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PNP 2019-018

Technical Specification 5.6.2

May 2, 2019

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

Subject: 2018 Radiological Environmental Operating Report

Palisades Nuclear Plant
Docket 50-255
License No. DPR-20

Dear Sir or Madam:

Entergy Nuclear Operations, Inc. is submitting the enclosed Radiological Environmental Operating Report for the Palisades Nuclear Plant. This report was prepared in accordance with the requirements of Technical Specification 5.6.2. The period covered by the enclosed report is 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 revision to existing commitments.

Respectfully,

A handwritten signature in blue ink, appearing to read "JAH" followed by a stylized flourish.

JAH/bed

Enclosure: Annual Radiological Environmental Operating Report

CC Administrator, Region III, USNRC
Project Manager, Palisades, USNRC
Resident Inspector, Palisades, USNRC



ENCLOSURE

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Annual Radiological Environmental Operating Report**1.0 EXECUTIVE SUMMARY****1.1 Radiological Environmental Monitoring Program**

The Annual Radiological Environmental Operating Report (AREOR) presents data obtained through analyses of environmental samples collected for the Palisades Nuclear Plant (PNP) Radiological Environmental Monitoring Program (REMP). The reporting period for this report is from January 1 through December 31, 2018. This report fulfills the requirements of PNP Technical Specification 5.6.2.

All required lower limit of detection (LLD) capabilities were achieved for all sample analyses during 2018, as required by the REMP. No measurable levels of radiation above baseline levels attributable to PNP operation were detected in the environment. The 2018 REMP thus substantiated the adequacy of source control and effluent monitoring at PNP with no observed impact of plant operations on the environment.

PNP established the REMP prior to the station becoming operational to provide data on background radiation and radioactivity normally present in the area. PNP has continued to monitor the environment by sampling air, water, sediment, broad leaf vegetation, fish and food products, as well as measuring direct radiation. PNP also samples milk, if milk-producing animals used for human consumption are present within five miles (8 km) of the plant. The requirements of the REMP are formally described in a site specific regulatory document referred to as the Offsite Dose Calculation Manual (ODCM).

The REMP includes sampling indicator and control locations. The REMP utilizes indicator locations near PNP to identify buildup of radioactivity and control locations to provide a comparison for indicator locations. Indicator, control, and pre-operational results are used to assess any impact PNP operation might have had on the surrounding environment.

The results of the 2018 REMP support the conclusion that the surrounding environment is minimally affected by PNP effluents. No activity in any REMP sample from 2018 was attributed to PNP effluents.

1.2 Reporting Levels

No samples equaled or exceeded reporting levels.

1.3 Sample Deviations

During 2018, environmental sampling was performed for seven media types (airborne, surface water, drinking water, sediment, broad leaf vegetation, fish, and food products) addressed in the ODCM and for direct radiation. All REMP samples were obtained as required by the ODCM in 2018 with the exception of four thermoluminescent dosimeters (TLDs). Attachment 1 contains the listing of all sample deviations and additional relevant details.

Annual Radiological Environmental Operating Report**1.4 Program Modifications**

1. There was one program modifications as a result of the 2018 land use census which will result in a change to the 2019 REMP sampling regiment. The 2018 land use census identified the availability of goat milk samples at a location within five miles of PNP. Therefore, goat milk sampling will begin as the goat milk becomes available (summer months). Due to the fact that there is insufficient goat milk indicator locations to meet the requirement of three milk indicator sampling locations, the broad leaf vegetation samples will continue to be collected in accordance with the PNP ODCM. This programmatic change has no effect on the radiological effluents program. As discussed in the 2018 Annual Radioactive Effluent Release Report (ARERR) there was no change in the critical receptors used to model dose consequence of PNP effluents.

2.0 INTRODUCTION**2.1 Radiological Environmental Monitoring Program**

PNP established the REMP as defined in the ODCM to fulfill 10 CFR 50, Appendix I, Section IV.B.2. The REMP supplements the radiological effluent monitoring program by verifying that the concentrations of radioactive materials and levels of radiation are not higher than expected on the basis of the effluent measurements and the modeling of the environmental exposure pathways.

2.2 Pathways Monitored

The airborne, direct radiation, waterborne, and ingestion pathways are monitored as required by Table 1 through Table 4.

Section 4.0 of this report provides a discussion of 2018 sampling results and Section 5.0 provides a summary of results for the monitored exposure pathways.

2.3 Land Use Census

PNP conducts a land use census annually to identify changes in uses of land within five miles of the site that would require modifications to the REMP and the ODCM. This census is performed to identify critical receptor pathways for the purpose of effluent modeling and REMP sampling.

3.0 RADIOLOGICAL ENVIRONMENTAL SAMPLING PROGRAM REQUIREMENTS

Table 1, Exposure Pathway – Airborne

Requirement	Sample Point Description Distance and Direction	Sampling and Collection Frequency	Type and Frequency Of Analyses
<p><u>RADIOIODINE AND PARTICULATES</u></p> <p>Six samples total. Four samples from within 6 km (3.7 miles) of the site boundary in different sectors. One sample from the vicinity of a community having the highest calculated annual average ground level deposition factor. One control sample in the least prevalent wind direction (considering practical direction and distance).</p>	<ul style="list-style-type: none"> • A8 (0.595 miles NE) - onsite near state park • A19 (0.423 miles SSE) - onsite near Bluestar Hwy • A9 (1.525 miles SSW) - offsite near blue star highway • A4 (3.882 miles SE) - offsite in Covert township • A5 (3.590 miles ESE) - offsite in Covert township • A10 (50.765 miles NE) - offsite near Grand Rapids 	<p>Continuous sampler operation with sample collection every week, or more frequently if required by dust loading.</p>	<p>I-131 analysis weekly for each filter change.</p> <p>Gross beta radioactivity analysis weekly for each filter change.</p> <p>Gamma isotopic analysis quarterly for a composite of all filters collected.</p> <p>IF filter gross beta is greater than 10 times the yearly mean of the control sample, THEN gamma isotopic is performed on the filter.</p>

Table 2, Exposure Pathway – Direct Radiation

Requirement	Sample Point Description Distance and Direction	Sampling and Collection Frequency	Type and Frequency Of Analyses
<p><u>TLDS</u> 23 routine monitoring stations either with two or more dosimeters or with one instrument for measuring and recording dose rate continuously, placed as follows:</p> <p>One on site TLD in the vicinity of the plant. An inner ring of stations consisting of one in each overland meteorological sector, one in the general area of the state park camping area in the NE sector, and one in the general area of the site boundary.</p>	<ul style="list-style-type: none"> • TLD-1 (0.213 miles E) - on site inner ring TLD • TLD-8 (0.602 miles NE)- inner ring TLD • TLD-13 (0.530 miles NNE) - inner ring TLD • TLD-14 (0.551 miles NE)- inner ring TLD • TLD-15 (0.834 miles ENE)- inner ring TLD • TLD-16 (0.804 miles E)- inner ring TLD • TLD-17 (0.572 miles ESE) - inner ring TLD • TLD-18 (0.469 miles SE) - inner ring TLD • TLD-19 (0.443 miles SSE)- inner ring TLD • TLD-20 (0.412 miles S)- inner ring TLD • TLD-21 (0.382 miles SSW) - inner ring TLD 	<p>Quarterly</p>	<p>Gamma dose (units of milliRoentgen, abbreviated mR) quarterly</p>

Table 2, Exposure Pathway – Direct Radiation

Requirement	Sample Point Description Distance and Direction	Sampling and Collection Frequency	Type and Frequency Of Analyses
<p>An outer ring of stations, one in each overland meteorological sector, within the 12 km range from the site.</p> <p>Three control stations sufficiently far from the plant as to not be affected by the plant.</p>	<ul style="list-style-type: none"> • TLD-2 (5.560 miles SE) - outer ring TLD • TLD-3 (5.684 miles SSE) - outer ring TLD • TLD-4 (3.668 miles S) - outer ring TLD • TLD-5 (3.475 miles ESE) - outer ring TLD • TLD-6 (5.314 miles NE) - outer ring TLD • TLD-7 (4.115 miles NNE) - outer ring TLD • TLD-9 (1.670 miles SSW) - outer ring TLD • TLD-23 (3.189 miles ENE) - outer ring TLD • TLD-24 (6.021 miles E) - outer ring TLD • TLD-10 (50.746 miles NE) - control TLD • TLD-11 (39.472 miles E) - control TLD • TLD-12 (27.971 miles SSE) - control TLD 	Quarterly	Gamma dose (mR) quarterly

