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U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

Subject: Annual Radiological Environmental Operating Report -2018
Waterford Steam Electric Station, Unit 3 (Waterford 3)
Docket No. 50-382
License No. NPF-38

Attached is the Annual Radiological Environmental Operating Report for the period of January 1 through December 31, 2018. This report is submitted pursuant to the Requirements of Waterford 3 Technical Specification Section 6.9.1.7.

This report contains no new commitments. Please contact Paul Wood, Regulatory Assurance Manager, at (504) 464-3786 if you have questions regarding this information.

Respectfully,

A handwritten signature in black ink, appearing to read "P. Wood".

PW/llb

Attachment: Annual Radiological Environmental Operating Report – 2018

cc: NRC Region IV Regional Administrator
NRC Senior Resident Inspector – Waterford Steam Electric Station Unit
NRC Project Manager
Entergy Legal, General Sr Council

Attachment to

W3F1-2019-0028

Annual Radiological Environmental Operating Report - 2018

(52 pages)



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Docket Number: 50-382	
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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 presents data obtained through analyses of environmental samples collected for Waterford 3 Radiological Environmental Monitoring Program (REMP) for the period January 1 through December 31, 2018. This report fulfills the requirements of Waterford 3 Technical Specification 6.9.1.7.

All required lower limit of detection (LLD) capabilities were achieved in all sample analyses during 2018, as required by Waterford 3's Technical Requirements Manual (TRM) Table 3.12-2. No measurable levels of radiation above baseline levels attributable to Waterford 3's operation were detected in the vicinity of Waterford 3. The 2018 Radiological Environmental Monitoring Program thus substantiated the adequacy of source control and effluent monitoring at Waterford 3 with no observed impact of plant operations on the environment.

Waterford 3 established the REMP prior to the station becoming operational 1985 to provide data on background radiation and radioactivity normally present in the area. Waterford 3 has continued to monitor the environment by sampling air, water, sediment, fish and broad leaf, as well as measuring direct radiation. Waterford 3 also samples milk if milk-producing animals used for human consumption are present within five miles (8 km) of the plant.

The REMP includes sampling indicator and control locations within an approximate 31-mile radius of the plant. The REMP utilizes indicator locations near the site to show any increases or buildup of radioactivity that might occur due to station operation and control locations farther away from the site to indicate the presence of only naturally occurring radioactivity. Waterford 3 personnel compare indicator results with control and preoperational results to assess any impact Waterford 3 operation might have had on the surrounding environment.

In 2018, environmental samples were collected for radiological analysis. The results of indicator locations were compared with control locations and previous studies. It was concluded that no significant relationship exists between Waterford 3 operation and effect on the area around the plant. The review of 2018 data showed radioactivity levels in the environment were undetectable in many locations and near background levels in significant pathways.

1.2 Reporting Levels

Waterford 3's review indicates that no samples equaled or exceeded reporting levels for radioactivity concentration in environmental samples, as outlined in Technical Requirements Manual (TRM) Table 3.12 2 when averaged over any calendar quarter, due to Waterford 3 effluents. Therefore, 2018 results did not trigger any radiological monitoring program special reports.

Annual Radiological Environmental Operating Report**1.3 Comparison to State Program**

Waterford 3 personnel compared REMP data to state monitoring programs as results became available. Historically, the programs used for comparison have included the U.S. Nuclear Regulatory Commission (NRC) Thermoluminescent Dosimeter (TLD) Direct Radiation Monitoring Network and the Environmental Radiological Laboratory – Department of Environmental Quality Laboratory Services Division (ERL-DEQLSD).

The NRC TLD Network Program was discontinued in 1998. Historically these results have compared to those from the Waterford 3 REMP. Waterford 3's TLD results continue to remain similar to the historical average and continue to verify that plant operation is not affecting the ambient radiation levels in the environment.

The ERL-DEQLSD and the Waterford 3 REMP entail similar radiological environmental monitoring program requirements. These programs include collecting air samples and splitting or sharing sample media such as water, sediment and fish. Both programs have obtained similar results over previous years.

1.4 Sample Deviations

During 2018, environmental sampling was performed for nine media types addressed in the ODCM and for direct radiation. A total of 466 samples of the 475 scheduled were obtained. Of the scheduled samples, 98% were collected and analyzed in accordance with the requirements specified in the ODCM. Attachment 1 contains the listing of sample deviations and actions taken.

1.5 Program Modifications

There were no program modifications during the reporting period.

2.0 INTRODUCTION**2.1 Radiological Environmental Monitoring Program**

Waterford 3 established the REMP to ensure that plant operating controls properly function to minimize any associated radiation endangerment to human health or the environment. The REMP is designed for:

Analyzing applicable pathways for anticipated types and quantities of radionuclides released into the environment.

- Considering the possibility of a buildup of long-lived radionuclides in the environment and identifying physical and biological accumulations that may contribute to human exposures.
- Considering the potential radiation exposure to plant and animal life in the environment surrounding Waterford 3.
- Correlating levels of radiation and radioactivity in the environment with radioactive releases from station operation.

Annual Radiological Environmental Operating Report**2.2 Pathways Monitored**

The airborne, direct radiation, waterborne and ingestion pathways are monitored as required by Waterford 3 TRM Table 3.12-1. A description of the REMP utilized to monitor the exposure pathways is described in the attached Tables and Figures.

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

2.3 Land Use Census

Waterford 3 conducts a land use census biennially, as required by Section 3.12.2 of the TRM. The purpose of this census is to identify changes in uses of land within five miles of Waterford 3 that would require modifications to the REMP and the Offsite Dose Calculation Manual (ODCM/TRM). The most important criteria during this census are to determine the location in each sector of the nearest:

- 1) Residence
- 2) Animal milked for human consumption
- 3) Garden of greater than 50 m² (500 ft²) producing broad leaf vegetation.

Waterford 3 conducts the land use census by:

- Field surveys in each meteorological sector out to five miles in order to confirm:
 - Nearest permanent residence
 - Nearest garden and approximate size
 - Nearest beef cow
 - Nearest food product
 - Nearest milking animal
- Identifying locations on maps, measuring distances to Waterford 3 and recording results on data sheets.
- Comparing current census results to previous results.

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>Three samples from close to the three SITE BOUNDARY locations, in different sectors, of the highest calculated annual average ground level D/Q.</p>	<ul style="list-style-type: none"> • APQ-1 (NW, 0.81 Miles) – (West bank) Located in soybean/sugarcane field off LA 18 east of LA 18/3141 intersection. • APF-1 (ESE, 0.35 Miles) – (West bank) Located on north side of Secondary Meteorological Tower. • APC-1 (NE, 0.67 Miles) – (East bank) Located inside Little Gypsy Cooling Water Intake Structure fence. 	<p>Continuous sampler operation with sample collection biweekly, or more frequently if required by dust loading.</p>	<ul style="list-style-type: none"> • Radioiodine Canisters – I-131 analysis biweekly. • Air Particulate – Gross beta radioactivity analysis following filter change. Gamma isotopic analysis of composite (by location) quarterly.
<p><u>RADIOIODINE AND PARTICULATES</u></p> <p>One sample from the vicinity of a community having the highest calculated annual average ground level D/Q.</p>	<ul style="list-style-type: none"> • APP-1 (WNW, 0.84 Miles) – (West bank) Located in soybean/sugarcane field on Short St. in Killona. 	<p>Continuous sampler operation with sample collection biweekly, or more frequently if required by dust loading.</p>	<ul style="list-style-type: none"> • Radioiodine Canisters – I-131 analysis biweekly. • Air Particulate – Gross beta radioactivity analysis following filter change. Gamma isotopic analysis of composite (by location) quarterly.
<p><u>RADIOIODINE AND PARTICULATES</u></p> <p>One sample from a control location, as for example 15 - 30 km distance and in the least prevalent wind direction.</p>	<ul style="list-style-type: none"> • APE-26 (E, 25.8 Miles) – (West bank) Located at Entergy office on Virgil Street in Gretna. (Control) 	<p>Continuous sampler operation with sample collection biweekly, or more frequently if required by dust loading.</p>	<ul style="list-style-type: none"> • Radioiodine Canisters – I-131 analysis biweekly. • Air Particulate – Gross beta radioactivity analysis following filter change. Gamma isotopic analysis of composite (by location) quarterly.

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> An inner ring of stations, one in each meteorological sector in the general area of the SITE BOUNDARY.</p>	<ul style="list-style-type: none"> • A-2 (N, 1.27 Miles) – (East bank) Located on pole on LA 628 at Zephrin L. Perriloux Fire House. • B-1 (NNE, 0.75 Miles) – (East bank) Located on fence west of Little Gypsy. • C-1 (NE, 0.67 Miles) – (East bank) Located on fence at Little Gypsy Cooling Water Intake structure. • D-2 (ENE, 1.24 Miles) – (East bank) Located on pole on levee at west entrance to Bonnet Carre Spillway • E-1 (E, 0.41 Miles) – (West bank) Located on pole on LA 18 east of Waterford 3 plant entrance. • F-2 (ESE, 1.15 Miles) – (West bank) Located on fence on LA 3142 south of LA 18. • G-2 (SE, 1.26 Miles) – (West bank) Located on fence on LA 3142 north of railroad overpass. • H-2 (SSE, 1.54 Miles) – (West bank) Located on fence on LA 3142 north of LA 3127/3142 intersection. 	Quarterly	<ul style="list-style-type: none"> • mR exposure quarterly.

