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PNP 2019-016

10 CFR 50.36(a)

April 24, 2019

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

Subject: 2018 Annual Radioactive Effluent Release and Waste Disposal Report

Palisades Nuclear Plant  
Docket Nos. 50-255 and 72-7  
Renewed Facility Operating  
License No. DPR-20

Big Rock Point  
Docket Nos. 50-155 and 72-043  
License No. DPR-6

Dear Sir or Madam:

Attached are the Entergy Nuclear Operations, Inc. 2018 Annual Radioactive Effluent Release and Waste Disposal Reports for Palisades Nuclear Plant (PNP) and Big Rock Point (BRP) Independent Spent Fuel Storage Installation (ISFSI). These reports are submitted in accordance with 10 CFR 50.36a(a)(2).

Attachment 1 contains the report for PNP. Attachment 2 contains the report for the BRP ISFSI.

These reports provide a summary of the quantities of radioactive liquid and gaseous effluent releases and solid radioactive waste processed during the period of January 1, 2018, through December 31, 2018.

If you have any questions regarding this submittal, please contact Mike Soja, Chemistry Manager, at 269-764-2536.

This letter contains no new commitments and no revisions to existing commitments.

Respectfully,  
  
JAH/bed

Attachment 1: Palisades Annual Radioactive Effluent Release Report  
Attachment 2: Big Rock Point ISFSI Annual Radioactive Effluent Release Report

CC Administrator, Region III, USNRC  
Project Manager, Palisades, USNRC (w/o Attachments)  
Resident Inspector, Palisades, USNRC (w/o Attachments)  
NRC NMSS Project Manager, USNRC (w/o Attachments)  
American Nuclear Insurers (ANI)



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	<b>YEAR: 2018</b>
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<b>Annual Radioactive Effluent Release Report</b>	

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**Annual Radioactive Effluent Release Report****1.0 INTRODUCTION**

Palisades Nuclear Plant (Palisades) entered the reporting period online on January 1, 2018, at 100% full power. Palisades experienced no unexpected scrams during the 2018 calendar year. Palisades entered into a maintenance outage on March 27, 2018, and was synchronized to the grid on March 29, 2018. Palisades entered into a maintenance outage on October 13, 2018, and remained offline for a planned refueling outage. Palisades synchronized to the grid on December 28, 2018. Palisades generated 5,455,944 MWh of net electrical energy during 2018.

This report is a summary of the effluent data in accordance with Technical Specification (TS) 5.6.3. Both liquid and gaseous effluents are released in accordance with the Offsite Dose Calculation Manual (ODCM). All releases in the reporting period were well below the limits defined in the ODCM.

**2.0 SUPPLEMENTAL INFORMATION****2.1 Regulatory Limits**

The ODCM contains the limits to which Palisades must adhere. Because of the "as low as reasonably achievable" (ALARA) philosophy at Palisades, actions are taken to reduce the amount of radiation released to the environment. Liquid and gaseous release data show that the dose from Palisades is considerably below the ODCM limits. This data reveals that the radioactive effluents have an overall minimal dose contribution to the surrounding environment. The following are the limits required by the ODCM:

1. Fission and activation gases:
  - a. Noble gases dose rate due to radioactive materials released in gaseous effluents from the areas at and beyond the site boundary shall be limited to the following:
    - Less than or equal to 500 mrem/year to the total body
    - Less than or equal to 3000 mrem/year to the skin
  - b. Noble gas air dose due to noble gases released in gaseous effluents to areas at and beyond the site boundary shall be limited to the following:
    - 1) Quarterly
      - Less than or equal to 5 mrad gamma
      - Less than or equal to 10 mrad beta
    - 2) Yearly
      - Less than or equal to 10 mrad gamma
      - Less than or equal to 20 mrad beta

**Annual Radioactive Effluent Release Report**

2. Iodine, tritium, and all radionuclides in particulate form with half-lives greater than 8 days.
  - a. The dose rate for Iodine-131, Iodine-133, tritium, and all radionuclides in particulate form with half-lives greater than 8 days in gaseous effluents released to areas at and beyond the site boundary shall be limited to the following:
    - Less than or equal to 1500 mrem/year to any organ
  - b. The dose to a MEMBER OF THE PUBLIC from Iodine-131, Iodine-133, tritium, and all radionuclides in particulate form with half-lives greater than 8 days in gaseous effluents released to areas at and beyond the site boundary shall be limited to the following:
    - 1) Quarterly
      - Less than or equal to 7.5 mrem to any organ
    - 2) Yearly
      - Less than or equal to 15 mrem to any organ
3. Liquid Effluents Dose
  - a. The dose or dose commitment to a MEMBER OF THE PUBLIC from radioactive materials in liquid effluents released to unrestricted areas shall be limited to the following:
    - 1) Quarterly
      - Less than or equal to 1.5 mrem total body
      - Less than or equal to 5 mrem to any organ
    - 2) Yearly
      - Less than or equal to 3 mrem total body
      - Less than or equal to 10 mrem to any organ
4. Total Dose (40 CFR 190)
  - a. The annual (calendar year) dose or dose commitment to any MEMBER OF THE PUBLIC due to releases of radioactivity and to radiation from uranium fuel cycle sources shall be limited to the following:
    - Less than or equal to 25 mrem, Total Body or any Organ except Thyroid.
    - Less than or equal to 75 mrem, Thyroid

**Annual Radioactive Effluent Release Report****2.2 Maximum Permissible Concentrations**

1. Fission & Activation Gases, Iodines, and Particulates With Half Lives > Eight (8) Days

The above limits are provided to ensure that radioactive material discharged in gaseous effluents will not result in the exposure of an individual in an unrestricted area to annual average concentrations exceeding the limits of 10 CFR 20, Appendix B, Table 2, Column 1.

2. Liquid Effluents

The concentration of radioactive material released shall be limited to ten times the concentration specified in 10 CFR 20, Appendix B, Table 2, Column 2, for radionuclides other than dissolved or entrained noble gases. For dissolved or entrained noble gases, the total concentration released shall be limited to 2.0E-04 microCurie/ml.

**2.3 Average Energy**

The average energy ( $\bar{E}$ ) of the radionuclide mixture in releases of fission and activation gases as defined in Regulatory Guide 1.21, Appendix B, Section A.3, is not applicable because the limits used for gaseous releases are based on calculated dose to members of the public.

**2.4 Measurements & Approximations of Total Radioactivity**

1. Palisades' gamma spectroscopy system uses 0.25 keV per channel with a range of 0-2000 keV. All analyses are performed to achieve the required lower limit of detection as specified in Palisades' Offsite Dose Calculation Manual (ODCM).

- a. Fission & activation gases

Noble Gas activity is continuously monitored via a beta scintillation detector on the main stack release point. Additional radiation monitors are located upstream for all likely radiological pathways. Data is reviewed and quantified at least weekly in accordance with the ODCM.

- b. Iodines

Iodine is continuously collected on a charcoal cartridge filter via an isokinetic sampling assembly from the main stack release point. Filters are analyzed once per week in accordance with the ODCM. Filters are analyzed on an HPGe system.

- c. Particulates (half-lives > 8 days)

Particulates are continuously collected on a filter paper via an isokinetic sampling assembly on each release point. Filters are analyzed once per week in accordance with the ODCM. Filters are analyzed on an HPGe system.

## Annual Radioactive Effluent Release Report

## d. Tritium

Tritium effluent is calculated monthly in accordance with the ODCM.

## e. Carbon-14

Carbon-14 release values were estimated using the methodology included in the EPRI Technical Report 1021106, using the 2018 normalized Carbon-14 production rate of 3.9 Ci/GW<sub>yr</sub>, a gaseous release fraction of 98%, a Carbon-14 carbon dioxide fraction of 30%, a reactor power rating of 2565.4 MW<sub>th</sub>, and equivalent full power operation of 282 days.

## f. Liquid Effluents

Each tank of liquid radwaste is sampled and analyzed for principal gamma emitters prior to release. Each sample tank is recirculated for a sufficient amount of time prior to sampling ensuring that a representative sample is obtained. Samples are then analyzed on an HPGe system and liquid release permits are generated based upon the isotopic analysis.

## g. Estimated Total Error Present

Estimates of measurement and analytical error for gaseous and liquid effluents are calculated as follows:

$$E_T = \sqrt{[(E_1)^2 + (E_2)^2 + \dots + (E_n)^2]}$$

Where:

$E_T$  = total percent error

$E_1 \dots E_n$  = percent error due to calibration standards, Laboratory analysis, instruments, sample flow, etc.