Table 3, Exposure Pathway – Waterborne

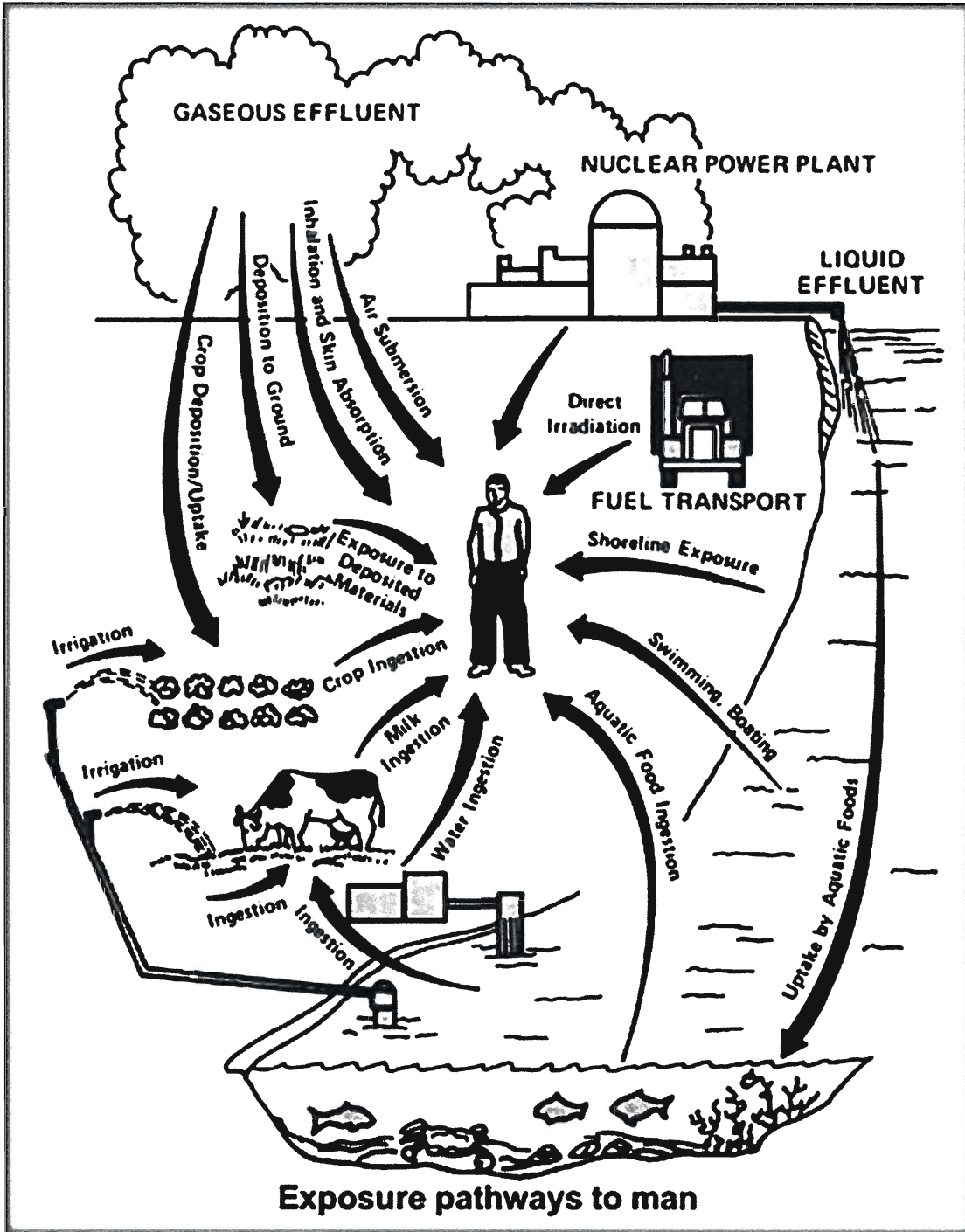
Requirement	Sample Point Description Distance and Direction	Sampling and Collection Frequency	Type and Frequency Of Analyses
<p><u>SURFACE WATER</u> Lake in (plant intake lake water).</p>	<p>Lake in - Lake Michigan intake water used in plant systems. Sample is collected onsite.</p>	<p>Daily samples are used to make a monthly composite sample.</p>	<p>Gamma isotopic and tritium analysis monthly.</p>
<p><u>DRINKING WATER</u> South Haven drinking water and Palisades Park (Pal Park) community drinking water is sampled when in operation (summer months).</p>	<p>City of South Haven drinking water intake structure (5.6 miles NNE of PNP) Pal Park community drinking water (0.7 miles SSW of PNP)</p>	<p>Daily South Haven drinking water samples are used to make a monthly composite sample. 1 grab sample of Palisades Park (Pal Park) community drinking water is sampled monthly when in operation (summer months).</p>	<p>Gamma isotopic and tritium analysis monthly. Gamma isotopic and tritium analysis monthly when operational.</p>
<p><u>Surface Water and Drinking Water Control</u> Lake water from Ludington Pump-house is analyzed as a control sample for drinking and surface water.</p>	<p>Ludington Control - Lake Michigan intake water from Ludington Pump-house (201 km North of PNP).</p>	<p>Daily samples are used to make a monthly composite sample.</p>	<p>Gamma isotopic, gross beta, and tritium analysis monthly.</p>
<p><u>SEDIMENT FROM SHORELINE</u> North sediment sample.</p>	<p>One sample between the north site boundary and Van Buren State Park beach, approximately 1/2 mile north of the plant discharge.</p>	<p>Semiannually</p>	<p>Gamma isotopic analysis semiannually.</p>

Table 4, Exposure Pathway – Ingestion

Requirement	Sample Point Description Distance and Direction	Sampling and Collection Frequency	Type and Frequency Of Analyses
<p><u>MILK</u></p> <p>Samples from milking animals in 3 locations between 5-8km distance</p> <p>One sample from milking animals at a control location.</p>	<p>For 2018 there were no available milking animals to sample at the specified distance from the plant.</p>	<p>Monthly</p>	<p>Gamma isotopic and I-131 monthly</p>
<p><u>Broad leaf Vegetation</u></p> <p>Samples of three different kinds of broad leaf vegetation grown nearest each of two different offsite locations of highest predicted annual average ground level deposition and one sample of each of the similar broad leaf vegetation grown 15-30 km distance in the least prevalent wind direction IF milk sample is not performed.</p>	<p>0.7 miles SE from PNP.</p> <p>0.4 miles SSE from PNP.</p> <p>13.6 miles NNE from PNP.</p>	<p>Monthly during growing season</p>	<p>Gamma isotopic and I-131 monthly during growing season</p>
<p><u>FISH</u></p> <p>Sample two species of commercially and/or recreationally important species in the vicinity of the plant discharge area.</p> <p>One sample of the same species in areas not influenced by plant discharge.</p>	<p>The indicator sample is obtained from Lake Michigan onsite within a few hundred feet of the main liquid discharge point.</p> <p>The control sample is obtained from Lake Michigan near Ludington MI (201 km North of PNP).</p>	<p>Semiannually</p>	<p>Gamma isotopic analysis semiannually</p>
<p><u>FOOD PRODUCTS</u></p> <p>One sample of each of two principal fruit crops (blueberries and apples).</p>	<p>3.7 miles SE from PNP.</p>	<p>Annually at time of harvest</p>	<p>Gamma isotopic and I-131 annually</p>

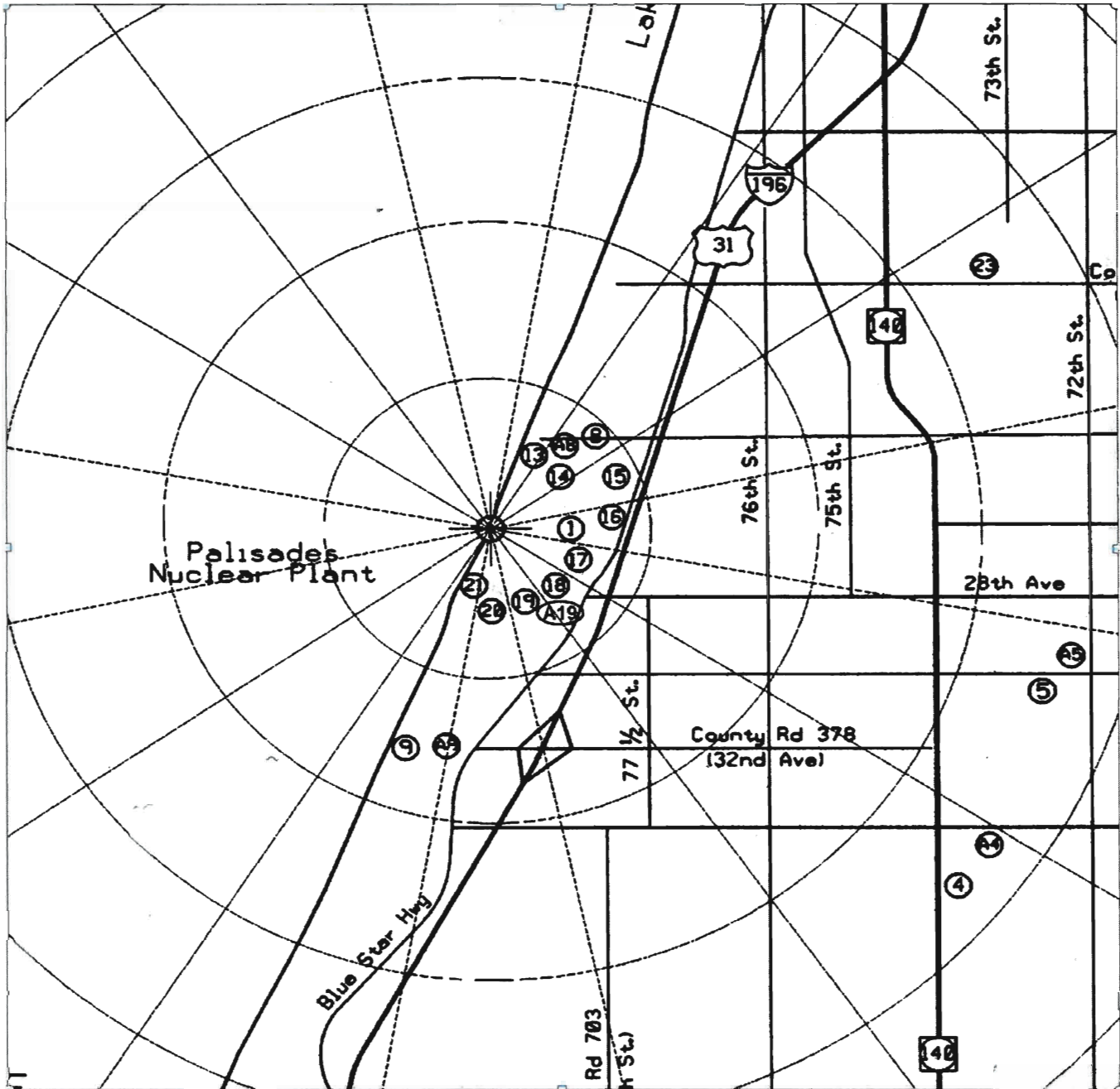
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Figure 1, Exposure Pathway