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> An inner ring of stations, one in each meteorological sector in the general area of the SITE BOUNDARY.</p>	<ul style="list-style-type: none"> • J-2 (S, 1.38 Miles) – (West bank) Located on fence south of LA 3127 west of LA 3127/3142 intersection. • K-1 (SSW, 1.06 Miles) – (West bank) Located on stop sign at entrance to Entergy Education Center on LA 3127. • L-1 (SW, 1.06 Miles) – (West bank) Located on gate on LA 3127 west of LA 3127/3142 intersection. • M-1 (WSW, 0.76 Miles) – (West bank) Located on south gate of Waterford 1 and 2. • N-1 (W, 0.98 Miles) – (West bank) Located on pole at corner of Railroad Avenue and School House Road. • P-1 (WNW, 0.84 Miles) – (West bank) Located on fence enclosing air sample station APP-1. • Q-1 (NW, 0.81 Miles) – (West bank) Located on fence enclosing air sample station APQ-1. • R-1 (NNW, 0.51 Miles) – (West bank) Located at Waterford 1 and 2 Cooling Water Intake Structure. 	Quarterly	<ul style="list-style-type: none"> • mR exposure quarterly.

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> An outer ring of stations, one in ten of the meteorological sectors in the 6 to 8 km ranges from the site.</p>	<ul style="list-style-type: none"> • A-5 (N, 4.59 Miles) – (East bank) Located on pole at intersection of Oswald Avenue and US 61. • B-4 (NNE, 3.75 Miles) – (East bank) Located on pole near weigh station on US 61. • D-5 (ENE, 4.09 Miles) – (East bank) Located on gate on shell road north of US61/LA48 intersection. • F-4 (ESE, 3.53 Miles) – (West bank) Located on pole behind house at 646 Aquarius St. in Hahnville. • E-5 (E, 4.08 Miles) – (East bank) Located on fence on Wesco Street off LA 48. • G-4 (SE, 3.30 Miles) – (West bank) Located on pole on LA 3160 north of railroad track. • H-8 (SSE, 8.13 Miles) – (West bank) Located on pole in front of Hahnville High School. • P-6 (WNW, 5.58 Miles) – (West bank) Located on fence at LA 640/railroad track intersection. • Q-5 (NW, 5.01 Miles) – (West bank) Located on pole on LA 18 across from Mississippi River marker 137. • R-6 (NNW, 5.52 Miles) – (East bank) Located on fence on LA 3223 near railroad crossing. 	Quarterly	<ul style="list-style-type: none"> • mR exposure quarterly.

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></p> <p>The balance of the stations (five) to be placed in special interest areas such as population centers, nearby residences, schools, and in one or two areas to serve as control locations.</p>	<ul style="list-style-type: none"> • F-9 (ESE, 8.18 Miles) – (East bank) Located on fence north of railroad tracks on Jonathan Street. • G-8 (SE, 7.74 Miles) – (West bank) Located on back fence of Luling Entergy Office. • E-15 (E, 11.7 Miles) – (East bank) Located on fence on Alliance Avenue. • J-15 (S, 11.7 Miles) - (West bank) Located on pole near LA 631/Hwy 90 intersection in Des Allemands. • E-26 (E, 25.8 Miles) - (West bank) Located at Entergy office on Virgil Street in Gretna. (Control) 	<p>Quarterly</p>	<ul style="list-style-type: none"> • mR exposure 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></p> <p>One sample upstream and one sample downstream.</p>	<ul style="list-style-type: none"> • SWP-7 (WNW, 7.37 Miles) - (West bank) Located at St. John Parish Waterworks in Edgard. (Control) • SWF-2 (ESE, 1.51 Miles) - (West bank) Located at Dow Chemical Plant drinking water canal. • SWE-5 (E, 4.59 Miles) - (East bank) Located at St. Charles Parish Waterworks in New Sarpy. • SWK-1 (SSW, 0.49 Miles) - (West bank) Located at 40 Arpent Canal south of the plant. 	<p>Composite sample over one quarter period.</p>	<ul style="list-style-type: none"> • Gamma isotopic analysis and tritium analysis quarterly.
<p><u>DRINKING WATER</u></p> <p>One sample upstream and one sample downstream.</p>	<ul style="list-style-type: none"> • DWP-7 (WNW, 7.37 Miles) - (West bank) Located at St. John Parish Waterworks in Edgard. (Control) • DWF-2 (ESE, 1.51 Miles) - (West bank) Located at Dow Chemical Plant drinking water canal. • DWE-5 (E, 4.59 Miles) - (East bank) Located at St. Charles Parish Waterworks in New Sarpy. 	<p>Composite sample over one month period when I-131 analysis is performed, quarterly composite otherwise.</p>	<ul style="list-style-type: none"> • I-131 analysis on each composite when the dose calculated for the consumption of the water is greater than one mrem per year. Composite for gross beta and gamma isotopic analyses quarterly. Composite for tritium analysis quarterly.
<p><u>SEDIMENT FROM SHORELINE</u></p> <p>One sample upstream and one samples downstream.</p>	<ul style="list-style-type: none"> • SHWQ-6 (NW, 5.99 Miles) – (East bank) Located on LA 628 east of Reserve ferry landing. (Control) • SHWE-3 (E, 2.99 Miles) – (West bank) Located at Foot Ferry landing on LA 18. • SHWK-1 (SSW, 0.49 Miles) – (West bank) Located at 40 Arpent Canal south of plant. 	<p>Annually</p>	<ul style="list-style-type: none"> • Gamma isotopic analysis annually.

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> <ul style="list-style-type: none"> • Samples from milking animals in the three locations within 5 km distance having the highest dose potential. If there are none, then, one sample from milking animals in each of the three areas between 5 to 8 km distant where doses are calculated to be greater than 1 mrem per year. • One sample from milking animals at a control location 15 – 30 km distant and in the least prevalent wind direction. 	<ul style="list-style-type: none"> • MKE-3 (E, 2.35 Miles) - (West bank) Located at the Zeringue's house on LA 18 in Taft. • MKA-31 (N, 31.2 Miles) – (East bank) Located at 18736 Sisters Road, Ponchatoula, LA. (Control) 	<p>Quarterly</p>	<ul style="list-style-type: none"> • Gamma isotopic and I-131 analysis quarterly.
<p><u>FISH AND INVERTEBRATES</u></p> <ul style="list-style-type: none"> • One sample of each commercially and/or recreationally important species in vicinity of plant discharge area. • One sample of same species in area not influenced by plant discharge. 	<ul style="list-style-type: none"> • FH-2 (Distance/Direction Not Applicable) – Downstream of the plant discharge structure. • FH-3 (Distance/Direction Not Applicable) - (Westbank) Waterways downstream of plant discharge directed to 40 Arpent Canal. • FH-1 (Distance/Direction Not Applicable) – Upstream of the plant intake structure. (Control) 	<p>Sample in season, or annually if they are not seasonal.</p>	<ul style="list-style-type: none"> • Gamma isotopic analysis on edible portions annually.
<p><u>BROAD LEAF VEGATATION</u></p> <ul style="list-style-type: none"> • Samples of one to three different types of broadleaf vegetation grown nearest each of the two different off-site locations of highest predicted annual average ground level D/Q if milk sampling is not performed. • One sample of each of the similar broadleaf vegetation grown 15 – 30 km distant in the least prevalent wind direction if milk sampling is not performed. 	<ul style="list-style-type: none"> • BLQ-1 (NW, 0.83 Miles) – (West bank) Located near air sample station. • BLB-1 (NNE, 0.81 Miles) – (East bank) Located west of Little Gypsy on LA 628 • BLE-20 (E, 19.7 Miles) – (West bank) Located on property of Nine Mile Point in Westwego. (Control) 	<p>Quarterly during the growing season.</p>	<ul style="list-style-type: none"> • Gamma isotopic and I-131 analysis quarterly.

