose Limit** (mrad)	**5.00E+00**				**1.00E+01**
		Max Gamma Air Dose (mrad)	1.12E-05	1.86E-05	3.69E-05	3.22E-05	9.89E-05
		% Dose Limit	< 0.001%	< 0.001%	< 0.001%	< 0.001%	< 0.001%
	Beta Air	**Dose Limit** (mrad)	**1.00E+01**				**2.00E+01**
		Maximum Beta Air Dose (mrad)	5.04E-06	7.74E-06	1.48E-05	1.39E-05	4.14E-05
		% Dose Limit	< 0.001%	< 0.001%	< 0.001%	< 0.001%	< 0.001%
Gaseous Dose From I-131, I-133, H-3, C-14* and Particulate Nuclides with half-life > 8 Days		**Organ Dose Limit** (mrem)	**7.50E+00**				**1.50E+01**
	* without C-14 Dose	ODCM Critical Receptor (mrem)	2.84E-04	1.08E-04	2.44E-04	3.38E-04	9.73E-04
		% Dose Limit	0.004%	0.001%	0.003%	0.005%	0.006%
	* with C-14 Dose	ODCM Critical Receptor (mrem)	2.95E-02	2.98E-02	3.02E-02	3.02E-02	1.20E-01
		% Dose Limit	0.393%	0.397%	0.403%	0.403%	0.800%

Table 2
2018 Doses and Percent of the Limits from Gaseous Effluents by Operating Unit (cont.)

SGS Unit 2							
Gaseous Effluent Parameter			**Qtr. 1**	**Qtr. 2**	**Qtr. 3**	**Qtr. 4**	**Annual**
Gaseous Dose From Noble Gas	Gamma Air	**Dose Limit** (mrad)	**5.00E+00**				**1.00E+01**
		Max Gamma Air Dose (mrad)	4.57E-05	3.45E-06	3.79E-05	1.25E-05	9.96E-05
		% Dose Limit	< 0.001%	< 0.001%	< 0.001%	< 0.001%	< 0.001%
	Beta Air	**Dose Limit** (mrad)	**1.00E+01**				**2.00E+01**
		Maximum Beta Air Dose (mrad)	1.80E-05	4.81E-06	2.03E-05	8.82E-06	5.20E-05
		% Dose Limit	< 0.001%	< 0.001%	< 0.001%	< 0.001%	< 0.001%
Gaseous Dose From I-131, I-133, H-3, C-14* and Particulate Nuclides with half-life > 8 Days		**Organ Dose Limit** (mrem)	**7.50E+00**				**1.50E+01**
	* without C-14 Dose	ODCM Critical Receptor (mrem)	2.17E-04	3.36E-04	3.28E-04	2.93E-04	1.17E-03
		% Dose Limit	0.003%	0.004%	0.004%	0.004%	0.008%
	* with C-14 Dose	ODCM Critical Receptor (mrem)	2.53E-02	2.56E-02	2.58E-02	2.58E-02	1.03E-01
		% Dose Limit	0.337%	0.341%	0.344%	0.344%	0.687%

HCGS							
Gaseous Effluent Parameter			**Qtr. 1**	**Qtr. 2**	**Qtr. 3**	**Qtr. 4**	**Annual**
Gaseous Dose From Noble Gas	Gamma Air	**Dose Limit** (mrad)	**5.00E+00**				**1.00E+01**
		Max Gamma Air Dose (mrad)	0.00E+00	1.00E-08	1.72E-05	3.05E-05	4.78E-05
		% Dose Limit	N/A	< 0.001%	< 0.001%	< 0.001%	< 0.001%
	Beta Air	**Dose Limit** (mrad)	**1.00E+01**				**2.00E+01**
		Maximum Beta Air Dose (mrad)	0.00E+00	1.28E-08	5.13E-05	9.08E-05	1.42E-04
		% Dose Limit	N/A	< 0.001%	< 0.001%	< 0.001%	< 0.001%
Gaseous Dose From I-131, I-133, H-3, C-14* and Particulate Nuclides with half-life > 8 Days		**Organ Dose Limit** (mrem)	**7.50E+00**				**1.50E+01**
	* without C-14 Dose	ODCM Critical Receptor (mrem)	1.25E-02	5.43E-03	8.45E-03	1.40E-02	4.04E-02
		% Dose Limit	0.166%	0.072%	0.113%	0.187%	0.269%
	* with C-14 Dose	ODCM Critical Receptor (mrem)	4.46E-02	3.69E-02	4.16E-02	4.54E-02	1.69E-01
		% Dose Limit	0.594%	0.492%	0.555%	0.605%	1.127%

Table 2
2018 Doses and Percent of the Limits from Gaseous Effluents by Operating Unit (cont.)

SGS-HCGS Site Total							
Gaseous Effluent Parameter			Qtr. 1	Qtr. 2	Qtr. 3	Qtr. 4	Annual
Gaseous Dose From Noble Gas	Gamma Air	**Dose Limit** (mrad)	1.50E+01				3.00E+01
		Max Gamma Air Dose (mrad)	5.69E-05	2.21E-05	9.20E-05	7.52E-05	2.46E-04
		% Dose Limit	< 0.001%	< 0.001%	0.001%	0.001%	0.001%
	Beta Air	**Dose Limit** (mrad)	3.00E+01				6.00E+01
		Maximum Beta Air Dose (mrad)	2.30E-05	1.26E-05	8.64E-05	1.14E-04	2.35E-04
		% Dose Limit	< 0.001%	< 0.001%	< 0.001%	< 0.001%	< 0.001%
Gaseous Dose From I-131, I-133, H-3, C-14* and Particulate Nuclides with half-life > 8 Days		**Organ Dose Limit** (mrem)	2.25E+01				4.50E+01
	* without C-14 Dose	ODCM Critical Receptor (mrem)	1.30E-02	5.87E-03	9.02E-03	1.47E-02	4.25E-02
		% Dose Limit	0.058%	0.026%	0.040%	0.065%	0.094%
	* with C-14 Dose	ODCM Critical Receptor (mrem)	9.94E-02	9.23E-02	9.76E-02	1.01E-01	3.92E-01
		% Dose Limit	0.442%	0.410%	0.434%	0.451%	0.871%

B. Doses from Liquid Effluent:

Quarterly and Annual Total Body and Critical Organ doses from liquid effluent were calculated using the methodology described in the SGS and HCGS ODCMs at the controlling receptor location of 0.75 miles N of SGS. Usage factors and dose conversion factors used in the liquid dose calculations were those presented in the SGS and HCGS ODCMs.

Table 3
2018 Doses and Percent of the Limits from Liquid Effluents by Operating Unit

SGS Unit 1					
Liquid Effluent Parameter	**Qtr. 1**	**Qtr. 2**	**Qtr. 3**	**Qtr. 4**	**Annual**
Total Body Dose Limit (mrem)	**1.50E+00**				**3.00E+00**
Maximum Total Body Dose (mrem)	1.30E-07	2.08E-06	1.33E-05	8.36E-06	1.06E-05
% Dose Limit	< 0.001	< 0.001	0.001	0.001	< 0.001
Organ Dose Limit (mrem)	**5.00E+00**				**1.00E+01**
Maximum Organ Dose (mrem)	1.30E-07	2.67E-06	1.94E-05	1.38E-04	1.41E-04
% Dose Limit	< 0.001	< 0.001	< 0.001	0.003	0.001
SGS Unit 2					
Liquid Effluent Parameter	**Qtr. 1**	**Qtr. 2**	**Qtr. 3**	**Qtr. 4**	**Annual**
Total Body Dose Limit (mrem)	**1.50E+00**				**3.00E+00**
Maximum Total Body Dose (mrem)	4.78E-06	9.28E-06	1.81E-05	2.92E-05	4.33E-05
% Dose Limit	< 0.001	0.001	0.001	0.002	0.001
Organ Dose Limit (mrem)	**5.00E+00**				**1.00E+01**
Maximum Organ Dose (mrem)	1.73E-05	1.11E-05	1.98E-05	1.17E-04	1.46E-04
% Dose Limit	< 0.001	< 0.001	< 0.001	0.002	0.001
HCGS					
Liquid Effluent Parameter	**Qtr. 1**	**Qtr. 2**	**Qtr. 3**	**Qtr. 4**	**Annual**
Total Body Dose Limit (mrem)	**1.50E+00**				**3.00E+00**
Maximum Total Body Dose (mrem)	5.10E-05	7.35E-03	8.22E-05	4.46E-05	7.53E-03
% Dose Limit	0.003	0.490	0.005	0.003	0.251
Organ Dose Limit (mrem)	**5.00E+00**				**1.00E+01**
Maximum Organ Dose (mrem)	9.41E-05	2.02E-02	1.76E-04	1.58E-04	2.07E-02
% Dose Limit	0.002	0.404	0.005	0.003	0.207

Table 3
2018 Doses and Percent of the Limits from Liquid Effluents by Operating Unit (cont.)

SGS Units 1&2 + HCGS Site Total					
Liquid Effluent Parameter	**Qtr. 1**	**Qtr. 2**	**Qtr. 3**	**Qtr. 4**	**Annual**
Total Body Dose Limit (mrem)	**4.50E+00**				**9.00E+00**
Maximum Total Body Dose (mrem)	5.59E-05	7.36E-03	1.14E-04	8.22E-05	7.58E-03
% Dose Limit	0.001%	0.164%	0.003%	0.002%	0.084%
Organ Dose Limit (mrem)	**1.50E+01**				**3.00E+01**
Maximum Organ Dose (mrem)	1.12E-04	2.02E-02	2.15E-04	4.13E-04	2.10E-02
% Dose Limit	0.001%	0.135%	0.001%	0.003%	0.070%

C. Doses from Gaseous Effluent using Annual Average Meteorology:

As a check on the use of conservative historical meteorological dispersion (X/Q) and deposition values (D/Q), the 2018 gaseous release curies (Tables 1C-1, 1C-2 and 1C-3) for each of the three units and the 2018 annual average dispersion and deposition data (Table 4) were entered into the NRC approved GASPAR computer program to calculate doses to the critical receptors and pathways identified by the 2018 Land Use Census (LUC). The receptor locations for this dose calculation were plotted with the 2018 wind rose overlay (Figure 7).

The methods used to determine gaseous doses were consistent with the methods described in SGS and HCGS ODCMs and in NRC Regulatory Guide 1.109. The 2018 LUC did not identify any gardens greater than 500 ft^2 within five miles producing broadleaf vegetation; however, that pathway was included in the dose analysis. Using the 2018 meteorology data the calculated doses (Table 5).were lower than that reported in Table 2 that used the conservative ODCM default meteorology

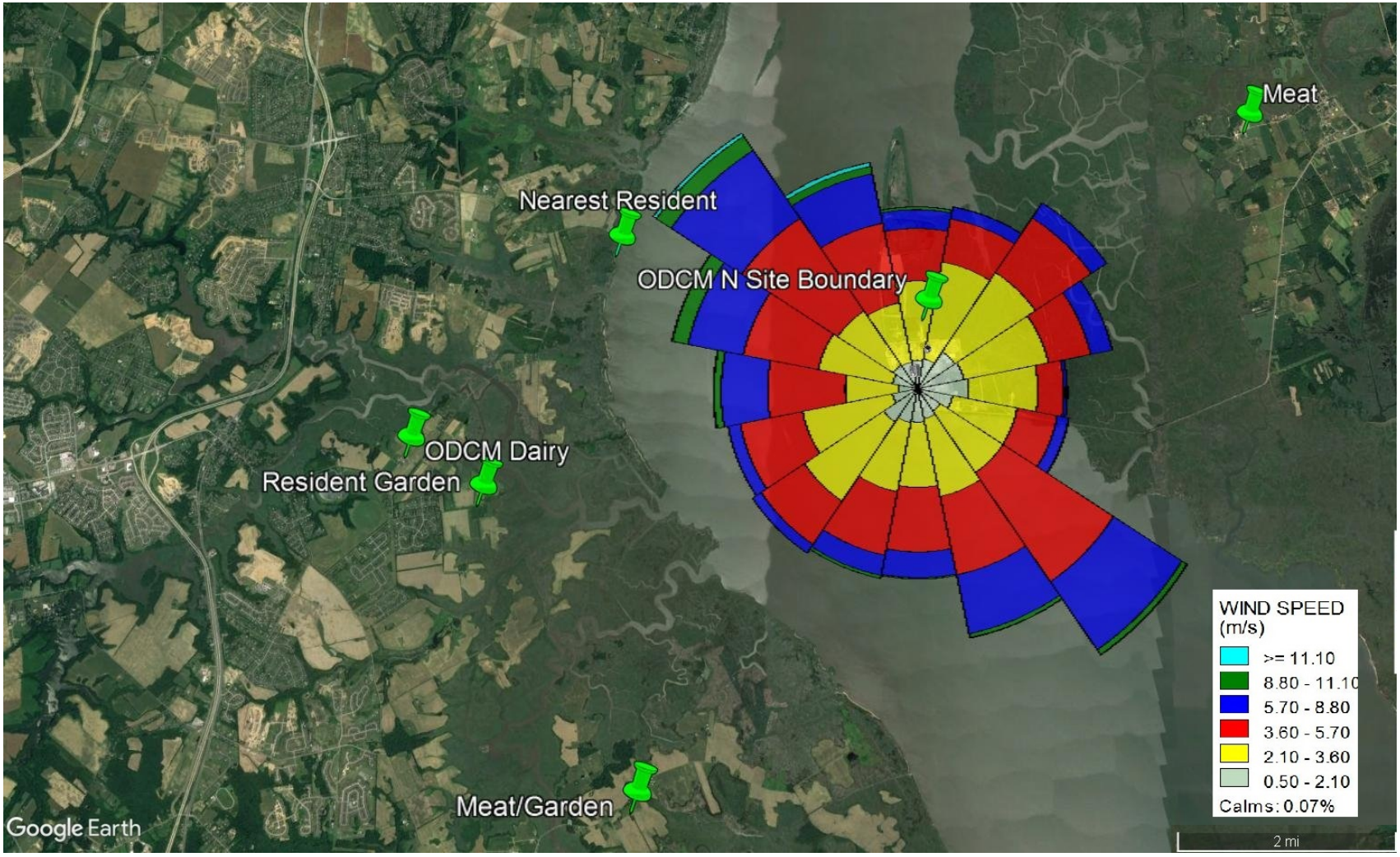
Table 4

2018 Annual Average Undepleted X/Q, Depleted X/Q and D/Q and Active Exposure Pathways

Receptor Location	Undepleted X/Q (sec./m^3)	Depleted X/Q (sec./m^3)	D/Q (1/m^2)	Active Exposure Pathways
HCGS Site- Boundary (0.5 mi N)	1.6E-06	1.4E-06	1.1E-08	Plume Immersion, Ground Deposition, Inhalation
SGS Site-Boundary (0.83 mi N)	7.3E-07	6.5E-07	4.6E-09	Plume Immersion, Ground Deposition, Inhalation
ODCM Dairy (4.9mi W)				Plume Immersion, Ground Deposition, Inhalation, Milk Ingestion
SGS	6.7E-08	5.0E-08	1.6E-10	
HCGS	6.7E-08	5.0E-08	1.6E-10	
Resident (3.7mi NW)				Plume Immersion, Ground Deposition, Inhalation
SGS	1.4E-07	1.1E-07	5.7E-10	
HCGS	1.4E-07	1.1E-07	5.7E-10	
Resident-Garden (4.4mi WSW)				Plume Immersion, Ground Deposition, Inhalation Vegetable Ingestion
SGS	8.4E-08	6.3E-08	2.7E-10	
HCGS	8.3E-08	6.3E-08	2.7E-10	
Resident-Meat (4.2mi NNE)				Plume Immersion, Ground Deposition, Inhalation, Meat Ingestion
SGS	7.5E-08	5.7E-08	2.8E-10	
HCGS	7.4E-08	5.7E-08	2.8E-10	
Resident-Garden-Meat (4.6mi SW)				Plume Immersion, Ground Deposition, Inhalation, Meat Ingestion, Vegetable Ingestion
SGS	8.8E-08	6.6E-08	2.8E-10	
HCGS	8.8E-08	6.6E-08	2.8E-10	

Figure 7

Locations of Dose Calculation Receptors with 2018 Wind Rose Overlay



Note: Wind rose depicts fraction of time wind transports gaseous effluents from each of the sixteen compass sectors.

Table 5
2018 Total Body and Critical Organ Doses at Receptor Locations
Using Annual Average X/Q and D/Q Data by Operating Unit

Operating Unit	ODCM Site Boundary Critical Organ Doses Inhalation, Ground Plane (0.5 / 0.8 mi N)			
	Excluding C-14		Including C-14	
	Organ (mrem)	Total Body (mrem)	Organ (mrem)	Total Body (mrem)
SGS Unit 1	3.19E-03	3.17E-03	3.19E-03	3.17E-03
SGS Unit 2	3.83E-03	3.82E-03	3.83E-03	3.82E-03
HCGS	1.76E-02	1.72E-02	1.76E-02	1.72E-02
Site Total	**2.46E-02**	**2.42E-02**	**2.46E-02**	**2.42E-02**

Operating Unit	ODCM Dairy Critical Organ Doses Inhalation, Ground Plane, Milk (4.9 mi W)			
	Excluding C-14		Including C-14	
	Organ (mrem)	Total Body (mrem)	Organ (mrem)	Total Body (mrem)
SGS Unit 1	6.99E-04	6.98E-04	8.02E-02	1.78E-02
SGS Unit 2	8.41E-04	8.39E-04	6.88E-02	1.55E-02
HCGS	2.31E-03	1.69E-03	1.31E-01	2.58E-02
Site Total	**3.85E-03**	**3.23E-03**	**2.80E-01**	**5.91E-02**

Operating Unit	Nearest Resident Critical Organ Doses Inhalation, Ground Plane (3.7 mi NW)			
	Excluding C-14		Including C-14	
	Organ (mrem)	Total Body (mrem)	Organ (mrem)	Total Body (mrem)
SGS Unit 1	6.12E-04	6.09E-04	6.12E-04	6.09E-04
SGS Unit 2	7.35E-04	7.32E-04	7.35E-04	7.32E-04
HCGS	1.52E-03	1.49E-03	1.52E-03	1.49E-03
Site Total	**2.87E-03**	**2.83E-03**	**2.87E-03**	**2.83E-03**

Operating Unit	Resident - Garden Critical Organ Doses Inhalation, Ground Plane, Vegetation (4.4 mi WSW)			
	Excluding C-14		Including C-14	
	Organ (mrem)	Total Body (mrem)	Organ (mrem)	Total Body (mrem)
SGS Unit 1	1.48E-03	1.48E-03	1.09E-01	2.33E-02
SGS Unit 2	1.78E-03	1.78E-03	9.36E-02	2.05E-02
HCGS	3.81E-03	3.55E-03	1.52E-01	3.39E-02
Site Total	**7.07E-03**	**6.81E-03**	**3.55E-01**	**7.77E-02**

Table 5

2018 Total Body and Critical Organ Doses at Receptor Locations Using Annual Average X/Q and D/Q Data by Each Operating Unit (continued)

Operating Unit	Meat Critical Organ Doses Inhalation, Ground Plane, Meat 4.2 mi NNE			
	Excluding C-14		Including C-14	
	Organ (mrem)	Total Body (mrem)	Organ (mrem)	Total Body (mrem)
SGS Unit 1	4.08E-04	4.07E-04	1.47E-02	3.29E-03
SGS Unit 2	4.91E-04	4.90E-04	1.26E-02	2.94E-03
HCGS	9.98E-04	9.78E-04	2.04E-02	4.93E-03
Site Total	**1.90E-03**	**1.88E-03**	**4.77E-02**	**1.12E-02**

Operating Unit	Meat - Garden Critical Organ Doses Inhalation, Ground Plane, Meat, Vegetation 4.6 mi SW			
	Excluding C-14		Including C-14	
	Organ (mrem)	Total Body (mrem)	Organ (mrem)	Total Body (mrem)
SGS Unit 1	1.62E-03	1.62E-03	1.31E-01	2.80E-02
SGS Unit 2	1.95E-03	1.95E-03	1.13E-01	2.45E-02
HCGS	4.22E-03	3.94E-03	1.85E-01	4.09E-02
Site Total	**7.79E-03**	**7.51E-03**	**4.29E-01**	**9.34E-02**

As set forth in 10CFR50 Appendix I, ALARA requirements for gaseous effluent were met if a licensee demonstrates that the estimated annual external dose from gaseous effluents to any individual in unrestricted areas does not exceed 5 mrem to the total body or 15 mrem to the skin. Compliance with these limits was demonstrated for 2018 gaseous effluents by the calculated total body and skin doses from external exposure pathways (i.e., plume and ground deposition) at the controlling site boundary location in the north sector. The calculated total body dose and skin dose from the combined gaseous releases for the site represent less than 0.48% (Total Body) and less than 0.16% (Organ) of the respective dose limits (Table 5 Site Boundary Location). This confirms that no single unit's radioactive gaseous effluent releases exceeded the Appendix I dose limits. These doses (presented below) were calculated using the GASPAR computer program, which was consistent with the methods described in Regulatory Guide 1.109.