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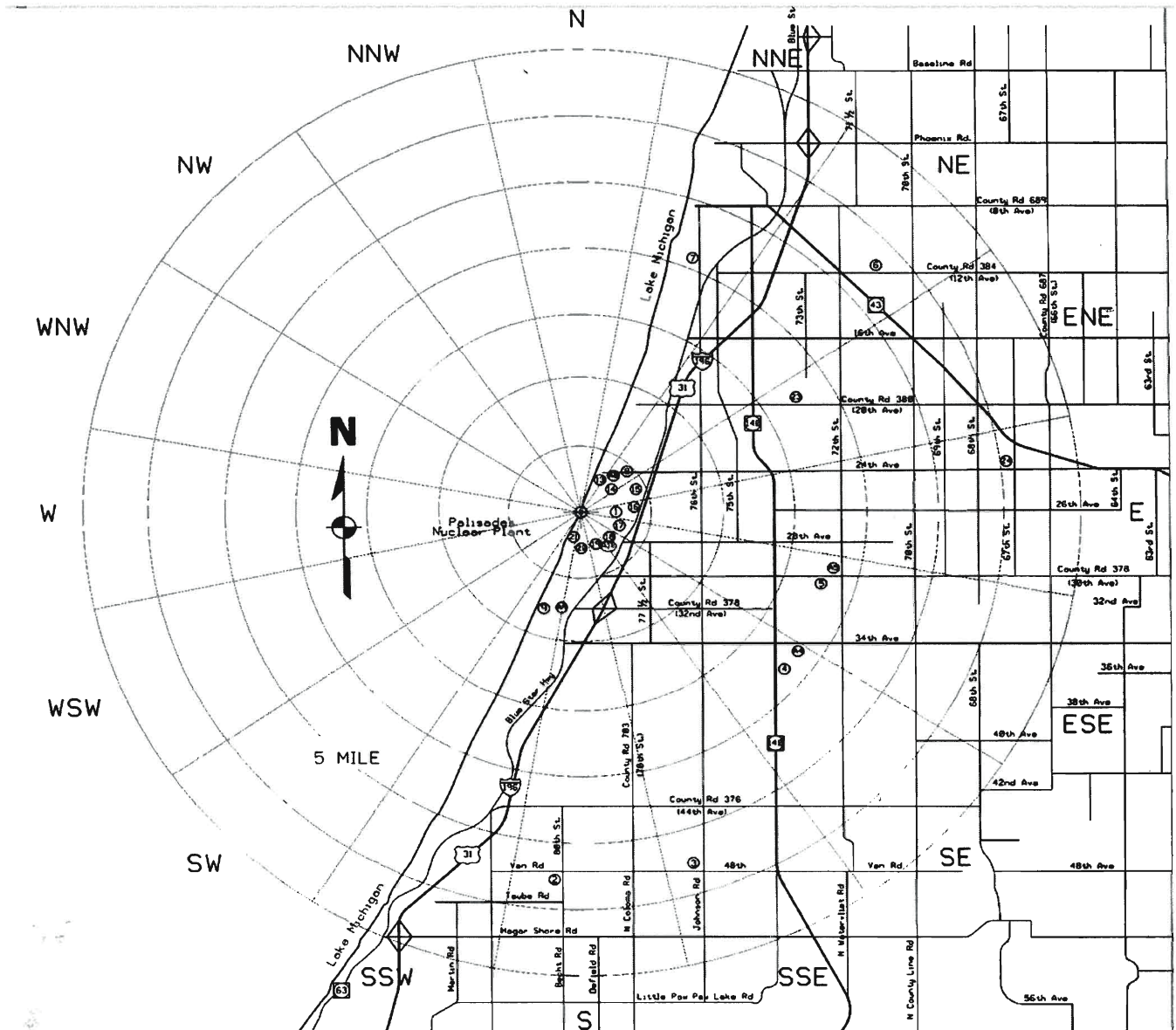
Figure 2, Sample Collection Sites –Near Field



The locations in Figure 2 correspond to the TLD and Air Sampler locations in Table 1 and Table 2.

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Figure 3, Sample Collection Sites - Far Field



The locations in Figure 3 correspond to the TLD and Air Sampler locations in Table 1 and Table 2.

Annual Radiological Environmental Operating Report**4.0 INTERPRETATION AND TRENDS OF RESULTS****4.1 Air Particulate and Radioiodine Sample Results**

There were 313 air samples collected and analyzed for gross beta and I-131 during 2018. Air iodine/particulate samples are collected weekly from six air-sampling locations. Air is metered into the sampling unit at an approximate one cubic foot per minute flow rate through a 47-mm air filter (air particulate) and an air iodine cartridge. Both filters are in-line with one another and housed within the same filter holder. An "as found" and "as left" leak test is performed at each station during each sample collection. Weekly samples were sent to Teledyne Brown Engineering Environmental Services for analysis.

Analysis of the airborne particulate sample data, between the five near-site indicator locations and the control location, indicate no difference between indicator and control locations. The average concentration of gross beta activity among all indicator locations was 2.24E-02 pCi/m³ and was 2.21E-02 pCi/m³ for the control location. All I-131 activity results, for both indicator and control locations, were below the minimum detectable activity (MDA). Gamma isotopic analysis is performed quarterly on a quarterly composite of the filter papers. All radionuclides detected (Be-7 and K-40) were naturally occurring radionuclides which are not attributed to plant effluents.

PNP pre-operational environmental study showed naturally occurring gross beta radiation between 0.03 and 3.0 pCi/m³ with a similar trend between stations on-site, in the surrounding community, and control stations. The activity results from 2018 indicate there is no measureable change between pre-operational airborne gross beta activity and present day airborne gross beta activity.

In the absence of plant-related gamma radionuclides, gross beta activity is attributed to naturally occurring radionuclides. The air sample results collected in accordance with the REMP support the conclusions of the effluents monitoring program for 2018. This conclusion is that the surrounding environment is minimally affected by PNP effluents. No REMP air samples from 2018 contained measureable radiological materials attributed to PNP effluents.

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4.2 Thermoluminescent Dosimetry (TLD) Sample Results

PNP reports measured dose as net exposure (subtracting transit reading) normalized to 92 days. TLDs are oriented in an inner ring, outer ring, and control locations. The inner ring consists of 11 TLDs, the outer ring consists of 9 TLDs, and there are 3 control locations. This orientation allows for monitoring of all 9 overland compass sectors surrounding PNP. To assess the effect of direct and shine radiation from PNP to the environment, the inner ring, outer ring, and control TLDs are compared to one another. Additionally, each individual TLD location is compared to a baseline of data which was created from a comprehensive review of data from 2011 through 2016. The high and low values for the baseline are based upon two standard deviations for each data point from 2011 through 2016. Upon receiving a value outside the baseline, additional follow-up investigation is performed to evaluate the cause. During 2018, all TLDs trended normal and no TLDs were outside the baseline. This evaluation identified no noticeable trend that would indicate that the ambient radiation levels are being affected by plant operations. During 2018, there were three instances in deviations from the REMP involving four total TLDs. These instances are discussed in Attachment 1, Table 8. Table 5 shows the consistent trend of average inner ring, outer ring, and control TLDs.

TLD measurements taken as part of PNP pre-operational environmental study used different instrumentation which had difficulty in achieving desired sensitivity and accuracy. A more sensitive type of TLD was implemented in 1971 and the present day TLD device used is the industry standard. TLD data has trended consistently throughout the several most recent independent spent fuel storage installation (ISFSI) loading campaigns which indicates these loading campaigns have had no measureable effect on the environment.

Activity from TLD measurements in the environment is attributed to naturally occurring background radiation and not from PNP direct or shine radiation.

Table 5, Direct Radiation Annual Summary

Year	Inner Ring (mR/Qtr)	Outer Ring (mR/Qtr)	Control Location (mR/Qtr)
2011	9.7	11.4	11.5
2012	9.7	11.9	11.6
2013	9.9	11.6	11.7
2014	9.1	10.9	10.7
2015	9.5	11.2	10.9
2016	9.6	11.3	11.2
2017	9.3	11.2	10.9
2018	9.3	11.1	11.0

Annual Radiological Environmental Operating Report**4.3 Waterborne Sample Results**

During 2018, PNP implemented the REMP in accordance with the ODCM for collection of surface, drinking, and groundwater without any deviations. For all surface, drinking, and groundwater indicator samples, the same control sample is used as a baseline for comparison. That control sample is referred to as the "Ludington Control," and is collected 201 km north of PNP. The Ludington Control sample is analyzed monthly and is a composite of daily samples. The Ludington Control sample is analyzed for gamma radionuclide, tritium, and gross beta activity. In 2018, the only radionuclide activity detected was naturally occurring isotopes (K-40). In 2018, three out of the twelve Ludington Control samples contained detectable gross beta with an average value of 2.64 pCi/L. The gross beta activity is a result of naturally occurring radionuclide (K-40) and is not attributed to PNP effluents.

4.3.1 Surface Water

The indicator surface water samples collected and analyzed for the REMP include "Lake In" water. This sample is Lake Michigan water after it has traveled through the PNP traveling screens. This sample is collected daily and composited into a monthly sample which is analyzed for gamma radionuclides and tritium onsite. This sample is also analyzed by Teledyne Brown Engineering Environmental Services for gamma, tritium, and gross beta activity. During 2018, zero Lake In samples contained detectable tritium. All radionuclides detected (Ra-226) were naturally occurring and are not attributed to PNP effluents. Three out of the twelve monthly samples contained measureable gross beta with the average detectable gross beta activity at 3.01 pCi/L.

PNP pre-operational environmental study established a baseline of gross beta activity for the site before PNP was operational. The study results for surface water showed consistently measurable results for gross beta activity between 11 - 18 (+/- 5) pCi/L.

The surface water sample results collected in accordance with the REMP support the conclusions of the effluents monitoring program for 2018. This conclusion is that the surrounding environment is minimally affected by PNP effluents. No REMP surface water samples from 2018 contained measureable radiological materials attributed to PNP effluents.

4.3.2 Drinking Water

The indicator drinking water samples collected and analyzed for the REMP include "Domestic Water," "South Haven Drinking Water," and "Palisades Park Community Water." Gross beta analysis is not required for these samples, however, gross beta analysis is performed to strengthen the REMP and provide an additional metric used for trending data.

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Domestic water is collected onsite from a potable water system, typically an eyewash station. This sample is collected daily and composited into a monthly sample which is analyzed for gamma radionuclide and tritium onsite. This sample is also analyzed by Teledyne Brown Engineering Environmental Services for gamma, tritium, and gross beta activity. All radionuclides detected (Th-228) were naturally occurring and are not attributed to PNP effluents. There was no detectable tritium in this sample in 2018. Five out of the twelve monthly samples contained measureable gross beta activity with the average detectable gross beta activity at 2.62 pCi/L. The gross beta activity is attributed to naturally occurring radionuclides.

South Haven Drinking Water is collected from the City of South Haven Water Treatment facility located in South Haven. The sample is analyzed monthly for gamma, tritium, and gross beta activity. All radionuclides detected (K-40 and Ra-226) were naturally occurring and are not attributed to PNP effluents. There was no detectable tritium for samples collected in 2018. Six out of the twelve monthly samples contained measureable gross beta with the average detectable gross beta activity at 2.86 pCi/L. The gross beta activity is attributed to naturally occurring radionuclides.

Palisades Park Community Water is collected once per month as a grab sample from a community just south of PNP while the facility is operational (summer months). This sample is analyzed for gamma, tritium, and gross beta activity. All radionuclides detected (K-40 and Th-228) were naturally occurring and are not attributed to PNP effluents. There was no detectable tritium in this sample in 2018. Two out of the six monthly samples contained measureable gross beta activity with the average detectable gross beta activity at 2.99 pCi/L. The gross beta activity is attributed to naturally occurring radionuclides.