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Figure 1: Exposure Pathway

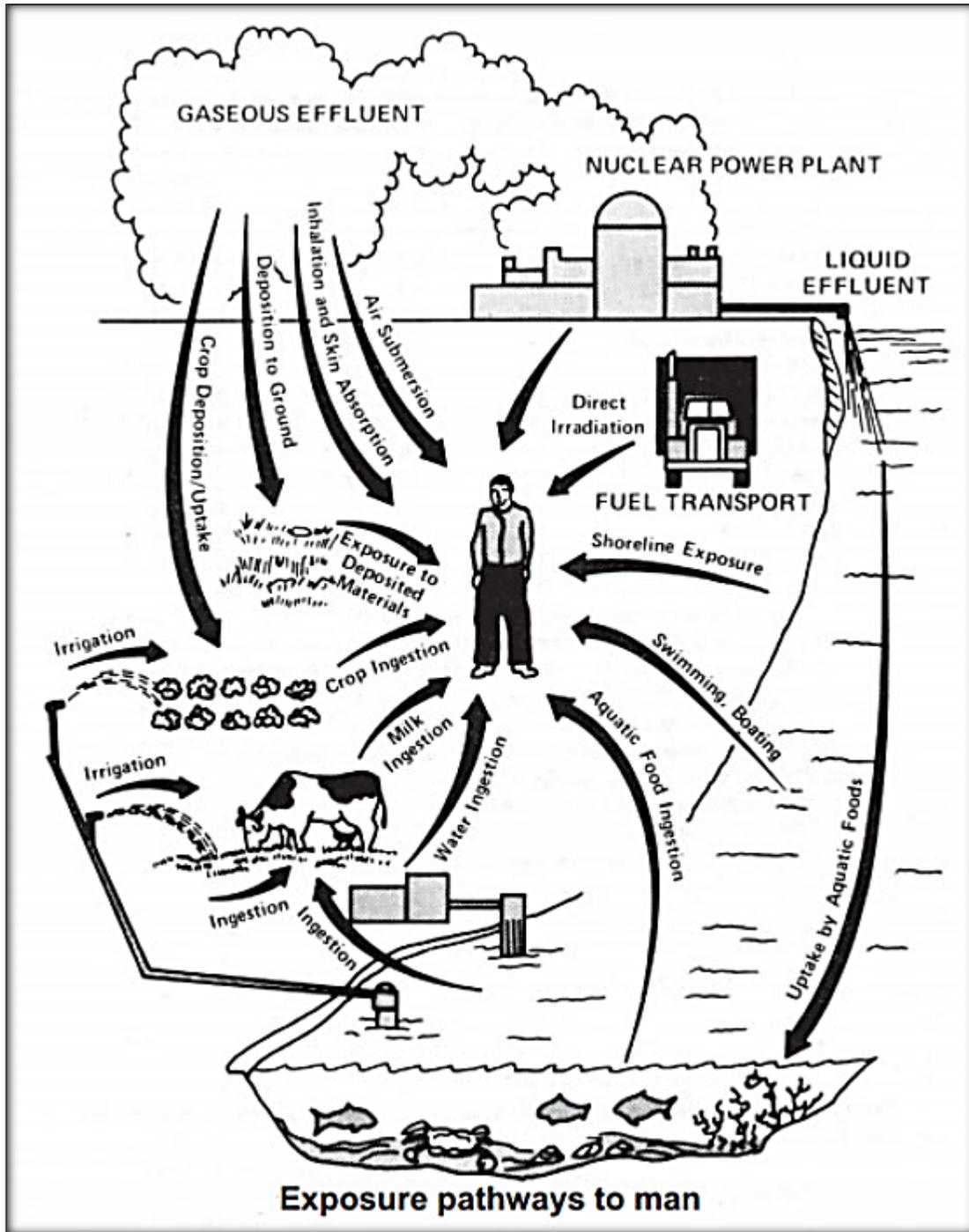


Figure 2: REMP Samples Within 2 Miles of Waterford 3

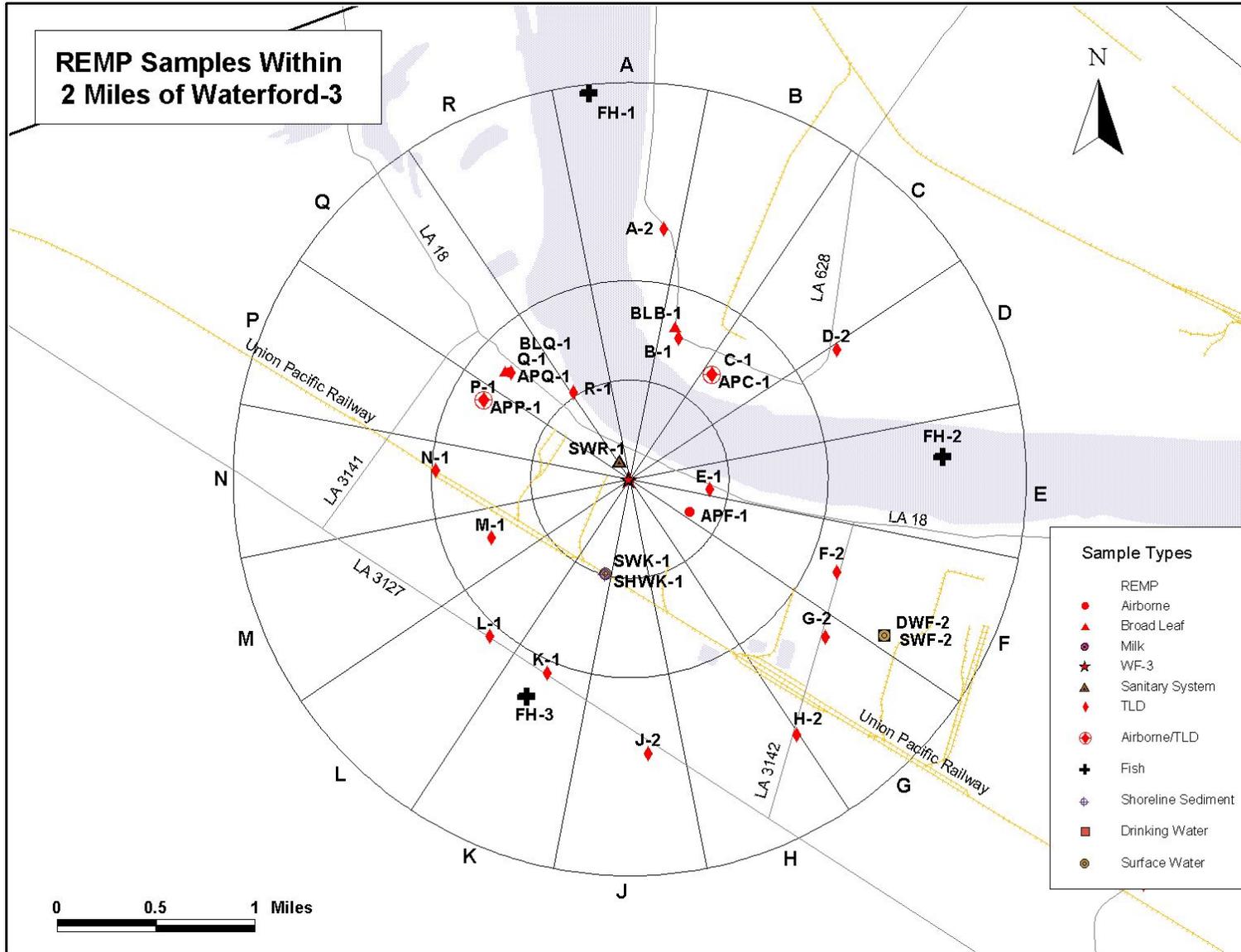
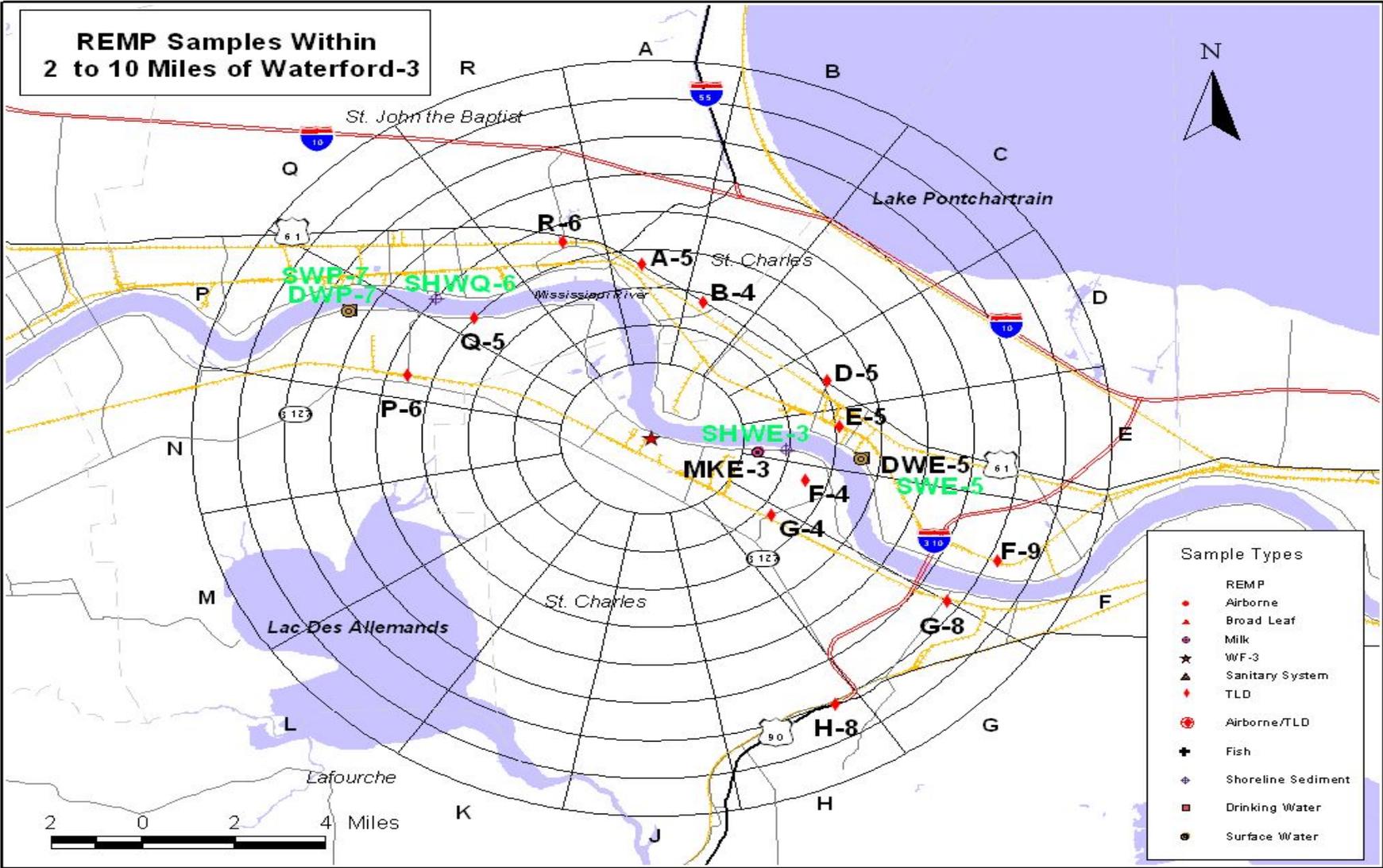
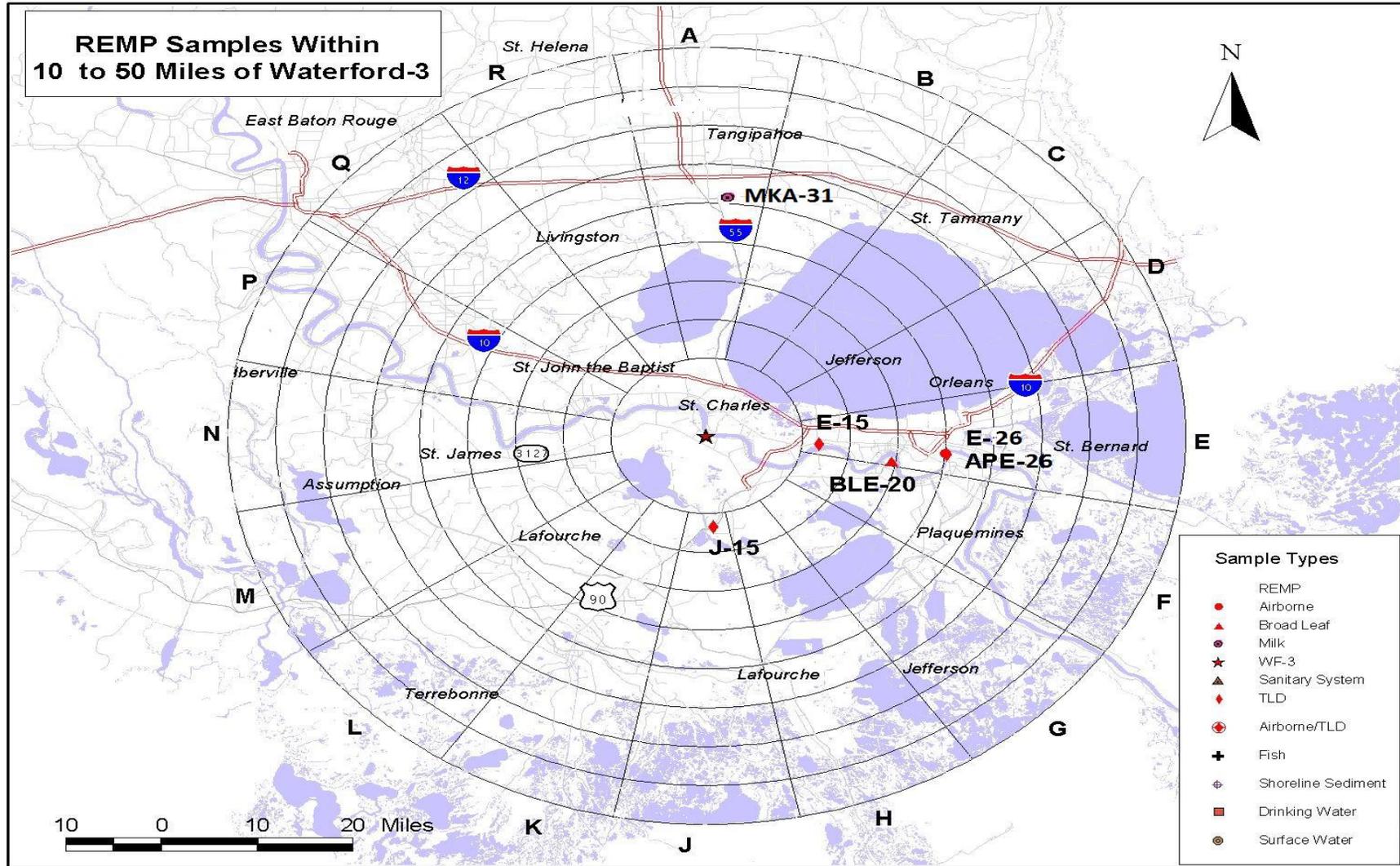