Dose Parameter from Table 5 Site Boundary	Annual Dose (mrem)
Total Body Dose from Noble Gases, Iodines, Particulates, H-3 and C-14:	2.42E-02
Percent of Appendix I Annual Limit (5 mrem):	0.48%
Skin Dose from Noble Gases, Iodines, Particulates, H-3 and C-14:	2.43E-02
Percent of Appendix I Annual Limit (15 mrem):	0.16%

2. Total Dose to a Member of the Public, Resulting from Radioactive Effluent Releases and Radiation from Uranium Fuel Cycle Sources

40 CFR 190 and 10 CFR 72.104 limit the total dose to a "Real Individual" to 25 mrem to the total body, 75 mrem to the thyroid and 25 mrem to other organs other than the thyroid. The maximum annual total body and organ doses from gaseous and liquid pathways with all other uranium fuel cycle sources present on site were calculated as required by section 3.11.4 of the SGS and HCGS ODCMs. The direct dose from the ISFSI pad was determined using the Radiological Environmental Monitoring Program (REMP) and the guidance provided in ANSI/HPS N13.37-2014 (see page 10).

The direct shine dose from the ISFSI to the Critical Receptor located at 4.6 miles in the SW sector was conservatively estimated at 4.17E-03 mrem. The doses from the gaseous and liquid radioactive effluents released from SGS Units 1 and Unit 2 and HCGS in 2018 resulted in a calculated total body and an organ dose of 9.94E-02 mrem and 4.13E-01mrem, respectively. The majority of dose was from the gaseous dose pathways from C-14. The total dose was calculated as 5.16E-01mrem, which was below the limits of 40 CFR 190 and 10 CFR 72.104. The results of this analysis are in Table 6.

Table 6

2018 Total Body and Organ Doses due to Liquid and Gaseous Effluents and Direct Shine ISFSI Dose to the Critical Receptor Located at 4.6 miles SW

Generating Station	Total Body Dose (mrem)		Critical Organ Dose (mrem)		ISFSI (mrem)
	Liquid	Gaseous*	Liquid	Gaseous*	
SGS Unit 1	1.06E-05	2.49E-02	1.41E-04	1.20E-01	
SGS Unit 2	4.33E-05	2.17E-02	1.46E-04	1.03E-01	
HCGS	7.53E-03	4.52E-02	2.07E-02	1.69E-01	
Total	7.58E-03	9.18E-02	2.10E-02	3.92E-01	
Total of Liquid and Gaseous (mrem)	**9.94E-02**		**4.13E-01**		**4.17E-01**
Total Dose (mrem)	**5.16E-01**				

* Includes C-14 dose.

3. Dose to Members of the Public Due to Activities inside the Site Boundary

In accordance with 10 CFR 20.1301 Members of the Public may receive up to a limit of 100 mrem Total Effective Dose Equivalent (TEDE) in a year. The TEDE dose is the combined organ Committed Dose Equivalent (CDE) and the Total Body Dose. The Total Body Dose includes the direct shine dose from the ISFSI. There were no liquid or airborne releases from the ISFSI. The dose from radioactive liquid and gaseous effluents to a Member of the Public performing activities inside the site boundary are to be calculated as required by ODCM 6.9.1.8 (SGS) and 6.9.1.7 (HCGS).

Two sets of TEDE doses were calculated to two different members of the public. The first TEDE dose calculation assumes that an adult emergency worker (i.e. National Guard, Police, etc.) was located at the site vehicle Security Checkpoint entrance. The second calculation was to an adult contract worker stationed at the sewage treatment plant (STP). Both sets of members of the public have assigned duties that do not involve exposure to radiation or to radioactive material. Neither group have Radiation Control Access. In addition exposure time was limited to 2000 hours in a year (0.25 occupancy).

The vehicle Security Checkpoint was located at 0.89 miles E from the gaseous release points for SGS Units 1 and 2 and 0.94 miles E from the HCGS and 1.18 miles from the ISFSI. The STP workers were located about 575 feet from the ISFSI pad.

The active exposure pathways at both locations were plume immersion, ground deposition and inhalation of airborne radioactivity in gaseous effluent. There was no liquid dose pathway to Members of the Public on site.

The 2018 atmospheric dispersion factors were imputed into the GASPAR computer program to calculate the gaseous effluent doses. For purposes of these calculations the gaseous doses for the STP worker used the highest site boundary sector doses located in the SW sector.

The calculated TEDE dose from gaseous effluents from the three reactors for each location was calculated by summing the total body and highest organ doses from SGS U1, SGS U2 and HCGS. The ISFSI dose was then added to each and then compared to the 10 CFR 20.1301 limit of 100 mrem. The results were as follows:

Table 7

Summary of TEDE doses to Members of the Public Due to Activities Inside the Site Boundary

Location	Operating Unit	CDE (Thyroid) mrem	Total Body Dose mrem	TEDE mrem	% of Limit (100 mrem) per 10 CFR 20.1301
Security Checkpoint	SGS U1	5.82E-04	5.82E-04		
	SGS U2	7.00E-04	7.00E-04		
	HCGS	1.36E-03	1.33E-03		
	ISFSI	N/A	1.56E-02		
	Total	**2.64E-03**	**1.82E-02**	**2.09E-02**	**0.02%**
STP	SGS U1	2.92E-02	2.92E-02		
	SGS U2	3.50E-02	3.50E-02		
	HCGS	3.51E-02	3.43E-02		
	ISFSI	N/A	1.86E+00		
	Total	**9.93E-02**	**1.96E+00**	**2.06E+00**	**2.06%**

N/A Not Applicable

The calculated doses were well below the 100 mrem limit of 10 CFR 20.1301.

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APPENDIX A-1

Effluent and Waste Disposal Summary, SGS Unit 1

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List of Tables

TABLE 1A-1

GASEOUS EFFLUENTS – SUMMATION OF ALL RELEASES

Facility: SGS Unit 1 Period: 2018

A. Fission & Activation Gases	Unit	Qtr. 1	Qtr. 2	Qtr. 3	Qtr. 4	Total	Est. Total Error %
Total Release	Ci	3.30E-02	4.65E-02	8.27E-02	8.70E-02	2.49E-01	3.400E+01
Average release rate for the period	μCi/sec	4.24E-03	5.91E-003	1.04E-02	1.09E-02	7.89E-09	
Percent of limit (ODCM 3.11.2.2(a))	Gamma Air % Beta Air %	See Table 2 on page 18					
B. Iodine							
Total I-131	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	3.00E+01
Average release rate for the period	μCi/sec	N/A	N/A	N/A	N/A	N/A	
Percent of limit (ODCM 3.11.2.3(a))	%	*	*	*	*	*	
C. Particulates							
Particulates with half-lives > 8 days	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	3.00E+01
Average release rate for the period	μCi/sec	N/A	N/A	N/A	N/A	N/A	
Percent of limit (ODCM 3.11.2.3(a))	%	*	*	*	*	*	
Gross alpha radioactivity	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	
D. Tritium							
Total Release	Ci	5.49E+01	2.08E+01	4.70E+01	6.49E+01	1.88E+02	3.10E+01
Average release rate for the period	μCi/sec	7.06E+00	2.65E+00	5.91E+00	8.16E+00	5.94E-06	
Percent of limit (ODCM 3.11.2.3(a))	%	*	*	*	*	*	
E. C-14							
Total Release	Ci	2.86E+00	2.89E+00	2.93E+00	2.93E+00	1.16E+01	N/A[a]
Average release rate for the period	μCi/sec	3.682E-01	3.682E-01	3.682E-01	3.682E-01	3.682E-01	
Percent of limit (ODCM 3.11.2.3(a))	%	*	*	*	*	*	
F. I-131, I-133, H-3 & Particulates > 8 day half-life							
Percent of limit (ODCM 3.11.2.3(a))	%	See Table 2 on page 18					
G. I-131, I-133, H-3, Particulates > 8 day half-life & C-14							
Percent of limit (ODCM 3.11.2.3(a))	%	See Table 2 on page 18					

N/A Not Applicable

* Iodine, Tritium, C-14, and Particulates were treated as a group. Although listed separately in the above table, the percent ODCM Limit is based on most limiting nuclide and organ dose for the group (even in cases when a sub-group member was not identified in effluents).

a. It is not necessary to calculate uncertainties for C-14 or to include C-14 uncertainty in any subsequent calculation of overall uncertainty. (Regulatory Guide 1.21 revision 2)

TABLE 1C-1

GASEOUS EFFLUENTS – GROUND LEVEL RELEASES

Facility: SGS Unit 1 Period: 2018

Nuclides Released		Continuous Mode					Batch Mode				
1.Fission gases	**Unit**	**Qtr. 1**	**Qtr. 2**	**Qtr. 3**	**Qtr. 4**	**Total**	**Qtr. 1**	**Qtr. 2**	**Qtr. 3**	**Qtr. 4**	**Total**
Ar-41	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	1.66E-02	2.79E-02	5.59E-02	4.81E-02	1.49E-01
Xe-133	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	1.60E-02	1.86E-02	2.68E-02	3.88E-02	1.00E-01
Xe-135	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	3.87E-04	< LLD	< LLD	< LLD	1.49E-01
Total for Period	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	3.30E-02	4.65E-02	8.27E-02	8.70E-02	2.49E-01
2. Iodines											
I-133	Ci	< LLD	< LLD	< LLD	1.83E-05	1.83E-05	< LLD	< LLD	< LLD	< LLD	< LLD
Total for Period	Ci	< LLD	< LLD	< LLD	1.83E-05	1.83E-05	< LLD	< LLD	< LLD	< LLD	< LLD
3. Particulates											
As-76	Ci	< LLD	< LLD	< LLD	1.81E-04	1.81E-04	< LLD	< LLD	< LLD	< LLD	< LLD
Total for Period	Ci	< LLD	< LLD	< LLD	1.81E-04	1.81E-04	< LLD	< LLD	< LLD	< LLD	< LLD
4. Tritium	Ci	5.47E+01	2.05E+01	4.50E+01	6.43E+01	1.85E+02	1.61E-01	3.40E-01	1.98E+00	6.17E-01	3.10E+00
5. C-14	Ci	2.86E+00	2.89E+00	2.93E+00	2.93E+00	1.16E+01	< LLD	< LLD	< LLD	< LLD	< LLD

Note: Only radionuclides with positive activity reported in this table.

TABLE 2A-1

LIQUID EFFLUENTS – SUMMATION OF ALL RELEASES

Facility: SGS Unit 1 Period: 2018

A. Fission & Activation Products	Unit	Qtr. 1	Qtr. 2	Qtr. 3	Qtr. 4	Total	Est. Total Error %
1. Total Release (not including tritium, gases & alpha)	Ci	<LLD	7.39E-04	2.65E-03	1.25E-02	1.59E-02	2.70E+01
2. Average diluted concentration during period	μCi/ml	N/A	1.50E-12	5.26E-12	2.60E-11	8.15E-12	
3. Percent of applicable limit (ODCM 3.11.1(a) & (b))	Total Body % Organ %	See Table 3 on page 21					
B. Tritium							
1. Total List	Ci	1.01E-01	4.65E+01	2.79E+02	1.53E+02	4.79E+02	2.70E+01
2. Average diluted concentration during period	μCi/ml	2.13E-10	9.46E-08	5.53E-07	3.18E-07	2.46E-07	
3. Percent of applicable limit (ODCM 3.11.1(a) & (b))	Total Body % Organ %	See Table 3 on page 21					
C. Dissolved & Entrained Gases							
1. Total Release	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	2.70E+01
2. Average diluted concentration during period	μCi/ml	N/A	N/A	N/A	N/A	N/A	
3. Percent of applicable limit (ODCM 3.11.1.1)	%	N/A	N/A	N/A	N/A	N/A	
D. Gross Alpha Activity							
Total Release	Ci	< LLD	< LLD	6.08E-08	< LLD	6.08E-08	2.70E+01
E. Volume Of Waste Released (prior to dilution)	Liters	4.26E+07	1.15E+07	4.30E+07	4.17E+07	1.39E+08	
F. Volume Of Dilution Water Used During Period	Liters	4.73E+11	4.91E+11	5.03E+11	4.82E+11	1.95E+12	

N/A Not Applicable

TABLE 2B-1

LIQUID EFFLUENTS

Facility: SGS Unit 1 Period: 2018

Nuclides Released	Unit	Continuous Mode					Batch Mode				
		Qtr. 1	Qtr. 2	Qtr. 3	Qtr. 4	Total	Qtr. 1	Qtr. 2	Qtr. 3	Qtr. 4	Total
H-3	Ci	1.01E-01	1.42E-01	1.60E-01	7.07E-02	4.74E-01	< LLD	4.63E+01	2.78E+02	1.53E+02	4.77E+02
Fission & Activation Products											
Cr-51	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	1.79E-03	1.79E-03
Mn-54	Ci	< LLD	< LLD	4.13E-07	< LLD	4.13E-07	< LLD	< LLD	1.06E-05	6.60E-05	7.66E-05
Co-57	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	6.69E-06	7.99E-06	4.03E-06	1.87E-05
Co-58	Ci	< LLD	< LLD	3.80E-07	< LLD	3.80E-07	< LLD	6.19E-04	1.41E-03	6.40E-03	8.43E-03
Co-60	Ci	< LLD	< LLD	5.96E-06	< LLD	5.96E-06	< LLD	9.26E-05	9.67E-04	3.51E-03	4.57E-03
Ni-63	Ci	< LLD	< LLD	4.43E-05	< LLD	4.43E-05	< LLD	< LLD	< LLD	< LLD	< LLD
Sr-89	Ci	< LLD	< LLD	1.37E-07	< LLD	1.37E-07	< LLD	< LLD	< LLD	< LLD	< LLD
Sr-90	Ci	< LLD	< LLD	3.93E-07	< LLD	3.93E-07	< LLD	< LLD	< LLD	< LLD	< LLD
Nb-95	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	4.72E-04	4.72E-04
Zr-95	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	1.60E-04	1.60E-04
Ru-105	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	6.43E-05	6.43E-05
Cs-134	Ci	< LLD	< LLD	1.54E-06	< LLD	1.54E-06	< LLD	4.06E-08	< LLD	< LLD	4.06E-08
Cs-137	Ci	< LLD	< LLD	1.28E-04	< LLD	1.28E-04	< LLD	2.01E-05	6.66E-05	1.49E-05	1.02E-04
Total for Period	Ci	< LLD	< LLD	1.81E-04	< LLD	1.81E-04	< LLD	7.39E-04	2.47E-03	1.25E-02	1.79E-03
Dissolved and Entrained Noble Gases											
None	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD

Note: Only radionuclides with positive activity reported in this table.

TABLE 4A-1

SUMMARY SHEET FOR LIQUID RADIOACTIVE EFFLUENTS RELEASED IN A BATCH MODE

Facility: SGS Unit 1 Period: 2018

Liquid	Qtr. 1	Qtr. 2	Qtr. 3	Qtr. 4	Total
Number of Batch Releases	0	20	21	17	58
Total time period for batch releases (min)	N/A	3090	6471	6187	15748
Maximum time period for batch release (min)	N/A	524	563	561	563
Average time period for batch release (min)	N/A	154	308	364	275
Minimum time period for batch release (min)	N/A	3	60	213	3
Average stream flow during periods of release of effluents into a flowing stream (Lpm)	N/A	1.59E+08	7.77E+07	7.79E+07	1.24E+08

TABLE 4B-1

SUMMARY SHEET FOR GASEOUS RADIOACTIVE EFFLUENTS RELEASED IN A BATCH MODE

Facility: SGS Unit 1 Period: 2018

Gaseous	Qtr. 1	Qtr. 2	Qtr. 3	Qtr. 4	Total
Number of Batch Releases	83	111	164	195	553
Total time period for batch releases (min)	8208	9972	15774	21159	55113
Maximum time period for batch release (min)	170	150	185	198	198
Average time period for batch release (min)	99	90	96	109	99
Minimum time period for batch release (min)	56	30	44	14	14

APPENDIX A-2

Effluent and Waste Disposal Summary, SGS Unit 2

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List of Tables

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TABLE 1A-2

GASEOUS EFFLUENTS – SUMMATION OF ALL RELEASES

Facility: SGS Unit 2 Period: 2018

A. Fission & Activation Gases	Unit	Qtr. 1	Qtr. 2	Qtr. 3	Qtr. 4	Total	Est. Total Error %
Total Release	Ci	9.81E-02	5.76E-02	1.50E-01	8.00E-02	3.86E-01	3.400E+01
Average release rate for the period	μCi/sec	1.26E-02	7.33E-03	1.88E-02	1.01E-02	1.22E-02	
Percent of limit (ODCM 3.11.2.2(a))	Gamma Air %	See Table 2 on page 18					
	Beta Air %						
B. Iodine							
Total Iodine – 131.	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	3.00E+01
Average release rate for the period	μCi/sec	< LLD	< LLD	< LLD	< LLD	< LLD	
Percent of limit (ODCM 3.11.2.3(a))	%	*	*	*	*	*	
C. Particulates							
Particulates with half-lives > 8 days	Ci	< LLD	< LLD	< LLD	4.65E-06	4.65E-06	3.00E+01
Average release rate for the period	μCi/sec	< LLD	< LLD	< LLD	5.85E-07	1.47E-07	
Percent of limit (ODCM 3.11.2.3(a))	%	*	*	*	*	*	
Gross alpha radioactivity	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	
D. Tritium							
Total Release	Ci	4.19E+01	6.48E+01	6.32E+01	5.66E+01	2.27E+02	3.10E+01
Average release rate for the period	μCi/sec	5.39E+00	8.24E+00	7.95E+00	7.12E+00	7.18E+00	
Percent of limit (ODCM 3.11.2.3(a))	%	*	*	*	*	*	
E. C-14							
Total Release	Ci	2.45E+00	2.48E+00	2.51E+00	2.51E+00	9.94E+00	N/A[a]
Average release rate for the period	μCi/sec	3.153E-01	3.153E-01	3.153E-01	3.153E-01	3.153E-01	
Percent of limit (ODCM 3.11.2.3(a))	%	*	*	*	*	*	
F. I-131, I-133, H-3 & Particulates > 8 day half-life							
Percent of limit (ODCM 3.11.2.3(a))	%	See Table 2 on page 18					
G. I-131, I-133, H-3, Particulates > 8 day half-life & C-14							
Percent of limit (ODCM 3.11.2.3(a))	%	See Table 2 on page 18					

* Iodine, Tritium, C-14, and Particulates were treated as a group. Although listed separately in the above table, the percent ODCM Limit is based on most limiting nuclide and organ dose for the group (even in cases when a sub-group member was not identified in effluent).

a. It is not necessary to calculate uncertainties for C-14 or to include C-14 uncertainty in any subsequent calculation of overall uncertainty. (Regulatory Guide 1.21 revision 2)

TABLE 1C-2

GASEOUS EFFLUENTS – GROUND LEVEL RELEASES

Facility: SGS Unit 2 Period: 2018

Nuclides Released		Continuous Mode					Batch Mode				
1. Fission gases	**Unit**	**Qtr. 1**	**Qtr. 2**	**Qtr. 3**	**Qtr. 4**	**Total**	**Qtr. 1**	**Qtr. 2**	**Qtr. 3**	**Qtr. 4**	**Total**
Ar-41	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	6.94E-02	3.04E-03	5.22E-02	1.60E-02	1.41E-01
Kr-85m	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	3.08E-04	< LLD	3.08E-04
Kr-88	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	2.97E-04	< LLD	2.97E-04
Xe-133	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	2.87E-02	5.34E-02	8.43E-02	5.86E-02	2.25E-01
Xe-133m	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	1.67E-04	8.10E-04	9.77E-04
Xe-135	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	1.24E-03	1.23E-02	4.50E-03	1.80E-02
Total for Period	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	9.81E-02	5.76E-02	1.50E-01	8.00E-02	3.86E-01
2. Iodines											
I-131	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD
I-132	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD
Total for Period	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD
3. Particulates											
Cr-51	Ci	< LLD	< LLD	< LLD	1.38E-06	1.38E-06	< LLD	< LLD	< LLD	< LLD	< LLD
Mn-54	Ci	< LLD	< LLD	< LLD	4.85E-08	4.85E-08	< LLD	< LLD	< LLD	< LLD	< LLD
Co-58	Ci	< LLD	< LLD	< LLD	8.68E-07	8.68E-07	< LLD	< LLD	< LLD	< LLD	< LLD
Co-60	Ci	< LLD	< LLD	< LLD	1.24E-06	1.24E-06	< LLD	< LLD	< LLD	< LLD	< LLD
Nb-95	Ci	< LLD	< LLD	< LLD	6.99E-07	6.99E-07	< LLD	< LLD	< LLD	< LLD	< LLD
Zr-95	Ci	< LLD	< LLD	< LLD	4.13E-07	4.13E-07	< LLD	< LLD	< LLD	< LLD	< LLD
Total for Period	Ci	< LLD	< LLD	< LLD	4.65E-06	4.65E-06	< LLD	< LLD	< LLD	< LLD	< LLD
4. Tritium	Ci	4.18E+01	6.47E+01	6.31E+01	5.65E+01	2.26E+02	6.07E-02	1.14E-01	1.32E-01	3.92E-02	3.46E-01
5. C-14	Ci	2.45E+00	2.48E+00	2.51E+00	2.51E+00	9.94E+00	< LLD	< LLD	< LLD	< LLD	< LLD

Note: Only radionuclides with positive activity reported in this table.