**Annual Radioactive Effluent Release Report****2.5 Batch Releases:**2.5.1 Liquid

1. Number of batch releases: 16
2. Total time period for a batch release: 21,597 minutes
3. Maximum time period for a batch release: 5,732 minutes
4. Average time period for a batch release: 1350 minutes
5. Minimum time period for a batch release: 77 minutes

2.5.2 Gaseous

1. Number of batch releases: 39
2. Total time period for a batch release: 1,846 hours
3. Maximum time period for a batch release: 1,654 hours
4. Average time period for a batch release: 47 hours
5. Minimum time period for a batch release: 56 minutes

**2.6 Continuous Releases:**2.6.1 Liquid

1. Palisades continuously monitors one common continuous release discharge point (the mixing basin) using radiation monitors and sample analysis in accordance with Palisades ODCM. The major input pathways to the mixing basin include the service water effluent, turbine building sump effluent, processed liquid radiological effluent, and dilution water effluent. All major input pathways are also continuously monitored using radiation monitors and/or sample analysis in accordance with Palisades ODCM. Palisades contracts an independent laboratory to perform redundant and specialized analysis.

2.6.2 Gaseous

1. Palisades continuously monitors one common continuous release discharge point (the plant stack) using radiation monitors and sample analysis in accordance with Palisades ODCM. The major input pathways to the plant stack include the auxiliary building, containment building, condenser offgas system, and waste gas decay tanks. All major input pathways are also continuously monitored using radiation monitors and/or sample analysis in accordance with Palisades ODCM. Palisades contracts an independent laboratory to perform redundant and specialized analysis.



**Annual Radioactive Effluent Release Report****2.7 Abnormal Releases**

- 2.7.1 During 2018 there was one abnormal release. The release was of low level tritium via the septic system which drains to a drain field just south of Palisades within the owner controlled area. The hydrological characteristics of this area indicate that the tritium would migrate to Lake Michigan. The depth to the water table in this area is estimated to be seven feet. The affected groundwater is not used for drinking water. The one positive indication of tritium contained 1980 pCi/L. A follow-up sample was promptly obtained which contained no detectable tritium. The septic system is sampled once per calendar quarter and analyzed for tritium.

The release was conservatively assumed to be the duration between two samples which contained less than detectable concentrations of tritium. This date range was June 2, 2018 to September 18, 2018 (108 days). The volume was conservatively assumed to be the total potable water used by the site over this period ( $6.82E+06$  L). Therefore, the total activity of tritium released was conservatively estimated to be  $1.35E-02$  Ci which is  $1.50E-03\%$  of the total tritium activity released during 2018. For dose considerations, the same parameters (onsite dilution, offsite dilution, pathway, etc.) used for the normal discharge point were assumed for this release. The estimated dose from this release was negligible. This is because liquid tritium is a low dose consequence nuclide, this release is a small fraction of total annual release totals, and as demonstrated in Table 6.1 dose limits were not challenged in 2018. On site NRC staff was notified of this event upon detection of the positive tritium sample through the corrective action process and a face-to-face brief. Palisades continues to monitor this system.

This activity was included in the applicable tables of this report. The volume of this release was not included in the tables in section 4 to ensure that the calculated dose and release rates would be conservative and accurate.

**2.7.2 Liquid**

1. Number of releases: 1
2. Total Activity (Ci) released:  $1.35E-02$  of tritium

**2.7.3 Gaseous**

1. Number of releases: 0
2. Total Activity (Ci) released: NA

**2.8 Non-routine, Planned Discharges**

1. Gaseous non-routine planned discharge of effluents accounted for a total of  $1.14E-03$  curies of activity associated with the category "Iodine, tritium, and all radionuclides in particulate form with half-lives greater than 8 days." This accounted for  $7.46E-03\%$  of the total activity of this category. These discharges are from radiologically controlled areas which are not ventilated to the stack. These areas are continuously monitored and are considered less significant release points in accordance with Regulatory Guide 1.21, "Measuring, Evaluating, and Reporting Radioactive Material in Liquid and Gaseous Effluents and Solid Waste," Revision 2.

**Annual Radioactive Effluent Release Report**

2. There was one liquid non-routine planned discharge in 2018. This consisted of a discharge of onsite groundwater which was collected in a 2,550 gallon holding tank. The tank was filled relatively quickly, independently sampled in accordance with site procedures, and discharged via the batch process to the approved discharge point (the mixing basin). This batch contained 6.53E-06 Ci of tritium which accounted for 7.24E-07 % of the total tritium released in 2018. After the completion of this release it was identified that the tank did not have the capability to recirculate the contents prior to sampling. The tank was promptly modified to include a recirculation pump and all available groundwater data was reviewed to assess if the independent sample could have been compromised. The data review supported the analysis results and therefore no modification to the release record was performed.

**2.9 Land Use Census Changes**

1. The 2018 Land Use Census resulted in no changes affecting the critical receptor location or routes of exposure. The critical resident and garden are within one mile of the plant in the S and SSE sectors. The critical livestock are within three miles of the plant in the ESE and NE sectors. The critical receptors are used in conjunction with meteorological data to model dose consequence of Palisades' effluent. Based on the results of the 2018 land use census, Palisades' has initiated goat milk sampling (in accordance with the ODCM) to be conducted during 2019 while the goat milk is being produced.

**2.10 Effluent Monitor Instrument Inoperability**

1. During 2018 there was one effluent radiation monitor that exceeded 30 consecutive days being non-functional. Radiation monitor RIA-0707, "Steam Generator Blowdown Effluent Radiation Monitor," was non-functional from December 7, 2017, to January 12, 2018, due to communication problems between the sample stream flow element and control room alarms. Upon troubleshooting, it was identified that a relay socket base needed to be replaced and a probe was loose at the flowmeter. The delay in restoring functionality in a timelier manner was in part due to ordering and obtaining the relay socket base replacement. During the time frame when this radiation monitor was non-functional there was no release of radiological material via this pathway. It is typical for this pathway (steam generator blowdown effluent) to be unused as a pathway for release of radiological material.

**2.11 Offsite Dose Calculation Manual (ODCM) Changes**

1. Palisades ODCM was not revised during 2018. Therefore the ODCM is not included in this report.

**2.12 Process Control Program (PCP) Changes**

1. No major radwaste system modifications (as defined in the ODCM) were implemented in 2018.
2. There were no changes to the procedure (EN-RW-105) governing the PCP in 2018 and therefore no copy of EN-RW-105 is being provided in this report.

## Annual Radioactive Effluent Release Report

**2.13 NON-REMP Groundwater Monitoring Results (NEI 07-07)**

- Ground water samples were taken in support of the Groundwater Protection Initiative (GPI). These samples are not part of the Radiological Environmental Monitoring Program. A summary of the sample results are below in Table 2.14A. All groundwater monitoring wells in Table 2.14A are located within the owner controlled area to allow for prompt detection of leaks from plant systems. The minimum, maximum, and average values in Table 2.14A are for all samples which contained detectable concentrations of tritium.
- Palisades has 23 groundwater monitoring wells (which have the prefix "MW"). Palisades also monitors 16 temporary wells (which have the prefix "TW") in addition to the 23 monitoring wells to provide additional monitoring for strategic locations where there have been historical leaks. Table 2.14A indicates that temporary wells TW-1, TW-5, TW-6, TW-7, TW-9, TW-10, TW-15, and TW-16 all contained detectable tritium in 2018. These wells traverse along an East-West transect (approximately 100 feet wide), are indicative of an inactive historic leak, and continue to be monitored. Tritium concentration typically parallels water table height in areas where there is historical contamination. For example, when the water table rises, an increase in tritium concentration is observed, and when the water table decreases, the tritium concentration decreases (often to less than detectable values). Tritium spikes from washout of the vadose zone (due to changes in water table) have been trending downward over time. This is indicative of washout from a historical leak, rather than an indication of a new active leak.
- Radiological effluents via groundwater are quantified in accordance with the methodology described in Regulatory Guide 4.25, "Assessment of Abnormal Radionuclide Discharges in Ground Water to the Unrestricted Area at Nuclear Power Plant Sites." The groundwater monitoring wells used for this analysis are those on the western perimeter of the site (between the site and Lake Michigan) and include MW1, MW1A, MW2, MW3, MW3A, MW4, MW5, MW11, MW12, MW13, TW9, and TW10. The total tritium activity discharged via groundwater to Lake Michigan was 6.29E-02 Curies in 2018. This is 6.97E-03% of the total tritium activity discharged to Lake Michigan in 2018.
- Palisades made no NEI 07-07 voluntary notifications in 2018.
- Palisades had zero active leaks to groundwater during 2018.