Figure 3: REMP Samples within 2 to 10 miles of Waterford 3



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Figure 4: REMP Samples within 10 to 50 Miles of Waterford 3



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

Samples of airborne particulate and radioiodine were collected at four indicator locations and one control location and analyzed for gross beta radionuclides, Iodine-131 and gamma radionuclides (quarterly air particulate filter composites only). Waterford 3 did not detect any gamma radionuclides in the quarterly air particulate composites or Iodine-131 in the radioiodine cartridges during the reporting period as has been the case in previous years. Indicator gross beta air particulate results for 2018 were similar to those background levels obtained in previous years of the operational REMP and well below preoperational levels as seen below. Results are reported as annual average pCi/m³.

<u>Monitoring Period</u>	<u>Result</u>
2008 – 2017 (Minimum Value)	0.018
2018 Average Value	0.018
2008 – 2017 (Maximum Value)	0.027
Preoperational	0.080

In the absence of plant-related gamma radionuclides, gross beta activity is attributed to naturally occurring radionuclides. Table 6, which include gross beta concentrations and provide a comparison of the indicator and control means and ranges emphasizes the consistent trends seen in this pathway to support the presence of naturally occurring activity. Therefore, it can be concluded that the airborne pathway continues to be unaffected by Waterford 3 operations.

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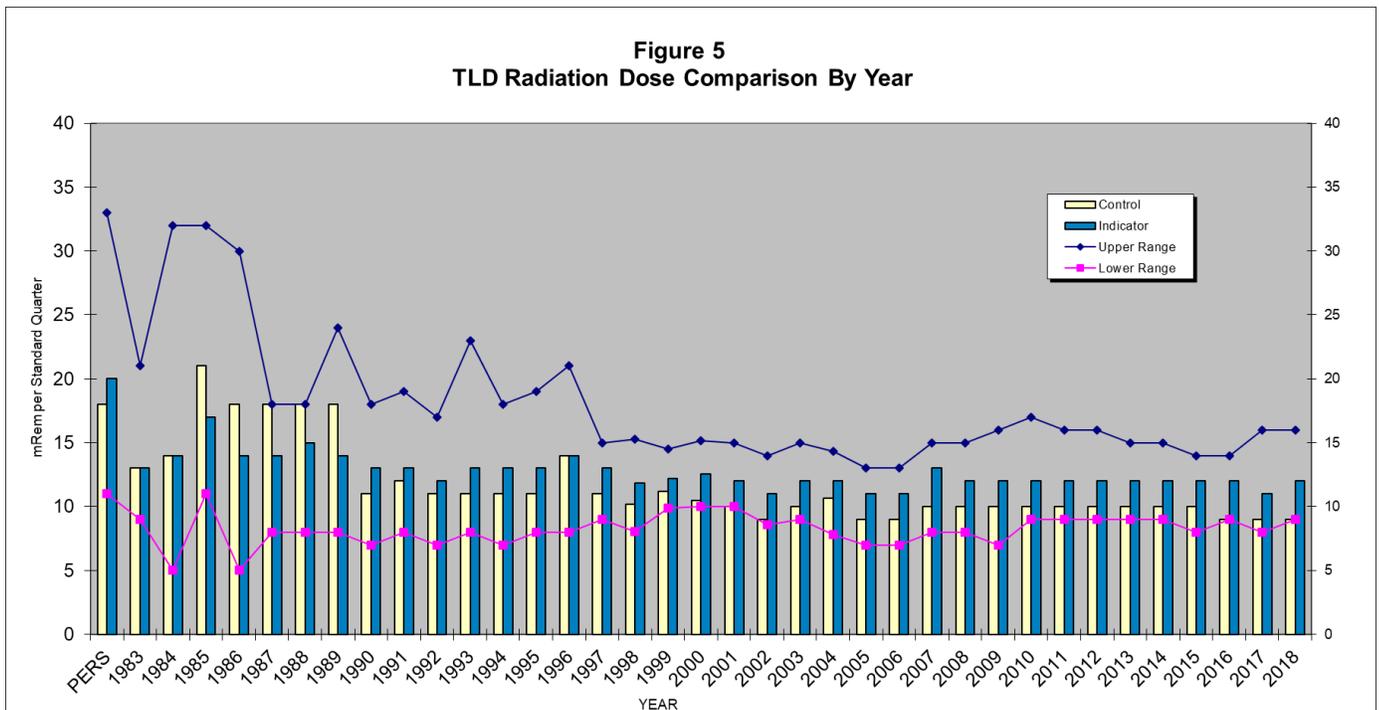
4.2 Thermoluminescent Dosimetry (TLD) Sample Results

Waterford 3 reports measured dose as net exposure (field reading less transit reading) normalized to 92 days and relies on comparison of the thirty indicator locations to the one control as a measure of plant impact. Waterford 3’s comparison of the inner ring, outer ring, and special interest area TLD results to the control, as seen in Table 6, identified no noticeable trend that would indicate that the ambient radiation levels are being affected by plant operations. In addition, the indicator value of 12.0 millirem (mrem) shown in the TLD radiation dose comparison graph below shows the 2018 concentration is comparable to historic results. Overall, Waterford 3 concluded that the ambient radiation levels are not being affected by plant operations.

The average exposure rates during 2018 are consistent with those from the preoperational program and the previous five years of operation. In particular, the preoperational survey indicates that exposure rates ranged between 11 and 33 mrem/standard quarter with an average of 20 mrem/standard quarter. The range during the previous five years of operation was 9 to 15 mrem/standard quarter with an average exposure rate of 12 mrem/standard quarter.

A comparison of the indicator results to the control results, as seen in Table 6, shows that the average indicator locations are slightly higher than that of the control. As shown in Attachment 2, Tables 11-14, several indicator locations are higher than the control by a few mrem with a maximum difference of seven mrem. The differences between indicator locations and the control, and TLD stations grouped by distance from the plant are expected due to a variety of factors not related to Waterford 3 plant operations that can affect background radiation in the vicinity of each TLD station.

Figure 5
TLD Radiation Dose Comparison By Year



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4.3 Waterborne Sample Results

Analytical results for 2018 drinking water/surface water samples were similar to those reported in previous years. Gamma radionuclides, iodine-131 and tritium analytical results for 2018 waterborne samples were below the ODCM-required LLD similar to those reported in previous years. Gross Beta continues to be detected in Waterford 3 drinking water samples consistent with historical results. These results are further explained below.

4.3.1 Surface Water Results

Samples were collected from one indicator location and analyzed for gamma radionuclides and tritium. Tritium and gamma radionuclides were below detectable limits which is consistent with results seen in previous operational years. Therefore, the operation of Waterford 3 had no definable impact on this waterborne pathway during 2018.

4.3.2 Drinking/Surface Water Results

Drinking water samples also serve as surface water samples for Waterford 3. Therefore, monthly and quarterly gamma spectroscopy and tritium analyses of drinking water also satisfy the surface water sampling requirement.

Samples were collected from two indicators and one control location. Drinking/Surface water samples were analyzed for, gamma radionuclides, gross beta, iodine-131, and tritium. Gamma radionuclides, iodine-131, and tritium concentrations were below the LLD limits at the indicator and control locations. Gross beta was detected in both indicator and control locations. The average concentration of the indicator locations is comparable to the 2008 – 2017 operational years and below background preoperational data as shown below. Gross beta results from 2018 are summarized in Table 6. Results are reported as annual average pCi/L.