TABLE 2A-2

LIQUID EFFLUENTS – SUMMATION OF ALL RELEASES

Facility: SGS Unit 2 Period: 2018

A. Fission & Activation Products	Unit	Qtr. 1	Qtr. 2	Qtr. 3	Qtr. 4	Total	Est. Total Error %
1. Total Release (not including tritium, gases & alpha)	Ci	2.77E-03	6.27E-04	6.09E-04	1.56E-02	1.96E-02	2.70E+01
2. Average diluted concentration during period	μCi/ml	5.68E-12	1.25E-12	1.19E-12	4.56E-11	1.06E-11	
3. Percent of applicable limit (ODCM 3.11.1(a) & (b))	Total Body %	See Table 3 on page 21					
	Organ %						
B. Tritium							
1. Total Release	Ci	1.05E+02	1.64E+02	3.72E+02	1.71E+02	8.12E+02	2.70E+01
2. Average diluted concentration during period	μCi/ml	2.15E-07	3.27E-07	7.27E-07	4.98E-07	4.41E-07	
3. Percent of applicable limit (ODCM 3.11.1(a) & (b))	Total Body %	See Table 3 on page 21					
	Organ %						
C. Dissolved & Entrained Gases							
1. Total Release	Ci	< LLD	< LLD	< LLD	1.74E-05	1.74E-05	2.70E+01
2. Average diluted concentration during period	μCi/ml	< LLD	< LLD	< LLD	5.06E-14	9.44E-15	
3. Percent of applicable limit (ODCM 3.11.1.1)	%	N/A	N/A	N/A	2.53E-08	4.72E-09	
D. Gross Alpha Activity							
Total Release	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	2.70E+01
E. Volume Of Waste Released (prior to dilution)	Liters	1.34E+07	1.36E+07	1.39E+07	1.02E+07	5.11E+07	
F. Volume Of Dilution Water Used During Period	Liters	4.88E+11	5.01E+11	5.11E+11	3.43E+11	1.84E+12	

N/A Not Applicable

TABLE 2B-2

LIQUID EFFLUENTS

Facility: SGS Unit 2 Period: 2018

	Unit	Continuous Mode					Batch Mode				
		Qtr. 1	Qtr. 2	Qtr. 3	Qtr. 4	Total	Qtr. 1	Qtr. 2	Qtr. 3	Qtr. 4	Total
H-3	Ci	< LLD	6.03E-03	< LLD	2.23E-03	8.26E-03	1.05E+02	1.64E+02	3.72E+02	1.71E+02	8.12E+02
Fission and Activation Products											
Mn-54	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	4.42E-05	4.42E-05
Cr-51	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	3.69E-04	3.69E-04
Co-57	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	1.72E-05	1.72E-05
Co-58	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	2.33E-03	4.77E-04	2.97E-04	1.11E-02	1.42E-02
Co-60	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	3.90E-04	1.50E-04	2.74E-04	3.82E-03	4.63E-03
Nb-95	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	3.19E-05	< LLD	< LLD	1.64E-04	1.96E-04
Zr-95	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	8.30E-05	8.30E-05
Ru-105	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	1.90E-05	< LLD	< LLD	4.86E-05	6.76E-05
Sb-125	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	3.41E-05	< LLD	4.42E-05
Cs-137	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	4.04E-06	< LLD	1.72E-05
Total for Period	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	2.77E-03	6.27E-04	6.09E-04	1.56E-02	1.96E-02
Dissolved and Entrained Noble Gases											
Xe-133	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	1.73E-05	1.73E-05
Total for Period	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	1.73E-05	1.73E-05

Note: Only radionuclides with positive activity reported in this table.

TABLE 3A-2
SOLID WASTE AND IRRADIATED FUEL SHIPMENTS
SOLID RADWASTE SHIPPED OFFSITE FOR BURIAL OR DISPOSAL
(Not Irradiated Fuel)

Facility: SGS Units 1 and 2 Period: 2018

a. Waste Stream; Resins, Filters, and Evaporator Bottoms
Liquid Waste Processing Resin

Waste Class	Volume ft^3	Volume m^3	Curies Shipped	% Error (Activity)
A	7.60E+02	2.15E+01	8.10E+00	+/-25%
B	1.00E+02	2.83E+00	4.32E+01	+/-25%
C	0.00E+00	0.00E+00	0.00E+00	+/-25%
All	8.60E+02	2.44E+010	5.13E+01	+/-25%

Major Nuclides for Above Table: Percent Cutoff 1%

Resins, Filters and Evaporator Bottoms
Waste Class A

Nuclide Name	Percent Abundance	Curies
H-3	1.26%	1.02E-01
Fe-55	9.30%	7.53E-01
Co-58	2.60%	2.11E-01
Co-60	25.50%	2.06E+00
Ni-63	55.02%	4.46E+00
Sb-125	1.84%	1.49E-01
Cs-137	2.34%	1.90E-01

Resins, Filters and Evaporator Bottoms
Waste Class B

Nuclide Name	Percent Abundance	Curies
Fe-55	2.42%	1.04E+00
Co-60	11.91%	5.14E+00
Ni-63	77.71%	3.36E+01
Cs-137	6.03%	2.60E+00

Resins, Filters and Evaporator Bottoms
Waste Class C

Nuclide Name	Percent Abundance	Curies
None	N/A	N/A

Resins, Filters and Evaporator Bottoms Waste Class All		
Nuclide Name	Percent Abundance	Curies
Fe-55	3.50%	1.80E+00
Co-60	14.05%	7.21E+00
Ni-63	74.13%	3.80E+01
Cs-137	5.45%	2.79E+00

N/A Not Applicable

TABLE 3A-2
SOLID WASTE AND IRRADIATED FUEL SHIPMENTS
SOLID RADWASTE SHIPPED OFFSITE FOR BURIAL OR DISPOSAL (continued)

(Not Irradiated Fuel)

b. Waste Stream; Dry Active Waste

Waste Class	Volume ft^3	Volume m^3	Curies Shipped	% Error (Activity)
A	1.10E+04	3.11E+02	2.62E+00	+/-25%
B	0.00E+00	0.00E+00	0.00E+00	+/-25%
C	0.00E+00	0.00E+00	0.00E+00	+/-25%
All	1.10E+04	3.11E+02	2.62E+00	+/-25%

Major Nuclides for Above Table: Percent Cutoff 1%

Dry Active Waste Waste Class A

Nuclide Name	Percent Abundance	Curies
H-3	7.58%	1.99E-01
Mn-54	1.02%	2.68E-02
Fe-55	13.45%	3.53E-01
Co-60	27.32%	7.16E-01
Ni-63	47.14%	1.24E+00
Sb-125	1.09%	2.87E-02
Cs-137	1.33%	3.49E-02

Dry Active Waste Waste Class B

Nuclide Name	Percent Abundance	Curies
None	N/A	N/A

Dry Active Waste Waste Class C

Nuclide Name	Percent Abundance	Curies
None	N/A	N/A

Dry Active Waste Waste Class All

Nuclide Name	Percent Abundance	Curies
H-3	7.58%	1.99E-01
Mn-54	1.02%	2.68E-02
Fe-55	13.45%	3.53E-01
Co-60	27.32%	7.16E-01
Ni-63	47.14%	1.24E+00
Sb-125	1.09%	2.87E-02
Cs-137	1.33%	3.49E-02

N/A Not Applicable

TABLE 3A-2
SOLID WASTE AND IRRADIATED FUEL SHIPMENTS
SOLID RADWASTE SHIPPED OFFSITE FOR BURIAL OR DISPOSAL (continued)

(Not Irradiated Fuel)

c. Waste Stream; Irradiated Components

Waste Class	Volume ft^3	Volume m^3	Curies Shipped	% Error (Activity)
A	0.00E+00	0.00E+00	0.00E+00	+/-25%
B	0.00E+00	0.00E+00	0.00E+00	+/-25%
C	0.00E+00	0.00E+00	0.00E+00	+/-25%
All	0.00E+00	0.00E+00	0.00E+00	+/-25%

Major Nuclides for Above Table: Percent Cutoff 1%

Irradiated Components Waste Class A		
Nuclide Name	Percent Abundance	Curies
None	N/A	N/A
Irradiated Components Waste Class B		
Nuclide Name	Percent Abundance	Curies
None	N/A	N/A
Irradiated Components Waste Class C		
Nuclide Name	Percent Abundance	Curies
None	N/A	N/A
Irradiated Components Waste Class All		
Nuclide Name	Percent Abundance	Curies
None	N/A	N/A

N/A Not Applicable

TABLE 3A-2
SOLID WASTE AND IRRADIATED FUEL SHIPMENTS
SOLID RADWASTE SHIPPED OFFSITE FOR BURIAL OR DISPOSAL (continued)
(Not Irradiated Fuel)

d. Waste Stream; Other Waste

Waste Class	Volume ft^3	Volume m^3	Curies Shipped	% Error (Activity)
A	0.00E+00	0.00E+00	0.00E+00	+/-25%
B	0.00E+00	0.00E+00	0.00E+00	+/-25%
C	0.00E+00	0.00E+00	0.00E+00	+/-25%
All	0.00E+00	0.00E+00	0.00E+00	+/-25%

Major Nuclides for Above Table: Percent Cutoff 1%

Other Waste Waste Class A		
Nuclide Name	Percent Abundance	Curies
None	N/A	N/A

Other Waste Waste Class B		
Nuclide Name	Percent Abundance	Curies
None	N/A	N/A

Other Waste Waste Class C		
Nuclide Name	Percent Abundance	Curies
None	N/A	N/A

Other Waste Waste Class All		
Nuclide Name	Percent Abundance	Curies
None	N/A	N/A

N/A Not Applicable

TABLE 3A-2
SOLID WASTE AND IRRADIATED FUEL SHIPMENTS
SOLID RADWASTE SHIPPED OFFSITE FOR BURIAL OR DISPOSAL (continued)
(Not Irradiated Fuel)

e. Waste Stream; Sum of All 4 Categories

Waste Class	Volume ft^3	Volume m^3	Curies Shipped	% Error (Activity)
A	1.17E+04	3.32E+02	1.07E+01	+/-25%
B	1.00E+02	2.83E+00	4.32E+01	+/-25%
C	0.00E+00	0.00E+00	0.00E+00	+/-25%
All	1.18E+04	3.35E+02	5.39E+01	+/-25%

Major Nuclides for Above Table: Percent Cutoff 1%

Waste Stream; Sum of All 4 Categories Waste Class A		
Nuclide Name	Percent Abundance	Curies
H-3	2.81%	3.01E-01
Fe-55	10.32%	1.11E+00
Co-58	2.06%	2.21E-01
Co-60	25.95%	2.78E+00
Ni-63	53.09%	5.69E+00
Sb-125	1.65%	1.77E-01
Cs-137	2.10%	2.25E-01
Waste Stream; Sum of All 4 Categories Waste Class B		
Nuclide Name	Percent Abundance	Curies
Fe-55	2.42%	1.04E+00
Co-60	11.91	5.14E+00
Ni-63	77.71%	3.36E+01
Cs-137	6.03%	2.60E+00
Waste Stream; Sum of All 4 Categories Waste Class C		
Nuclide Name	Percent Abundance	Curies
None	N/A	N/A
Waste Stream; Sum of All 4 Categories Waste Class All		
Nuclide Name	Percent Abundance	Curies
Fe-55	3.99%	2.15E+00
Co-60	14.70%	7.92E+00
Ni-63	72.82%	3.93E+01
Cs-137	5.25%	2.83E+00

N/A Not Applicable

TABLE 3A-2
SOLID WASTE AND IRRADIATED FUEL SHIPMENTS
SOLID RADWASTE SHIPPED OFFSITE FOR BURIAL OR DISPOSAL (continued)
(Not Irradiated Fuel)

Number of Shipments	Mode Of Transportation	Destination
1	Hittman Transport Services, Inc.	Barnwell Disposal Facility Operated by Chem-Nuclear Systems, Inc.
4	Hittman Transport Services, Inc.	Barnwell Processing Facility Energy Solutions, LLC
3	Hittman Transport Services, Inc.	Energy Solutions Services Inc. 1560 Bear Creek Road
2	Interstate Ventures	UniTech Processing Facility. 2323 Zirconium Road
1	Landstar Inway For Hittman	Energy Solutions Services Inc. 1560 Bear Creek Road

TABLE 4A-2

SUMMARY SHEET FOR LIQUID RADIOACTIVE EFFLUENTS RELEASED IN A BATCH MODE

Facility: SGS Unit 2 Period: 2018

Liquid	Qtr. 1	Qtr. 2	Qtr. 3	Qtr. 4	Total
Number of Batch Releases	18	20	23	35	96
Total time period for batch releases (min)	7801	9435	9902	13453	40591
Maximum time period for batch release (min)	563	669	1094	1290	1290
Average time period for batch release (min)	433	472	431	384	430
Minimum time period for batch release (min)	292	254	65	8	8
Average stream flow during periods of release of effluents into a flowing stream (Lpm)	6.26E+07	5.31E+07	5.16E+07	2.55E+07	4.54E+07

TABLE 4B-2

SUMMARY SHEET FOR GASEOUS RADIOACTIVE EFFLUENTS RELEASED IN A BATCH MODE

Facility: SGS Unit 2 Period: 2018

Gaseous	Qtr. 1	Qtr. 2	Qtr. 3	Qtr. 4	Total
Number of Batch Releases	155	125	112	113	505
Total time period for batch releases (min)	16321	11303	9514	17930	55068
Maximum time period for batch release (min)	240	240	172	1835	1835
Average time period for batch release (min)	105	90	85	158.67	110
Minimum time period for batch release (min)	56	52	55	51	51

APPENDIX A-3

Effluent and Waste Disposal Summary, HCGS

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List of Tables

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TABLE 1A-3

GASEOUS EFFLUENTS – SUMMATION OF ALL RELEASES

Facility: HCGS Period: 2018

A. Fission & Activation Gases	Unit	Qtr. 1	Qtr. 2	Qtr. 3	Qtr. 4	Total	Est. Total Error %
Total Release	Ci	< LLD	7.69E-05	7.20E-01	1.27E+00	1.99E+00	3.40E+01
Average release rate for the period	μCi/sec	< LLD	9.78E-06	9.06E-02	1.60E-01	6.32E-02	
Percent of limit (ODCM 3.11.2.2(a))	Gamma Air %	See Table 2 on page 18					
	Beta Air %						
B. Iodines and Halogens							
Total Release	Ci	2.05E-03	2.45E-04	2.20E-06	7.83E-06	2.30E-03	3.00E+01
Average release rate for the period	μCi/sec	2.63E-04	3.11E-05	2.77E-07	9.85E-07	7.29E-05	
Percent of limit (ODCM 3.11.2.3(a))	%	*	*	*	*	*	
C. Particulates							
Particulates with half-lives > 8 days	Ci	2.29E-04	< LLD	4.45E-06	2.16E-06	2.35E-04	3.00E+01
Average release rate for the period	μCi/sec	2.94E-05	< LLD	5.60E-07	2.72E-07	7.46E-06	
Percent of limit (ODCM 3.11.2.3(a))	%	*	*	*	*	*	
Gross alpha radioactivity	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	
D. Tritium							
Total Release	Ci	1.34E+02	6.21E+01	9.77E+01	1.62E+02	4.56E+02	3.10E+01
Average release rate for the period	μCi/sec	1.72E+01	7.90E+00	1.23E+01	2.04E+01	1.44E+01	
Percent of limit (ODCM 3.11.2.3(a))	%	*	*	*	*	*	
E. C-14							
Total Release	Ci	4.32E+00	3.58E+00	4.03E+00	4.40E+00	1.63E+01	N/A
Average release rate for the period	μCi/sec	5.56E-01	4.55E-01	5.07E-01	5.53E-01	5.18E-01	
Percent of limit (ODCM 3.11.2.3(a))	%	*	*	*	*	*	
F. I-131, I-133, H-3 & Particulates > 8 day half-life							
Percent of limit (ODCM 3.11.2.3(a))	%	See Table 2 on page 18					
G. I-131, I-133, H-3, Particulates > 8 day half-life & C-14							
Percent of limit (ODCM 3.11.2.3(a))	%	See Table 2 on page 18					

* Iodine, Tritium, C-14, and Particulates were treated as a group. Although listed separately in the above table, the percent ODCM Limit is based on most limiting nuclide and organ dose for the group (even in cases when a sub-group member was not identified in effluent).

a. It is not necessary to calculate uncertainties for C-14 or to include C-14 uncertainty in any subsequent calculation of overall uncertainty. (Regulatory Guide 1.21 revision 2)

TABLE 1C-3

GASEOUS EFFLUENTS – GROUND LEVEL RELEASES

Facility: HCGS Period: 2018

Nuclides Released	Unit	Continuous Mode					Batch Mode				
1. Fission gases		**Qtr. 1**	**Qtr. 2**	**Qtr. 3**	**Qtr. 4**	**Total**	**Qtr. 1**	**Qtr. 2**	**Qtr. 3**	**Qtr. 4**	**Total**
Xe-133	Ci	< LLD	< LLD	7.20E-01	1.27E+00	1.99E+00	< LLD	< LLD	< LLD	< LLD	< LLD
Xe-135	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	7.69E-05	< LLD	< LLD	7.69E-05
Total for Period	Ci	< LLD	< LLD	7.20E-01	1.27E+00	1.99E+00	< LLD	7.69E-05	< LLD	< LLD	7.69E-05
2. Iodines and Halogens											
I-131	Ci	1.68E-04	3.00E-05	2.20E-06	7.83E-06	2.08E-04	< LLD	< LLD	< LLD	< LLD	< LLD
I-133	Ci	1.88E-03	2.15E-04	< LLD	< LLD	2.09E-03	< LLD	< LLD	< LLD	< LLD	< LLD
Total for Period	Ci	2.05E-03	2.45E-04	2.20E-06	7.83E-06	2.30E-03	< LLD	< LLD	< LLD	< LLD	< LLD
3. Particulates											
Na-24	Ci	1.81E-04	< LLD	< LLD	< LLD	1.81E-04	< LLD	< LLD	< LLD	< LLD	< LLD
Mn-54	Ci	4.37E-06	< LLD	1.94E-06	< LLD	6.31E-06	< LLD	< LLD	< LLD	< LLD	< LLD
Co-58	Ci	3.44E-06	< LLD	< LLD	< LLD	3.44E-06	< LLD	< LLD	< LLD	< LLD	< LLD
Co-60	Ci	4.01E-05	< LLD	2.51E-06	< LLD	4.26E-05	< LLD	< LLD	< LLD	< LLD	< LLD
Cs-137	Ci	< LLD	< LLD	< LLD	2.16E-06	2.16E-06	< LLD	< LLD	< LLD	< LLD	< LLD
Total for Period	Ci	2.29E-04	< LLD	4.45E-06	2.16E-06	2.35E-04	< LLD	< LLD	< LLD	< LLD	< LLD
4. Tritium	Ci	1.34E+02	6.21E+01	9.77E+01	1.62E+02	4.56E+02	< LLD	2.36E-03	< LLD	< LLD	2.36E-03
5. C-14	Ci	4.32E+00	3.58E+00	4.03E+00	4.40E+00	1.63E+01	< LLD	< LLD	< LLD	< LLD	< LLD

Note: Only radionuclides with positive activity reported in this table.