## Annual Radioactive Effluent Release Report

Table 2.14A, Non-REMP Groundwater Monitoring Results Summary (Palisades)

Well Number	Total Samples	Samples With Detectable Tritium	Minimum Tritium (pCi/L)	Maximum Tritium (pCi/L)	Average Tritium (pCi/L)
MW1	4	0	NA	NA	NA
MW1A	4	0	NA	NA	NA
MW2	16	14	701	8945	4086
MW3	5	0	NA	NA	NA
MW3A	4	0	NA	NA	NA
MW4	4	0	NA	NA	NA
MW5	4	0	NA	NA	NA
MW6	4	0	NA	NA	NA
MW7	4	0	NA	NA	NA
MW8	4	0	NA	NA	NA
MW9	4	0	NA	NA	NA
MW9A	4	0	NA	NA	NA
MW10	4	0	NA	NA	NA
MW11	8	3	861	4104	2991
MW-12	4	0	NA	NA	NA
MW-13	5	1	703	703	703
MW14	4	0	NA	NA	NA
MW15	4	0	NA	NA	NA
MW16	4	0	NA	NA	NA
MW17	4	0	NA	NA	NA
MW18	4	0	NA	NA	NA
MW19	4	0	NA	NA	NA
MW20	4	0	NA	NA	NA
TW1	11	1	1954	1954	1954
TW2	12	0	NA	NA	NA
TW3	4	0	NA	NA	NA
TW4	5	0	NA	NA	NA
TW5	7	1	906	906	906
TW6	14	1	592	592	592
TW7	17	9	908	3654	2213
TW9	13	3	3411	4199	3870
TW10	17	10	768	7334	3016
TW11	4	0	NA	NA	NA
TW13	4	0	NA	NA	NA
TW14	10	0	NA	NA	NA
TW15	12	3	1105	4601	2383
TW16	12	1	1984	1984	1984
TW17	6	0	NA	NA	NA
TW18	5	0	NA	NA	NA

**Annual Radioactive Effluent Release Report****2.14 Outside Tanks**

1. All outdoor tanks as described in the ODCM were maintained within the ODCM limit of less than 1,000 times the effluent concentration (EC) as listed in 10 CFR 20, Appendix B, Table 2, Column 2.

**2.15 Errata/Corrections to Previous ARERRs**

1. A less conservative analysis was used for the calculated effluents for one waste gas decay tank in 2017. This error resulted in no ODCM limits being exceeded. The difference between the analysis used and the more conservative analysis is considered a "small error" in accordance with Regulatory Guide 1.21, Revision 2, on the basis that the error accounted for less than 10% of the total annual activity reported. The corrected data table (page 1 of 1, Attachment 1 Table 1B) has been included with revision bars noting the changes. All changes affected the 4th quarter column only. Palisades has submitted this error to the corrective action process to ensure actions are created as necessary to prevent recurrence. One of the corrective actions included procedural enhancements, including a required checklist to be used when performing less frequent activities relating to the waste gas decay tank batch process.
2. It was identified that there was an error in the 2017 and 2016 Annual Radioactive Effluent Release Report (ARERR) for how C-14 activity, and consequentially, 40 CFR 190 dose values were calculated. The affected pages in the 2017 and 2016 ARERR are attached and include Section 15, Carbon-14, Table 1A, Table 1C, and Table 5. In accordance with Regulatory Guide 1.21 Revision 2, the error is dose-calculated and is considered a "small error," as the effect on the final value was less than 10% of the dose limit. The error in activity (curies) reported is considered a "large error," as the effect on the final value was greater than 10% of the value reported. The difference in the corrected activity and the activity reported was 15%. No limits of any type were challenged or exceeded as a result of this error. Palisades has submitted this error to the corrective action process to ensure actions are created, as necessary, to prevent recurrence.

**Annual Radioactive Effluent Release Report**

3. In 2018 it was identified that the 1 Liter gas marinelli geometry used to perform some radiological analysis which feeds data into this report is in fact 1.24 L in volume. This error resulted in all noble gas effluents measured using this geometry to be over-reported (conservative) by 19.4% of the reported value. All 2018 analyses were reviewed and corrected for this report. The cumulative effect on total noble gas activity for 2018 was that total noble gas activity was (at the most) over-reported by 1.28%. Similarly, the cumulative effect for 2017, 2016, and 2015 was that the total noble gas activity was (at the most) over-reported by 0.8%, 0.05%, and 0.1% respectively. Data prior to 2015 was unaffected. The reason the total annual noble gas activity was only slightly affected by this error is because the marinelli geometry analysis contributes a relatively low fraction to the total noble gas activity when considering all analyses (continuous radiation monitoring and other geometries). The dose for all of the affected years was over-reported by less than percentages listed above because iodine and particulates are larger dose contributors than noble gases and these parameters were unaffected. This error is considered a "small error" in accordance with Regulatory Guide 1.21, Revision 2, on the basis that the error accounted for less than 10% of the total annual activity reported. Copies of the corrected pages from past reports for this error are not included in this report.

## Annual Radioactive Effluent Release Report

## 3.0 GASEOUS EFFLUENTS

3.1 Gas Effluent and Waste Disposal Report

Table 1, Gaseous Effluents-Summation of All Releases (Palisades)

A. Fission & Activation Gases	Unit	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total	Est. Total Error %
1. Total Release	Ci	9.39E+00	6.95E+00	1.23E+00	1.07E+01	2.82E+01	2.23%
2. Average release rate for the period	μCi/sec	1.21E+00	8.84E-01	1.55E-01	1.34E+00	8.95E-01	
<b>B. Iodine</b>							
1. Total Iodine	Ci	3.92E-04	4.10E-04	ND	2.83E-04	1.09E-03	18.7%
2. Average release rate for the period	μCi/sec	5.05E-05	5.21E-05	NA	3.56E-05	3.44E-05	
<b>C. Particulates</b>							
1. Particulates with half-lives > 8 days	Ci	7.82E-06	1.06E-07	ND	1.26E-04	1.34E-04	25.2%
2. Average release rate for the period	μCi/sec	1.01E-06	1.35E-08	NA	1.59E-05	4.26E-06	
<b>D. Tritium</b>							
1. Total Release	Ci	3.16E+00	2.32E+00	1.88E+00	7.92E+00	1.53E+01	5.77%
2. Average release rate for the period	μCi/sec	4.06E-01	2.95E-01	2.36E-01	9.97E-01	4.84E-01	
<b>E. Gross Alpha</b>							
1. Total Release	Ci	ND	ND	ND	ND	ND	NA
2. Average release rate for the period	μCi/sec	NA	NA	NA	NA	NA	
<b>F. Carbon-14</b>							
1. Total Release	Ci	2.28E+00	2.44E+00	2.47E+00	3.81E-01	7.57E+00	
2. Average release rate for the period	μCi/sec	2.93E-01	3.10E-01	3.11E-01	4.79E-02	2.40E-01	

## Annual Radioactive Effluent Release Report

Table 2, Gaseous Effluents – Ground Level Release - Batch Mode (Palisades)

Radionuclide Released	Unit	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
<b>Fission Gases</b>						
Ar-41	Ci	3.68E-03	7.12E-04	ND	7.60E-03	1.20E-02
Kr-85	Ci	1.75E-01	9.29E-02	1.33E-01	1.51E-01	5.53E-01
Kr-85m	Ci	1.79E-07	1.69E-02	ND	4.70E-03	2.16E-02
Kr-88	Ci	ND	5.29E-03	ND	6.11E-03	1.14E-02
Xe-131m	Ci	7.35E-02	1.77E-02	2.76E-03	5.49E-02	1.49E-01
Xe-133	Ci	7.07E+00	2.59E-01	1.62E-03	4.14E+00	1.15E+01
Xe-133m	Ci	6.98E-02	6.16E-05	ND	4.33E-02	1.13E-01
Xe-135	Ci	7.26E-03	7.58E-01	ND	7.81E-02	8.43E-01
Total	Ci	7.40E+00	1.15E+00	1.37E-01	4.48E+00	1.32E+01
<b>Iodines</b>						
I-131	Ci	2.66E-05	1.25E-06	ND	2.96E-06	3.08E-05
I-132	Ci	4.02E-08	5.60E-07	ND	1.28E-06	1.88E-06
I-133	Ci	3.10E-05	6.23E-05	ND	2.67E-06	9.60E-05
I-135	Ci	2.36E-09	1.99E-05	ND	ND	1.99E-05
Total	Ci	5.76E-05	8.41E-05	ND	6.90E-06	1.49E-04
<b>Particulates</b>						
Na-24	Ci	5.23E-09	ND	ND	ND	5.23E-09
Co-58	Ci	ND	ND	ND	2.87E-06	2.87E-06
Rb-88	Ci	ND	3.15E-05	ND	1.13E-03	1.17E-03
Y-88	Ci	7.19E-06	ND	ND	3.54E-05	4.26E-05
Nb-97	Ci	ND	ND	ND	3.52E-09	3.52E-09
Total	Ci	7.19E-06	3.15E-05	ND	1.17E-03	1.21E-03
<b>Tritium</b>						
H-3	Ci	2.30E-01	NA	NA	6.29E-02	2.93E-01