PNP pre-operational environmental study established a baseline of gross beta activity for the site before PNP was operational. The study relied upon for a baseline for drinking water analysis results are the same results as with surface water, which is consistent gross beta activity between 11 - 18 (+/- 5) pCi/L.

The drinking water sample results collected in accordance with the REMP support the conclusions of the effluents monitoring program for 2018. This conclusion is that the surrounding environment is minimally affected by PNP effluents. No REMP drinking water samples from 2018 contained measureable radiological materials attributed to PNP effluents.

Annual Radiological Environmental Operating Report**4.3.3 Groundwater**

PNP implements an extensive groundwater monitoring program in accordance with NEI 07-07, "Industry Ground Water Protection Initiative - Final Guidance Document." This program is designed to identify onsite leaks to groundwater to allow for prompt repair or isolation of the leak. The results of the onsite groundwater program are described in the ARERR. PNP samples one offsite groundwater location. This sample is not required by PNP ODCM, but is procedurally implemented to strengthen the program overall. The REMP groundwater sample is the "Palisades Park Commercial Well Water" sample. This sample is collected once per month as a grab sample from a community just south of PNP while the facility is operational (summer months). This sample is analyzed for gamma, tritium, and gross beta activity. All radionuclides detected (K-40) were naturally occurring and are not attributed to PNP effluents. There was no detectable tritium in this sample in 2018. Five out of the six monthly samples contained measureable gross beta with the average detectable gross beta activity at 3.65 pCi/L. The gross beta activity is attributed to naturally occurring radionuclides.

PNP pre-operational environmental study established a baseline of gross beta activity for the site before PNP was operational. The study results were that five well water samples from PNP contained gross beta activity above 5 pCi/L, with the highest value being 16 pCi/L. Two samples from Covert Park well water contained gross beta activity at 6 and 7 pCi/L.

The groundwater sample results collected in accordance with the REMP support the conclusions of the effluents monitoring program for 2018. This conclusion is that the surrounding environment is minimally affected by PNP effluents. No REMP groundwater samples from 2018 contained measureable radiological materials attributed to PNP effluents.

Annual Radiological Environmental Operating Report**4.4 Soil Sample Results**

Sediment samples are collected two times per year north and south of the plant from the beach on Lake Michigan. One sample is collected at the southern edge of the property and a second sample is collected approximately 0.5 miles north of the plant. The sample south of the plant is not required by the ODCM but is collected and analyzed to strengthen the REMP. Both the north and south sediment samples are analyzed for gamma radionuclides. In 2018, the only radionuclides detected were naturally occurring (K-40, Ra-226, Th-228, Th-232) isotopes which are not attributed to PNP effluents. In accordance with the ODCM, no control sample is collected for this sample type.

Soil samples were not specifically part of the PNP pre-operational environmental study however, a study of Cs-137 found in soil (due to historical atomic testing and fallout) was performed by PNP in 2011. Analysis was performed of soil in the surrounding area (Southwest Michigan) which showed Cs-137 concentrations between $1.41\text{E-}08$ uCi/g and $5.68\text{E-}07$ uCi/g with an average of $2.68\text{E-}07$ uCi/g. Considering similar studies performed by other utilities, a conservative (low) background of $1.8\text{E-}07$ uCi/g Cs-137 is assumed to be due to global fallout.

The sediment sample results collected in accordance with the REMP support the conclusions of the effluents monitoring program for 2018. This conclusion is that the surrounding environment is minimally affected by PNP effluents. No REMP sediment samples from 2018 contained measureable radiological materials attributed to PNP effluents.

4.5 Ingestion Sample Results**4.5.1 Milk Sample Results**

Milk samples were not collected during 2018 due to the unavailability of indicator locations within five miles of PNP.

4.5.2 Broad leaf Sample Results

In accordance with PNP ODCM, three different kinds of broad leaf vegetation are sampled from two onsite (indicator) locations and one offsite (control) location due to the fact that milk sampling is not performed. Broad leaf samples are collected once per month during the growing season and analyzed for gamma radionuclides, including iodine-131. Naturally occurring radionuclides detected in broad leaf vegetation (Be-7, K-40, and Th-228) are not attributed to PNP effluents. Cs-137 detected in broad leaf vegetation was attributed to historical global atomic testing, fallout, and biological uptake. Cs-137 was detected at location BV1 (0.4 miles SSE). The average concentration of Cs-137 was 62.6 pCi/kg. It is not abnormal to detect Cs-137 in broad leaf samples. PNP procedurally implements a conservative administrative action value to perform additional reviews if the activity of broad leaf samples exceeds 146 pCi/kg Cs-137.

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Broad leaf sampling is performed due to the lack of milk producing animals near PNP. The pre-operational environmental study consisted in part of Cs-137 and Sr-90 analysis for crops and milk. These samples, along with broad leaf samples, are a result of fallout and biological uptake. The pre-operational study identified Cs-137 in milk samples ranging from 2 to 70 pCi/L and Sr-90 ranging from 5 to 15 pCi/L. For crop samples gross gamma activity was generally between 0.11 and 0.22 pCi/g and gross beta activity was generally between 0.72 to 3.31 pCi/g.

4.5.3 Fish Sample Results

Indicator and Control fish samples are collected and analyzed twice per year. The filet of the fish is analyzed for gamma radionuclide. The indicator fish are collected near PNP lake-out discharge point. At least two species of commercial or recreational importance are collected and analyzed. At least one sample of the same species is collected as a control sample. The control fish are collected 201 km north of PNP near Ludington, MI. In 2018, the only radionuclides detected among all fish samples were naturally occurring radionuclides (K-40 and Ra-226) which were not attributed to PNP effluents.

PNP pre-operational environmental study established a baseline for radiological material in fish. The study established that gross beta activity is generally between 2 and 4 pCi/g and gross gamma activity is generally between 0.04 and 0.4 pCi/g in fish. Cs-137 and Sr-90 were measured in the pre-operational study and were expected to be measured due to known worldwide contamination from historical atomic testing and fallout. Cs-137 detected was generally between 0.10 and 0.25 pCi/g and Sr-90 detected was generally between 0.01 to 0.04 pCi/g in the pre-operational environmental study.

The fish sample results collected in accordance with the REMP support the conclusions of the effluents monitoring program for 2018. This conclusion is that the surrounding environment is minimally affected by PNP effluents. No REMP fish water samples from 2018 contained measureable radiological materials attributed to PNP effluents.

4.5.4 Food Product Sample Results

Two principal fruit crops are collected once per year and analyzed for gamma isotopic and I-131 in accordance with the REMP. The two crops sampled in 2018 were blueberries and apples. The results of all sample analyses show that only naturally occurring radionuclide (K-40) was present. In accordance with the ODCM, no control sample is collected for this sample type.

PNP pre-operational environmental study performed radiological analysis on a variety of crop samples. Gross gamma activity was generally between 0.11 and 0.22 pCi/g and gross beta activity was generally between 0.72 to 3.31 pCi/g.

The fruit sample results collected in accordance with the REMP support the conclusions of the effluents monitoring program for 2018. This conclusion is that the surrounding environment is minimally affected by PNP effluents. No REMP fruit samples from 2018 contained measureable radiological materials attributed to PNP effluents.

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4.6 Land Use Census Results

The 2018 land use census results are tabulated in Table 6. The results of the census yielded no new critical receptors for dose modeling purposes. The results of the land use census did reveal a new goat location from which goat milk could be sampled. Goat milk sampling will be performed as available (seasonally) in 2019.

Table 6, Land Use Census – 2018 Nearest Receptors (units = miles)

Sector	Direction	Residence	Garden	Beef Cattle	Dairy Cow	Goat
2	NNE	1.67	2.52	> 5	> 5	> 5
3	NE	1.14	3.95	> 5	> 5	2.45
4	ENE	1.19	> 5	2.29	> 5	> 5
5	E	1.67	2.46	3.51	> 5	3.26
6	ESE	1.35	2.04	2.04	> 5	> 5
7	SE	0.87	> 5	3.88	> 5	3.88
8	SSE	0.80	0.70	> 5	> 5	> 5
9	S	0.51	> 5	> 5	> 5	> 5
10	SSW	0.48	> 5	> 5	> 5	> 5

4.7 Interlaboratory Comparison Results

Attachment 3 contains a summary for Interlaboratory Comparison program for Teledyne Brown Engineering.

5.0 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM SUMMARY

1. Table 7, Radiological Environmental Monitoring Program Summary, summarizes data for the 2018 REMP program.

Table 7, Radiological Environmental Monitoring Program Summary

Sample Type (Units)	Type / Number of Analyses	LLD ^[Note 1]	Indicator Locations Mean (F) ^[Note 2] [Range]	Location ^[Note 3] [Highest Annual Mean]	Mean (F) ^[Note 2] [Range]	Control Locations Mean (F) ^[Note 2] [Range]	Number of Reportable Occurrences ^[Note 4]
Air (pCi/m³)	Gross Beta / 313	0.01	0.0224 (260 / 260) [0.0134 – 0.0459]	Station A8 (0.595 miles NE)	0.0238 (52/52) [0.0155 - 0.0459]	0.0221 (53 / 53) [0.0109 - 0.0462]	0
	I-131 / 313	0.07	< MDA (0 / 260)	N/A	N/A	< MDA (0 / 53)	0
	Cs-134 / 24	0.05	< MDA (0 / 20)	N/A	N/A	< MDA (0 / 4)	0
	Cs-137 / 24	0.06	< MDA (0 / 20)	N/A	N/A	< MDA (0 / 4)	0
Inner Ring TLDs (mR/Qtr)	Gamma / 55	Sensitivity of 3 mR per vendor	9.29 (43 / 43) [7.73 – 11.15]	Station 1 (onsite 0.213 miles E)	10.63 (4 / 4) [10.28 – 11.15]	11.01 (12/12) [10.18 – 11.82]	0
Outer Ring TLDs (mR/Qtr)	Gamma / 46	Sensitivity of 3 mR per vendor	11.13 (34 / 34) [9.17 – 14.21]	Station 2 (5.560 miles SE)	13.85 (4 / 4) [13.44 - 14.21]	11.01 (12/12) [10.18 – 11.82]	0
Lake Water (pCi/L)	Gross Beta / 24	4.0	3.01 (3 / 12) (2.46 - 4.02)	Lake In (Plant lake intake)	3.01 (3 / 12) (2.46 - 4.02)	2.64 (3 / 12) (2.31 - 3.10)	0
	H-3 / 24	2000	<MDA (0 / 12)	N/A	N/A	<MDA (0 / 12)	0
	Mn-54 / 24	15	<MDA (0 / 12)	N/A	N/A	<MDA (0 / 12)	0
	Fe-59 / 24	30	<MDA (0 / 12)	N/A	N/A	<MDA (0 / 12)	0
	Co-58 / 24	15	<MDA (0 / 12)	N/A	N/A	<MDA (0 / 12)	0
	Co-60 / 24	15	<MDA (0 / 12)	N/A	N/A	<MDA (0 / 12)	0
	Zn-65 / 24	30	<MDA (0 / 12)	N/A	N/A	<MDA (0 / 12)	0
	Zr-95 / 24	15	<MDA (0 / 12)	N/A	N/A	<MDA (0 / 12)	0
	Nb-95 / 24	15	<MDA (0 / 12)	N/A	N/A	<MDA (0 / 12)	0
	Cs-134 / 24	15	<MDA (0 / 12)	N/A	N/A	<MDA (0 / 12)	0
	Cs-137 / 24	18	<MDA (0 / 12)	N/A	N/A	<MDA (0 / 12)	0
	Ba-140 / 24	60	<MDA (0 / 12)	N/A	N/A	<MDA (0 / 12)	0
La-140 / 24	15	<MDA (0 / 12)	N/A	N/A	<MDA (0 / 12)	0	