TABLE 2A-3

LIQUID EFFLUENTS – SUMMATION OF ALL RELEASES

Facility: HCGS Period: 2018

A. Fission & Activation Products	Unit	Qtr. 1	Qtr. 2	Qtr. 3	Qtr. 4	Total	Est. Total Error %
1. Total Release (not including tritium, gases & alpha)	Ci	1.34E-04	7.60E-02	5.22E-04	4.78E-04	7.71E-02	2.70E+01
2. Average diluted concentration during period	μCi/ml	2.38E-11	1.43E-08	8.19E-11	7.77E-11	3.29E-09	
3. Percent of applicable limit (ODCM 3.11.1(a) & (b))	Total Body %	See Table 3 on page 21					
	Organ %						
B. Tritium							
1. Total Release	Ci	4.97E+00	3.22E+01	2.24E+01	1.06E+01	7.01E+01	2.70E+01
2. Average diluted concentration during period	μCi/ml	8.87E-07	6.07E-06	3.51E-06	1.72E-06	2.99E-06	
3. Percent of applicable limit (ODCM 3.11.1(a) & (b))	Total Body %	See Table 3 on page 21					
	Organ %						
C. Dissolved & Entrained Gases							
1. Total Release	Ci	< LLD	1.14E-05	8.33E-06	3.08E-06	2.28E-05	2.70E+01
2. Average diluted concentration during period	μCi/ml	< LLD	2.15E-12	1.31E-12	5.00E-13	9.74E-13	
3. Percent of applicable limit (ODCM 3.11.1.1)	%	See Table 3 on page 21					
D. Gross Alpha Activity							
Total Release	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	2.70E+01
E. Volume Of Waste Released (prior to dilution)	Liters	4.84E+06	8.44E+06	1.21E+07	1.17E+07	3.71E+07	
F. Volume Of Dilution Water Used During Period	Liters	5.61E+09	5.29E+09	6.36E+09	6.14E+09	2.34E+10	

TABLE 2B-3

LIQUID EFFLUENTS

Facility: HCGS Period: 2018

		Continuous Mode					Batch Mode				
Nuclides Released	**Unit**	**Qtr. 1**	**Qtr. 2**	**Qtr. 3**	**Qtr. 4**	**Total**	**Qtr. 1**	**Qtr. 2**	**Qtr. 3**	**Qtr. 4**	**Total**
H-3	Ci	2.65E-01	8.14E-01	1.67E+00	1.02E+00	3.77E+00	4.71E+00	3.14E+01	2.07E+01	9.58E+00	6.64E+01
Fission and Activation Products											
Na-24	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	9.24E-08	7.68E-05	< LLD	< LLD	7.69E-05
Cr-51	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	2.56E-03	< LLD	< LLD	2.56E-03
Mn-54	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	8.40E-06	1.50E-02	5.83E-05	3.09E-05	1.51E-02
Fe-59	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	1.02E-04	< LLD	< LLD	1.02E-04
Co-57	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	4.85E-06	< LLD	< LLD	4.85E-06
Co-58	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	9.70E-06	9.05E-03	8.82E-06	8.85E-06	9.08E-03
Co-60	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	1.00E-04	3.11E-02	4.32E-04	4.35E-04	3.20E-02
Zn-65	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	1.47E-05	2.66E-03	1.93E-05	3.45E-06	2.70E-03
Zr-95	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	2.28E-05	< LLD	< LLD	2.28E-05
Nb-95	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	6.09E-05	< LLD	< LLD	6.09E-05
Mo-99	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	1.87E-06	< LLD	1.87E-06
Tc-99m	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	1.90E-06	< LLD	1.90E-06
Sb-122	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	4.79E-04	< LLD	< LLD	4.79E-04
Sb-124	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	2.87E-03	< LLD	< LLD	2.87E-03
Sb-125	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	3.71E-04	< LLD	< LLD	3.71E-04
I-131	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	2.99E-07	7.40E-07	< LLD	< LLD	1.04E-06
Cs-134	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	2.57E-03	< LLD	< LLD	2.57E-03
Cs-137	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	9.13E-03	< LLD	< LLD	9.13E-03
Total for Period	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	1.34E-04	7.60E-02	5.22E-04	4.78E-04	7.71E-02
Dissolved and Entrained Noble Gases											
Ar-41	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	9.03E-06	< LLD	< LLD	9.03E-06
Xe-133	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	4.86E-06	3.08E-06	7.94E-06
Xe-135	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	2.39E-06	3.47E-06	< LLD	5.86E-06
Total for Period	Ci	< LLD	< LLD	< LLD	< LLD	< LLD	< LLD	1.14E-05	8.33E-06	3.08E-06	2.28E-05

Note: Only radionuclides with positive activity reported in this table.

TABLE 3A-3
SOLID WASTE AND IRRADIATED FUEL SHIPMENTS
SOLID RADWASTE SHIPPED OFFSITE FOR BURIAL OR DISPOSAL
(Not Irradiated Fuel)

Facility: HCGS Period: 2018

a. Waste Stream; Resins, Filters, and Evaporator Bottoms

Waste Class	Volume ft^3	Volume m^3	Curies Shipped	% Error (Activity)
A	4.12E+03	1.17E+02	7.17E+01	+/-25%
B	0.00E+00	0.00E+00	0.00E+00	+/-25%
C	0.00E+00	0.00E+00	0.00E+00	+/-25%
All	4.12E+03	1.17E+02	7.17E+01	+/-25%

Major Nuclides for Above Table: Percent Cutoff: 1%

Resins, Filters and Evaporator Bottoms
Waste Class A

Nuclide Name	Percent Abundance	Curies
C-14	3.57%	2.57E+00
Mn-54	5.34%	3.84E+00
Fe-55	38.42%	2.76E+01
Co-60	41.64%	2.99E+01
Ni-63	5.14%	3.69E+00
Zn-65	1.37%	9.89E-01
Nb-97	1.08%	7.74E-01
Cs-137	1.71%	1.23E+00

Resins, Filters and Evaporator Bottoms
Waste Class B

Nuclide Name	Percent Abundance	Curies
None	N/A	N/A

Resins, Filters and Evaporator Bottoms
Waste Class C

Nuclide Name	Percent Abundance	Curies
None	N/A	N/A

Resins, Filters and Evaporator Bottoms
Waste Class All

Nuclide Name	Percent Abundance	Curies
C-14	3.57%	2.57E+00
Mn-54	5.34%	3.84E+00
Fe-55	38.42%	2.76E+01
Co-60	41.64%	2.99E+01
Ni-63	5.14%	3.69E+00
Zn-65	1.37%	9.89E-01
Nb-97	1.08%	7.74E-01
Cs-137	1.71%	1.23E+00

N/A Not Applicable

TABLE 3A-3
SOLID WASTE AND IRRADIATED FUEL SHIPMENTS
SOLID RADWASTE SHIPPED OFFSITE FOR BURIAL OR DISPOSAL (continued)
(Not Irradiated Fuel)

b. Waste Stream; Dry Active Waste

Waste Class	Volume ft^3	Volume m^3	Curies Shipped	% Error (Activity)
A	7.47E+03	2.11E+02	5.05E+00	+/-25%
B	0.00E+00	0.00E+00	0.00E+00	+/-25%
C	0.00E+00	0.00E+00	0.00E+00	+/-25%
All	7.47E+03	2.11E+02	5.05E+00	+/-25%

Major Nuclides for Above Table: Percent Cutoff: 1%

Dry Active Waste
Waste Class A

Nuclide Name	Percent Abundance	Curies
Mn-54	1.85%	9.29E-02
Fe-55	68.36%	3.43E+00
Co-60	22.85%	1.15E+00
Zn-65	1.74%	8.74E-02
Nb-95	2.62%	1.32E-01
Sb-125	1.10%	5.54E-02

Dry Active Waste
Waste Class B

Nuclide Name	Percent Abundance	Curies
None	N/A	N/A

Dry Active Waste
Waste Class C

Nuclide Name	Percent Abundance	Curies
None	N/A	N/A

Dry Active Waste

Waste Class All

Nuclide Name	Percent Abundance	Curies
Mn-54	1.85%	9.29E-02
Fe-55	68.36%	3.43E+00
Co-60	22.85%	1.15E+00
Zn-65	1.74%	8.74E-02
Nb-95	2.62%	1.32E-01
Sb-125	1.10%	5.54E-02

N/A Not Applicable

TABLE 3A-3
SOLID WASTE AND IRRADIATED FUEL SHIPMENTS
SOLID RADWASTE SHIPPED OFFSITE FOR BURIAL OR DISPOSAL (continued)
(Not Irradiated Fuel)

c. Waste Stream; Irradiated Components

Waste Class	Volume ft^3	Volume m^3	Curies Shipped	% Error (Activity)
A	0.00E+00	0.00E+00	0.00E+00	+/-25%
B	0.00E+00	0.00E+00	0.00E+00	+/-25%
C	0.00E+00	0.00E+00	0.00E+00	+/-25%
All	0.00E+00	0.00E+00	0.00E+00	+/-25%

Major Nuclides for Above Table: Percent Cutoff: 1%

Irradiated Components Waste Class A		
Nuclide Name	Percent Abundance	Curies
None	N/A	N/A
Irradiated Components Waste Class B		
Nuclide Name	Percent Abundance	Curies
None	N/A	N/A
Irradiated Components Waste Class C		
Nuclide Name	Percent Abundance	Curies
None	N/A	N/A
Irradiated Components Waste Class All		
Nuclide Name	Percent Abundance	Curies
None	N/A	N/A

N/A Not Applicable

TABLE 3A-3
SOLID WASTE AND IRRADIATED FUEL SHIPMENTS
SOLID RADWASTE SHIPPED OFFSITE FOR BURIAL OR DISPOSAL (continued)
(Not Irradiated Fuel)

d. Waste Stream; Other Waste

Waste Class	Volume ft^3	Volume m^3	Curies Shipped	% Error (Activity)
A	1.15E+03	3.27E+01	4.03E-02	+/-25%
B	0.00E+00	0.00E+00	0.00E+00	+/-25%
C	0.00E+00	0.00E+00	0.00E+00	+/-25%
All	1.15E+03	3.27E+01	4.03E-02	+/-25%

Major Nuclides for Above Table: Percent Cutoff: 1%

Other Waste
Waste Class A

Nuclide Name	Percent Abundance	Curies
H-3	6.89%	2.77E-03
C-14	22.68%	9.14E-03
Mn-54	1.80%	7.26E-04
Fe-55	32.85%	1.32E-02
Co-60	27.69%	1.12E-02
Ni-63	2.76%	1.11E-03
Cs-137	1.40%	5.63E-04

Other Waste
Waste Class B

Nuclide Name	Percent Abundance	Curies
None	N/A	N/A

Other Waste
Waste Class C

Nuclide Name	Percent Abundance	Curies
None	N/A	N/A

Other Waste
Waste Class All

Nuclide Name	Percent Abundance	Curies
H-3	6.89%	2.77E-03
C-14	22.68%	9.14E-03
Mn-54	1.80%	7.26E-04
Fe-55	32.85%	1.32E-02
Co-60	27.69%	1.12E-02
Ni-63	2.76%	1.11E-03
Cs-137	1.40%	5.63E-04

N/A Not Applicable

TABLE 3A-3
SOLID WASTE AND IRRADIATED FUEL SHIPMENTS
SOLID RADWASTE SHIPPED OFFSITE FOR BURIAL OR DISPOSAL (continued)
(Not Irradiated Fuel)

e. Waste Stream; Sum of All 4 Categories

Waste Class	Volume ft^3	Volume m^3	Curies Shipped	% Error (Activity)
A	1.27E+04	3.61E+02	7.68E+01	+/-25%
B	0.00E+00	0.00E+00	0.00E+00	+/-25%
C	0.00E+00	0.00E+00	0.00E+00	+/-25%
All	1.27E+04	3.61E+02	7.68E+01	+/-25%

Major Nuclides for Above Table: Percent Cutoff: 1%

Sum of All 4 Categories
Waste Class A

Nuclide Name	Percent Abundance	Curies
C-14	3.34%	2.58E+00
Mn-54	5.11%	3.93E+00
Fe-55	40.37%	3.11E+01
Co-60	40.40%	3.11E+01
Ni-63	4.82%	3.71E+00
Zn-65	1.33%	1.03E+00
Nb-95	1.01%	7.74E-01
Cs-137	1.60%	1.24E+00

Waste Class B

Nuclide Name	Percent Abundance	Curies
None	N/A	N/A

Waste Class C

Nuclide Name	Percent Abundance	Curies
None	N/A	N/A

Sum of All 4 Categories
Waste Class All

Nuclide Name	Percent Abundance	Curies
C-14	3.34%	2.58E+00
Mn-54	5.11%	3.93E+00
Fe-55	40.37%	3.11E+01
Co-60	40.40%	3.11E+01
Ni-63	4.82%	3.71E+00
Zn-65	1.33%	1.03E+00
Nb-95	1.01%	7.74E-01
Cs-137	1.60%	1.24E+00

N/A Not Applicable

TABLE 3A-3
SOLID WASTE AND IRRADIATED FUEL SHIPMENTS
SOLID RADWASTE SHIPPED OFFSITE FOR BURIAL OR DISPOSAL (continued)

(Not Irradiated Fuel)

Number of Shipments	Mode Of Transportation	Destination
11	Hittman Transport Services, Inc.	Barnwell Disposal Facility Operated by Chem – Nuclear Systems, Inc.
2	Hittman Transport Services, Inc.	Energy Solutions – BCO Bear Creek Operations
10	R&R Trucking	Babcock Services, Inc. Oak Ridge Service Center
1	Hittman Transport Services Inc	Energy Solutions, LLC Barnwell Processing Facility
6	Hittman Transport Services Inc	Barnwell Disposal Facility Operated by Chem-Nuclear Systems, Inc.
2	Hittman Transport Services Inc	Energy Solutions - GRF Gallaher Road Facility
4	Hittman Transport Services Inc	Energy Solutions, LLC Barnwell Processing Facility
2	Tri State Motor Transit	UniTech Services - ORSC Oak Ridge Service Center
1	Visionary Solutions LLC	UniTech Services - ORSC Oak Ridge Service Center

TABLE 4A-3

SUMMARY SHEET FOR LIQUID RADIOACTIVE EFFLUENTS RELEASED IN A BATCH MODE

Facility: HCGS Period: 2018

Liquid	Qtr. 1	Qtr. 2	Qtr. 3	Qtr. 4	Total
Number of Batch Releases	11	76	35	12	134
Total time period for batch releases (min)	6.980E+02	5.282E+03	2.530E+03	8.630E+02	9.373E+03
Maximum time period for batch release (min)	8.500E+01	8.800E+01	8.600E+01	8.600E+01	8.800E+01
Average time period for batch release (min)	6.345E+01	6.950E+01	7.229E+01	7.192E+01	6.995E+01
Minimum time period for batch release (min)	4.700E+01	3.200E+01	4.200E+01	5.200E+01	3.200E+01
Average stream flow during periods of release of effluents into a flowing stream (Lpm)	8.04E+06	1.00E+06	2.52E+06	7.13E+06	2.50E+06

TABLE 4B-3

SUMMARY SHEET FOR GASEOUS RADIOACTIVE EFFLUENTS RELEASED IN A BATCH MODE

Facility: HCGS Period: 2018

Gaseous	Qtr. 1	Qtr. 2	Qtr. 3	Qtr. 4	Total
Number of Batch Releases	0	2	0	0	2
Total time period for batch releases (min)	0	2.153E+03	0	0	2.153E+03
Maximum time period for batch release (min)	0	1.528E+03	0	0	1.528E+03
Average time period for batch release (min)	0	1.077E+03	0	0	1.077E+03
Minimum time period for batch release (min)	0	6.250E+02	0	0	6.250E+02

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APPENDIX B

Meteorological Data

Salem/Hope Creek Meteorological Tower

Joint Frequency Distribution of Wind Direction and Speed
All Stability Classes Total Hours and Frequency (%)

33 Ft. Wind Level

300 – 33 Ft. Delta Temperature

January – December 2018

SALEM / HOPE CREEK
JOINT FREQUENCY DISTRIBUTION OF WIND DIRECTION AND SPEED BY ATMOSPHERIC STABILITY CLASS
JANUARY - DECEMBER 2018
WIND LEVEL: 33 FT
DELTA T: (300-33 FT)
ALL STABILITY CLASSES
TOTAL HOURS

WIND DIRECTION (blowing from)		WIND SPEED GROUPS (m/sec)											
		< 0.5	0.5 - 1.0	1.1 - 1.5	1.6 - 2.0	2.1 - 3.0	3.1 - 4.0	4.1 - 5.0	5.1 - 6.0	6.1 - 8.0	8.1 - 10.0	> 10.0	Total
Degrees	Sect.												
348.75 - 11.25	N	0	6	22	40	149	95	54	43	22	10	2	443
11.25 - 33.75	NNE	2	6	15	52	174	102	57	21	22	3	0	454
33.75 - 56.25	NE	0	11	38	57	163	121	63	61	26	4	0	544
56.25 - 78.75	ENE	1	12	32	67	150	86	54	34	33	0	0	469
78.75 - 101.25	E	0	12	49	59	121	73	25	6	6	0	0	351
101.25 - 123.75	ESE	0	7	25	52	115	80	44	12	22	3	0	360
123.75 - 146.25	SE	0	12	17	35	99	161	140	118	134	21	3	740
146.25 - 168.75	SSE	0	10	15	48	133	97	89	83	91	21	1	588
168.75 - 191.25	S	0	6	23	50	110	96	68	46	37	6	1	443
191.25 - 213.75	SSW	0	6	31	45	109	99	69	53	29	9	0	450
213.75 - 236.25	SW	0	9	24	62	165	111	54	21	10	5	0	461
236.25 - 258.75	WSW	0	8	11	41	152	112	71	39	15	2	0	451
258.75 - 281.25	W	1	7	9	27	88	84	73	84	75	24	7	479
281.25 - 303.75	WNW	2	6	16	38	117	116	73	77	82	53	11	591
303.75 - 326.25	NW	0	11	19	38	103	120	116	150	131	53	15	756
326.25 - 348.75	NNW	0	7	25	33	108	97	85	78	86	30	16	565