## Annual Radioactive Effluent Release Report

Table 3, Gaseous Effluents – Ground Level Release - Continuous Mode (Palisades)

Radionuclide Released	Unit	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
<b>Fission Gases</b>						
Ar-41	Ci	1.12E-01	1.26E+00	1.76E-01	5.88E-01	2.14E+00
Kr-85m	Ci	3.19E-02	1.92E-01	2.42E-02	4.32E-02	2.91E-01
Kr-87	Ci	6.15E-02	3.03E-01	4.35E-02	9.02E-02	4.98E-01
Kr-88	Ci	8.74E-02	4.28E-01	6.77E-02	1.12E-01	6.95E-01
Xe-133	Ci	1.12E+00	1.25E+00	2.30E-01	3.71E+00	6.31E+00
Xe-135	Ci	2.84E-01	1.25E+00	1.80E-01	8.99E-01	2.61E+00
Xe-135m	Ci	7.76E-03	1.45E-01	3.68E-03	5.11E-04	1.57E-01
Xe-137	Ci	5.35E-02	1.80E-02	1.88E-01	3.94E-01	6.54E-01
Xe-138	Ci	2.33E-01	9.53E-01	1.82E-01	3.51E-01	1.72E+00
Total	Ci	1.99E+00	5.80E+00	1.10E+00	6.18E+00	1.51E+01
<b>Iodines</b>						
I-131	Ci	1.51E-04	2.67E-04	ND	1.91E-04	6.09E-04
I-135	Ci	1.84E-04	5.91E-05	ND	8.51E-05	3.28E-04
Total	Ci	3.35E-04	3.26E-04	ND	2.76E-04	9.37E-04
<b>Particulates</b>						
Cr-51	Ci	ND	ND	ND	3.15E-06	3.15E-06
Mn-54	Ci	ND	ND	ND	5.44E-07	5.44E-07
Ni-57	Ci	ND	ND	ND	2.46E-10	2.46E-10
Co-58	Ci	1.23E-07	ND	ND	2.36E-05	2.38E-05
Co-60	Ci	4.12E-07	1.06E-07	ND	4.32E-06	4.83E-06
Sr-92	Ci	ND	ND	ND	2.88E-06	2.88E-06
Nb-95	Ci	ND	ND	ND	1.65E-05	1.65E-05
Zr-95	Ci	ND	ND	ND	1.12E-05	1.12E-05
Ag-108m	Ci	ND	ND	ND	3.35E-08	3.35E-08
Ag-110m	Ci	ND	ND	ND	2.87E-05	2.87E-05
Cs-137	Ci	9.56E-08	ND	ND	ND	9.56E-08
Total	Ci	6.30E-07	1.06E-07	ND	9.09E-05	9.17E-05
<b>Tritium</b>						
H-3	Ci	2.93E+00	2.32E+00	1.88E+00	7.86E+00	1.50E+01
<b>Gross Alpha</b>						
Alpha	Ci	ND	ND	ND	ND	ND
<b>Carbon-14</b>						
C-14	Ci	2.28E+00	2.44E+00	2.47E+00	3.81E-01	7.58E+00

## Annual Radioactive Effluent Release Report

## 4.0 LIQUID EFFLUENTS

4.1 Liquid Effluent and Waste Disposal Report

Table 4, Liquid Effluents-Summation of All Releases (Palisades)

A. Fission & Activation Products	Unit	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total	Est. Total Error %
1. Total Release (not including tritium, gases or alpha)	Ci	3.48E-03	1.59E-03	8.28E-03	1.84E-03	1.52E-02	25.7%
2. Average diluted concentration during period	μCi/mL	9.03E-11	4.01E-11	2.09E-10	1.13E-10	1.13E-10	

B. Tritium							
1. Total Release	Ci	9.61E+01	3.82E+02	2.41E+02	1.83E+02	9.02E+02	5.83%
2. Average diluted concentration during period	μCi/mL	2.49E-06	9.65E-06	6.09E-06	1.12E-05	6.73E-06	

C. Dissolved & Entrained Gases							
1. Total Release	Ci	0.00E+00	1.89E-03	5.29E-05	3.87E-03	5.82E-03	18.0%
2. Average diluted concentration during period	μCi/mL	0.00E+00	4.78E-11	1.33E-12	2.38E-10	4.34E-11	

D. Gross Alpha Activity							
1. Total Release	Ci	ND	ND	ND	ND	ND	NA

E. Volume Of Waste Released (prior to dilution)	Liters	4.29E+06	4.96E+06	5.72E+06	9.42E+06	2.44E+07
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F. Volume Of Dilution Water Used During Period	Liters	3.86E+10	3.96E+10	3.97E+10	1.63E+10	1.34E+11
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## Annual Radioactive Effluent Release Report

Table 5, Batch Mode Liquid Effluents (Palisades)

Nuclides Released	Unit	Batch Mode				
		Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
<b>Fission Products</b>						
Mn-54	Ci	2.76E-05	ND	7.10E-05	ND	9.87E-05
Fe-55	Ci	6.85E-04	4.34E-04	3.05E-03	ND	4.17E-03
Co-57	Ci	1.29E-05	ND	ND	ND	1.29E-05
Co-58	Ci	5.25E-04	5.17E-04	3.67E-04	6.41E-05	1.47E-03
Co-60	Ci	9.27E-04	2.78E-04	2.98E-03	8.64E-04	5.05E-03
Ni-63	Ci	3.21E-04	ND	ND	ND	3.21E-04
Sr-92	Ci	ND	ND	1.06E-05	1.47E-06	1.21E-05
Ag-108m	Ci	2.30E-05	ND	1.53E-04	7.17E-05	2.48E-04
Ag-110m	Ci	9.59E-04	3.02E-04	1.65E-03	8.36E-04	3.75E-03
Total	Ci	3.48E-03	1.53E-03	8.28E-03	1.84E-03	1.51E-02
<b>Dissolved and Entrained Gases</b>						
Xe-133	Ci	ND	1.89E-03	5.29E-05	3.84E-03	5.79E-03
Xe-135	Ci	ND	ND	ND	2.95E-05	2.95E-05
Total	Ci	ND	1.89E-03	5.29E-05	3.87E-03	5.82E-03
<b>Tritium</b>						
H-3	Ci	9.60E+01	3.82E+02	2.41E+02	1.83E+02	9.02E+02
<b>Gross Alpha</b>						
Alpha	Ci	ND	ND	ND	ND	ND

## Annual Radioactive Effluent Release Report

Table 6, Continuous Mode Liquid Effluents (Palisades)

Nuclides Released	Unit	Continuous Mode				
		Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
<b>Fission Products</b>						
Cs-137	Ci	ND	5.67E-05	ND	ND	5.67E-05
Total	Ci	ND	5.67E-05	ND	ND	5.67E-05
<b>Tritium</b>						
H-3	Ci	1.33E-01	5.93E-02	7.34E-02	1.70E-02	2.83E-01

## Annual Radioactive Effluent Release Report

## 5.0 SOLID WASTE SUMMARY

5.1 Solid Waste Shipped Offsite for Burial or Disposal (Not Irradiated Fuel)5.1.1 Types of Waste

Table 7, Types of Solid Waste Summary (Palisades)

Types of Waste	Total Quantity (m <sup>3</sup> )	Total Activity (Ci)	Est. Total Error (%)
a. Spent resins, filter sludges, evaporator bottoms, etc.	2.06E+01	5.49E+00	25
b. Dry compressible waste, contaminated equip, etc.	3.52E+02	2.47E+00	25
c. Irradiated components, control rods, etc.	1.36E-01	6.74E+03	25
d. Other (sludge, used oil, water, etc.)	2.02E+01	6.84E-04	25

5.1.2 Estimate of major nuclide composition (by waste type) only >1%<sup>[Note 1]</sup> are reported.

Table 8, Major Nuclides (Palisades)

Major Nuclide Composition	%	Curies
a. Spent resins, filter sludges, evaporator bottoms, etc.		
H-3	98.69%	5.41E+00
b. Dry compressible waste, contaminated equip, etc.		
H-3	1.82%	4.46E-02
Cr-51	2.23%	5.45E-02
Fe-55	6.63%	1.62E-01
Co-58	42.13%	1.03E+00
Co-60	12.97%	3.18E-01
Ni-63	13.25%	3.24E-01
Zr-95	2.91%	7.12E-02
Nb-95	4.62%	1.13E-01
Ag-110m	8.12%	1.99E-01
Cs-137	2.58%	6.31E-02
c. Irradiated components, control rods, etc.		