Table 7, Radiological Environmental Monitoring Program Summary

Sample Type (Units)	Type / Number of Analyses	LLD ^[Note 1]	Indicator Locations Mean (F) ^[Note 2] [Range]	Location ^[Note 3] [Highest Annual Mean]	Mean (F) ^[Note 2] [Range]	Control Locations Mean (F) ^[Note 2] [Range]	Number of Reportable Occurrences ^[Note 4]
Drinking Water (pCi/L)	Gross Beta / 42	4	2.80 (14 / 30) [2.27 – 3.96]	Pal Park Community Water (0.7 miles SSW)	2.99 (2 / 6) [2.57 – 3.40]	2.64 (3 / 12) [2.31 – 3.10]	0
	H-3 / 42	2000	<MDA (0 / 30)	N/A	N/A	<MDA (0 / 12)	0
	Mn-54 / 42	15	<MDA (0 / 30)	N/A	N/A	<MDA (0 / 12)	0
	Fe-59 / 42	30	<MDA (0 / 30)	N/A	N/A	<MDA (0 / 12)	0
	Co-58 / 42	15	<MDA (0 / 30)	N/A	N/A	<MDA (0 / 12)	0
	Co-60 / 42	15	<MDA (0 / 30)	N/A	N/A	<MDA (0 / 12)	0
	Zn-65 / 42	30	<MDA (0 / 30)	N/A	N/A	<MDA (0 / 12)	0
	Zr-95 / 42	15	<MDA (0 / 30)	N/A	N/A	<MDA (0 / 12)	0
	Nb-95 / 42	15	<MDA (0 / 30)	N/A	N/A	<MDA (0 / 12)	0
	Cs-134 / 42	15	<MDA (0 / 30)	N/A	N/A	<MDA (0 / 12)	0
	Cs-137 / 42	18	<MDA (0 / 30)	N/A	N/A	<MDA (0 / 12)	0
	Ba-140 / 42	60	<MDA (0 / 30)	N/A	N/A	<MDA (0 / 12)	0
	La-140 / 42	15	<MDA (0 / 30)	N/A	N/A	<MDA (0 / 12)	0
Fish (pCi/kg)	Mn-54 / 12	130	<MDA (0 / 30)	N/A	N/A	<MDA (0 / 30)	0
	Fe-59 / 12	260	<MDA (0 / 30)	N/A	N/A	<MDA (0 / 30)	0
	Co-58 / 12	130	<MDA (0 / 30)	N/A	N/A	<MDA (0 / 30)	0
	Co-60 / 12	130	<MDA (0 / 30)	N/A	N/A	<MDA (0 / 30)	0
	Zn-65 / 12	260	<MDA (0 / 30)	N/A	N/A	<MDA (0 / 30)	0
	Cs-134 / 12	130	<MDA (0 / 30)	N/A	N/A	<MDA (0 / 30)	0
	Cs-137 / 12	150	<MDA (0 / 30)	N/A	N/A	<MDA (0 / 30)	0

Table 7, Radiological Environmental Monitoring Program Summary

Sample Type (Units)	Type / Number of Analyses	LLD ^[Note 1]	Indicator Locations Mean (F) ^[Note 2] [Range]	Location ^[Note 3] [Highest Annual Mean]	Mean (F) ^[Note 2] [Range]	Control Locations Mean (F) ^[Note 2] [Range]	Number of Reportable Occurrences ^[Note 4]
Food Products (pCi/kg)	I-131 / 2	60	<MDA (0 / 2)	N/A	N/A	Control sample not required	0
	Cs-134 / 2	60	<MDA (0 / 2)	N/A	N/A		0
	Cs-137 / 2	80	<MDA (0 / 2)	N/A	N/A		0
Broad leaf Vegetation (pCi/kg)	I-131 / 15	60	<MDA (0 / 10)	N/A	N/A	<MDA (0 / 5)	0
	Cs-134 / 15	60	<MDA (0 / 10)	N/A	N/A	<MDA (0 / 5)	0
	Cs-137 / 15	80	62.6 (5 / 10) [39.7 – 92.3]	BV1 (onsite 0.4 miles SSE)	62.6 (5 / 5) [39.7 – 92.3]	<MDA (0 / 5)	0
Sediment (pCi/kg)	Cs-134 / 4	150	<MDA (0 / 4)	N/A	N/A	Control sample not required	0
	Cs-137 / 4	180	<MDA (0 / 4)	N/A	N/A		0

Table 7, Radiological Environmental Monitoring Program Summary

Sample Type (Units)	Type / Number of Analyses	LLD ^[Note 1]	Indicator Locations Mean (F) ^[Note 2] [Range]	Location ^[Note 3] [Highest Annual Mean]	Mean (F) ^[Note 2] [Range]	Control Locations Mean (F) ^[Note 2] [Range]	Number of Reportable Occurrences ^[Note 4]
Offsite Groundwater (Pal Park Commercial Well) (pCi/L)	Gross Beta / 18	4	3.65 (5 / 6) [3.17 - 4.38]	Pal Park Commercial Well (0.7 miles SSW)	3.65 (5 / 6) [3.17 - 4.38]	2.64 (3 / 12) [2.31 – 3.10]	0
	H-3 / 18	2000	<MDA (0 / 6)	N/A	N/A	N/A	0
	Mn-54 / 18	15	<MDA (0 / 6)	N/A	N/A	N/A	0
	Fe-59 / 18	30	<MDA (0 / 6)	N/A	N/A	N/A	0
	Co-58 / 18	15	<MDA (0 / 6)	N/A	N/A	N/A	0
	Co-60 / 18	15	<MDA (0 / 6)	N/A	N/A	N/A	0
	Zn-65 / 18	30	<MDA (0 / 6)	N/A	N/A	N/A	0
	Zr-95 / 18	15	<MDA (0 / 6)	N/A	N/A	N/A	0
	Nb-95 / 18	15	<MDA (0 / 6)	N/A	N/A	N/A	0
	Cs-134 / 18	15	<MDA (0 / 6)	N/A	N/A	N/A	0
	Cs-137 / 18	18	<MDA (0 / 6)	N/A	N/A	N/A	0
	Ba-140 / 18	60	<MDA (0 / 6)	N/A	N/A	N/A	0
	La-140 / 18	15	<MDA (0 / 6)	N/A	N/A	N/A	0

LEGEND:

[Note 1] - LLD = Required lower limit of detection based upon PNP Offsite Dose Calculation Manual (ODCM).

[Note 2] - Mean and range based upon detectable measurements only. Fraction of detectable measurements at specified locations is indicated in parenthesis (F).

[Note 3] - Locations are specified (1) by name and (2) compass sector relative to the site.

[Note 4] - A reportable occurrence is a situation in which an NRC report was submitted in accordance with the requirements in the PNP ODCM.

Sample Deviations

Table 8, Sample Deviations Table

Comment No.	Sample Media Affected	Sample Location	Date	Problem	Evaluation / Actions
1	TLD	TLD #6	4/23/18	Equipment Malfunction	The first quarter 2018 TLD #6 was discovered on the ground ~20 yards from where it is typically installed. It appears the TLD was dislodged from its housing and moved by the wind. This TLD location is 5.314 miles from the plant in the NE sector. Upon discovery, a new TLD was installed in the correct location. The TLD discovered on the ground was analyzed and the results were slightly less (lower mR/quarter) than normal. All TLD readings are interpreted to determine the effect of direct and shine from PNP on the environmental. For first quarter 2018 the effect of direct and shine from PNP on the environment was less than measurable.
2	TLD	TLD #18	1/15/19	Equipment Malfunction	During the weekly REMP air sample collection it was noticed that TLD #18 was missing. The immediate area was searched and the TLD could not be located. A new TLD was placed in the location. It is suspected that high wind was a cause for the missing TLD. An action to improve upon the TLD housing was initiated. TLD #18 is located in the SE sector as part of the inner ring TLDs. An evaluation of all 4th quarter 2018 TLD results indicate no direct radiation was measureable from PNP.
3	TLD	TLD #3 TLD #23	1/25/19	Equipment Malfunction	During the fourth quarter TLD collection it was noticed that TLD #3 and TLD #23 were missing. The immediate area was searched and the TLDs could not be located. A new TLD was placed at each location. It is suspected that high wind was a cause for the missing TLDs. An action to improve upon the TLD housing was initiated. Both TLD #3 and TLD #23 are part of the outer ring TLDs. An evaluation of all 4th quarter 2018 TLD results indicate no detectable direct radiation was measureable from PNP.