<u>Monitoring Period</u>	<u>Result</u>
2008 – 2017 (Minimum Value)	3.0
2018 Value	5.2
2008 – 2017 (Maximum Value)	6.6
Preoperational	7.0

Table 17, which includes gross beta concentrations for 2018, provides a comparison of the indicator and control means. It shows that the waterborne pathway continues to remain at background levels. Waterford 3 personnel have noted no definable trends associated with drinking water results at the indicator location. Therefore, the operation of Waterford 3 had no definable impact on this waterborne pathway during 2018 and levels of radionuclides remain similar to those obtained in previous operational years.

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4.3.3 Sediment Sample Results

Sediment samples were collected from two indicators and one control location in 2018 and analyzed for gamma radionuclides. Gamma radionuclides were below the LLD limits at both indicator and control locations. Waterford 3 operations had no significant impact on the environment or public by this waterborne pathway.

4.4 Ingestion Sample Results

4.4.1 Fish Sample Results

Fish samples were collected from two indicator and one control location and analyzed for gamma radionuclides. In 2018, gamma radionuclides were below detectable limits which are consistent with the preoperational monitoring period and operational results. Therefore, based on these measurements, Waterford 3 operations had no significant radiological impact upon the environment or public by this ingestion pathway.

4.4.2 Broad Leaf Vegetation Sample Results

The REMP has detected radionuclides prior to 1990 that are attributable to other sources. These include the radioactive plume release due to reactor core degradation at Chernobyl Nuclear Power Plant in 1986 and atmospheric weapons testing.

In 2018, broad leaf vegetation samples were collected from two indicator and one control location and analyzed for iodine-131 and gamma radionuclides. The 2018 levels remained undetectable, as has been the case in previous years. Therefore, based on these measurements, Waterford 3 operations had no significant radiological impact upon the environment or public by this ingestion pathway.

4.4.3 Milk Sample Results

Milk samples from the indicator location were unavailable for collection during 2018, broad leaf vegetation was therefore performed as required by TRM 3.12-1; results are in section 4.4.2. Milk samples were collected from one control location and analyzed for iodine-131 and gamma radionuclides. Cesium-137 was measured at concentrations consistent with the preoperational program as well as operational years 2008-2017 seen below; concentrations were well below the reporting level required by the TRM. Therefore, Waterford 3 concluded that plant operations had no significant impact on this pathway during 2018.

<u>Monitoring Period</u>	<u>Result</u>
2008 – 2017 (Minimum Value)	5.0
2018 Value	4.8
2008 – 2017 (Maximum Value)	5.4

Annual Radiological Environmental Operating Report**4.5 Land Use Census Results**

The latest land use census was conducted September 17 – September 18, 2018. The nearest residence, garden, beef cow, food product and milk animal in each sector within a five mile radius of the plant was located by visual inspection and verbal inquiry.

The land use census identified several changes. The nearest residence in sector D has changed to 111 Kenner Drive at a distance of 0.9 miles from the plant. The goats located 2.4 miles from the plant in sector E have been removed. Beef cows from sector G 4.6 miles from the plant, sector M 1.2 miles from the plant, and sector N 1.0 miles from the plant were removed. There were no changes in the nearest garden, milk cows, or food products in 2018. Based upon the locations identified in this survey, the locations identified in previous surveys and the locations currently being used to calculate dose commitments from liquid and gaseous effluents released from Waterford 3, no REMP sampling location changes are necessary. Results of the 2018 biennial census are shown in Table 5.

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Table 5: 2018 Land Use Census Results

Sector	Direction	Nearest Residence (miles)	Nearest Garden (miles)	Nearest Milk Cow (miles)	Nearest Beef Cow (miles)	Nearest Goat (miles)	Nearest Food Products (miles)
A	N	1.3	1.7	^	4.8	*4.8	4.1
B	NNE	1.1	1.3	^	1.7	^	1.3
C	NE	0.9	1.0	^	^	^	^
D	ENE	0.9	0.9	^	^	^	^
E	E	2.2	2.3	**2.3	2.3	*3.2	0.3
F	ESE	3.1	2.3	^	2.3	^	0.3
G	SE	4.0	4.1	^	2.4	^	0.3
H	SSE	^	^	^	^	^	0.3
J	S	^	^	^	^	^	0.5
K	SSW	^	^	^	^	^	0.5
L	SW	^	^	^	^	^	0.5
M	WSW	^	1.4	^	^	^	0.5
N	W	1.0	1.1	^	^	^	0.6
P	WNW	0.9	0.9	^	^	^	0.6
Q	NW	0.9	1.1	^	^	^	0.6
R	NNW	3.0	3.0	^	4.9	^	2.6

Symbol	Comment
^	Nothing was located within a five-mile radius of Waterford 3.
*	Animals were located at this distance from Waterford 3, but the milk is not used for human consumption.
**	Milk samples are being obtained from animals at this location (MKE-3) for REMP.

Annual Radiological Environmental Operating Report**4.6 Interlaboratory Comparison Results**

Attachment 3 contains result summary for Interlaboratory Comparison program for Teledyne Brown Engineering to fulfill the requirements of section 5.7.2 of the ODCM.

5.0 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM SUMMARY

1. Table 6, Radiological Environmental Monitoring Program Summary, summarizes data for the 2018 REMP program.

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Table 6: Radiological Environmental Monitoring Program Summary

Sample Type (Units)	Type / Number of Analyses ⁽¹⁾	LLD ⁽²⁾	Indicator Locations Mean (F) ⁽³⁾ [Range]	Indicator ⁽⁴⁾ Location [Highest Annual Mean]	Mean (F) ⁽³⁾ [Range]	Control Locations Mean (F) ⁽³⁾ [Range]	Number of Non Routine Results ⁽⁵⁾
Air Particulates (pCi/m ³)	GB / 130	0.01	0.0182 (104 / 104) [0.009 – 0.035]	APP-1 (119°, 0.84 mi)	0.0185 (26 / 26) [0.010 - 0.028]	0.0187 (26 / 26) [0.011 - 0.028]	0
	GS / 20						
	Cs-134 Cs-137	0.05 0.06	< LLD < LLD	N/A N/A	N/A N/A	< LLD < LLD	0 0
Airborne Iodine (pCi/m ³)	I-131 / 130	0.07	< LLD	N/A	N/A	< LLD	0
Inner Ring TLDs (mR/Qtr)	Gamma / 64	⁽⁶⁾	11.1 (64 / 64) [8.6 – 14.0]	L-1 (42°, 1.06 mi)	13.5 (4 / 4) [12.9 – 14.0]	N/A	0
Outer Ring TLDs (mR/Qtr)	Gamma / 39	⁽⁶⁾	12.5 (39 / 39) [8.9 – 15.7]	P-6 (107°, 5.58 mi)	13.7 (4 / 4) [12.8 – 14.3]	N/A	0
Special Interest TLDs (mR/Qtr)	Gamma / 15	⁽⁶⁾	10.7 (15 / 15) [9.9 – 11.6]	F-9 (294°, 8.18 mi)	11.1 (4 / 4) [10.5 – 11.5]	N/A	0
Control TLDs (mR/Qtr)	Gamma / 4	⁽⁶⁾	N/A	N/A	N/A	9.2 (4 / 4) [8.4 – 9.7]	0

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Table 6: Radiological Environmental Monitoring Program Summary

Sample Type (Units)	Type / Number of Analyses ⁽¹⁾	LLD ⁽²⁾	Indicator Locations Mean (F) ⁽³⁾ [Range]	Indicator ⁽⁴⁾ Location [Highest Annual Mean]	Mean (F) ⁽³⁾ [Range]	Control Locations Mean (F) ⁽³⁾ [Range]	Number of Non Routine Results ⁽⁵⁾
Surface Water (pCi/L)	H-3 / 4	2000	< LLD	N/A	N/A	< LLD	0
	GS / 13						
	Mn-54	15	< LLD	N/A	N/A	< LLD	0
	Co-58	15	< LLD	N/A	N/A	< LLD	0
	Fe-59	30	< LLD	N/A	N/A	< LLD	0
	Co-60	15	< LLD	N/A	N/A	< LLD	0
	Zn-65	30	< LLD	N/A	N/A	< LLD	0
	Nb-95	15	< LLD	N/A	N/A	< LLD	0
	I-131	15	< LLD	N/A	N/A	< LLD	0
	Zr-95	15	< LLD	N/A	N/A	< LLD	0
	Cs-134	15	< LLD	N/A	N/A	< LLD	0
	Cs-137	18	< LLD	N/A	N/A	< LLD	0
	Ba-140	15	< LLD	N/A	N/A	< LLD	0
	La-140	15	< LLD	N/A	N/A	< LLD	0

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Table 6: Radiological Environmental Monitoring Program Summary

Sample Type (Units)	Type / Number of Analyses ⁽¹⁾	LLD ⁽²⁾	Indicator Locations Mean (F) ⁽³⁾ [Range]	Indicator ⁽⁴⁾ Location [Highest Annual Mean]	Mean (F) ⁽³⁾ [Range]	Control Locations Mean (F) ⁽³⁾ [Range]	Number of Non Routine Results ⁽⁵⁾
Drinking/Surface Water (pCi/L)	GB / 12	4	5.19 (8 / 8) [3.34 – 9.91]	DWF/SWF-2 (302°, 1.51 mi)	6.11 (4 / 4) [4.36 – 9.91]	5.04 (4 / 4) [3.76 – 6.20]	0
	I-131 / 37	1	< LLD	N/A	N/A	< LLD	0
	H-3 / 12	2000	< LLD	N/A	N/A	< LLD	0
	GS / 12						
	Mn-54	15	< LLD	N/A	N/A	< LLD	0
	Co-58	15	< LLD	N/A	N/A	< LLD	0
	Fe-59	30	< LLD	N/A	N/A	< LLD	0
	Co-60	15	< LLD	N/A	N/A	< LLD	0
	Zn-65	30	< LLD	N/A	N/A	< LLD	0
	Nb-95	15	< LLD	N/A	N/A	< LLD	0
	Zr-95	15	< LLD	N/A	N/A	< LLD	0
	Cs-134	15	< LLD	N/A	N/A	< LLD	0
	Cs-137	18	< LLD	N/A	N/A	< LLD	0
	Ba-140	15	< LLD	N/A	N/A	< LLD	0
La-140	15	< LLD	N/A	N/A	< LLD	0	
Sediment (pCi/kg dry)	GS / 3						
	Cs-134	150	< LLD	N/A	N/A	< LLD	0
	Cs-137	180	< LLD	N/A	N/A	< LLD	0