## Annual Radioactive Effluent Release Report

Table 8, Major Nuclides (Palisades)

Mn-54	2.15%	1.44E+02
Fe-55	41.52%	2.80E+03
Co-60	48.5%	3.27E+03
Ni-63	7.39%	4.98E+02
d. Other (sludge, used oil, water, etc.)		
H-3	9.54%	5.59E-05
C-14	2.03%	1.19E-05
F-55	6.04%	3.55E-05
Co-58	15.22%	8.93E-05
Co-60	20.53%	1.20E-04
Ni-63	16.05%	9.42E-05
Sr-90	1.11%	6.50E-06
Nb-95	1.81%	1.06E-05
Tc-99	2.61%	1.53E-05
Ag-110m	3.15%	1.85E-05
Cs-137	17.55%	1.03E-04
Cs-144	1.96%	1.15E-05

[Note 1] – “Major” radionuclide is equivalent to a “principle” radionuclide, i.e. greater than 1 percent of total activity.

## Annual Radioactive Effluent Release Report

5.1.3 Solid Waste Disposition

Table 9, Solid Waste Disposition (Palisades)

Number of Shipments	Mode of Transportation	Destination
14	Hittman Transport	Energy Solutions Bear Creek Facility 1560 Bear Creek Road
2	Hittman Transport	Waste Control Specialist LLC Compact Waste Disposal Facility
1	Tri-State Motor Transit Co	Energy Solutions Bear Creek Facility 1560 Bear Creek Road

Table 10, Irradiated Fuel Shipments Disposition (Palisades)

Number of Shipments	Mode of Transportation	Destination
0	NA	NA

## Annual Radioactive Effluent Release Report

## 6.0 RADIOLOGICAL IMPACT TO MAN

6.1 10 CFR 50, Appendix I Evaluation

Table 11, Dose Assessment (Palisades)

	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual
Liquid Effluent Dose Limit, Total Body	1.5 mrem	1.5 mrem	1.5 mrem	1.5 mrem	3 mrem
Total Body Dose (mrem)	4.85E-04	3.94E-04	1.42E-03	1.21E-03	3.51E-03
% of Limit	3.23E-02	2.63E-02	9.47E-02	8.07E-02	1.17E-01
Liquid Effluent Dose Limit, Any Organ	5 mrem	5 mrem	5 mrem	5 mrem	10 mrem
Maximum Organ Dose (mrem)	4.98E-04	4.68E-04	1.48E-03	1.23E-03	3.68E-03
% of Limit	9.96E-03	9.36E-03	2.96E-02	2.46E-02	3.68E-02
Gaseous Effluent Dose Limit, Gamma Air	5 mrad	5 mrad	5 mrad	5 mrad	10 mrad
Gamma Air Dose (mrad)	3.12E-04	1.77E-03	2.69E-04	9.37E-04	3.29E-03
% of Limit	6.24E-03	3.54E-02	5.38E-03	1.87E-02	3.29E-02
Gaseous Effluent Dose Limit, Beta Air	10 mrad	10 mrad	10 mrad	10 mrad	20 mrad
Beta Air Dose (mrad)	2.89E-04	1.02E-03	1.77E-04	1.07E-03	2.56E-03
% of Limit	2.89E-03	1.02E-02	1.77E-03	1.07E-02	1.28E-02
Gaseous Effluent Organ Dose Limit (Iodine, Tritium, Particulates with > 8 day half-life)	7.5 mrem	7.5 mrem	7.5 mrem	7.5 mrem	15 mrem
Gaseous Effluent Organ Dose (Iodine, Tritium, Particulates with > 8 day half-life) (mrem)	1.09E-02	1.65E-02	2.94E-03	1.57E-02	4.61E-02
% of Limit	1.46E-01	2.20E-01	3.92E-02	2.09E-01	3.07E-01



## Annual Radioactive Effluent Release Report

6.2 40 CFR 190 Evaluation for an Individual in the Unrestricted Area

Table 12, EPA 40 CFR PART 190 Evaluation

	Whole Body	Thyroid	Any Other Organ
Dose Limit	25 mrem	75 mrem	25 mrem
Dose (mrem)	9.35E-02	1.27E-01	4.05E-01
% of Limit	3.74E-01	1.70E-01	1.62E+00

Liquid dose, gaseous dose including C14, direct shine from each unit, ISFSI and any other nuclear power related facility within 5 miles of the station are considered when calculating dose compliance with 40 CFR 190.

## Annual Radioactive Effluent Release Report

## 7.0 METEOROLOGICAL DATA

7.1 Joint Frequency Distributions

1. Period of Record: 01/01/2018 - 12/31/2018
2. Elevation: 10 meter

Table 13, Hours of Each Wind Speed and Direction

Wind Direction	Wind Speed (m/s)						Total
	0.1 - 1.0	1.1 - 2.0	2.1 - 3.0	3.1 - 4.0	4.1 - 5.0	5.1 and greater	
N	33	109	108	70	26	37	383
NNE	26	2.6	198.4	30	9	6	272
NE	28	170	113	23	12	10	356
ENE	25	105	117	88	39	32	406
E	25	55	50	69	55	91	345
ESE	30	62	28	16	36	41	213
SE	22	95	120	177	152	346	912
SSE	36	263	385	214	100	105	1103
S	40	274	231	60	18	4	627
SSW	34	102	118	60	19	0	333
SW	37	107	157	129	91	31	552
WSW	34	121	118	74	62	31	440
W	50	115	105	91	65	29	455
WNW	36	157	145	134	54	27	553
NWN	58	295	220	134	131	100	938
NNW	36	193	209	144	114	142	838

3. Variable
  - a. There were 31 calm hours in 2018.

### Annual Radioactive Effluent Release Report

- b. From January 1 through July 1, 2018, data recovery was 100.0% for all parameters except the 10-meter temperature and 10-60 meter delta-T. For these two parameters there was 26 hours of missing data. Sigma-theta was used as a surrogate for the stability class derived from delta-T and therefore the joint control room availability was 100.0%. From July 1 through December 31, 2018, data recovery was 99.9% for all parameters except the 60 meter sigma-theta which was 99.7%. The joint control room availability from July 1 through December 31, 2018, was 99.9%.

## 7.2 Stability Class

**Table 14, Classification of Atmospheric Stability**

Stability Condition	Pasquill Categories	Hours (Percentage)
Extremely Unstable	A	826 (9.46%)
Moderately Stable	B	264 (3.02%)
Slightly Unstable	C	409 (4.68%)
Neutral	D	3865 (44.3%)
Slightly Stable	E	2204 (25.2%)
Moderately Stable	F	656 (7.51%)
Extremely Stable	G	507 (5.81%)

Palisades' meteorological data is maintained on-site and available for review upon request

**Enclosure 1 to Attachment 1**

**Errata/Corrections to Previous ARERRs**

**15. Carbon-14**

In 2010, PNP and other facilities participated in an EPRI task force to build a model to accurately estimate gaseous C-14 releases, given some key site-specific plant parameters (mass of the primary coolant, average thermal neutron cross section, rated MW, etc.). This work was completed in November 2010. The estimates for C-14 were constructed using the aforementioned EPRI methodology contained within EPRI 1021106, "Estimation of Carbon-14 in Nuclear Power Plant Gaseous Effluents." Using the C-14 curie estimates, the annual dose to man was derived from guidance contained within 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." The dose contribution of C-14 from liquid radioactive waste is much less than that contributed by gaseous radioactive waste and therefore the evaluation of C-14 in liquid radioactive waste is not required. Gaseous C-14 is reported as CO<sub>2</sub> Curies because the major pathway by which C-14 contributes to the dose to man is by entering vegetables in the form of CO<sub>2</sub> and then being ingested. The "total body" and the "bone" dose reported below is the maximum among the four age groups; Adult, Teenage, Child, Infant.

Annual C-14 release for PNP and subsequent doses for 2017:

Total Gaseous C-14 Released =	8.55E+00 Curies
Gaseous C-14 as CO <sub>2</sub> =	2.56E+00 Curies
Effective Total Body Dose, C-14 =	1.32E-01 mrem
Effective Bone Dose, C-14 =	6.60E-01 mrem

The quarterly curies released are provided in Table 1A, 1B, and 1C. Airborne doses due to C-14 are contained in Table 1A.