Total 8,145

MISSING HOURS: 615
JOINT DATA RECOVERY: 93.0%

SALEM / HOPE CREEK
JOINT FREQUENCY DISTRIBUTION OF WIND DIRECTION AND SPEED BY ATMOSPHERIC STABILITY CLASS
JANUARY - DECEMBER 2018
WIND LEVEL: 33 FT
DELTA T: (300-33 FT)
ALL STABILITY CLASSES
FREQUENCY (%)

WIND DIRECTION (blowing from)		WIND SPEED GROUPS (m/sec)											
		< 0.5	0.5 - 1.0	1.1 - 1.5	1.6 - 2.0	2.1 - 3.0	3.1 - 4.0	4.1 - 5.0	5.1 - 6.0	6.1 - 8.0	8.1 - 10.0	> 10.0	Total
Degrees	Sect.												
348.75 - 11.25	N	0.000	0.074	0.270	0.491	1.829	1.166	0.663	0.528	0.270	0.123	0.025	5.44
11.25 - 33.75	NNE	0.025	0.074	0.184	0.638	2.136	1.252	0.700	0.258	0.270	0.037	0.000	5.57
33.75 - 56.25	NE	0.000	0.135	0.467	0.700	2.001	1.486	0.773	0.749	0.319	0.049	0.000	6.68
56.25 - 78.75	ENE	0.012	0.147	0.393	0.823	1.842	1.056	0.663	0.417	0.405	0.000	0.000	5.76
78.75 - 101.25	E	0.000	0.147	0.602	0.724	1.486	0.896	0.307	0.074	0.074	0.000	0.000	4.31
101.25 - 123.75	ESE	0.000	0.086	0.307	0.638	1.412	0.982	0.540	0.147	0.270	0.037	0.000	4.42
123.75 - 146.25	SE	0.000	0.147	0.209	0.430	1.215	1.977	1.719	1.449	1.645	0.258	0.037	9.09
146.25 - 168.75	SSE	0.000	0.123	0.184	0.589	1.633	1.191	1.093	1.019	1.117	0.258	0.012	7.22
168.75 - 191.25	S	0.000	0.074	0.282	0.614	1.351	1.179	0.835	0.565	0.454	0.074	0.012	5.44
191.25 - 213.75	SSW	0.000	0.074	0.381	0.552	1.338	1.215	0.847	0.651	0.356	0.110	0.000	5.52
213.75 - 236.25	SW	0.000	0.110	0.295	0.761	2.026	1.363	0.663	0.258	0.123	0.061	0.000	5.66
236.25 - 258.75	WSW	0.000	0.098	0.135	0.503	1.866	1.375	0.872	0.479	0.184	0.025	0.000	5.54
258.75 - 281.25	W	0.012	0.086	0.110	0.331	1.080	1.031	0.896	1.031	0.921	0.295	0.086	5.88
281.25 - 303.75	WNW	0.025	0.074	0.196	0.467	1.436	1.424	0.896	0.945	1.007	0.651	0.135	7.26
303.75 - 326.25	NW	0.000	0.135	0.233	0.467	1.265	1.473	1.424	1.842	1.608	0.651	0.184	9.28
326.25 - 348.75	NNW	0.000	0.086	0.307	0.405	1.326	1.191	1.044	0.958	1.056	0.368	0.196	6.94

Total 100.00

MISSING HOURS: 615
JOINT DATA RECOVERY: 93.0%

Salem and Hope Creek Ground Level Release

Dispersion (X/Q)

and

Deposition Factors (D/Q)

January – December 2018

SALEM GROUND LEVEL RELEASE DISPERSION (X/Q) AND DEPOSITION FACTORS (D/Q)

SPECIFIC POINTS OF INTEREST

Location	Direction From Site	Distance (MI)	X/Q (Sec/M^3) No Decay Undepleted	X/Q (Sec/M^3) No Decay Depleted	D/Q (1/M^2)
Site Boundary	S	0.17	1.10E-05	1.00E-05	5.80E-08
Site Boundary	SSW	0.13	1.90E-05	1.90E-05	8.70E-08
Site Boundary	SW	0.11	2.70E-05	2.60E-05	1.20E-07
Site Boundary	WSW	0.11	2.40E-05	2.40E-05	1.00E-07
Site Boundary	W	0.12	2.00E-05	1.90E-05	7.10E-08
Site Boundary	WNW	0.16	1.20E-05	1.20E-05	5.10E-08
Site Boundary	NW	0.28	6.60E-06	6.20E-06	4.30E-08
Site Boundary	NNW	0.68	1.10E-06	1.00E-06	8.70E-09
Site Boundary	N	0.83	7.30E-07	6.50E-07	4.60E-09
Site Boundary	NNE	0.89	6.90E-07	6.10E-07	4.10E-09
Site Boundary	NE	1.07	5.90E-07	5.10E-07	3.10E-09
Site Boundary	ENE	0.88	6.80E-07	6.00E-07	4.30E-09
Site Boundary	E	0.89	5.40E-07	4.80E-07	4.40E-09
Site Boundary	ESE	0.24	5.20E-06	4.90E-06	4.40E-08
Site Boundary	SE	0.15	1.40E-05	1.40E-05	1.10E-07
Site Boundary	SSE	0.15	1.20E-05	1.20E-05	8.60E-08
Dairy & Cattle	N	4.00	7.60E-08	5.90E-08	3.00E-10
Dairy & Cattle	N	5.70	4.60E-08	3.40E-08	1.60E-10
Dairy & Cattle	N	11.5	1.70E-08	1.10E-08	4.90E-11
Dairy & Cattle	NNE	4.20	7.50E-08	5.70E-08	2.80E-10
Dairy & Cattle	NNE	5.00	5.80E-08	4.30E-08	2.00E-10
Dairy & Cattle	NE	3.90	9.20E-08	7.10E-08	3.20E-10
Dairy & Cattle	NE	5.60	5.50E-08	4.00E-08	1.70E-10
Dairy & Cattle	ENE	3.90	8.00E-08	6.10E-08	3.20E-10
Dairy & Cattle	E	5.30	4.10E-08	3.00E-08	1.90E-10
Dairy & Cattle	ESE	5.90	4.60E-08	3.40E-08	2.00E-10
Dairy & Cattle	SE	9.50	2.70E-08	1.80E-08	1.10E-10
Dairy & Cattle	SSE	9.50	2.30E-08	1.60E-08	8.50E-11
Dairy & Cattle	S	5.20	5.80E-08	4.30E-08	1.90E-10
Dairy & Cattle	SSW	3.90	9.70E-08	7.50E-08	3.20E-10
Dairy & Cattle	SSW	8.30	3.40E-08	2.30E-08	8.50E-11
Dairy & Cattle	SW	4.30	9.60E-08	7.30E-08	3.20E-10
Dairy & Cattle	SW	4.60	8.80E-08	6.60E-08	2.80E-10
Dairy & Cattle	WSW	4.40	8.40E-08	6.30E-08	2.70E-10
Dairy & Cattle	W	4.00	8.90E-08	6.80E-08	2.40E-10
Dairy & Cattle	W	4.90	6.70E-08	5.00E-08	1.60E-10
Dairy & Cattle	WNW	3.40	1.10E-07	8.50E-08	3.20E-10
Dairy & Cattle	WNW	8.50	3.10E-08	2.20E-08	6.50E-11
Dairy & Cattle	NW	3.70	1.40E-07	1.10E-07	5.70E-10
Dairy & Cattle	NNW	4.20	7.90E-08	6.10E-08	3.60E-10
Gardens	N	0.57	1.30E-06	1.20E-06	8.60E-09
Gardens	NNE	7.50	3.30E-08	2.30E-08	9.90E-11
Gardens	NE	5.60	5.50E-08	4.00E-08	1.70E-10
Gardens	ENE	5.00	5.60E-08	4.20E-08	2.00E-10
Gardens	E	6.00	3.40E-08	2.50E-08	1.60E-10
Gardens	ESE	6.30	4.20E-08	3.10E-08	1.70E-10
Gardens	SSW	3.90	9.70E-08	7.50E-08	3.20E-10
Gardens	SW	4.60	8.80E-08	6.60E-08	2.80E-10
Gardens	WSW	4.40	8.40E-08	6.30E-08	2.70E-10
Gardens	NW	0.58	2.00E-06	1.80E-06	1.40E-08
Gardens	NW	5.40	8.60E-08	6.30E-08	2.90E-10
Gardens	NNW	0.57	1.50E-06	1.30E-06	1.10E-08

VENT AND BUILDING PARAMETERS:			
Release Height (Meters)	**0.00**	Rep. Wind Height (Meters)	**10.00**
Diameters (Meters)	**0.00**	Building Height (Meters)	**61.00**
Exit Velocity (Meters)	**0.00**	BLDG.MIN.CRS.SEC. AREA (Square Meters)	**3720.00**
		Heat Emission Rate (Cal/Sec)	**0.00**

HOPE CREEK GROUND LEVEL RELEASE DISPERSION (X/Q) AND DEPOSITION FACTORS (D/Q)

SPECIFIC POINTS OF INTEREST

LOCATION	DIRECTION FROM SITE	Distance (MI)	X/Q (Sec/M^3) No Decay Undepleted	X/Q (Sec/M^3) No Decay Depleted	D/Q (1/M^2)
SITE BOUNDARY	S	0.25	5.10E-06	4.80E-06	3.10E-08
SITE BOUNDARY	SSW	0.19	9.30E-06	8.90E-06	4.80E-08
SITE BOUNDARY	SW	0.17	1.30E-05	1.30E-05	6.80E-08
SITE BOUNDARY	WSW	0.17	1.20E-05	1.10E-05	5.90E-08
SITE BOUNDARY	W	0.18	9.70E-06	9.30E-06	4.10E-08
SITE BOUNDARY	WNW	0.22	6.90E-06	6.60E-06	3.20E-08
SITE BOUNDARY	NW	0.31	5.70E-06	5.40E-06	3.80E-08
SITE BOUNDARY	NNW	0.55	1.50E-06	1.40E-06	1.20E-08
SITE BOUNDARY	N	0.50	1.60E-06	1.40E-06	1.10E-08
SITE BOUNDARY	NNE	0.63	1.10E-06	1.00E-06	7.40E-09
SITE BOUNDARY	NE	0.74	9.90E-07	8.80E-07	5.80E-09
SITE BOUNDARY	ENE	0.94	6.10E-07	5.40E-07	3.80E-09
SITE BOUNDARY	E	0.94	5.00E-07	4.40E-07	4.00E-09
SITE BOUNDARY	ESE	0.75	9.30E-07	8.30E-07	7.30E-09
SITE BOUNDARY	SE	0.47	2.00E-06	1.90E-06	2.00E-08
SITE BOUNDARY	SSE	0.42	2.10E-06	1.90E-06	1.80E-08
DAIRY & CATTLE	N	4.00	7.60E-08	5.80E-08	3.00E-10
DAIRY & CATTLE	N	5.70	4.60E-08	3.40E-08	1.60E-10
DAIRY & CATTLE	N	11.50	1.70E-08	1.10E-08	4.90E-11
DAIRY & CATTLE	NNE	4.20	7.40E-08	5.70E-08	2.80E-10
DAIRY & CATTLE	NNE	5.00	5.80E-08	4.30E-08	2.00E-10
DAIRY & CATTLE	NE	3.90	9.20E-08	7.10E-08	3.20E-10
DAIRY & CATTLE	NE	5.60	5.50E-08	4.00E-08	1.70E-10
DAIRY & CATTLE	ENE	3.90	8.00E-08	6.10E-08	3.20E-10
DAIRY & CATTLE	E	5.30	4.10E-08	3.00E-08	1.90E-10
DAIRY & CATTLE	ESE	5.90	4.60E-08	3.40E-08	2.00E-10
DAIRY & CATTLE	SE	9.50	2.70E-08	1.80E-08	1.10E-10
DAIRY & CATTLE	SSE	9.50	2.30E-08	1.60E-08	8.50E-11
DAIRY & CATTLE	S	5.20	5.80E-08	4.30E-08	1.90E-10
DAIRY & CATTLE	SSW	3.90	9.70E-08	7.50E-08	3.20E-10
DAIRY & CATTLE	SSW	8.30	3.40E-08	2.30E-08	8.50E-11
DAIRY & CATTLE	SW	4.30	9.60E-08	7.30E-08	3.20E-10
DAIRY & CATTLE	SW	4.60	8.80E-08	6.60E-08	2.80E-10
DAIRY & CATTLE	WSW	4.40	8.30E-08	6.30E-08	2.70E-10
DAIRY & CATTLE	W	4.00	8.90E-08	6.80E-08	2.40E-10
DAIRY & CATTLE	W	4.90	6.70E-08	5.00E-08	1.60E-10
DAIRY & CATTLE	WNW	3.40	1.10E-07	8.50E-08	3.20E-10
DAIRY & CATTLE	WNW	8.50	3.10E-08	2.20E-08	6.50E-11
DAIRY & CATTLE	NW	3.70	1.40E-07	1.10E-07	5.70E-10
DAIRY & CATTLE	NNW	4.20	7.90E-08	6.00E-08	3.60E-10
GARDENS	N	0.57	1.30E-06	1.20E-06	8.60E-09
GARDENS	NNE	7.50	3.30E-08	2.30E-08	9.90E-11
GARDENS	NE	5.60	5.50E-08	4.00E-08	1.70E-10
GARDENS	ENE	5.00	5.60E-08	4.20E-08	2.00E-10
GARDENS	E	6.00	3.40E-08	2.50E-08	1.60E-10
GARDENS	ESE	6.30	4.20E-08	3.10E-08	1.70E-10
GARDENS	SSW	3.90	9.70E-08	7.50E-08	3.20E-10
GARDENS	SW	4.60	8.80E-08	6.60E-08	2.80E-10
GARDENS	WSW	4.40	8.30E-08	6.30E-08	2.70E-10
GARDENS	NW	0.58	2.00E-06	1.80E-06	1.40E-08
GARDENS	NW	5.40	8.60E-08	6.30E-08	2.90E-10
GARDENS	NNW	0.57	1.50E-06	1.30E-06	1.10E-08

VENT AND BUILDING PARAMETERS:			
Release Height (Meters)	**0.00**	Rep. Wind Height (Meters)	**10.0**
Diameters (Meters)	**0.00**	Building Height (Meters)	**61.8**
Exit Velocity (Meters)	**0.00**	BLDG.MIN.CRS.SEC.AREA (Square Meters)	**3819.0**
		Heat Emission Rate (Cal/Sec)	**0.0**

APPENDIX C

Maximum Permissible Concentration (MPC) Data

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The following radionuclide concentrations were obtained from 10 CFR 20 Appendix B, Table II, Column 2 as revised January 1, 1991.

Maximum Permissible Concentrations			
Element	**Isotope**	**Soluble Conc. (μCi/ml)**	**Insoluble Conc. (μCi/ml)**
Actinium (89)	Ac-227	2E-6	3E-4
	Ac-228	9E-5	9E-5
Americium (95)	Am-241	4E-6	3E-5
	Am-242m	4E-6	9E-5
	Am-242	1E-4	1E-4
	Am-243	4E-6	3E-5
	Am-244	5E-3	5E-3
Antimony (51)	Sb-122	3E-5	3E-5
	Sb-124	2E-5	2E-5
	Sb-125	1E-4	1E-4
	Sb-126	3E-6	3E-6
Arsenic (33)	As-73	5E-4	5E-4
	As-74	5E-5	5E-5
	As-76	2E-5	2E-5
	As-77	8E-5	8E-5
Astatine (85)	At-211	2E-6	7E-5
Barium (56)	Ba-131	2E-4	2E-4
	Ba-140	3E-5	2E-5
Berkelium (97)	Bk-249	6E-4	6E-4
	Bk-250	2E-4	2E-4
Beryllium (4)	Be-7	2E-3	2E-3
Bismuth (83)	Bi-206	4E-5	4E-5
	Bi-207	6E-5	6E-5
	Bi-210	4E-5	4E-5
	Bi-212	4E-4	4E-4
Bromine (35)	Br-82	3E-4	4E-5
	Br-83	3E-6	3E-6
Cadmium (48)	Cd-109	2E-4	2E-4
	Cd-115m	3E-5	3E-5
	Cd-115	3E-5	4E-5
Calcium (20)	Ca-45	9E-6	2E-4
	Ca-47	5E-5	3E-5
Californium (98)	Cf-249	4E-6	2E-5
	Cf-250	1E-5	3E-5
	Cf-251	4E-6	3E-5
	Cf-252	7E-6	7E-6
	Cf-253	1E-4	1E-4
	Cf-254	1E-7	1E-7
Carbon (6)	C-14	8E-4	-------
Cerium (58)	Ce-141	9E-5	9E-5
	Ce-143	4E-5	4E-5
	Ce-144	1E-5	1E-5
Cesium (55)	Cs-131	2E-3	9E-4

Maximum Permissible Concentrations			
Element	**Isotope**	**Soluble Conc. (μCi/ml)**	**Insoluble Conc. (μCi/ml)**
	Cs-134m	6E-3	1E-3
	Cs-134	9E-6	4E-5
	Cs-135	1E-4	2E-4
	Cs-136	9E-5	6E-5
	Cs-137	2E-5	4E-5
Chlorine (17)	Cl-36	8E-5	6E-5
	Cl-38	4E-4	4E-4
Chromium (24)	Cr-51	2E-3	2E-3
Cobalt (27)	Co-57	5E-4	4E-4
	Co-58m	3E-3	2E-3
	Co-58	1E-4	9E-5
	Co-60	5E-5	3E-5
Copper (29)	Cu-64	3E-4	2E-4
Curium (96)	Cm-242	2E-5	2E-5
	Cm-243	5E-6	2E-5
	Cm-244	7E-6	3E-5
	Cm-245	4E-6	3E-5
	Cm-246	4E-6	3E-5
	Cm-247	4E-6	2E-5
	Cm-248	4E-7	1E-6
	Cm-249	2E-3	2E-3
Dysprosium (66)	Dy-165	4E-4	4E-4
	Dy-166	4E-5	4E-5
Einsteinium (99)	Es-253	2E-5	2E-5
	Es-254m	2E-5	2E-5
	Es-254	1E-5	1E-5
	Es-255	3E-5	3E-5
Erbium (68)	Er-169	9E-5	9E-5
	Er-171	1E-4	1E-4
Europium (63)	Eu-152 (9.2 hrs)	6E-5	6E-5
	Eu-152 (13 yrs)	8E-5	8E-5
	Eu-154	2E-5	2E-5
	Eu-155	2E-4	2E-4
Fermium (100)	Fm-254	1E-4	1E-4
	Fm-255	3E-5	3E-5
	Fm-256	9E-7	9E-7
Fluorine (9)	F-18	8E-4	5E-4
Gadolinium (64)	Gd-153	2E-4	2E-4
	Gd-159	8E-5	8E-5
Gallium (31)	Ga-72	4E-5	4E-5
Germanium (32)	Ge-71	2E-3	2E-3
Gold (79)	Au-196	2E-4	1E-4
	Au-198	5E-5	5E-5
	Au-199	2E-4	2E-4
Hafnium (72)	Hf-181	7E-5	7E-5
Holmium (67)	Ho-166	3E-5	3E-5
Hydrogen (3)	H-3	3E-3	3E-3
Indium (49)	In-113m	1E-3	1E-3