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Table 6: Radiological Environmental Monitoring Program Summary

Sample Type (Units)	Type / Number of Analyses ⁽¹⁾	LLD ⁽²⁾	Indicator Locations Mean (F) ⁽³⁾ [Range]	Indicator ⁽⁴⁾ Location [Highest Annual Mean]	Mean (F) ⁽³⁾ [Range]	Control Locations Mean (F) ⁽³⁾ [Range]	Number of Non Routine Results ⁽⁵⁾
Fish (pCi/kg wet)	GS / 12						
	Mn-54	130	< LLD	N/A	N/A	< LLD	0
	Co-58	130	< LLD	N/A	N/A	< LLD	0
	Fe-59	260	< LLD	N/A	N/A	< LLD	0
	Co-60	130	< LLD	N/A	N/A	< LLD	0
	Zn-65	260	< LLD	N/A	N/A	< LLD	0
	Cs-134	130	< LLD	N/A	N/A	< LLD	0
	Cs-137	150	< LLD	N/A	N/A	< LLD	0
Broad Leaf (pCi/kg wet)	GS / 12						
	I-131	60	< LLD	N/A	N/A	N/A	0
	Cs-134	60	< LLD	N/A	N/A	N/A	0
	Cs-137	80	< LLD	N/A	N/A	N/A	0
Milk (pCi/L)	I-131 / 6	1	< LLD	N/A	N/A	N/A	0
	GS / 7						
	Cs-134	15	< LLD	N/A	N/A	N/A	0
	Cs-137	18	N/A	N/A	N/A	4.75 (4 / 7) [3.31 – 5.65]	0
	Ba-140	15	< LLD	N/A	N/A	N/A	0
	La-140	15	< LLD	N/A	N/A	N/A	0

LEGEND:

⁽¹⁾ - GB = Gross beta; I-131 = Iodine-131; H-3 = Tritium; GS = Gamma scan.

⁽²⁾ - LLD = Required lower limit of detection based on Waterford 3 TRM.

⁽³⁾ - Mean and range based upon detectable measurements only. Fraction of detectable measurements at specified locations is indicated in parenthesis (F).

⁽⁴⁾ - Locations are specified (1) by name and (2) degrees relative to reactor site.

⁽⁵⁾ - Non-routine results are those which exceed ten times the control station value. If no control station value is available, the result is considered non-routine if it exceeds ten times the preoperational value for the location.

⁽⁶⁾ - LLD is not defined in Waterford 3 TRM.

Sample Deviations

Table 7: Sample Deviations Table

Comment No.	Sample Media Affected	Sample Location	Date	Problem	Evaluation / Actions
1	Milk	MKE-3	2018	Sample Unavailable	Milk samples from indicator station MKE-3 were unavailable for all four quarters of 2018 due to the cows not producing enough milk. Broad Leaf vegetation sampling was performed in place of the milk indicator sampling.
2	Milk	MKA-31	03/15/18	Spoiled Sample	I-131 (Low Level) analysis could not be performed due to the sample being curdled. Sample was shipped for next day but there was a 4-day delay, which caused the sample to spoil. Milk was re-sampled on 3/27/18.
3	TLD	G-8	3 rd Qtr.	Sample Missing	TLD from station G-8 was unable to be analyzed due to sample being missing at time of collection.
4	AP/C	APQ-1	07/30/18-08/13/18	Low Volume	The air particulate and charcoal sample collected from 07/30/18-08/13/18 had low volumes due to the sample pump being tripped during the run period. Sample pump was changed out the next day, 8/14/18.
5	TLD	G-4	4 th Qtr.	Sample missing	TLD from station G-4 was unable to be analyzed due to sample being missing at time of collection.
6	TLD	G-8	4 th Qtr.	Reduced Exposure Time	TLD from station G-8 has a reduced exposure time; it was found missing during monthly inspection on 11/12/18. TLD was replaced on 11/19/18.
7	AP/C	APC-1	12/03/18-12/17/18	Low Volume	The air particulate and charcoal sample collected from 12/03/18-12/17/18 had low volumes due to the sample pump being tripped during the run period. The sample pump was replaced on the day of discovery, 12/17/18.

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Table 8: Air Particulate Data Table

Analysis: Gross Beta				Units: pCi/m ³		
Start Date	End Date	APF-1 (Indicator)	APQ-1 (Indicator)	APP-1 (Indicator)	APC-1 (Indicator)	APE-26 ⁽¹⁾ (Control)
REQUIRED LLD →		<u>0.01</u>	<u>0.01</u>	<u>0.01</u>	<u>0.01</u>	<u>0.01</u>
01/02/2018	01/15/2018	0.025	0.023	0.024	0.024	0.025
01/15/2018	01/29/2018	0.020	0.017	0.018	0.015	0.018
01/29/2018	02/12/2018	0.018	0.015	0.016	0.017	0.017
02/12/2018	02/26/2018	0.009	0.010	0.010	0.009	0.011
02/26/2018	03/12/2018	0.019	0.017	0.017	0.018	0.019
03/12/2018	03/26/2018	0.021	0.021	0.023	0.018	0.022
03/26/2018	04/10/2018	0.017	0.016	0.016	0.015	0.017
04/10/2018	04/23/2018	0.019	0.015	0.019	0.019	0.019
04/23/2018	05/07/2018	0.020	0.019	0.021	0.021	0.021
05/07/2018	05/21/2018	0.025	0.029	0.028	0.026	0.027
05/21/2018	06/04/2018	0.015	0.014	0.015	0.014	0.014
06/04/2018	06/18/2018	0.016	0.017	0.018	0.016	0.019
06/18/2018	07/02/2018	0.014	0.014	0.015	0.015	0.019
07/02/2018	07/16/2018	0.013	0.012	0.013	0.013	0.013
07/16/2018	07/30/2018	0.020	0.020	0.021	0.021	0.020
07/30/2018	08/13/2018	0.010	0.035 ⁽²⁾	0.016	0.013	0.012
08/13/2018	08/27/2018	0.021	0.017	0.018	0.019	0.021
08/27/2018	09/10/2018	0.012	0.009	0.011	0.010	0.011
09/10/2018	09/24/2018	0.017	0.015	0.019	0.017	0.018
09/24/2018	10/08/2018	0.016	0.015	0.015	0.015	0.015
10/08/2018	10/22/2018	0.016	0.019	0.019	0.015	0.019
10/22/2018	11/05/2018	0.024	0.027	0.027	0.023	0.026
11/05/2018	11/19/2018	0.019	0.021	0.019	0.018	0.020
11/19/2018	12/03/2018	0.028	0.025	0.028	0.022	0.028
12/03/2018	12/17/2018	0.020	0.019	0.022	0.033 ⁽³⁾	0.021
12/17/2018	01/01/2019	0.018	0.018	0.017	0.015	0.015

⁽¹⁾ Station with highest annual mean.

⁽²⁾ See Attachment 1, Table 7, Samples Deviations Table, Comment 4

⁽³⁾ See Attachment 1, Table 7, Samples Deviations Table, Comment 7

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Table 9: Radioiodine Cartridge Data Table

Analysis: I-131				Units: pCi/m ³		
Start Date	End Date	APF-1 (Indicator)	APQ-1 (Indicator)	APP-1 (Indicator)	APC-1 (Indicator)	APE-26 (Control)
REQUIRED LLD →		0.07	0.07	0.07	0.07	0.07
01/02/2018	01/15/2018	< 0.020	< 0.044	< 0.046	< 0.043	< 0.046
01/15/2018	01/29/2018	< 0.016	< 0.035	< 0.036	< 0.033	< 0.036
01/29/2018	02/12/2018	< 0.037	< 0.014	< 0.035	< 0.035	< 0.035
02/12/2018	02/26/2018	< 0.015	< 0.032	< 0.033	< 0.032	< 0.033
02/26/2018	03/12/2018	< 0.016	< 0.034	< 0.035	< 0.034	< 0.036
03/12/2018	03/26/2018	< 0.016	< 0.017	< 0.018	< 0.017	< 0.018
03/26/2018	04/10/2018	< 0.034	< 0.013	< 0.032	< 0.031	< 0.032
04/10/2018	04/23/2018	< 0.016	< 0.038	< 0.038	< 0.036	< 0.037
04/23/2018	05/07/2018	< 0.015	< 0.036	< 0.036	< 0.034	< 0.035
05/07/2018	05/21/2018	< 0.016	< 0.019	< 0.019	< 0.018	< 0.019
05/21/2018	06/04/2018	< 0.026	< 0.026	< 0.026	< 0.017	< 0.018
06/04/2018	06/18/2018	< 0.013	< 0.015	< 0.015	< 0.014	< 0.015
06/18/2018	07/02/2018	< 0.013	< 0.030	< 0.030	< 0.029	< 0.029
07/02/2018	07/16/2018	< 0.019	< 0.022	< 0.022	< 0.020	< 0.021
07/16/2018	07/30/2018	< 0.018	< 0.021	< 0.021	< 0.020	< 0.021
07/30/2018	08/13/2018	< 0.008	< 0.049 ⁽¹⁾	< 0.018	< 0.017	< 0.017
08/13/2018	08/27/2018	< 0.009	< 0.022	< 0.022	< 0.020	< 0.021
08/27/2018	09/10/2018	< 0.017	< 0.016	< 0.017	< 0.009	< 0.016
09/10/2018	09/24/2018	< 0.009	< 0.021	< 0.022	< 0.020	< 0.021
09/24/2018	10/08/2018	< 0.010	< 0.011	< 0.012	< 0.011	< 0.012
10/08/2018	10/22/2018	< 0.021	< 0.019	< 0.020	< 0.008	< 0.020
10/22/2018	11/05/2018	< 0.012	< 0.012	< 0.012	< 0.010	< 0.012
11/05/2018	11/19/2018	< 0.008	< 0.018	< 0.019	< 0.018	< 0.018
11/19/2018	12/03/2018	< 0.006	< 0.014	< 0.015	< 0.014	< 0.014
12/03/2018	12/17/2018	< 0.025	< 0.023	< 0.024	< 0.025 ⁽²⁾	< 0.023
12/17/2018	01/01/2019	< 0.007	< 0.016	< 0.017	< 0.015	< 0.017