## Annual Radioactive Effluent Release Report

**ATTACHMENT 1**  
**Palisades - Table 1A**  
**2017 Gaseous Effluents – Summation of All Releases**

Summation of All Releases	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total	Uncertainty (%)
Fission and Activation Gases	Ci	7.17E+00	6.76E+00	2.32E+00	6.40E+00	2.27E+01	4.04E+00
Average Release Rate	μCi/s	9.23E-01	8.60E-01	2.92E-01	8.05E-01	7.19E-01	
% of Limit	%	2.53E-03	7.81E-03	2.88E-03	5.57E-03	4.70E-03	
Iodines (Halogens)	Ci	1.53E-04	9.66E-05	7.42E-06	3.86E-05	2.96E-04	1.65E+01
Average Release Rate	μCi/s	1.97E-05	1.23E-05	9.34E-07	4.86E-06	9.39E-06	
% of Limit	%	1.01E-05	7.45E-06	1.07E-06	2.70E-06	5.31E-06	
Particulates	Ci	3.43E-06	3.52E-05	6.23E-07	3.43E-05	7.36E-05	7.99E+00
Average Release Rate	μCi/s	4.41E-07	4.47E-06	7.83E-08	4.32E-06	2.33E-06	
% of Limit	%	2.66E-07	1.07E-06	6.13E-08	8.24E-06	2.42E-06	
Tritium	Ci	2.06E+00	2.79E+00	2.59E+00	3.10E+00	1.05E+01	9.98E+00
Average Release Rate	μCi/s	2.65E-01	3.54E-01	3.26E-01	3.89E-01	3.34E-01	
% of Limit	%	6.09E-04	8.15E-04	7.50E-04	8.96E-04	7.68E-04	
Gross Alpha	Ci	ND	ND	ND	ND	ND	N/A
C-14	Ci	2.17E+00	1.44E+00	2.47E+00	2.47E+00	8.55E+00	
Average Release Rate	μCi/s	2.79E-01	1.83E-01	3.11E-01	3.11E-01	2.71E-01	
% of Limit	%	2.14E-04	1.24E-04	2.38E-04	2.38E-04	2.08E-04	

% of Limit = Percentage of one EC (Effluent Concentration) defined per 10 CFR Part 20 Appendix B Table 2 Column 1

ND = Measurement performed and no activity detected

NA = Not applicable

Ci = Curies

μCi/s = microCurie per second

## Annual Radioactive Effluent Release Report

**ATTACHMENT 1**  
**Palisades - Table 1B**  
**2017 Gaseous Effluents – Ground Level Release – Batch Mode**

Fission and Activation Gases	Units	Quarter 1	Quarter 2	Quarter 3	*Quarter 4	Annual
Kr-85	Ci	1.36E-03	2.02E-03	7.75E-04	9.82E-04	4.92E-03
Kr-85m	Ci	1.93E-08	ND	ND	2.93E-170	1.93E-08
Kr-88	Ci	3.32E-10	3.51E-08	ND	ND	3.54E-08
Xe-131m	Ci	7.53E-03	1.03E-02	8.58E-04	1.91E-06	1.87E-02
Xe-133	Ci	1.83E+00	3.90E-01	8.68E-02	6.08E-06	2.31E+00
Xe-133m	Ci	3.53E-02	9.83E-05	1.18E-03	3.03E-17	3.66E-02
Xe-135	Ci	6.51E-02	5.24E-02	2.19E-04	1.28E-84	1.18E-01
Total	Ci	1.94E+00	4.55E-01	8.98E-02	9.90E-04	2.49E+00
Iodines/Halogens	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual
I-131	Ci	1.81E-06	2.77E-06	9.12E-10	7.53E-13	4.58E-06
I-132	Ci	8.58E-11	ND	ND	2.73E-45	8.58E-11
I-133	Ci	2.23E-06	3.15E-14	ND	ND	2.23E-06
I-135	Ci	1.26E-06	ND	ND	ND	1.26E-06
Total	Ci	5.29E-06	2.77E-06	9.12E-10	7.53E-13	8.06E-06
Particulates	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual
Cr-51	Ci	1.42E-07	ND	ND	ND	1.42E-07
Mn-54	Ci	8.68E-09	ND	ND	ND	8.68E-09
Co-57	Ci	3.14E-09	ND	ND	ND	3.14E-09
Co-58	Ci	1.61E-06	2.32E-07	5.48E-08	ND	1.90E-06
Co-60	Ci	3.40E-07	ND	ND	ND	3.40E-07
Rb-88	Ci	1.11E-06	ND	ND	ND	1.11E-06
Nb-95	Ci	6.50E-08	7.37E-08	1.37E-09	ND	1.40E-07
Zr-95	Ci	6.57E-08	5.34E-08	ND	ND	1.19E-07
Nb-97	Ci	2.00E-11	ND	ND	ND	2.00E-11
Ag-110m	Ci	2.67E-08	ND	ND	ND	2.67E-08
Ru-105	Ci	ND	ND	1.37E-08	ND	1.37E-08
Total	Ci	3.38E-06	3.59E-07	6.99E-08	ND	3.81E-06
Other radionuclide	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual
Tritium	Ci	1.54E-02	5.41E-03	ND	ND	2.08E-02

ND = Measurement performed and no activity detected

Ci = Curies

\* = Very small values are due to a long decay correct of a Waste Gas Decay Tank and are conservative values.

## Annual Radioactive Effluent Release Report

**ATTACHMENT 1**  
**Palisades - Table 1C**  
**2017 Gaseous Effluents – Ground-Level Release – Continuous Mode**

Fission and Activation Gases	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual
Ar-41	Ci	ND	2.06E+00	5.10E-01	5.54E-01	3.13E+00
Kr-85	Ci	ND	3.32E-03	ND	ND	3.32E-03
Kr-85m	Ci	ND	3.47E-03	3.79E-02	1.50E-01	1.92E-01
Kr-87	Ci	ND	8.36E-02	1.05E-01	2.55E-01	4.43E-01
Kr-88	Ci	4.60E-01	8.70E-03	1.01E-01	3.78E-01	9.48E-01
Xe-131m	Ci	ND	1.06E-01	ND	ND	1.06E-01
Xe-133	Ci	3.14E+00	2.51E+00	5.34E-01	2.80E+00	8.98E+00
Xe-133m	Ci	ND	6.64E-04	6.43E-04	8.04E-04	2.11E-03
Xe-135	Ci	1.63E+00	7.70E-01	4.63E-01	1.04E+00	3.90E+00
Xe-135m	Ci	2.06E-03	2.51E-03	1.47E-02	2.37E-02	4.30E-02
Xe-137	Ci	ND	ND	5.01E-02	2.17E-01	2.67E-01
Xe-138	Ci	ND	7.54E-01	4.16E-01	9.81E-01	2.15E+00
Total	Ci	5.23E+00	6.31E+00	2.23E+00	6.40E+00	2.02E+01
Iodines/Halogens	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual
I-131	Ci	4.58E-05	3.67E-05	7.42E-06	1.36E-05	1.04E-04
I-133	Ci	1.02E-04	5.71E-05	ND	2.50E-05	1.84E-04
Total	Ci	1.48E-04	9.38E-05	7.42E-06	3.86E-05	2.88E-04
Particulates	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual
Cr-51	Ci	2.23E-08	1.71E-09	ND	ND	2.40E-08
Mn-54	Ci	ND	ND	ND	5.28E-07	5.28E-07
Co-57	Ci	ND	ND	ND	1.59E-07	1.59E-07
Co-58	Ci	ND	3.46E-05	ND	1.27E-05	4.74E-05
Co-60	Ci	3.76E-09	2.85E-08	3.88E-08	7.42E-06	7.49E-06
Nb-95	Ci	ND	3.25E-08	5.09E-11	1.28E-06	1.31E-06
Zr-95	Ci	ND	2.66E-08	5.14E-07	6.35E-07	1.18E-06
Mo-99	Ci	2.23E-08	ND	ND	ND	2.23E-08
Ag-108m	Ci	ND	ND	ND	2.02E-07	2.02E-07
Ag-110m	Ci	ND	7.04E-08	ND	1.14E-05	1.15E-05
Cs-137	Ci	ND	ND	ND	1.14E-11	1.14E-11
Total	Ci	4.84E-08	3.48E-05	5.53E-07	3.43E-05	6.98E-05
Other radionuclide	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual
Tritium	Ci	2.04E+00	2.78E+00	2.59E+00	3.10E+00	1.05E+01
C-14	Ci	2.17E+00	1.44E+00	2.47E+00	2.47E+00	8.55E+00

ND = Measurement performed and no activity detected  
Ci = Curies

## Annual Radioactive Effluent Release Report

## ATTACHMENT 1

## Palisades - Table 5

## 2017 Dose Assessments, EPA 40 CFR Part 190, Individual in the Unrestricted Area

	Whole Body	Thyroid	Any Other Organ
Dose Limit (mrem)	25	75	25
Dose (mrem)	1.43E-01	1.49E-01	6.74E-01
% of Limit	0.57%	0.20%	2.70%



## Annual Radioactive Effluent Release Report

**15. Carbon-14**

In 2010, PNP and other facilities participated in an EPRI task force to build a model to accurately estimate gaseous C-14 releases, given some key site-specific plant parameters (mass of the primary coolant, average thermal neutron cross section, rated MW, etc). This work was completed in November 2010. The estimates for C-14 were constructed using the aforementioned EPRI methodology contained within EPRI 1021106, Estimation of Carbon-14 in Nuclear Power Plant Gaseous Effluents. Using the C-14 curie estimates, the annual dose to man was derived from guidance contained within 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." Because the dose contribution of C-14 from liquid radioactive waste is much less than that contributed by gaseous radioactive waste, evaluation of C-14 in liquid radioactive waste is not required. Gaseous C-14 is reported as CO<sub>2</sub> Curies because the major pathway by which C-14 contributes to the dose to man is by entering vegetables in the form of CO<sub>2</sub> and then being ingested.