Maximum Permissible Concentrations			
Element	**Isotope**	**Soluble Conc. (μCi/ml)**	**Insoluble Conc. (μCi/ml)**
	In-114m	2E-5	2E-5
	In-115m	4E-4	4E-4
	In-115	9E-5	9E-5
Iodine (53)	I-125	2E-7	2E-4
	I-126	3E-7	9E-5
	I-129	6E-8	2E-4
	I-130	3E-6	3E-6
	I-131	3E-7	6E-5
	I-132	8E-6	2E-4
	I-133	1E-6	4E-5
	I-134	2E-5	6E-4
	I-135	4E-6	7E-5
Iridium (77)	Ir-190	2E-4	2E-4
	Ir-192	4E-5	4E-5
	Ir-194	3E-5	3E-5
Iron (26)	Fe-55	8E-4	2E-3
	Fe-59	6E-5	5E-5
Lanthanum (57)	La-140	2E-5	2E-5
Lead (82)	Pb-203	4E-4	4E-4
	Pb-210	1E-7	2E-4
	Pb-212	2E-5	2E-5
Lutetium (71)	Lu-177	1E-4	1E-4
Manganese (25)	Mn-52	3E-5	3E-5
	Mn-54	1E-4	1E-4
	Mn-56	1E-4	1E-4
Mercury (80)	Hg-197m	2E-4	2E-4
	Hg-197	3E-4	5E-4
	Hg-203	2E-5	1E-4
Molybdenum (42)	Mo-99	2E-4	4E-5
Neodymium (60)	Nd-144	7E-5	8E-5
	Nd-147	6E-5	6E-5
	Nd-149	3E-4	3E-4
Neptunium (93)	Np-237	3E-6	3E-5
	Np-239	1E-4	1E-4
Nickel (28)	Ni-59	2E-4	2E-3
	Ni-63	3E-5	7E-4
	Ni-65	1E-4	1E-4
Niobium (41)	Nb-93m	4E-4	4E-4
	Nb-95	1E-4	1E-4
	Nb-97	9E-4	9E-4
Osmium (76)	Os-185	7E-5	7E-5
	Os-191m	3E-3	2E-3
	Os-191	2E-4	2E-4
	Os-193	6E-5	5E-5
Palladium (46)	Pd-103	3E-4	3E-4
	Pd-109	9E-5	7E-5
Phosphorus (15)	P-32	2E-5	2E-5

Maximum Permissible Concentrations			
Element	**Isotope**	**Soluble Conc. (μCi/ml)**	**Insoluble Conc. (μCi/ml)**
Platinum (78)	Pt-191	1E-4	1E-4
	Pt-193m	1E-3	1E-3
	Pt-193	9E-4	2E-3
	Pt-197m	1E-3	9E-4
	Pt-197	1E-4	1E-4
Plutonium (94)	Pu-238	5E-6	3E-5
	Pu-239	5E-6	3E-5
	Pu-240	5E-6	3E-5
	Pu-241	2E-4	1E-3
	Pu-242	5E-6	3E-5
	Pu-243	3E-4	3E-4
Polonium (84)	Po-210	7E-7	3E-5
Potassium (19)	K-42	3E-4	2E-5
Praseodymium(59)	Pr-142	3E-5	3E-5
	Pr-143	5E-5	5E-5
Promethium (61)	Pm-147	2E-4	2E-4
	Pm-149	4E-5	4E-5
Protactinium(91)	Pa-230	2E-4	2E-4
	Pa-231	9E-7	2E-5
	Pa-233	1E-4	1E-4
Radium (88)	Ra-223	7E-7	4E-6
	Ra-224	2E-6	5E-6
	Ra-226	3E-8	3E-5
	Ra-228	3E-8	3E-5
Rhenium (75)	Re-183	6E-4	3E-4
	Re-186	9E-5	5E-5
	Re-187	3E-3	2E-3
	Re-188	6E-5	3E-5
Rhodium (45)	Rh-103m	1E-2	1E-2
	Rh-105	1E-4	1E-4
Rubidium (37)	Rb-86	7E-5	2E-5
	Rb-87	1E-4	2E-4
Ruthenium (44)	Ru-97	4E-4	3E-4
	Ru-103	8E-5	8E-5
	Ru-103m	3E-6	3E-6
	Ru-105	1E-4	1E-4
	Ru-106	1E-5	1E-5
Samarium (62)	Sm-147	6E-5	7E-5
	Sm-151	4E-4	4E-4
	Sm-153	8E-5	8E-5
Scandium (21)	Sc-46	4E-5	4E-5
	Sc-47	9E-5	9E-5
	Sc-48	3E-5	3E-5
Selenium (34)	Se-75	3E-4	3E-4
Silicon (14)	Si-31	9E-4	2E-4
Silver (47)	Ag-105	1E-4	1E-4
	Ag-110m	3E-5	3E-5

Maximum Permissible Concentrations			
Element	**Isotope**	**Soluble Conc. (μCi/ml)**	**Insoluble Conc. (μCi/ml)**
	Ag-111	4E-5	4E-5
Sodium (11)	Na-22	4E-5	3E-5
	Na-24	2E-4	3E-5
Strontium (38)	Sr-85m	7E-3	7E-3
	Sr-85	1E-4	2E-4
	Sr-89	3E-6	3E-5
	Sr-90	3E-7	4E-5
	Sr-91	7E-5	5E-5
	Sr-92	7E-5	6E-5
Sulfur (16)	S-35	6E-5	3E-4
Tantalum (73)	Ta-182	4E-5	4E-5
Technetium (43)	Tc-96m	1E-2	1E-2
	Tc-96	1E-4	5E-5
	Tc-97m	4E-4	2E-4
	Tc-97	2E-3	8E-4
	Tc-99m	6E-3	3E-3
	Tc-99	3E-4	2E-4
Tellurium (52)	Te-125m	2E-4	1E-4
	Te-127m	6E-5	5E-5
	Te-127	3E-4	2E-4
	Te-129m	3E-5	2E-5
	Te-129	8E-4	8E-4
	Te-131m	6E-5	4E-5
	Te-132	3E-5	2E-5
Terbium (65)	Tb-160	4E-5	4E-5
Thallium (81)	Tl-200	4E-4	2E-4
	Tl-201	3E-4	2E-4
	Tl-202	1E-4	7E-5
	Tl-204	1E-4	6E-5
Thorium (90)	Th-227	2E-5	2E-5
	Th-228	7E-6	1E-5
	Th-230	2E-6	3E-5
	Th-231	2E-4	2E-4
	Th-232	2E-6	4E-5
	Th-natural	2E-6	2E-5
	Th-234	2E-5	2E-5
Thulium (69)	Tm-170	5E-5	5E-5
	Tm-171	5E-4	5E-4
Tin (50)	Sn-113	9E-5	8E-5
	Sn-124	2E-5	2E-5
Tungsten (74)	W-181	4E-4	3E-4
	W-185	1E-4	1E-4
	W-187	7E-5	6E-5
Uranium (92)	U-230	5E-6	5E-6
	U-232	3E-5	3E-5
	U-233	3E-5	3E-5
	U-234	3E-5	3E-5
	U-235	3E-5	3E-5

Maximum Permissible Concentrations			
Element	**Isotope**	**Soluble Conc. (μCi/ml)**	**Insoluble Conc. (μCi/ml)**
	U-236	3E-5	3E-5
	U-238	4E-5	4E-5
	U-240	3E-5	3E-5
	U-natural	3E-5	3E-5
Vanadium (23)	V-48	3E-5	3E-5
Ytterbium (70)	Yb-175	1E-4	1E-4
Yttrium	Y-90	2E-5	2E-5
	Y-91m	3E-3	3E-3
	Y-91	3E-5	3E-5
	Y-92	6E-5	6E-5
	Y-93	3E-5	3E-5
Zinc (30)	Zn-65	1E-4	2E-4
	Zn-69m	7E-5	6E-5
	Zn-69	2E-3	2E-3
Zirconium (40)	Zr-93	8E-4	8E-4
	Zr-95	6E-5	6E-5
	Zr-97	2E-5	2E-5
Any single radionuclide not listed above with decay mode other than alpha emission or spontaneous fission and with radioactive half-life greater than 2 hours		3E-6	3E-6
Any single radionuclide not listed above, which decays by alpha emission or spontaneous fission.		3E-8	3E-8

Notes:

1. If the identity of any radionuclide is not known, the limiting values for purposes of this table shall be: 3E-8 μCi/ml.

2. If the identity and concentration of each radionuclide were known, the limiting values should be derived as follows: Determine, for each radionuclide in the mixture, the ratio between the quantity present in the mixture and the limit otherwise established in Appendix B for the specific radionuclide not in a mixture. The sum of such ratios for all the radionuclides in the mixture may not exceed “1” (i.e. “unity”).

APPENDIX D

2018 Radiological Groundwater Protection Program (RGPP) Report

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2018 Radiological Groundwater Protection Program (RGPP) Report

Results of the Integrated Tritium Management Program

With

2018 Radiological Groundwater Protection Program (RGPP)

And

2018 Monitoring Well and Remedial Action Work Plan

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I. Introduction

This report presents results of the 2018 groundwater monitoring activities performed by PSEG Nuclear at both the Hope Creek Generating Station (HCGS) and Salem Generating Station (SGS); collectively referred to as "the Station". Well locations at the Station are shown on Figures 1 and 2, respectively. To link the various groundwater monitoring programs at the Station, PSEG implemented the Integrated Tritium Management Program (ITMP) which integrates the following four broad programs:

- The Radiological Groundwater Protection Program (RGPP) is a program that was developed to ensure the timely detection of an unpermitted release of radioactive material;
- The Remedial Action Work Plan (RAWP) is a program that monitors the remediation of the historical release from the SGS Unit 1 Spent Fuel Pool;
- Investigation wells were installed as part of independent investigations into groundwater quality, that are not included as part of the RGPP or RAWP; and
- Early Site Permit (ESP) wells which are periphery wells that were installed outside of the protected area to support the potential licensing of a new nuclear plant.

Well construction details for the Station's RGPP wells are presented on Tables 1 and 2, respectively. Well construction details for the wells that are not specifically part of the RGPP are presented on Table 3.

PSEG initiated the RGPP in 2006 to characterize groundwater at, and in the vicinity of, the Station with respect to historical releases of radionuclides and to provide the mechanism to detect such releases, if one were to occur. The RGPP is a voluntary program implemented by PSEG in conjunction with the nuclear industry initiatives and associated guidance (NEI 2007). The other key elements that comprise the RGPP and contribute to public safety are spill/leak prevention, effective remediation of spills and leaks, and effective stakeholder communication.

In 2002, PSEG operations personnel at SGS identified a release of tritiated water from the SGS Unit 1 Spent Fuel Pool to the environment. PSEG developed a RAWP to remediate the tritium in groundwater, which was reviewed by the United States Nuclear Regulatory Commission (USNRC) and approved by the New Jersey Department of Environmental Protection (NJDEP) Bureau of Nuclear Engineering (BNE). A Groundwater Recovery System (GRS) was installed to control the migration of groundwater in the shallow, water-bearing unit and to reduce the remaining mass of tritiated groundwater. The operation and performance of the GRS is documented in the Remedial Action Progress Reports (RAPRs) provided to the NRC and NJDEP-BNE by PSEG. PSEG generates an effluent release permit for the residual tritium in groundwater discharging to the Delaware River. The permit values are included in the liquid effluent data reported earlier in this document.

The Station is located in a flat, largely undeveloped region of southern New Jersey, which is bordered to the west and south by the Delaware River and to the east and north by extensive marshlands. The Station obtains cooling water from the Delaware River.

The Station is underlain by over 1,000 feet of inter-layered sand, silt and clay. PSEG owns seven production/potable wells, which range in depth from 270 feet below ground surface (bgs) to 1135 feet bgs. These wells are installed in deeper formations isolated by confining units beneath the Vincentown Formation.

The results from a computer based well search identified the nearest off-site permitted potable well is located approximately 3.5 miles away. Shallow groundwater and the Vincentown aquifer (the two most shallow water bearing units underlying the Station) flow toward and discharge to the Delaware River, thus reducing the potential that Station operations have or will influence off-site potable wells.

II. Radiological Groundwater Protection Program

This section of the annual report is prepared to summarize the status, activities, and groundwater analytical results collected in 2018 at the Site. This report also describes any changes made to the monitoring program during the 2018 reporting year.

1. Objectives of the Radiological Groundwater Protection Program

The long-term sampling program objectives are as follows:

- Identify suitable locations to monitor and evaluate potential impacts from Station operations before significant radiological impact to the environment or potential drinking water sources can occur.
- Refine the conceptual understanding of local hydrogeology and maintain current knowledge of potential flow paths on the surface and in groundwater beneath the Station.
- Evaluate systems, structures, components (SSCs) and work practices, which have the potential to release licensed radioactive material to the groundwater and develop strategies to mitigate potential releases to the environment.
- Perform routine groundwater monitoring and evaluate analytical results.
- Report any leaks, spills, or other detections with potential radiological significance to stakeholders in a timely manner.
- Take necessary corrective actions to protect groundwater resources.

2. Sample Collection

In 2006, the RGPP monitoring wells (Tables 1 and 2) were installed at the Station as part of site investigation activities. Details pertaining to these activities are documented in the Site Investigation Reports (Arcadis 2006A and 2006B). Groundwater samples are collected from all RGPP monitoring wells at least semi-annually, with additional monitoring conducted as appropriate. The groundwater sample collection schedule is adaptively managed to ensure that representative data are collected to provide the information necessary to evaluate groundwater quality conditions. Monitoring wells are sampled following the low-flow purging and sampling techniques in accordance with the Field Sampling Procedures Manual (NJDEP 2005). This methodology is consistent with protocols established in the RAWP.

3. New RGPP Wells

No new wells were added as part of the RGPP during 2018.

4. Sample Analysis

Groundwater samples collected from RGPP wells are analyzed for plant-related gamma emitting radionuclides (semi-annually), strontium (annually), iron 55 (biennially) and tritium (every sample) by an off-site radiochemical analytical laboratory.

The samples are maintained under chain of custody procedures throughout sample handling, screening, shipping and laboratory analysis process. Samples are submitted to the respective Station's on-site chemistry laboratory for radiological analysis screening prior to shipment to Teledyne Brown Engineering (TBE) located in Knoxville, Tennessee, for radiological analysis. Analytical laboratories are subject to internal quality assurance programs and inter-laboratory cross-check programs. Station personnel review and evaluate analytical data obtained from the laboratory.

5. Data Evaluation

Analytical results are reviewed for adverse trends or anomalies. Investigations and corrective action program notifications (Notification) are made as required by program procedures. The radiological data collected since the inception of the RGPP program is the basis for the baseline statistical evaluation to which current operational data are compared. Several factors are important in the interpretation and evaluation of the radiological data:

A. Detection limits

The Offsite Dose Calculation Manual (ODCM) specifies detection capabilities for each isotope that may be produced by the Station. While the detection capability for tritium specified in the ODCM is 3,000 picocuries per liter (pCi/L) in water, RGPP tritium analyses are performed to a lower value of 200 pCi/L. Lower values for LLDs are used to be consistent with the State of New Jersey where PSEG conducts split samples with the NJDEP-BNE for specific wells. Each well has a statistically derived action level. When an action level is exceeded, PSEG may increase monitoring frequency and evaluates potential sources of the elevated tritium. Relevant groundwater evaluation criteria are listed in Table 4.

B. Laboratory Measurements Uncertainty

Statistically, the value of a measurement is expressed as a range with a stated level of confidence. PSEG is required to report results with a 95% level of confidence.

Analytical uncertainties are reported at the 95% confidence level in this report and are consistent with the methodologies used to report data in the Annual Radiological Environmental Operating Report.

6. RGPP Data Quality

Groundwater samples consist of up to four aliquots. One of the aliquots is submitted to the respective Site's on-site chemistry laboratory for initial screening, which includes tritium and gamma spectroscopy analysis. The second aliquot is sent to TBE for tritium analysis. In accordance with NJDEP request, the third aliquot is collected from specific wells and submitted for split sample analysis to GEL Laboratories located in Charleston, South Carolina. The fourth aliquot is held as a back-up, "retained" sample until all the analytical results are received and determined to be valid.

All radionuclide results are compared to the following limitations defined as part of the RGPP:

- Internal Administrative Control Limits are defined within the RGPP procedures. They are developed based on a statistical analysis of the historical baseline concentrations of tritium in each specific well and are used to identify tritium concentrations that warrant further investigation for that specific well. Solely exceeding an Administrative Control Limit does not initiate external communication, unless the external reporting limit is also exceeded.

- The Courtesy Communication Limit is a tritium concentration, below regulatory requirements, based on agreements with NJDEP-BNE, USNRC and other stakeholders ensuring the stakeholders are cognizant of potential issues. If a confirmed tritium result, collected from a RGPP well,

exceeds the Courtesy Communication Limit of 3,000 pCi/L, PSEG provides a courtesy communication by telephone no later than the end of the next business day to NJDEP-BNE. The NRC Site Resident is also informed. This is not a regulatory required communication.

- Voluntary Communication Limits are those concentrations of radionuclides that require voluntary communication and reporting to regulators and/or stakeholders based on NEI 07-07, the ODCMs, and Site procedures.

III. Discussion

The locations of the RGPP monitoring wells located at HCGS and SGS are depicted on Figures 1 and 2, respectively. Additionally, well construction details for the HCGS RGPP wells and SGS RGPP wells are presented on Tables 1 and 2, respectively. The relevant radiological parameters used to evaluate the groundwater analytical results are provided in Table 4. The groundwater tritium analytical results for HCGS and SGS are shown on Tables 5 and 6, respectively.

1. Groundwater Results - RGPP

Groundwater samples were collected from all RGPP monitoring wells during 2018 in accordance with the Station and PSEG's Laboratory and Testing Services (LTS) procedures for the RGPP. Sample results are discussed below.

A. HCGS RGPP Wells

Tritium analytical results for groundwater samples collected during 2018 from HCGS RGPP monitoring wells are summarized below and are presented in Table 5.

- Tritium was not detected in groundwater samples collected from 8 of the 13 HCGS RGPP wells (wells BH, BK, BL, BP, BQ, BR, BS, and BT).
- Well BI: Tritium was detected in the sample collected in February 2018 (258 pCi/L), May 2018 (611 pCi/L), and November 2018 (224 pCi/L). Tritium was not detected in the sample collected in August 2018. Well BI is located west of the reactor containment and is a sentinel (source) well for facilities and buried piping.
- Well BJ: Tritium concentrations detected in well BJ ranged from 1,650 pCi/L (August 2018) to 2,920 pCi/L (April 2018) and averaged 2,291 pCi/L, during 2018. Well BJ is located near the HCGS main permitted gaseous effluent vent (i.e., south plant vent).
- Well BM: Tritium was detected at concentrations ranging from 318 pCi/L (January 2018) to 374 pCi/L (November 2018). Well BM is located northwest of the reactor containment and is a sentinel (source) well for facilities and buried piping.

- Well BN: Tritium concentrations detected in well BN ranged from 474 pCi/L (August 2018) to 1,320 pCi/L (February 2018) and averaged 777 pCi/L. Well BN is located northeast of the Materials Control Center and is a sentinel (source) well for the Auxiliary Boiler building and buried piping.
- Well BO: Tritium was not detected in the sample collected in May 2018. Detected concentrations ranged from 199 pCi/L (January 2018) to 657 pCi/L (November 2018). Well BO is located northeast of the Materials Control Center and is a sentinel (source) well for the Auxiliary Boiler building and buried piping.
- There were no analytical results for which a Courtesy Communication (greater than 3,000 pCi/L tritium) was required as part of the HCGS RGPP.

With the exception of tritium, no plant-related radionuclides were detected in any HCGS RGPP well sampled in 2018.

B. SGS RGPP Wells

Tritium analytical results for groundwater samples collected during 2018 from SGS RGPP monitoring wells are summarized below and are presented on Table 6.