⁽¹⁾ See Attachment 1, Table 7, Samples Deviations Table, Comment 4⁽²⁾ See Attachment 1, Table 7, Samples Deviations Table, Comment 7

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Table 10: Air Particulate Composite Data Table

Analysis: Gamma Isotopic		Units: pCi/m³	
Location	Collection Date	Cs-134	Cs-137
REQUIRED LLD →		<u>0.05</u>	<u>0.06</u>
APF-1 (Indicator)	03/26/2018	< 0.002	< 0.002
APQ-1 (Indicator)	03/26/2018	< 0.003	< 0.002
APP-1 (Indicator)	03/26/2018	< 0.003	< 0.003
APC-1 (Indicator)	03/26/2018	< 0.002	< 0.002
APE-26 (Control)	03/26/2018	< 0.002	< 0.002
APF-1 (Indicator)	07/02/2018	< 0.003	< 0.002
APQ-1 (Indicator)	07/02/2018	< 0.003	< 0.002
APP-1 (Indicator)	07/02/2018	< 0.002	< 0.001
APC-1 (Indicator)	07/02/2018	< 0.003	< 0.002
APE-26 (Control)	07/02/2018	< 0.003	< 0.002
APF-1 (Indicator)	09/24/2018	< 0.003	< 0.003
APQ-1 (Indicator)	09/24/2018	< 0.004	< 0.003
APP-1 (Indicator)	09/24/2018	< 0.004	< 0.002
APC-1 (Indicator)	09/24/2018	< 0.004	< 0.003
APE-26 (Control)	09/24/2018	< 0.002	< 0.002
APF-1 (Indicator)	01/01/2019	< 0.003	< 0.002
APQ-1 (Indicator)	01/01/2019	< 0.002	< 0.002
APP-1 (Indicator)	01/01/2019	< 0.002	< 0.002
APC-1 (Indicator)	01/01/2019	< 0.003	< 0.002
APE-26 (Control)	01/01/2019	< 0.003	< 0.003

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Table 11: Thermoluminescent Dosimeters – Inner Ring

Analysis: Gamma Dose			Units: mrem/Std. Qtr.		
Station	1 st Qtr 2018	2 nd Qtr 2018	3 rd Qtr 2018	4 th Qtr 2018	Annual Mean 2018
A-2	13.0	13.0	11.9	12.3	12.5
B-1	13.7	13.5	11.9	12.5	12.9
C-1	9.7	9.7	8.6	9.5	9.4
D-2	13.0	12.6	11.8	12.3	12.4
E-1	12.1	12.4	10.7	11.7	11.7
F-2	12.6	11.5	11.0	11.7	11.7
G-2	10.8	10.5	9.7	10.1	10.3
H-2	11.3	10.5	10.4	10.9	10.8
J-2	11.0	9.8	9.9	10.2	10.2
K-1	11.1	10.9	10.4	10.8	10.8
L-1⁽¹⁾	13.8	13.3	12.9	14.0	13.5
M-1	10.9	10.1	9.6	10.0	10.1
N-1	11.2	10.4	10.3	10.0	10.5
P-1	10.7	9.8	9.3	9.7	9.8
Q-1	12.7	11.8	11.7	12.0	12.1
R-1	10.0	9.4	9.0	9.5	9.5

⁽¹⁾ Inner ring station with highest annual mean.

Table 12: Thermoluminescent Dosimeters – Outer Ring

Analysis: Gamma Dose			Units: mrem/Std. Qtr.		
Station	1 st Qtr 2018	2 nd Qtr 2018	3 rd Qtr 2018	4 th Qtr 2018	Annual Mean 2018
A-5	13.2	12.7	11.8	12.3	12.5
B-4	13.7	14.4	13.4	13.2	13.7
D-5	11.8	12.3	11.1	11.6	11.7
E-5	15.7	12.3	11.8	13.5	13.3
F-4	14.4	13.5	13.5	13.4	13.7
G-4	12.0	10.7	10.4	Lost ⁽²⁾	11.0
H-8	13.5	13.0	12.6	12.7	12.9
P-6⁽¹⁾	14.3	13.6	12.8	13.5	13.5
Q-5	13.4	12.6	11.4	12.2	12.4
R-6	10.4	9.9	8.9	10.0	9.8

⁽¹⁾ Outer ring station with highest annual mean.

⁽²⁾ See Attachment 1, Table 7, Samples Deviations Table, Comment 5

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Table 13: Thermoluminescent Dosimeters – Special Interest Areas

Analysis: Gamma Dose			Units: mrem/Std. Qtr.		
Station	1st Qtr 2018	2nd Qtr 2018	3rd Qtr 2018	4th Qtr 2018	Annual Mean 2018
E-15	11.0	10.8	9.9	10.0	10.4
F-9⁽¹⁾	11.5	11.2	10.5	10.8	11.0
G-8	11.4	10.7	Lost ⁽²⁾	10.0 ⁽³⁾	10.7
J-15	11.6	10.8	10.3	10.5	10.8

⁽¹⁾ Special interest station with highest annual mean.

⁽²⁾ See Attachment 1, Table 7, Samples Deviations Table, Comment 3

⁽³⁾ See Attachment 1, Table 7, Samples Deviations Table, Comment 6

Table 14: Thermoluminescent Dosimeters – Control

Analysis: Gamma Dose			Units: mrem/Std. Qtr.		
Station	1st Qtr 2018	2nd Qtr 2018	3rd Qtr 2018	4th Qtr 2018	Annual Mean 2018
E-26	9.7	9.7	8.4	8.9	9.2

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Table 15: Surface Water – Gamma

Analysis: Gamma Isotopic								Units: pCi/L						
Location	Start Date	End Date	Mn 54	Co 58	Fe 59	Co 60	Zn 65	Nb 95	I-131	Zr 95	Cs 134	Cs 137	Ba 140	La 140
REQUIRED LLD →			15	15	30	15	30	15	15	15	15	18	15	15
SWK-1 (Indicator)	12/27/2017	01/23/2018	< 2.68	< 3.00	< 6.04	< 2.85	< 5.57	< 2.65	< 3.27	< 5.01	< 3.01	< 2.86	< 10.8	< 3.44
SWK-1 (Indicator)	01/23/2018	02/20/2018	< 2.01	< 1.85	< 4.19	< 2.50	< 4.14	< 2.26	< 2.71	< 3.64	< 2.34	< 2.27	< 9.15	< 2.95
SWK-1 (Indicator)	02/20/2018	03/20/2018	< 2.35	< 2.26	< 5.00	< 3.01	< 5.00	< 2.46	< 3.00	< 4.27	< 2.58	< 2.41	< 9.49	< 3.24
SWK-1 (Indicator)	03/20/2018	04/17/2018	< 2.38	< 2.52	< 5.11	< 2.58	< 4.42	< 2.65	< 4.60	< 4.21	< 2.88	< 2.93	< 12.2	< 3.99
SWK-1 (Indicator)	04/17/2018	05/15/2018	< 4.39	< 3.99	< 7.92	< 4.98	< 8.89	< 3.62	< 5.09	< 7.00	< 4.98	< 4.54	< 14.6	< 6.20
SWK-1 (Indicator)	05/15/2018	06/12/2018	< 2.66	< 2.42	< 4.73	< 3.12	< 5.73	< 2.84	< 3.38	< 4.85	< 2.92	< 2.95	< 11.0	< 3.69
SWK-1 (Indicator)	06/12/2018	07/10/2018	< 1.56	< 1.61	< 3.42	< 1.59	< 3.08	< 1.67	< 3.28	< 2.87	< 1.74	< 1.72	< 8.10	< 2.20
SWK-1 (Indicator)	07/10/2018	08/07/2018	< 2.24	< 2.20	< 4.87	< 2.51	< 4.85	< 2.32	< 2.76	< 3.94	< 2.61	< 2.36	< 9.14	< 2.95
SWK-1 (Indicator)	08/07/2018	09/04/2018	< 1.28	< 1.34	< 2.91	< 1.39	< 2.77	< 1.38	< 2.25	< 2.37	< 1.45	< 1.42	< 6.61	< 2.31
SWK-1 (Indicator)	09/04/2018	10/02/2018	< 1.73	< 1.82	< 3.53	< 2.02	< 3.38	< 1.82	< 2.39	< 3.16	< 2.13	< 1.96	< 7.57	< 2.33
SWK-1 (Indicator)	10/02/2018	10/30/2018	< 1.80	< 1.85	< 3.99	< 2.02	< 3.59	< 1.86	< 3.29	< 2.98	< 1.99	< 1.90	< 9.03	< 3.03
SWK-1 (Indicator)	10/30/2018	11/27/2018	< 1.67	< 1.75	< 3.98	< 1.97	< 3.50	< 1.84	< 3.05	< 3.22	< 1.87	< 1.84	< 8.39	< 2.80
SWK-1 (Indicator)	11/27/2018	12/26/2018	< 1.60	< 1.52	< 3.44	< 1.62	< 3.29	< 1.61	< 2.90	< 2.74	< 1.67	< 1.66	< 8.30	< 2.50