Annual Radiological Environmental Operating Report

Attachment 2

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Monitoring Results Tables

Table 9, Air Particulate Data Summary Table

Analysis: Gross Beta			Units: pCi/m ³				
Start Date	End Date	Station A4(Indicator)	Station A5 (Indicator)	Station A8 ^[Note 1] (Indicator)	Station A9 (Indicator)	Station A19 (Indicator)	Station A10 ^[Note 2] (Control)
REQUIRED LLD →		1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02
01/02/18	01/08/18	2.86E-02	2.80E-02	2.54E-02	2.34E-02	2.68E-02	2.32E-02
01/08/18	01/15/18	2.64E-02	2.47E-02	2.16E-02	2.62E-02	2.36E-02	1.74E-02
01/15/18	01/22/18	2.44E-02	3.03E-02	3.17E-02	2.58E-02	2.35E-02	3.14E-02
01/22/18	01/29/18	1.85E-02	2.37E-02	1.85E-02	2.17E-02	1.80E-02	2.48E-02
01/29/18	02/05/18	1.82E-02	2.05E-02	1.89E-02	1.93E-02	2.20E-02	1.70E-02
02/05/18	02/12/18	2.55E-02	2.80E-02	2.92E-02	3.04E-02	2.50E-02	2.58E-02
02/12/18	02/20/18	2.55E-02	3.58E-02	2.96E-02	2.66E-02	2.48E-02	1.09E-02
02/20/18	02/26/18	1.73E-02	1.95E-02	2.33E-02	2.11E-02	1.93E-02	1.71E-02
02/26/18	03/05/18	2.63E-02	3.21E-02	3.14E-02	2.67E-02	2.60E-02	2.92E-02
03/05/18	03/12/18	1.51E-02	1.72E-02	1.89E-02	1.34E-02	1.70E-02	1.34E-02
03/12/18	03/19/18	2.30E-02	2.77E-02	2.82E-02	2.72E-02	2.21E-02	2.64E-02
03/19/18	03/26/18	1.77E-02	1.95E-02	1.76E-02	1.76E-02	1.58E-02	1.59E-02
03/26/18	04/02/18	1.91E-02	1.91E-02	2.25E-02	1.83E-02	2.06E-02	1.94E-02
04/02/18	04/09/18	2.10E-02	2.56E-02	2.45E-02	2.11E-02	2.04E-02	2.40E-02
04/09/18	04/16/18	1.98E-02	2.56E-02	1.99E-02	2.32E-02	2.60E-02	1.33E-02
04/16/18	04/23/18	1.61E-02	1.71E-02	2.15E-02	1.46E-02	1.70E-02	1.96E-02
04/23/18	04/30/18	1.99E-02	2.14E-02	2.09E-02	1.83E-02	1.60E-02	1.94E-02
04/30/18	05/07/18	2.19E-02	2.37E-02	2.42E-02	2.05E-02	2.04E-02	2.37E-02
05/07/18	05/14/18	1.81E-02	2.41E-02	2.34E-02	1.67E-02	1.59E-02	2.27E-02
05/14/18	05/21/18	1.89E-02	2.00E-02	2.63E-02	1.87E-02	1.89E-02	1.74E-02
05/21/18	05/29/18	2.14E-02	2.59E-02	2.93E-02	2.26E-02	2.28E-02	2.42E-02
05/29/18	06/04/18	1.76E-02	1.97E-02	1.83E-02	1.84E-02	1.90E-02	1.93E-02
06/04/18	06/11/18	1.57E-02	2.06E-02	1.77E-02	1.85E-02	1.73E-02	1.88E-02
06/11/18	06/18/18	2.05E-02	1.95E-02	2.11E-02	2.10E-02	2.19E-02	2.17E-02
06/18/18	06/25/18	1.40E-02	1.79E-02	2.15E-02	1.55E-02	1.54E-02	1.74E-02
06/25/18	07/02/18	2.58E-02	2.58E-02	2.41E-02	2.22E-02	2.55E-02	2.77E-02
07/02/18	07/09/18	2.16E-02	2.58E-02	2.14E-02	2.07E-02	2.15E-02	2.50E-02
07/09/18	07/16/18	2.50E-02	2.59E-02	2.63E-02	2.44E-02	2.66E-02	2.78E-02
07/16/18	07/23/18	2.06E-02	2.49E-02	1.90E-02	2.27E-02	1.80E-02	2.21E-02
07/23/18	07/30/18	1.76E-02	2.00E-02	1.84E-02	1.90E-02	2.06E-02	2.03E-02
07/30/18	08/07/18	2.71E-02	2.98E-02	2.90E-02	2.80E-02	2.45E-02	3.72E-02
08/07/18	08/13/18	2.81E-02	2.84E-02	3.29E-02	3.10E-02	2.67E-02	2.04E-02
08/13/18	08/20/18	2.11E-02	2.73E-02	2.78E-02	2.75E-02	2.66E-02	3.02E-02
08/20/18	08/27/18	2.49E-02	2.97E-02	2.72E-02	3.19E-02	2.72E-02	2.52E-02
08/27/18	09/03/18	2.02E-02	2.00E-02	1.97E-02	1.78E-02	2.05E-02	1.66E-02
09/03/18	09/10/18	1.86E-02	1.50E-02	1.80E-02	1.64E-02	1.51E-02	1.48E-02
09/10/18	09/17/18	1.99E-02	2.02E-02	2.03E-02	2.04E-02	2.32E-02	2.13E-02
09/17/18	09/24/18	1.61E-02	1.87E-02	1.80E-02	1.63E-02	1.68E-02	1.81E-02

Monitoring Results Tables

Table 10, Air Sample Radioiodine Cartridge Data Table Summary

Analysis: I-131			Units: pCi/m ³				
Start Date	End Date	Station A4(Indicator)	Station A5 (Indicator)	Station A8 (Indicator)	Station A9 (Indicator)	Station A19 (Indicator)	Station A10 ^[Note 1] (Control)
12/17/18	12/25/18	< MDA	< MDA	< MDA	< MDA	< MDA	< MDA
12/25/18	12/31/18	< MDA	< MDA	< MDA	< MDA	< MDA	< MDA
12/27/18	01/02/19	NA ^[Note 2]	NA ^[Note 2]	NA ^[Note 2]	NA ^[Note 2]	NA ^[Note 2]	< MDA

[Note 1] – The sample date range for the last three samples for A10 is from 12/17/18 - 12/21/18, 12/21/18 - 12/27/18, and 12/27/18 - 01/02/19.

[Note 2] - There is no sample result for the indicator stations from 12/27/18 - 01/02/19 because the date ranges ended on 12/31/18 for these samples. Note 1 described the date ranges for the last three Station A10 samples.

Table 11, Air Sample Gamma Isotopic

Analysis: Gamma Isotopic			Units: pCi/m ³			
Location	Start Date	End Date	Cs-134	Cs-137	K-40 ^[Note 1]	Be-7 ^[Note 1]
REQUIRED LLD →			0.05	0.06	NA	NA
Station A4	1/2/18	4/2/18	<MDA	<MDA	<MDA	0.103
Station A4	4/2/18	7/2/18	<MDA	<MDA	<MDA	<MDA
Station A4	7/2/18	10/2/18	<MDA	<MDA	<MDA	<MDA
Station A4	10/2/18	12/31/18	<MDA	<MDA	<MDA	0.0995
Station A5	1/2/18	4/2/18	<MDA	<MDA	0.0297	0.0939
Station A5	4/2/18	7/2/18	<MDA	<MDA	<MDA	<MDA
Station A5	7/2/18	10/2/18	<MDA	<MDA	<MDA	0.176
Station A5	10/2/18	12/31/18	<MDA	<MDA	<MDA	0.0710
Station A8	1/2/18	4/2/18	<MDA	<MDA	<MDA	0.144
Station A8	4/2/18	7/2/18	<MDA	<MDA	<MDA	<MDA
Station A8	7/2/18	10/2/18	<MDA	<MDA	0.0330	<MDA
Station A8	10/2/18	12/31/18	<MDA	<MDA	<MDA	0.0989
Station A9	1/2/18	4/2/18	<MDA	<MDA	<MDA	0.118
Station A9	4/2/18	7/2/18	<MDA	<MDA	0.0156	<MDA
Station A9	7/2/18	10/2/18	<MDA	<MDA	<MDA	0.182
Station A9	10/2/18	12/31/18	<MDA	<MDA	<MDA	0.0642
Station A19	1/2/18	4/2/18	<MDA	<MDA	<MDA	<MDA
Station A19	4/2/18	7/2/18	<MDA	<MDA	<MDA	<MDA
Station A19	7/2/18	10/2/18	<MDA	<MDA	<MDA	<MDA
Station A19	10/2/18	12/31/18	<MDA	<MDA	0.0230	<MDA
Station A10	1/2/18	4/2/18	<MDA	<MDA	<MDA	0.121
Station A10	4/2/18	7/2/18	<MDA	<MDA	<MDA	0.207
Station A10	7/2/18	10/1/18	<MDA	<MDA	<MDA	<MDA
Station A10	10/2/18	12/27/18	<MDA	<MDA	<MDA	0.0934

[Note 1] - This nuclide is naturally occurring and there is no ODCM required LLD.

Monitoring Results Tables

Table 12, Thermoluminescent Dosimeters – Inner Ring

Analysis: Gamma Dose				Units: mR	
Station	1 st Qtr 2018	2 nd Qtr 2018	3 rd Qtr 2018	4 th Qtr 2018	Annual Mean
1 ^[Note 1]	10.50	11.15	10.28	10.59	10.63
8	9.68	10.22	10.28	10.07	10.06
13	9.53	9.49	9.05	8.87	9.24
14	8.23	7.99	7.99	7.73	7.99
15	9.14	9.37	8.44	8.78	8.93
16	9.33	9.54	8.72	9.08	9.17
17	8.63	8.93	8.34	8.42	8.58
18	9.52	9.60	9.56	NA ^[Note 2]	9.56
19	9.09	9.41	9.27	9.20	9.24
20	9.45	9.75	9.30	9.22	9.43
21	9.58	9.59	9.34	9.28	9.45

[Note 1] - Station with the highest annual mean

[Note 2] - Reference Attachment 1, Sample Deviations, Table 8, Sample Deviations Table

Monitoring Results Tables

Table 13, Thermoluminescent Dosimeters – Outer Ring

Analysis: Gamma Dose			Units: mR		
Station	1 st Qtr 2018	2 nd Qtr 2018	3 rd Qtr 2018	4 th Qtr 2018	Annual Mean
2 ^[Note 1]	13.44	14.21	14.01	13.74	13.85
3	10.74	10.42	10.71	NA ^[Note 2]	10.62
4	11.93	12.19	11.92	11.53	11.89
5	10.93	11.26	10.97	10.92	11.02
6	9.96 ^[Note 2]	10.42	9.95	10.49	10.21
7	9.34	9.74	9.17	9.48	9.43
9	10.39	10.41	10.23	9.97	10.25
23	11.92	11.15	11.07	NA ^[Note 2]	11.38
24	11.54	11.31	11.42	11.60	11.47

[Note 1] – Station with highest annual mean.