- Tritium was not detected in groundwater samples collected from 6 of the 13 SGS RGPP wells (wells BA, BB, BF, BU, T, and Y).
- Well AL: Well AL was sampled in May and November 2018, with results of 539 pCi/L and 636 pCi/L respectively. Well AL is located south of the SGS Unit 1 reactor building and is a sentinel (source) well.
- Well BC: Tritium was detected at concentrations ranging from 689 pCi/L (February 2018) to 1,830 pCi/L (November 2018) and averaged 1,255 pCi/L. Well BC is a sentinel (source)/perimeter well located southwest of Facilities, Refueling Water Storage Tank, Auxiliary Feedwater Storage Tank and Primary Water Storage Tank (RAP) tanks and piping.
- Well BD: Tritium was detected at concentrations ranging from 423 pCi/L (May 2018) to 780 pCi/L (November 2018) and averaged 548 pCi/L. Well BD is located to the west of SGS Unit 2 reactor building and is a sentinel (source) well for Facilities, RAP tanks, and piping.
- Well BE: Tritium was detected at concentrations ranging from 248 pCi/L (November 2018) to 597 pCi/L (May 2018) and averaged 444 pCi/L. Well BE is located to the west of SGS Unit 2 reactor building and is a perimeter well.
- Well BG: Tritium was not detected in the sample collected in May 2018. Tritium was detected at a concentration of 199 pCi/L, 259 pCi/L, and 208 pCi/L in February 2018, August 2018, and November 2018, respectively.

Well BG is located northwest of SGS Unit 2 reactor building and is a perimeter well.

- Well U: Tritium was detected at concentrations ranging from 280 pCi/L (May 2018) to 327 pCi/L (August 2018). Well U is located north of SGS Unit 2 reactor building and is a sentinel (source) well for the House Heating Boilers.
- Well Z: Tritium was detected in the sample collected in May 2018 (360 pCi/L) and in November 2018 (386 pCi/L). Well Z is located west of the SGS Unit 1 & 2 reactor buildings and is a perimeter well.
- There were no analytical results for which a Courtesy Communication (greater than 3,000 pCi/L tritium) was required as part of the SGS RGPP.

With the exception of tritium, no plant-related radionuclides were detected in any SGS RGPP well sampled in 2018.

2. Mass Flux Estimation of Tritium to the Delaware River

PSEG uses transect methods to calculate the mass flux of tritium to the Delaware River in the shallow, water bearing unit and the deeper basal sand unit and Vincentown Formation. To calculate the mass flux, the tritium concentration was conservatively estimated using the average concentration detected in monitoring wells located nearest to the Delaware River during each quarter. During 2018, the mass flux within the shallow, water bearing unit and deeper groundwater was estimated to be 0.0098 Ci and 0.0074 Ci, respectively. Therefore, the total potential estimated mass flux of tritium in groundwater reaching the Delaware River during 2018 was 0.0172 Ci. The calculated mass flux was included in Salem's data tables 2A-1 and 2B-1 of this Report.

3. Investigations

A. Groundwater Monitoring Well Data (Non-RGPP)

As previously discussed, PSEG monitors a series of wells located at the Station. The ITMP is comprised of the RGPP wells, the RAWP wells, the ESP wells and a series of monitoring wells that were installed to investigate groundwater quality, but are not included as part of the RGPP, RAWP, or ESP. Well construction details and tritium analytical results for the wells described above that are not specifically part of the RGPP are presented on Table 3 and Table 7, respectively.

B. Focused Remediation at Well AC

On April 2, 2018, PSEG resumed the focused remediation at well AC by purging, on average, approximately 550 gallons of groundwater per week. The focused remediation continued until July 27, 2018 at which time it was

permanently suspended with NJDEP-BNE approval. Purged groundwater was transferred to the non-radiological liquid waste basin for release through the PSEG permitted liquid effluent outfall. During 2018 focused remediation activities, a total of approximately 9,475 gallons were purged and approximately 0.00179 curies of tritium were removed from groundwater.

C. Past Spills and Leaks: Impacts to Groundwater

In 2018, there were no known active unmonitored or unevaluated releases into the groundwater at the Station.

IV. RGPP 2019 Status

The RGPP long-term sampling program will be modified as required to meet the RGPP objectives. Baseline sampling and analysis of groundwater is planned to continue on the following schedule:

- Tritium will be analyzed at least semi-annually each calendar year to a detection capability less than or equal to 200 pCi/L;
- Plant-related gamma emitters will be analyzed at least semi-annually to the environmental detection limits specified in the ODCM;
- RGPP monitoring well sample frequency will be adjusted as needed based on analytical results.

V. References

1. Arcadis, 2004. Remedial Investigation Work Plan. PSEG Nuclear LLC. Salem Generating Station, Hancocks Bridge, New Jersey.
2. Arcadis, 2006A. Site Investigation Report July 2006. PSEG Nuclear LLC. Hope Creek Generating Station, Hancock's Bridge, New Jersey.
3. Arcadis, 2006B. Site Investigation Report July 2006. PSEG Nuclear LLC. Salem Generating Station, Hancock's Bridge, New Jersey.
4. Arcadis, 2013. Revised Salem Unit 2 Remedial Investigation Work Plan Addendum. PSEG Nuclear LLC. December 2013.
5. Arcadis, 2014. Remedial Action Work Plan Addendum. PSEG Nuclear LLC. Salem, Hancock's Bridge, New Jersey. April 10, 2014.
6. NEI, 2007. NEI 07-07, Industry Groundwater Protection Initiative – Final Guidance Document, Nuclear Energy Institute, Washington, DC, June 2007.

Table 1. RGPP Well Construction Details, HCGS

Well ID	Installation Date	Construction Details	Diameter (inches)	Total Depth (feet bgs)	Monitoring Interval (feet bgs)	MP Elevation (feet RPD)	MP Elevation (feet amsl)	Monitoring Purpose	Source Targets
Well BH	May-06	Sch-40 PVC	4	37.0	27.0 - 37.0	101.16	11.24	Perimeter	NA
Well BI	May-06	Sch-40 PVC	4	37.0	27.0 - 37.0	103.07	13.15	Source	Facilities; Piping
Well BJ	May-06	Sch-40 PVC	4	38.0	28.0 - 38.0	102.97	13.05	Source	Condensate Storage & Transfer; Facilities; Piping
Well BK	May-06	Sch-40 PVC	4	38.5	28.5 - 38.5	101.42	11.50	Perimeter	NA
Well BL	May-06	Sch-40 PVC	4	37.0	27.0 - 37.0	102.69	12.77	Perimeter	NA
Well BM	May-06	Sch-40 PVC	4	37.5	27.5 - 37.5	102.75	12.83	Source	Facilities; Piping
Well BN	May-06	Sch-40 PVC	4	12.5	7.5 - 12.5	102.64	12.72	Source	Auxiliary Boiler Building; Piping
Well BO	May-06	Sch-40 PVC	4	35.0	25.0 - 35.0	97.98	8.06	Perimeter/Source	Building Sewage
Well BP	May-06	Sch-40 PVC	4	38.0	28.0 - 38.0	99.06	9.14	Perimeter/Source	Building Sewage
Well BQ	May-06	Sch-40 PVC	4	42.0	32.0 - 42.0	105.62	15.70	Source	Auxiliary Boiler Building; Dry Cask Storage Building; Piping
Well BR	May-06	Sch-40 PVC	4	40.5	30.5 - 40.5	104.28	14.36	Perimeter/Source	Piping; Dry Cask Storage Building
Well BS	May-06	Sch-40 PVC	4	35.0	25.0 - 35.0	100.55	10.63	Upgradient	NA
Well BT	May-06	Sch-40 PVC	4	38.5	28.5 - 38.5	99.60	9.68	Upgradient	NA

Notes:
MP Measuring Point
bgs Below ground surface
RPD Relative to plant datum
amsl Above mean sea level (NAVD 1988)
NA Not applicable

Table 2. RGPP Well Construction Details, SGS

Well ID	Installation Date	Construction Details	Diameter (inches)	Total Depth (feet bgs)	Monitoring Interval (feet bgs)	MP Elevation (feet RPD)	MP Elevation (feet amsl)	Monitoring Purpose	Source Targets
Well T	Jun-03	Sch-40 PVC	2	31.2	21.2 - 31.2	104.13	14.21	Source	Facilities; House Heating Boiler
Well U[1]	May-03	Sch-40 PVC	2	32.2	27.2 - 32.2	101.46	11.54	Source	Facilities; House Heating Boiler
Well Y	Sep-03	Sch-40 PVC	2	37.0	27.0 - 37.0	101.81	11.89	Perimeter	NA
Well Z	Sep-03	Sch-40 PVC	2	37.5	27.5 - 37.5	101.86	11.94	Perimeter	NA
Well AL	Jan-04	Sch-40 PVC	2	25.3	15.3 - 25.3	99.13	9.21	Perimeter	NA
Well BA	May-06	Sch-40 PVC	4	39.5	29.5 - 39.5	101.07	11.15	Perimeter	NA
Well BB[1]	May-06	Sch-40 PVC	4	47.0	37.0 - 47.0	102.18	12.26	Perimeter	NA
Well BC	May-06	Sch-40 PVC	4	38.0	28.0 - 38.0	98.78	8.86	Source / Perimeter	Facilities; RAP Tanks; Piping
Well BD	May-06	Sch-40 PVC	4	40.5	30.5 - 40.5	98.78	8.86	Source	Facilities; RAP Tanks; Piping
Well BE	May-06	Sch-40 PVC	4	37.0	27.0 - 37.0	98.31	8.39	Perimeter	NA
Well BF[1]	May-06	Sch-40 PVC	4	42.0	32.0 - 42.0	101.45	11.53	Perimeter	NA
Well BG[1]	May-06	Sch-40 PVC	4	37.0	27.0 - 37.0	103.34	13.42	Perimeter	NA
Well BU	May-06	Sch-40 PVC	4	36.0	26.0 - 36.0	100.16	10.24	Upgradient	NA

Notes:
MP Measuring Point
bgs Below ground surface
RPD Relative to plant datum
amsl Above mean sea level (NAVD 1988)
NA Not applicable
[1] Monitoring wells U, BB, BF, and BG were surveyed in July/August 2013 following retrofitting or repair activities.

Table 3. Well Construction Details, Investigation and Monitoring Wells

Well ID	Installation Date	Construction Details	Diameter (inches)	Total Depth (feet bgs)	Monitoring Interval (feet bgs)	Monitored Hydrogeologic Unit	MP Elevation (feet RPD)	MP Elevation (feet amsl)
Well K	Feb-03	Sch-40 PVC	2	80.0	70.0 - 80.0	Vincentown[1]	102.00	12.08
Well L	Jan-03	Sch-40 PVC	2	80.0	70.0 - 80.0	Vincentown[1]	101.46	11.54
Well M	May-03	Sch-40 PVC	1	20.0	10.0 - 20.0	Cofferdam[2]	102.17	12.25
Well N	Jan-03	Sch-40 PVC	2	20.0	10.0 - 20.0	Cofferdam[2]	101.65	11.73
Well O	Jan-03	Sch-40 PVC	2	20.0	10.0 - 20.0	Cofferdam[2]	101.33	11.41
Well P	Mar-03	Sch-40 PVC	2	80.0	70.0 - 80.0	Vincentown[1]	101.13	11.21
Well Q	Mar-03	Sch-40 PVC	2	80.0	70.0 - 80.0	Vincentown[1]	106.59	16.67
Well EOW-4L	Jan-09	Sch-40 PVC	2	120.2	110.2-120.2	Vincentown[1]	112.23	22.31
Well R	Jun-03	Sch-40 PVC	1	19.0	9.0 - 19.0	Cofferdam[2]	102.35	12.43
Well S[4]	May-03	Sch-40 PVC	2	34.7	24.7 - 34.7	Shallow[3]	99.04	9.12
Well S-V	May-14	Sch-40 PVC	4	85.0	75.0 - 85.0	Vincentown[1]	101.00	11.08
Well V[6]	Jun-03	Sch-40 PVC	2	79.5	69.5 - 79.5	Vincentown[1]	101.72	11.80
Well W[6]	Jun-03	Sch-40 PVC	2	35.0	25.0 - 35.0	Shallow[3]	98.49	8.57
Well AA[4]	Sep-03	Sch-40 PVC	2	36.0	26.0 - 36.0	Shallow[3]	99.07	9.15
Well AA-V	May-13	Sch-40 PVC	2	85.0	75.0 - 85.0	Vincentown[1]	100.80	10.88
Well AB[4]	Oct-03	Sch-40 PVC	2	42.0	32.0- 42.0	Shallow[3]	98.93	9.01
Well AC[4]	Sep-03	Sch-40 PVC	2	24.0	14.0 - 24.0	Cofferdam[2]	98.77	8.85
Well AD[4]	Oct-03	Sch-40 PVC	6	43.0	33.0 - 43.0	Shallow[3]	98.99	9.07
Well AE	Oct-03	Sch-40 PVC	2	27.5	17.5 - 27.5	Cofferdam[2]	101.54	11.62
Well AF	Oct-03	Sch-40 PVC	2	45.0	35.0 - 45.0	Shallow[3]	101.61	11.69
Well AF-V	Nov-16	Sch-40 PVC	4	91.0	71.0 - 91.0	Vincentown[1]	101.38	11.46
Well AG-Shallow	Feb-04	Sch-40 PVC	1	24.2	14.2 - 24.2	Shallow[3]	99.29	9.37
Well AG-Deep	Feb-04	Sch-40 PVC	1	40.0	30.0 - 40.0	Shallow[3]	99.20	9.28
Well AH-Shallow	Feb-04	Sch-40 PVC	1	24.5	14.5 - 24.5	Shallow[3]	102.58	12.66

Table 3. Well Construction Details, Investigation and Monitoring Wells

Well ID	Installation Date	Construction Details	Diameter (inches)	Total Depth (feet bgs)	Monitoring Interval (feet bgs)	Monitored Hydrogeologic Unit	MP Elevation (feet RPD)	MP Elevation (feet amsl)
Well AH-Deep	Feb-04	Sch-40 PVC	1	40.0	30.0 - 40.0	Shallow[3]	102.70	12.78
Well AI	Jan-04	Sch-40 PVC	4	22.0	12.0 - 22.0	Cofferdam[2]	98.79	8.87
Well AJ	Jan-04	Sch-40 PVC	4	35.3	15.3 - 35.3	Shallow[3]	98.85	8.93
Well AM	Jan-04	Sch-40 PVC	4	20.9	10.9 - 20.9	Cofferdam[2]	98.55	8.63
Well AN	Jun-04	Sch-40 PVC	4	25.0	10.0 - 25.0	Cofferdam[2]	98.76	8.84
Well AO	Jun-04	Sch-40 PVC	4	21.0	11.0 - 21.0	Cofferdam[2]	98.82	8.90
Well AP	Jun-04	Sch-40 PVC	4	40.0	15.0 - 40.0	Shallow[3]	98.65	8.73
Well AQ[5]	Jun-04	Sch-40 PVC	4	45.0	20.0 - 45.0	Shallow[3]	99.05	9.13
Well AR	Jun-04	Sch-40 PVC	4	43.0	18.0 - 43.0	Shallow[3]	99.22	9.30
Well AS	Jun-04	Sch-40 PVC	4	41.5	16.5 - 41.5	Shallow[3]	99.44	9.52
Well AT	Jun-04	Sch-40 PVC	4	44.0	19.0 - 44.0	Shallow[3]	99.25	9.33
Well BW[6]	Dec-06	Sch-40 PVC	1	10.0	5.0 - 10.0	Shallow[3]	101.62	11.70
Well BX[6]	Dec-06	Sch-40 PVC	1	10.0	5.0 - 10.0	Shallow[3]	101.79	11.87
Well BY	Nov-10	Sch-40 PVC	4	40.0	35.0 - 40.0	Shallow[3]	103.36	13.44
Well BZ	Nov-10	Sch-40 PVC	4	36.0	31.0 - 36.0	Shallow[3]	104.29	14.37
Well CA[6]	Dec-06	Sch-40 PVC	4	38.0	28.0 - 38.0	Shallow[3]	101.96	12.04
Well CB[7]	Dec-06	Sch-40 PVC	2	80.0	70.0 - 80.0	Vincentown[1]	98.98	9.06
Well DA[6]	Nov-10	Sch-40 PVC	4	17.0	12.0 - 17.0	Cofferdam[2]	99.04	9.12
Well DB	Nov-10	Sch-40 PVC	4	21.0	16.0 - 21.0	Cofferdam[2]	101.69	11.77
Well DC	Nov-10	Sch-40 PVC	4	22.0	17.0 - 22.0	Cofferdam[2]	100.90	10.98
Well DD	Nov-10	Sch-40 PVC	4	19.0	14.0 - 19.0	Cofferdam[2]	101.23	11.31
Well DE	Nov-10	Sch-40 PVC	4	18.0	13.0 - 18.0	Cofferdam[2]	101.43	11.51
Well DF	Nov-10	Sch-40 PVC	4	19.0	14.0 - 19.0	Cofferdam[2]	101.32	11.40

Table 3. Well Construction Details, Investigation and Monitoring Wells

Well ID	Installation Date	Construction Details	Diameter (inches)	Total Depth (feet bgs)	Monitoring Interval (feet bgs)	Monitored Hydrogeologic Unit	MP Elevation (feet RPD)	MP Elevation (feet amsl)
Well DG	Nov-10	Sch-40 PVC	2	13.5	11.5 - 13.5	Cofferdam[2]	98.98	9.06
Well DH	Oct-10	Sch-40 PVC	4	21.0	16.0 - 21.0	Cofferdam[2]	101.54	11.62
Well DI	Oct-10	Sch-40 PVC	4	18.0	13.0 - 18.0	Cofferdam[2]	101.64	11.72
Well DJ	Oct-10	Sch-40 PVC	2	11.0	6.0 - 11.0	Cofferdam[2]	99.03	9.11

Notes:

MP Measuring point
bgs Below ground surface
RPD Relative to plant datum
amsl Above mean sea level (NAVD 1988)

[1] Monitoring well is screened in the Vincentown Formation.

[2] Monitoring well is screened in the shallow, water-bearing unit at a location within the limits of the cofferdam.

[3] Monitoring well is screened in the shallow, water-bearing unit at a location outside the limits of the cofferdam.

[4] The surface completions of Monitoring Wells S, AA, AB, AC, and AD were converted from above-grade to flush-grade in February 2004.

[5] Monitoring well AQ was abandoned in November 2016.

[6] Monitoring wells BW, BX, CA, DA, V, and W were surveyed in July/August 2013 following retrofitting or repair activities.

[7] Monitoring well CB was abandoned in May 2013

Table 4. Relevant Groundwater Evaluation Criteria, SGS and HCGS

Isotope	RGPP LLD (pCi/L)	PSEG Reporting Level (pCi/L)
Tritium	200	30,000
Total Strontium	2	8
Mn-54	15	1,000
Fe-59	30	400
Co-60	15	300
Zn-65	30	300
Nb-95	15	400
Zr-95	15	400
Cs-134	15	30
Cs-137	18	50
Ba-140	60	200
La-140	15	200

Notes:
LLD Lower Limit of Detection
pCi/L Picocuries per liter

Table 5. Tritium Analytical Results, HCGS RGPP Wells

Well ID	Sample Date	Tritium Result (pCi/L)
Well BH	02/05/18	< 187
Well BH	05/07/18	< 176
Well BH	08/06/18	< 194
Well BH	11/06/18	< 189
Well BI	02/05/18	**258**
Well BI	05/07/18	**611**
Well BI	08/06/18	< 194
Well BI	11/05/18	**224**
Well BJ	01/02/18	**2,440**
Well BJ	02/06/18	**2,200**
Well BJ	03/06/18	**2,320**
Well BJ	04/02/18	**2,920**
Well BJ	05/07/18	**2,750**
Well BJ	06/04/18	**2,700**
Well BJ	07/11/18	**1,760**
Well BJ	08/06/18	**1,650**
Well BJ	09/04/18	**1,820**
Well BJ	10/01/18	**1,980**
Well BJ	11/08/18	**2,130**
Well BJ	12/03/18	**2,610**
Well BK	05/07/18	< 180
Well BK	11/06/18	< 190
Well BL	05/07/18	< 179
Well BL	11/07/18	< 191
Well BM	01/02/18	**318**
Well BM	02/05/18	**329**
Well BM	05/07/18	**322**
Well BM	08/06/18	**346**
Well BM	11/05/18	**374**
Well BN	01/09/18	**594**
Well BN	02/06/18	**1,320**
Well BN	03/05/18	**1,270**
Well BN	04/05/18	**1,020**
Well BN	05/08/18	**742**
Well BN	06/04/18	**605**
Well BN	07/09/18	**477**
Well BN	08/06/18	**474**
Well BN	11/07/18	**492**

Table 5. Tritium Analytical Results, HCGS RGPP Wells (cont.)