Annual C-14 release for PNP and subsequent doses for 2016:

Total Gaseous C-14 Released Curies =	9.82
Gaseous C-14 as CO <sub>2</sub> Curies =	2.95
Effective Child TB Dose, C-14 mrem =	0.0784
Effective Child Bone Dose, C-14 mrem =	0.393

The quarterly curies released are provided in Table 1A, Table 1B, and Table 1C.  
Airborne doses due to C-14 are contained in Table 1A.

## Annual Radioactive Effluent Release Report

**ATTACHMENT 1**  
**Palisades - Table 1A**  
**2016 Gaseous Effluents – Sum of All Releases**

Summation of All Releases	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total	Uncertainty (%)
Fission and Activation Gases	Ci	4.12E+00	2.37E+00	3.65E-01	1.81E+00	8.66E+00	23.18
Average Release Rate	μCi/s	5.24E-01	3.02E-01	4.60E-02	2.28E-01	2.74E-01	
% of Limit	%	5.29E-03	9.78E-04	5.02E-04	2.42E-03	2.29E-03	
Iodines (Halogens)	Ci	3.96E-05	2.97E-05	9.69E-05	2.88E-05	1.95E-04	51.17
Average Release Rate	μCi/s	5.04E-06	3.78E-06	1.22E-05	3.62E-06	6.17E-06	
% of Limit	%	2.15E-06	1.60E-06	4.90E-06	2.11E-06	2.69E-06	
Particulates	Ci	1.58E-08	0.00E+00	1.68E-07	7.86E-11	1.83E-07	27.9
Average Release Rate	μCi/s	2.00E-09	0.00E+00	2.11E-08	9.89E-12	5.80E-09	
% of Limit	%	9.18E-09	0.00E+00	1.50E-08	2.26E-11	6.06E-09	
Tritium	Ci	3.57E+00	3.54E+00	3.65E+00	2.91E+00	1.37E+01	4.42
Average Release Rate	μCi/s	4.54E-01	4.50E-01	4.59E-01	3.66E-01	4.32E-01	
% of Limit	%	1.04E-03	1.03E-03	1.05E-03	8.38E-04	9.89E-04	
Gross Alpha	Ci	ND	ND	ND	ND	ND	N/A
C-14	Ci	2.44E+00	2.44E+00	2.47E+00	2.47E+00	9.82E+00	
Average Release Rate	μCi/s	3.10E-01	3.10E-01	3.11E-01	3.11E-01	3.11E-01	
% of Limit	%	2.37E-06	2.37E-06	2.37E-06	2.37E-06	2.37E-06	

## Annual Radioactive Effluent Release Report

**ATTACHMENT 1**  
**Palisades - Table 1C**  
**2016 Gaseous Effluents – Ground Level Release, Continuous Mode**

Tritium	Ci	3.57E+00	3.54E+00	3.65E+00	2.89E+00	1.36E+01
Gross Alpha	Ci	ND	ND	ND	ND***	ND
C-14	Ci	2.44E+00	2.44E+00	2.47E+00	2.47E+00	9.82E+00

ND = Measurement performed but no activity detected

NR = Analysis not required and not performed

NA = Not applicable

\*\*\* = Analysis does not include December data, see section 14 for explanation.

## Annual Radioactive Effluent Release Report

**ATTACHMENT 1**  
**Palisades - Table 5**  
**2016 Dose Assessments, EPA 40 CFR Part 190, Individual in the Unrestricted Area**

	Whole Body	Thyroid	Any Other Organ
Dose Limit (mrem)	25	75	25
Dose (mrem)	8.51E-02	1.54E-01	4.03E-01
% of Limit	0.34%	0.21%	1.61%



<b>Plant: Big Rock Point ISFSI</b>	<b>Page 36 of 43</b>
	<b>YEAR: 2018</b>
<b>Document Number: PNP 2019-016</b>	
<b>Annual Radioactive Effluent Release Report</b>	

This report provides information relating to radioactive effluent releases and solid radioactive waste disposal at Big Rock Point (BRP) for the year 2018. The report format is detailed in the BRP Offsite Dose Calculation Manual (ODCM). Effluent releases from BRP are controlled by the Defueled Technical Specifications and the ODCM requirements.

#### 2018 Operating History

On January 8, 2007, the Nuclear Regulatory Commission (NRC) approved release of the former BRP nuclear plant property for unrestricted use in accordance with the BRP License Termination Plan<sup>1</sup>. On April 11, 2007, the license for BRP, DPR-06, was transferred to Entergy Nuclear Operations, Inc.

During 2018, normal independent spent fuel storage installation (ISFSI) operations continued. There were no operational activities that generated any solid radioactive waste.

Liquid and gaseous effluent monitoring is no longer conducted as the former BRP nuclear plant property has been released from the license. Short-lived radionuclides, including iodine and noble gas, are neither expected nor reported.

#### 1. Supplemental Information

##### A. Batch Releases

There were no batch releases of gaseous or liquid effluents during 2018. All batch releases of radioactive liquids as described in the ODCM ceased in 2004. Reference Table 1.

##### B. Abnormal Releases

There were no abnormal releases from BRP during 2018.

<sup>1</sup> Letter from the USNRC dated January 8, 2007, "Release of Land from Part 50 License for Unrestricted Use"

**Annual Radioactive Effluent Release Report**

## C. Radioactive Effluent Monitoring Instrumentation

BRP ODCM currently specifies required actions when less than the minimum numbers of radioactive effluent monitoring instrument channels are operable. The ODCM also specifies these actions be taken when installed effluent monitoring systems are removed from service for decommissioning.

All plant-installed liquid and gaseous radioactive effluent monitoring instrument channels have been permanently removed and dismantled.

2. Gaseous Effluents

Although there were no gaseous effluents released during 2018, Table 2 provides a summary of all gaseous radioactive effluent monitoring conducted during the reporting period as required by the ODCM.

3. Liquid Effluents

There were no liquid effluent batch releases during 2018. Table 3 lists and summarizes liquid effluent releases in accordance with the ODCM.

4. Solid Waste

There was no solid radioactive waste generated or shipped during 2018.

5. Summary of Radiological Impact on Man

The ODCM specifies that the annual effluent release report provide potential dose calculations based on measured effluent to liquid and gaseous pathways, if estimates of dose exceed one millirem to an organ or total body of any individual or more than one person-rem to the population within 50 miles. During 2018, there were no releases. Therefore, no calculations were required.

6. Offsite Dose Calculation Manual

The ODCM describes the radiological release requirements for the BRP site. No ODCM changes in 2018 had any effect on the Radiological Effluent Program at BRP.

7. Process Control Program (PCP)

The Process Control Program (PCP) describes solid waste processing and disposal methods utilized at the BRP site. Changes to the fleet procedure governing the PCP have no effect on the BRP site in 2018.