[Note 2] - Reference Attachment 1, Sample Deviations, Table 8, Sample Deviations Table

Table 14, Thermoluminescent Dosimeters – Control

Analysis: Gamma Dose			Units: mR		
Station	1 st Qtr 2018	2 nd Qtr 2018	3 rd Qtr 2018	4 th Qtr 2018	Annual Mean
10	10.18	10.29	10.29	10.61	10.34
11	11.58	11.82	11.55	11.79	11.69
12	10.80	11.38	10.31	11.54	11.01

Monitoring Results Tables

Table 15, Surface Water – Gamma Isotopic

Analysis: Gamma Isotopic							Units: pCi/L								
Location	Start Date	End Date	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Nb-95	Zr-95	Cs-134	Cs-137	Ba-140	La-140	Ra-226	K-40
Ludington (Control)	08/01/18	09/01/18	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	27.5
Ludington (Control)	09/01/18	10/01/18	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Ludington (Control)	10/01/18	11/01/18	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Ludington (Control)	11/01/18	12/01/18	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Ludington (Control)	12/01/18	01/01/19	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	36.2

[Note 1] - This nuclide is naturally occurring and there is no ODCM required LLD.

Monitoring Results Tables

Table 16, Surface Water – Tritium and Gross Beta

Analysis: Tritium and Gross Beta			Units: pCi/L	
Location	Start Date	End Date	H-3	Gross Beta
<u>REQUIRED LLD →</u>			2000	4.00
Lake In (Indicator)	01/01/18	02/01/18	<MDA	<MDA
Lake In (Indicator)	02/01/18	03/01/18	<MDA	<MDA
Lake In (Indicator)	03/01/18	04/01/18	<MDA	<MDA
Lake In (Indicator)	04/01/18	05/01/18	<MDA	<MDA
Lake In (Indicator)	05/01/18	06/01/18	<MDA	<MDA
Lake In (Indicator)	06/01/18	07/01/18	<MDA	4.02
Lake In (Indicator)	07/01/18	08/01/18	<MDA	<MDA
Lake In (Indicator)	08/01/18	09/01/18	<MDA	<MDA
Lake In (Indicator)	09/01/18	10/01/18	<MDA	2.54
Lake In (Indicator)	10/01/18	11/01/18	<MDA	<MDA
Lake In (Indicator)	11/01/18	12/01/18	<MDA	2.46
Ludington (Control)	01/01/18	02/01/18	<MDA	<MDA
Ludington (Control)	02/01/18	03/01/18	<MDA	<MDA

Monitoring Results Tables

Table 16, Surface Water – Tritium and Gross Beta

Analysis: Tritium and Gross Beta			Units: pCi/L	
Location	Start Date	End Date	H-3	Gross Beta
Ludington (Control)	03/01/18	04/01/18	<MDA	<MDA
Ludington (Control)	04/01/18	05/01/18	<MDA	<MDA
Ludington (Control)	05/01/18	06/01/18	<MDA	<MDA
Ludington (Control)	06/01/18	07/01/18	<MDA	2.50
Ludington (Control)	07/01/18	08/01/18	<MDA	<MDA
Ludington (Control)	08/01/18	09/01/18	<MDA	<MDA
Ludington (Control)	09/01/18	10/01/18	<MDA	3.10
Ludington (Control)	10/01/18	11/01/18	<MDA	2.31
Ludington (Control)	11/01/18	12/01/18	<MDA	<MDA
Ludington (Control)	12/01/18	01/01/19	<MDA	<MDA

Monitoring Results Tables

Table 17, Drinking Water – Gamma Isotopic

Analysis: Gamma Isotopic								Units: pCi/L								
Location	Start Date	End Date	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Nb-95	Zr-95	Cs-134	Cs-137	Ba-140	La-140	K-40	Th-228	Ra-226
<u>REQUIRED LLD</u> →			15	15	30	15	30	15	15	15	18	60	15	NA <small>[Note 2]</small>	NA <small>[Note 2]</small>	NA <small>[Note 2]</small>
South Haven	10/01/18	11/01/18	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	46.7
South Haven	11/01/18	12/01/18	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
South Haven	12/01/18	01/01/19	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA

[Note 1] - This is a grab sample and therefore there is no "end date".

[Note 2] - This nuclide is naturally occurring and there is no ODCM required LLD.

Table 18, Drinking Water – Tritium and Gross Beta

Analysis: H-3			Units: pCi/L	
Location	Start Date	End Date	H-3	Gross Beta
<u>REQUIRED LLD</u> →			2000	4.00
Domestic Water	01/01/18	02/01/18	<MDA	<MDA
Domestic Water	02/01/18	03/01/18	<MDA	<MDA
Domestic Water	03/01/18	04/01/18	<MDA	<MDA

Monitoring Results Tables

Table 18, Drinking Water – Tritium and Gross Beta

Analysis: H-3			Units: pCi/L	
Location	Start Date	End Date	H-3	Gross Beta
Domestic Water	04/01/18	05/01/18	<MDA	<MDA
Domestic Water	05/01/18	06/01/18	<MDA	2.70
Domestic Water	06/01/18	07/01/18	<MDA	3.28
Domestic Water	07/01/18	08/01/18	<MDA	<MDA
Domestic Water	08/01/18	09/01/18	<MDA	<MDA
Domestic Water	09/01/18	10/01/18	<MDA	2.27
Domestic Water	10/01/18	11/01/18	<MDA	<MDA
Domestic Water	11/01/18	12/01/18	<MDA	2.33
Domestic Water	12/01/18	01/01/19	<MDA	2.52
Pal Park Community	05/14/18	NA ^[Note 1]	<MDA	<MDA
Pal Park Community	06/15/18	NA ^[Note 1]	<MDA	<MDA
Pal Park Community	07/18/18	NA ^[Note 1]	<MDA	<MDA
Pal Park Community	08/20/18	NA ^[Note 1]	<MDA	<MDA
Pal Park Community	09/24/18	NA ^[Note 1]	<MDA	3.40
Pal Park Community	10/11/18	NA ^[Note 1]	<MDA	2.57
South Haven	01/01/18	02/01/18	<MDA	<MDA

Monitoring Results Tables

Table 18, Drinking Water – Tritium and Gross Beta

Analysis: H-3			Units: pCi/L	
Location	Start Date	End Date	H-3	Gross Beta
South Haven	02/01/18	03/01/18	<MDA	<MDA
South Haven	03/01/18	04/01/18	<MDA	<MDA
South Haven	04/01/18	05/01/18	<MDA	<MDA
South Haven	05/01/18	06/01/18	<MDA	2.40
South Haven	06/01/18	07/01/18	<MDA	2.54
South Haven	07/01/18	08/01/18	<MDA	<MDA
South Haven	08/01/18	09/01/18	<MDA	<MDA
South Haven	09/01/18	10/01/18	<MDA	3.96
South Haven	10/01/18	11/01/18	<MDA	2.69
South Haven	11/01/18	12/01/18	<MDA	3.00
South Haven	12/01/18	01/01/19	<MDA	<MDA

Monitoring Results Tables

Table 19, Sediment

Analysis: Gamma Isotopic		Units: pCi/kg					
Location	Collection Date	Cs-134	Cs-137	K-40	Ra-226	Th-228	Th-232
<u>REQUIRED LLD →</u>		150	180	NA <small>[Note 1]</small>	NA <small>[Note 1]</small>	NA <small>[Note 1]</small>	NA <small>[Note 1]</small>
North Sediment	06/15/18	<MDA	<MDA	4590	1240	143	<MDA
North Sediment	10/11/18	<MDA	<MDA	3550	<MDA	369	<MDA
South Sediment	06/15/18	<MDA	<MDA	2840	1420	325	472
South Sediment	10/11/18	<MDA	<MDA	3370	<MDA	115	<MDA

[Note 1] - This nuclide is naturally occurring and there is no ODCM required LLD.

Table 20, Fish

Analysis: Gamma Isotopic				Units: pCi/kg						
Location / species	Collection Date	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Cs-134	Cs-137	K-40	Ra-226
<u>REQUIRED LLD →</u>		130	130	260	130	260	130	150	NA <small>[Note 1]</small>	NA <small>[Note 1]</small>
PNP / Carp	05/09/18	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	2670	1630
PNP / Carp	09/18/18	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	2960	<MDA
PNP / Drum	05/16/18	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	2790	<MDA
PNP / Gizzard Shad	05/16/18	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	3790	<MDA

Monitoring Results Tables

Table 20, Fish

Analysis: Gamma Isotopic				Units: pCi/kg						
Location / species	Collection Date	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Cs-134	Cs-137	K-40	Ra-226
PNP / Redhorse Sucker	09/05/18	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	3970	<MDA
PNP / Smallmouth Bass	09/18/18	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	3390	<MDA
Ludington / Carp	05/14/18	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	3110	<MDA
Ludington / Drum	05/28/18	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	3220	<MDA
Ludington / Drum	09/14/18	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	2880	<MDA
Ludington / Redhorse Sucker	09/13/18	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	3090	<MDA
Ludington / Trout	05/14/18	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	3350	<MDA
Ludington / Trout	09/22/18	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	2660	<MDA

[Note 1] - This nuclide is naturally occurring and there is no ODCM required LLD.

Monitoring Results Tables

Table 22, Groundwater - Gamma and Iodine

Analysis: Gamma Isotopic							Units: pCi/L						
Location	Collection Date	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Nb-95	Zr-95	Cs-134	Cs-137	Ba-140	La-140	K-40
<u>REQUIRED LLD →</u>		15	15	30	15	30	15	15	15	18	60	15	NA <small>[Note 1]</small>
Pal Park Commercial Well	07/18/18	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Pal Park Commercial Well	08/20/18	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Pal Park Commercial Well	09/24/18	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Pal Park Commercial Well	10/11/18	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA

[Note 1] - This nuclide is naturally occurring and there is no ODCM required LLD.