Well ID	Sample Date	Tritium Result (pCi/L)
Well BO	01/09/18	**199**
Well BO	02/06/18	**337**
Well BO	05/08/18	< 173
Well BO	08/06/18	**251**
Well BO	11/07/18	**657**
Well BP	05/08/18	< 173
Well BP	11/07/18	< 196
Well BQ	02/06/18	< 181
Well BQ	05/10/18	< 173
Well BQ	08/07/18	< 193
Well BQ	11/05/18	< 195
Well BR	05/09/18	< 175
Well BR	11/07/18	< 188
Well BS	05/09/18	< 177
Well BS	11/07/18	< 195
Well BT	04/05/18	< 190
Well BT	05/08/18	< 175
Well BT	11/07/18	< 194

Notes:

pCi/L	Picocuries per liter
<	Tritium not detected above indicated concentration
251	Bolded values indicate tritium was detected

Table 6. Tritium Analytical Results, SGS RGPP Wells

Well ID	Sample Date	Tritium Result (pCi/L)
Well AL	05/09/18	**539**
Well AL	11/08/18	**636**
Well BA	05/11/18	< 198
Well BA	11/08/18	< 195
Well BB	05/11/18	< 197
Well BB	11/08/18	< 192
Well BC	02/06/18	**689**
Well BC	05/10/18	**1,370**
Well BC	08/07/18	**1,130**
Well BC	11/08/18	**1,830**
Well BD	02/05/18	**455**
Well BD	05/09/18	**423**
Well BD	08/07/18	**533**
Well BD	11/07/18	**780**
Well BE	02/05/18	**436**
Well BE	05/11/18	**597**
Well BE	08/08/18	**495**
Well BE	11/07/18	**248**
Well BF	05/11/18	< 190
Well BF	11/07/18	< 193
Well BG	02/06/18	**199**
Well BG	05/08/18	< 193
Well BG	08/06/18	**259**
Well BG	11/08/18	**208**
Well BU	05/08/18	< 187
Well BU	11/07/18	< 196
Well T	02/05/18	< 183
Well T	05/10/18	< 184
Well T	08/08/18	< 196
Well T	11/07/18	< 197
Well U	02/05/18	**281**
Well U	05/09/18	**280**
Well U	08/07/18	**327**
Well U	11/08/18	**322**
Well Y	05/11/18	< 186
Well Y	11/08/18	< 196

Table 6. Tritium Analytical Results, SGS RGPP Wells (cont.)

Well ID	Sample Date	Tritium Result (pCi/L)
Well Z	05/11/18	**360**
Well Z	11/08/18	**386**

Notes:

pCi/L	Picocuries per liter
<	Tritium not detected above indicated concentration
322	Bolded values indicate tritium was detected

Table 7. Tritium Analytical Results, Investigation & Monitoring Wells

Well ID	Sample Date	Tritium Result (pCi/L)
Well AA	01/10/18	**1,350**
Well AA	07/09/18	**1,090**
Well AA-V	01/10/18	**806**
Well AA-V	04/04/18	< 191
Well AA-V	07/09/18	**724**
Well AA-V	10/04/18	**1,730**
Well AB	01/02/18	**11,400**
Well AB	04/04/18	**8,660**
Well AB	07/11/18	**7,450**
Well AB	10/04/18	**6,120**
Well AC	01/09/18	**33,600**
Well AC	02/06/18	**26,000**
Well AC	03/06/18	**21,100**
Well AC	04/05/18	**60,400**
Well AC	05/10/18	**45,200**
Well AC	06/05/18	**48,100**
Well AC	07/11/18	**46,500**
Well AC	08/07/18	**21,600**
Well AC	09/04/18	**15,800**
Well AC	10/02/18	**17,500**
Well AC	11/07/18	**31,700**
Well AC	12/03/18	**38,700**
Well AC-MT*	04/13/18	**55,500**
Well AC-MT*	07/27/18	**36,300**
Well AD	01/02/18	**13,900**
Well AD	04/04/18	**13,500**
Well AD	07/11/18	**12,800**
Well AD	10/04/18	**12,300**
Well AE	01/11/18	**5,210**
Well AE	04/02/18	**13,300**
Well AE	06/04/18	**10,200**
Well AE	07/11/18	**9,720**
Well AE	10/04/18	**5,700**
Well AF	01/10/18	< 190
Well AF	07/12/18	**207**
Well AF-V	01/10/18	< 163
Well AF-V	04/02/18	< 192

Table 7. Tritium Analytical Results, Investigation & Monitoring Wells (cont.)

Well ID	Sample Date	Tritium Result (pCi/L)
Well-AF-V	07/12/18	< 198
Well-AF-V	10/01/18	**501**
Well AG-D	01/10/18	**1,110**
Well AG-D	07/12/18	**697**
Well AG-S	01/10/18	**229**
Well AG-S	08/08/18	**456**
Well AH-D	01/10/18	**701**
Well AH-D	07/10/18	**454**
Well AH-S	01/10/18	**2,840**
Well AH-S	02/06/18	**2,970**
Well AH-S	03/06/18	**1,830**
Well AH-S	07/10/18	**864**
Well AI	01/08/18	**4,050**
Well AI	07/09/18	**4,010**
Well AM	01/09/18	**6,570**
Well AM	04/05/18	**8,390**
Well AM	07/02/18	**11,800**
Well AM	10/02/18	**11,000**
Well AN	01/02/18	**19,100**
Well AN	02/05/18	**21,300**
Well AN	03/06/18	**16,800**
Well AN	04/04/18	**17,600**
Well AN	05/24/18	**12,000**
Well AN	06/06/18	**14,700**
Well AN	07/11/18	**16,800**
Well AN	08/08/18	**14,300**
Well AN	09/04/18	**13,600**
Well AN	10/04/18	**13,000**
Well AN	11/08/18	**13,500**
Well AN	12/03/18	**13,500**
Well AP	01/08/18	**1,400**
Well AP	07/10/18	**1,360**
Well AR	01/11/18	**9,460**
Well AR	04/02/18	**5,490**
Well AR	07/10/18	**5,260**
Well AR	10/03/18	**5,900**
Well AS	01/08/18	**15,600**
Well AS	07/11/18	**11,800**
Well AT	01/02/18	**2,250**
Well AT	07/11/18	**1,770**

Table 7. Tritium Analytical Results, Investigation & Monitoring Wells (cont.)

Well ID	Sample Date	Tritium Result (pCi/L)
Well BW	05/10/18	**847**
Well BW	11/08/18	**943**
Well BX	05/10/18	**839**
Well BX	11/08/18	**503**
Well BY	01/02/18	**26,900**
Well BY	02/05/18	**71,300**
Well BY	03/05/18	**95,800**
Well BY	04/02/18	**110,000**
Well BY	04/05/18	**106,000**
Well BY	05/07/18	**90,600**
Well BY	06/04/18	**89,500**
Well BY	07/02/18	**77,500**
Well BY	08/06/18	**66,900**
Well BY	09/04/18	**43,600**
Well BY	10/01/18	**34,700**
Well BY	11/05/18	**37,800**
Well BY	12/03/18	**30,200**
Well BZ	01/09/18	**2,050**
Well BZ	02/06/18	**1,050**
Well BZ	03/06/18	**839**
Well BZ	04/02/18	**845**
Well BZ	05/07/18	**835**
Well BZ	06/04/18	**864**
Well BZ	07/11/18	**950**
Well BZ	11/08/18	**836**
Well CA	01/03/18	**2,270**
Well CA	07/03/18	**1,950**
Well DA	01/09/18	**3,640**
Well DA	04/03/18	**3,340**
Well DA	07/02/18	**2,810**
Well DA	10/01/18	**2,860**
Well DB	01/09/18	**4,460**
Well DB	04/05/18	**3,790**
Well DB	07/02/18	**4,610**
Well DB	10/02/18	**13,500**
Well DB	11/07/18	**10,800**
Well DB	12/03/18	**9,260**
Well DC	01/09/18	**2,330**
Well DC	07/02/18	**1,140**
Well DD	01/09/18	**6,580**

Table 7. Tritium Analytical Results, Investigation & Monitoring Wells (cont.)

Well ID	Sample Date	Tritium Result (pCi/L)
Well DD	04/05/18	**6,790**
Well DD	07/02/18	**6,510**
Well DD	10/03/18	**7,230**
Well DE	01/09/18	**12,900**
Well DE	04/05/18	**13,400**
Well DE	07/02/18	**12,300**
Well DE	10/03/18	**11,700**
Well DF	01/09/18	**1,560**
Well DF	07/02/18	**1,460**
Well DG	01/13/18	**3,230**
Well DG	04/03/18	**3,050**
Well DG	07/03/18	**3,220**
Well DG	10/01/18	**2,940**
Well DH	01/03/18	**9,630**
Well DH	04/03/18	**8,820**
Well DH	07/03/18	**10,500**
Well DH	10/03/18	**10,600**
Well DI	01/03/18	**2,550**
Well DI	04/03/18	**2,240**
Well DI	07/03/18	**1,880**
Well DI	10/03/18	**1,750**
Well DJ	01/03/18	**1,240**
Well DJ	07/03/18	**1,030**
EOW-4L †	01/09/18	< 192
EOW-4L †	07/09/18	< 186
Well K	01/02/18	**1,970**
Well K	02/06/18	< 182
Well K	03/06/18	< 174
Well K	04/03/18	< 177
Well K	07/09/18	< 190
Well L	01/11/18	< 191
Well L	07/09/18	< 194
Well M	01/10/18	**4,750**
Well M	04/04/18	**10,200**
Well M	07/09/18	**8,330**
Well M	10/03/18	**8,250**
Well N	01/09/18	**10,600**
Well N	04/05/18	**8,000**
Well N	07/02/18	**10,000**

Table 7. Tritium Analytical Results, Investigation & Monitoring Wells (cont.)

Well ID	Sample Date	Tritium Result (pCi/L)
Well N	10/02/18	**6,240**
Well O	01/11/18	**6,620**
Well O	04/02/18	**35,300**
Well O	06/04/18	**10,800**
Well O	07/11/18	**3,380**
Well O	10/04/18	**6,500**
Well P	01/10/18	< 192
Well P	07/02/18	< 189
Well R	01/09/18	**2,830**
Well R	07/09/18	**3,330**
Well S	01/02/18	**7,940**
Well S	04/06/18	**7,930**
Well S-V	01/11/18	**1,450**
Well S-V	04/04/18	**1,490**
Well S-V	07/10/18	**1,200**
Well S-V	10/04/18	**2,830**
Well T	02/05/18	< 183
Well T	05/10/18	< 184
Well T	08/08/18	< 196
Well T	11/07/18	< 197
Well U	02/05/18	**281**
Well U	05/09/18	**280**
Well U	08/07/18	**327**
Well U	11/08/18	**322**
Well V	01/10/18	**285**
Well V	07/03/18	**313**
Well V	10/01/18	**338**
Well W	01/08/18	**6,770**
Well W	04/04/18	**3,280**
Well W	07/09/18	**3,450**
Well W	10/03/18	**4,730**

Table 7. Tritium Analytical Results, Investigation & Monitoring Wells (cont.)

Well ID	Sample Date	Tritium Result (pCi/L)
Well Y	05/11/18	< 186
Well Y	11/08/18	< 196
Well Z	05/11/18	**360**
Well Z	11/08/18	**386**

Notes:

pCi/L	Picocuries per liter
*	AC-MT samples are collected from a mobile water tank during purge activities associated with well AC.
†	EOW-4L is presented as supplemental data for Well Q
<	Tritium not detected above indicated concentration
313	Bolded values indicate tritium was detected
20,000	Tritium was detected above the New Jersey Department of Environmental Protection (NJDEP) Class II-A Groundwater Quality Standard (GWQS) of 20,000 pCi/L.

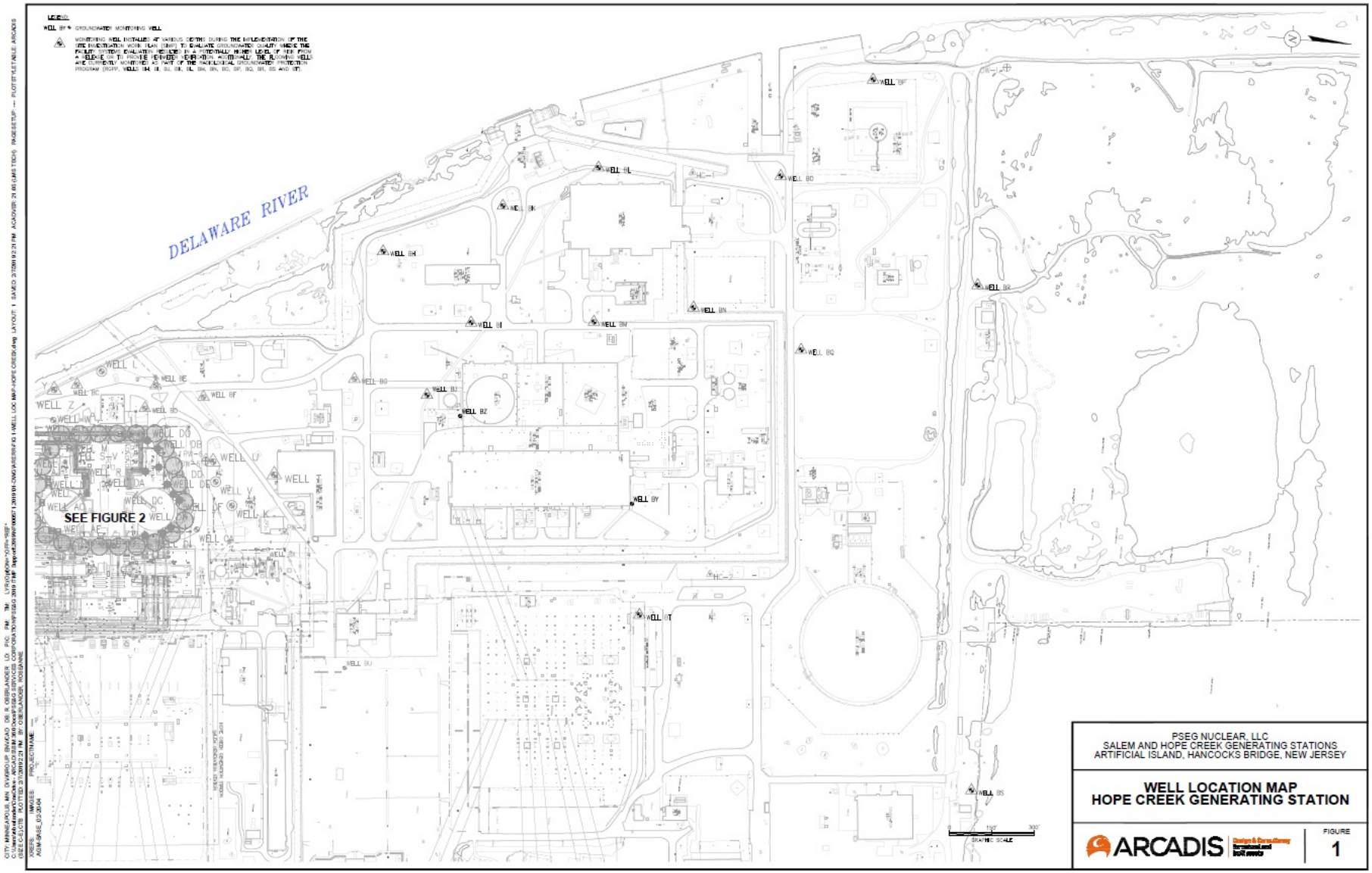

Figure 1. Well Location Map, Hope Creek Generating Station

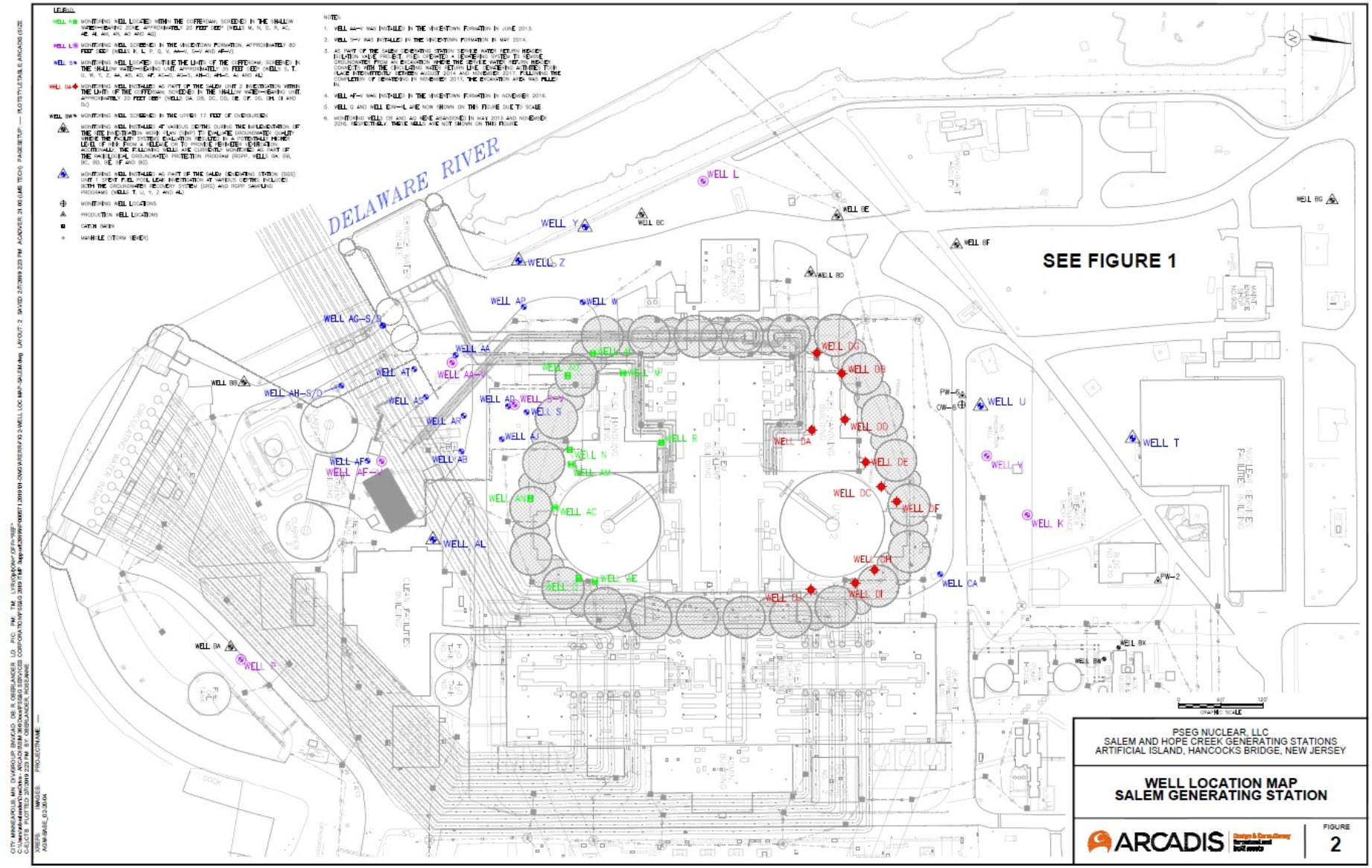

Figure 2. Well Location Map, Salem Generating Station