## Annual Radioactive Effluent Release Report

**TABLE 1**  
**Batch Releases**

January 1, 2018 to December 31, 2018

<b>A. GASEOUS</b>	Units	1ST QTR	2ND QTR	3RD QTR	4TH QTR
Number of Releases		N/A	N/A	N/A	N/A
Total Release Time	Minutes	N/A	N/A	N/A	N/A
Maximum Release Time	Minutes	N/A	N/A	N/A	N/A
Average Release Time	Minutes	N/A	N/A	N/A	N/A
Minimum Release Time	Minutes	N/A	N/A	N/A	N/A

<b>B. LIQUID</b>	Units	1ST QTR	2ND QTR	3RD QTR	4TH QTR
Number of Releases		N/A	N/A	N/A	N/A
Total Release Time	Minutes	N/A	N/A	N/A	N/A
Maximum Release Time	Minutes	N/A	N/A	N/A	N/A
Average Release Time	Minutes	N/A	N/A	N/A	N/A
Minimum Release Time	Minutes	N/A	N/A	N/A	N/A

## Annual Radioactive Effluent Release Report

**TABLE 2**  
**Gaseous Effluent Releases**  
 January 1, 2018 to December 31, 2018

<b>A. FISSION AND ACTIVATION GASES</b>	Units	1ST QTR	2ND QTR	3RD QTR	4TH QTR	Est Total Error %
1. Total release	Ci	N/A	N/A	N/A	N/A	N/A
2. Average release rate for period	μCi/sec	N/A	N/A	N/A	N/A	
3. Percent of annual avg EC	%	N/A	N/A	N/A	N/A	

**B. IODINES**

1. Total iodine	Ci	N/A	N/A	N/A	N/A	N/A
2. Average release rate for period	μCi/sec	N/A	N/A	N/A	N/A	
3. Percent of annual avg EC	%	N/A	N/A	N/A	N/A	

**C. PARTICULATES**

1. Particulates with half-life >8 day	Ci	N/A	N/A	N/A	N/A	N/A
2. Average release rate for period	μCi/sec	N/A	N/A	N/A	N/A	
3. Percent of annual avg EC	%	N/A	N/A	N/A	N/A	
4. Gross alpha radioactivity	Ci	N/A	N/A	N/A	N/A	

**D. TRITIUM**

1. Total Release	Ci	N/A	N/A	N/A	N/A
2. Average release rate for period	μCi/sec	N/A	N/A	N/A	N/A
3. Percent of annual avg EC	%	N/A	N/A	N/A	N/A

**E. WHOLE BODY DOSE**

1. Beta Air dose at Site Boundary due to Noble Gases (ODCM Section 1, 1.3.2 a (1) (2))	mrads	N/A	N/A	N/A	N/A
2. Percent limit	%	N/A	N/A	N/A	N/A
3. Gamma Air dose at Site Boundary due to Noble Gas (ODCM Section 1, 1.3.2 a (1) (2))	mrads	N/A	N/A	N/A	N/A
4. Percent limit	%	N/A	N/A	N/A	N/A

**F. ORGAN DOSE (ODCM Section 1, 1.3.2b (1) (2))**

1. Maximum organ dose to pubic based on Critical Receptors (child bone)	mrem	N/A	N/A	N/A	N/A
2. Percent of limit (7.5 mrem/quarter)	%	N/A	N/A	N/A	N/A



## Annual Radioactive Effluent Release Report

**TABLE 2**  
**Gaseous Effluent Releases**  
 January 1, 2018 to December 31, 2018

1. FISSION GASES	Units	1ST QTR	2ND QTR	3RD QTR	4TH QTR
Krypton-85m	Ci	N/A	N/A	N/A	N/A
Krypton-87	Ci	N/A	N/A	N/A	N/A
Krypton-88	Ci	N/A	N/A	N/A	N/A
Xenon-133	Ci	N/A	N/A	N/A	N/A
Xenon-133m	Ci	N/A	N/A	N/A	N/A
Xenon-135	Ci	N/A	N/A	N/A	N/A
Xenon-135m	Ci	N/A	N/A	N/A	N/A
Xenon-138	Ci	N/A	N/A	N/A	N/A
Total for Period	Ci	N/A	N/A	N/A	N/A

2. IODINES					
Iodine-131	Ci	N/A	N/A	N/A	N/A
Iodine-132	Ci	N/A	N/A	N/A	N/A
Iodine-133	Ci	N/A	N/A	N/A	N/A
Iodine-134	Ci	N/A	N/A	N/A	N/A
Iodine-135	Ci	N/A	N/A	N/A	N/A
Total for Period	Ci	N/A	N/A	N/A	N/A

## Annual Radioactive Effluent Release Report

**TABLE 2**  
**Gaseous Effluent Releases**  
 January 1, 2018 to December 31, 2018

3. PARTICULATES*	Units	1ST QTR	2ND QTR	3RD QTR	4TH QTR
Chromium-51	Ci	N/A	N/A	N/A	N/A
Manganese-54	Ci	N/A	N/A	N/A	N/A
Cobalt-58	Ci	N/A	N/A	N/A	N/A
Iron-59	Ci	N/A	N/A	N/A	N/A
Cobalt-60	Ci	N/A	N/A	N/A	N/A
Zinc-65	Ci	N/A	N/A	N/A	N/A
Silver-110m	Ci	N/A	N/A	N/A	N/A
Cesium-134	Ci	N/A	N/A	N/A	N/A
Cesium-137	Ci	N/A	N/A	N/A	N/A
Barium-140	Ci	N/A	N/A	N/A	N/A
Europium-152	Ci	N/A	N/A	N/A	N/A
Strontium-89	Ci	N/A	N/A	N/A	N/A
Strontium-90	Ci	N/A	N/A	N/A	N/A
Net unidentified beta	Ci	N/A	N/A	N/A	N/A
Total	Ci	N/A	N/A	N/A	N/A

\* Particulates with half-life >8 days

## Annual Radioactive Effluent Release Report

**TABLE 3**  
**Liquid Effluent Releases**  
 January 1, 2018 to December 31, 2018

<b>A. FISSION AND ACTIVATION PRODUCTS</b>	Units	1ST QTR	2ND QTR	3RD QTR	4TH QTR	Est Total Error %
1. Total release (not including tritium, gases, alpha)	Ci	N/A	N/A	N/A	N/A	N/A
2. Average diluted concentration during period	μCi/ml	N/A	N/A	N/A	N/A	
3. Percent of EC	%	N/A	N/A	N/A	N/A	
<b>B. TRITIUM</b>						
1. Total release	Ci	N/A	N/A	N/A	N/A	N/A
2. Average diluted concentration during period	μCi/ml	N/A	N/A	N/A	N/A	
3. Percent of EC	%	N/A	N/A	N/A	N/A	
<b>C. DISSOLVED AND ENTRAINED GASES</b>						
1. Total release	Ci	N/A	N/A	N/A	N/A	N/A
2. Average diluted concentration during period	μCi/ml	N/A	N/A	N/A	N/A	
3. Percent of EC	%	N/A	N/A	N/A	N/A	
<b>D. GROSS ALPHA RADIOACTIVITY</b>	Ci	N/A	N/A	N/A	N/A	
<b>E. VOLUME OF WASTE RELEASED</b> (Prior to dilution)	Liters	N/A	N/A	N/A	N/A	
<b>F. VOLUME OF DILUTION WATER USED DURING PERIOD</b>	Liters	N/A	N/A	N/A	N/A	
<b>G. MAXIMUM DOSE COMMITMENT WHOLEBODY</b>	mrem	N/A	N/A	N/A	N/A	
Percent of ODCM Section 1, 2.3.2 a (1.5 mrem)	%	N/A	N/A	N/A	N/A	
<b>H. MAXIMUM DOSE COMMITMENT – ORGAN</b>	Mrem	N/A	N/A	N/A	N/A	
Percent of ODCM Section 1, 2.3.2 b (3.0 mrem)	%	N/A	N/A	N/A	N/A	

## Annual Radioactive Effluent Release Report

**TABLE 3**  
**Liquid Effluent Releases**  
 January 1, 2018 to December 31, 2018

1. NUCLIDES RELEASED	Units	1ST QTR	2ND QTR	3RD QTR	4TH QTR
Chromium-51	Ci	N/A	N/A	N/A	N/A
Manganese 54	Ci	N/A	N/A	N/A	N/A
Cobalt-58	Ci	N/A	N/A	N/A	N/A
Iron-59	Ci	N/A	N/A	N/A	N/A
Cobalt-60	Ci	N/A	N/A	N/A	N/A
Zinc-65	Ci	N/A	N/A	N/A	N/A
Strontium-89	Ci	N/A	N/A	N/A	N/A
Strontium-90	Ci	N/A	N/A	N/A	N/A
Molybdenum-99	Ci	N/A	N/A	N/A	N/A
Silver-110m	Ci	N/A	N/A	N/A	N/A
Iodine-131	Ci	N/A	N/A	N/A	N/A
Cesium-134	Ci	N/A	N/A	N/A	N/A
Cesium-137	Ci	N/A	N/A	N/A	N/A
Antimony-125	Ci	N/A	N/A	N/A	N/A
Tin-113	Ci	N/A	N/A	N/A	N/A
Net Unidentified Beta	Ci	N/A	N/A	N/A	N/A
Fission & Activation Product Total	Ci	N/A	N/A	N/A	N/A
Xenon-133	Ci	N/A	N/A	N/A	N/A
Tritium	Ci	N/A	N/A	N/A	N/A
Total	Ci	N/A	N/A	N/A	N/A