Monitoring Results Tables

Table 23, Groundwater – Tritium and Gross Beta Activity

Analysis: H-3	Units: pCi/L		
Location	Collection Date	H-3	Gross Beta
<u>REQUIRED LLD</u> →		2000	4.00
Pal Park Commercial Well	05/14/18	<MDA	3.17
Pal Park Commercial Well	06/15/18	<MDA	3.25
Pal Park Commercial Well	07/18/18	<MDA	4.22
Pal Park Commercial Well	08/20/18	<MDA	4.38
Pal Park Commercial Well	09/24/18	<MDA	<MDA
Pal Park Commercial Well	10/11/18	<MDA	3.21

Monitoring Results Tables

Table 24, Broad Leaf Vegetation

Analysis: I-131, Gamma Isotopic		Units: pCi/kg						
Location	Collection Date	I-131	Cs-134	Cs-137	K-40	Be-7	K-40	Th-228
<u>REQUIRED LLD →</u>		60	60	80	NA [Note 1]	NA [Note 1]	NA [Note 1]	NA [Note 1]
Location BV1, 0.4 miles SSE	05/29/18	<MDA	<MDA	92.3	1260	1240	2360	55.0
Location BV1, 0.4 miles SSE	06/25/18	<MDA	<MDA	46.4	836	3860	1740	<MDA
Location BV1, 0.4 miles SSE	07/25/18	<MDA	<MDA	72.6	<MDA	3410	1610	<MDA
Location BV1, 0.4 miles SSE	08/24/18	<MDA	<MDA	62.1	<MDA	3230	2040	<MDA
Location BV1, 0.4 miles SSE	09/24/18	<MDA	<MDA	39.7	<MDA	5000	2130	<MDA
Location BV2, 0.7 miles SSE	05/29/18	<MDA	<MDA	<MDA	<MDA	634	4010	<MDA
Location BV2, 0.7 miles SSE	06/25/18	<MDA	<MDA	<MDA	<MDA	1530	2430	<MDA
Location BV2, 0.7 miles SSE	07/25/18	<MDA	<MDA	<MDA	<MDA	1570	2920	<MDA
Location BV2, 0.7 miles SSE	08/24/18	<MDA	<MDA	<MDA	<MDA	832	2900	<MDA

Monitoring Results Tables

Table 24, Broad Leaf Vegetation

Analysis: I-131, Gamma Isotopic		Units: pCi/kg						
Location	Collection Date	I-131	Cs-134	Cs-137	K-40	Be-7	K-40	Th-228
Location BV2, 0.7 miles SSE	09/24/18	<MDA	<MDA	<MDA	<MDA	1700	2660	<MDA
Location BVC, 13.6 miles SSE	05/29/18	<MDA	<MDA	<MDA	<MDA	1390	3820	<MDA
Location BVC, 13.6 miles SSE	06/25/18	<MDA	<MDA	<MDA	<MDA	1320	2910	51.1
Location BVC, 13.6 miles SSE	07/25/18	<MDA	<MDA	<MDA	<MDA	1330	2900	<MDA
Location BVC, 13.6 miles SSE	08/24/18	<MDA	<MDA	<MDA	<MDA	2230	3160	<MDA
Location BVC, 13.6 miles SSE	09/24/18	<MDA	<MDA	<MDA	<MDA	1810	4170	<MDA

[Note 1] - This nuclide is naturally occurring and there is no ODCM required LLD.

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Interlaboratory Comparison Program Results

1.0 Summary

Summary of Results – Inter-laboratory Comparison Program (ICP)

The Teledyne Brown Engineering (TBE) Laboratory analyzed Performance Evaluation (PE) samples of air particulate, air iodine, milk, soil, vegetation, and water matrices for various analytes. The PE samples supplied by Analytics Inc., Environmental Resource Associates (ERA) and Department of Energy (DOE) Mixed Analyte Performance Evaluation Program (MAPEP), were evaluated against the following pre-set acceptance criteria:

A. Analytics Evaluation Criteria

Analytics evaluation report provides a ratio of TBE's result and Analytics known value. Since flag values are not assigned by Analytics, TBE evaluates the reported ratios based on internal Quality Control (QC) requirements based on the DOE MAPEP criteria.

B. ERA Evaluation Criteria

ERA's evaluation report provides an acceptance range for control and warning limits with associated flag values. ERA's acceptance limits are established per the United States Environmental Protection Agency (USEPA), National Environmental Laboratory Accreditation Conference (NELAC), state-specific Performance Testing (PT) program requirements or ERA's Standard Operating Procedure (SOP) for the Generation of Performance Acceptance Limits, as applicable. The acceptance limits are either determined by a regression equation specific to each analyte or a fixed percentage limit promulgated under the appropriate regulatory document.

C. DOE Evaluation Criteria

MAPEP's evaluation report provides an acceptance range with associated flag values. MAPEP defines three levels of performance:

- Acceptable (flag = "A") - result within $\pm 20\%$ of the reference value
- Acceptable with Warning (flag = "W") - result falls in the $\pm 20\%$ to $\pm 30\%$ of the reference value
- Not Acceptable (flag = "N") - bias is greater than 30% of the reference value

Note: The Department of Energy (DOE) Mixed Analyte Performance Evaluation Program (MAPEP) samples are created to mimic conditions found at DOE sites which do not resemble typical environmental samples obtained at commercial nuclear power facilities.

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Interlaboratory Comparison Program Results

For the TBE laboratory, 166 out of 172 analyses performed met the specified acceptance criteria. Six analyses did not meet the specified acceptance criteria for the following reasons and were addressed through the TBE Corrective Action Program.

1. TBE was unable to report the February 2018 DOE MAPEP vegetation Sr-90 result due to QC failure and limited sample amount. (NCR 18-09)
2. The Analytics September 2018 milk Fe-59 result was evaluated as *Not Acceptable* (Ratio of TBE to known result at 133%). The reported value was 158 ± 17.6 pCi/L and the known value was 119 ± 19.9 pCi/L. No cause for the failure could be determined. TBE has passed 24 of the previous 27 milk cross-check results since 2012. This sample was run in duplicate on a different detector with comparable results (162 ± 16 pCi/L). *NOTE: TBE's 4th Qtr result passed at 105%* (NCR 18-20)
3. The Analytics September milk I-131 result was evaluated as *Not Acceptable* (Ratio of TBE to known result at 143%). Due to a personnel change in the gamma prep lab, the sample was not prepped/counted in a timely manner such as to accommodate the I-131 8-day half-life. Analysts have been made aware of the urgency for this analysis and it will be monitored more closely by QA. *NOTE: TBE's 4th Qtr result passed at 101%* (NCR 18-24)
4. The Analytics September soil Cr-51 result was evaluated as *Not Acceptable* (Ratio of TBE to known result at 131%). As with #3 above, the sample was not prepped/counted in a timely manner such as to accommodate the Cr-51 27-day half-life. The same corrective action applies here as in #3. (NCR 18-21)
5. The MAPEP November vegetation Sr-90 result of 0.338 Becquerel/sample was evaluated as *Not Acceptable* (Lower acceptable range was 0.554 Bq/sample). It appears that there has been incomplete dissolution of Sr-90 due to the composition of the MAPEP vegetation "matrix." To resolve this issue, the TBE-2018 procedure has been modified to add H₂O₂ to assist in breaking down the organic material that comprises this "matrix." This corrective action will be monitored closely by QA. (NCR 18-25).

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Attachment 3

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Interlaboratory Comparison Program Results

6. The Environmental Resource Associates (ERA) November 2018 water Sr-90 sample was evaluated as *Not Acceptable*. TBE's initial reported result of 36.8 pCi/L exceeded the upper acceptance range (22.9 – 36.4 pCi/L). After reviewing the data for this sample, it was discovered that there was a typographical error at the time the results were entered at the ERA website. The correct result in Laboratory Information Management System (LIMS) of 36.2 should have been submitted instead. This result is within ERA's acceptance limits. In addition to the typo error, ERA's very stringent upper acceptance limit of 116% is not a reflection of TBE's ability to successfully perform this analysis. (NCR 18-23)

The Inter-Laboratory Comparison Program provides evidence of "in control" counting systems and methods, and demonstrates that the laboratories are producing accurate and reliable data.

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Attachment 4

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Previous AREOR ERRATA

The 2017 PNP AREOR contained one section which should have been elaborated upon. As part of this report, a change to the 2017 report is being issued in the ERRATA section. The change to the 2017 report is that the statement, "All detectable radionuclide in 2017 REMP water were naturally occurring isotopes which are not attributed to PNP effluents" is being added to Section III, page 5 of 14. This change is on the following page of this report. The change is noted by a vertical revision bar in the margin. The change is considered a "small error" following the Regulatory Guide 1.21, Revision 2 guidance in that the "error" does not "impede the NRC's ability to adequately assess the information by the licensee or... alter the intent of the report." In the 2017 report, the acronyms "PNP" is Palisades Nuclear Plant and "MDC" is minimum detectable concentration.

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Previous AREOR ERRATA

Gross beta activity was detected in 8 of the 12 Ludington (Control) samples. The average gross beta concentration in these samples was 3.09 pCi/L.

Out of the 20 samples which had detectable gross beta activity, 3 of those samples' activity was greater than 2 sigma above the MDC. All 3 of those samples were Ludington (Control) samples. No statistical difference was found between the indicator and control location samples and no PNP ODCM, reporting limits were exceeded.

All detectable radionuclides in 2017 REMP water were naturally occurring isotopes which are not attributed to PNP effluents.

D. Milk

There are no dairy farms meeting the sampling criteria of being within eight kilometers (km) of PNP. Because of a lack of dairy farms, PNP analyzes broad leaf vegetation samples as a substitute for milk sampling.

E. Thermoluminescent Dosimeters (TLDs) - Gamma Dose

Environmental gamma doses are measured quarterly by placement of TLDs at designated locations. Sensitivity for the TLDs is 3 mrem, with a linear response of 1 mrem to 50 rem.

The PNP direct radiation monitoring program consists of TLDs placed at 23 locations. There are ten inner ring TLDs, one on-site TLD, nine outer ring TLDs, and three control TLDs located in Grand Rapids, Kalamazoo and Dowagiac, MI. TLDs are collected and sent to an offsite vendor quarterly for analysis. All environmental TLDs were collected and analyzed during 2017 with no deviations from the sampling program. The on-site TLD is included with the inner ring (site boundary) TLDs for evaluating any dose effect that could be attributed to PNP operations.

The TLD data evaluations were performed by comparing the inner ring TLDs and the outer ring TLDs against the control TLDs.

The quarterly average gamma readings in mrem were:

Inner Ring = 9.3 mrem
Outer Ring = 11.1 mrem
Control = 10.9 mrem

The highest average quarterly reading was observed at outer ring location number 2 with an average value of 14.1 mrem and a maximum reading of 14.6 mrem. This location is historically the highest among the outer ring