Monitoring Results Tables

Table 16: Surface Water – Tritium

Analysis: H-3		Units: pCi/L	
Location	Start Date	End Date	H 3
REQUIRED LLD →			3000
SWK-1 (Indicator)	12/27/2017	03/20/2018	< 655
SWK-1 (Indicator)	03/20/2018	06/12/2018	< 596
SWK-1 (Indicator)	06/12/2018	09/04/2018	< 635
SWK-1 (Indicator)	09/04/2018	11/27/2018	< 530

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Table 17: Drinking/Surface Water – Gamma and Gross Beta

Analysis: Gamma Isotopic, Gross Beta							Units: pCi/L						
Location	Collection Date	Gross Beta	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Nb-95	Zr-95	Cs-134	Cs-137	Ba-140	La-140
REQUIRED LLD →		4	15	15	30	15	30	15	15	15	18	15	15
DWF/SWF-2 ⁽¹⁾ (Indicator)	03/20/2018	5.29	< 1.78	< 1.88	< 4.09	< 2.10	< 3.45	< 2.01	< 3.67	< 2.01	< 1.96	< 12.4	< 4.12
DWE/SWE-5 (Indicator)	03/20/2018	4.27	< 1.86	< 1.83	< 4.03	< 1.81	< 3.96	< 2.00	< 3.48	< 1.99	< 1.85	< 13.3	< 3.55
DWP/SWP-7 (Control)	03/20/2018	6.20	< 1.45	< 1.51	< 3.66	< 1.53	< 2.77	< 1.70	< 2.71	< 1.52	< 1.62	< 10.4	< 3.41
DWF/SWF-2 ⁽¹⁾ (Indicator)	06/12/2018	9.91	< 3.38	< 4.04	< 8.47	< 5.70	< 8.31	< 3.21	< 6.27	< 4.09	< 4.12	< 14.7	< 7.31
DWE/SWE-5 (Indicator)	06/12/2018	3.34	< 2.88	< 2.80	< 6.30	< 2.74	< 5.85	< 3.20	< 4.62	< 3.00	< 3.10	< 14.4	< 5.16
DWP/SWP-7 (Control)	06/12/2018	3.76	< 2.88	< 3.04	< 6.73	< 3.70	< 6.64	< 3.91	< 5.85	< 3.32	< 3.42	< 14.9	< 6.04
DWF/SWF-2 ⁽¹⁾ (Indicator)	09/04/2018	4.86	< 1.77	< 1.86	< 4.43	< 1.83	< 3.41	< 1.96	< 3.38	< 1.83	< 1.79	< 14.3	< 4.85
DWE/SWE-5 (Indicator)	09/04/2018	4.82	< 1.63	< 1.71	< 3.92	< 1.63	< 3.27	< 1.80	< 3.17	< 1.74	< 1.73	< 13.9	< 3.86
DWP/SWP-7 (Control)	09/04/2018	4.12	< 1.87	< 1.85	< 4.64	< 1.87	< 3.36	< 1.92	< 3.30	< 1.87	< 1.82	< 14.5	< 4.83
DWF/SWF-2 ⁽¹⁾ (Indicator)	11/27/2018	4.36	< 1.75	< 1.71	< 4.01	< 1.81	< 3.35	< 2.00	< 3.38	< 1.79	< 1.93	< 14.3	< 4.29
DWE/SWE-5 (Indicator)	11/27/2018	4.63	< 1.63	< 1.76	< 3.94	< 1.58	< 3.08	< 1.87	< 2.99	< 1.81	< 1.67	< 12.4	< 4.11
DWP/SWP-7 (Control)	11/27/2018	6.09	< 1.54	< 1.74	< 4.00	< 1.65	< 3.19	< 1.92	< 3.16	< 1.76	< 1.71	< 13.8	< 4.03

⁽¹⁾ Station with highest annual Gr-B mean.

Monitoring Results Tables

Table 18: Drinking/Surface Water- Iodine-131

Analysis: Iodine-131		Units: pCi/L	
Location	Start Date	End Date	I-131
REQUIRED LLD →			1.0
DWF/SWF-2 (Indicator) ⁽¹⁾	12/27/2017	01/23/2018	< 0.411
DWF/SWF-2 (Indicator)	12/27/2017	01/23/2018	< 0.526
DWE/SWE-5 (Indicator)	12/27/2017	01/23/2018	< 0.455
DWP/SWP-7 (Control)	12/27/2017	01/23/2018	< 0.554
DWF/SWF-2 (Indicator)	01/23/2018	02/20/2018	< 0.335
DWE/SWE-5 (Indicator)	01/23/2018	02/20/2018	< 0.302
DWP/SWP-7 (Control)	01/23/2018	02/20/2018	< 0.326
DWF/SWF-2 (Indicator)	02/20/2018	03/20/2018	< 0.533
DWE/SWE-5 (Indicator)	02/20/2018	03/20/2018	< 0.520
DWP/SWP-7 (Control)	02/20/2018	03/20/2018	< 0.772
DWF/SWF-2 (Indicator)	03/20/2018	04/17/2018	< 0.396
DWE/SWE-5 (Indicator)	03/20/2018	04/17/2018	< 0.492
DWP/SWP-7 (Control)	03/20/2018	04/17/2018	< 0.952
DWF/SWF-2 (Indicator)	04/17/2018	05/15/2018	< 0.316
DWE/SWE-5 (Indicator)	04/17/2018	05/15/2018	< 0.466
DWP/SWP-7 (Control)	04/17/2018	05/15/2018	< 0.398
DWF/SWF-2 (Indicator)	05/15/2018	06/12/2018	< 0.395
DWE/SWE-5 (Indicator)	05/15/2018	06/12/2018	< 0.382
DWP/SWP-7 (Control)	05/15/2018	06/12/2018	< 0.531
DWF/SWF-2 (Indicator)	06/12/2018	07/11/2018	< 0.388
DWE/SWE-5 (Indicator)	06/12/2018	07/10/2018	< 0.590
DWP/SWP-7 (Control)	06/12/2018	07/10/2018	< 0.514
DWF/SWF-2 (Indicator)	07/11/2018	08/07/2018	< 0.348
DWE/SWE-5 (Indicator)	07/10/2018	08/07/2018	< 0.416
DWP/SWP-7 (Control)	07/10/2018	08/07/2018	< 0.324
DWF/SWF-2 (Indicator)	08/07/2018	09/04/2018	< 0.655
DWE/SWE-5 (Indicator)	08/07/2018	09/04/2018	< 0.349
DWP/SWP-7 (Control)	08/07/2018	09/04/2018	< 0.526
DWF/SWF-2 (Indicator)	09/04/2018	10/02/2018	< 0.406
DWE/SWE-5 (Indicator)	09/04/2018	10/02/2018	< 0.516
DWP/SWP-7 (Control)	09/04/2018	10/02/2018	< 0.376
DWF/SWF-2 (Indicator)	10/02/2018	10/30/2018	< 0.465
DWE/SWE-5 (Indicator)	10/02/2018	10/30/2018	< 0.740
DWP/SWP-7 (Control)	10/02/2018	10/30/2018	< 0.481
DWF/SWF-2 (Indicator)	10/30/2018	11/27/2018	< 0.467
DWE/SWE-5 (Indicator)	10/30/2018	11/27/2018	< 0.689
DWP/SWP-7 (Control)	10/30/2018	11/27/2018	< 0.441
DWF/SWF-2 (Indicator)	11/27/2018	12/26/2018	< 0.666
DWE/SWE-5 (Indicator)	11/27/2018	12/26/2018	< 0.541
DWP/SWP-7 (Control)	11/27/2018	12/26/2018	< 0.457

⁽¹⁾ Duplicate sample

Monitoring Results Tables

Table 19: Drinking/Surface Water – Tritium

Analysis: H-3		Units: pCi/L	
Location	Start Date	End Date	H 3
REQUIRED LLD →			2000
DWF/SWF-2 (Indicator)	12/27/2017	03/20/2018	< 656
DWE/SWE-5 (Indicator)	12/27/2017	03/20/2018	< 655
DWP/SWP-7 (Control)	12/27/2017	03/20/2018	< 662
DWF/SWF-2 (Indicator)	03/20/2018	06/12/2018	< 598
DWE/SWE-5 (Indicator)	03/20/2018	06/12/2018	< 590
DWP/SWP-7 (Control)	03/20/2018	06/12/2018	< 585
DWF/SWF-2 (Indicator)	06/12/2018	09/04/2018	< 637
DWE/SWE-5 (Indicator)	06/12/2018	09/04/2018	< 636
DWP/SWP-7 (Control)	06/12/2018	09/04/2018	< 624
DWF/SWF-2 (Indicator)	09/04/2018	11/27/2018	< 547
DWE/SWE-5 (Indicator)	09/04/2018	11/27/2018	< 540
DWP/SWP-7 (Control)	09/04/2018	11/27/2018	< 551

Monitoring Results Tables

Table 20: Sediment - Gamma

Analysis: Gamma Isotopic		Units: pCi/kg (dry)	
Location	Collection Date	Cs-134	Cs-137
<u>REQUIRED LLD →</u>		<u>150</u>	<u>180</u>
SHWK-1	03/14/2018	< 77.74	< 73.49
SHWE-3	04/30/2018	< 137.7	< 140.5
SHWQ-6	04/30/2018	< 66.15	< 59.67

Monitoring Results Tables

Table 21: Fish - Gamma

Analysis: Gamma Isotopic				Units: pCi/kg (wet)				
Location	Collection Date	Mn 54	Co 58	Fe 59	Co 60	Zn 65	Cs 134	Cs 137
REQUIRED LLD →		<u>130</u>	<u>130</u>	<u>260</u>	<u>130</u>	<u>260</u>	<u>130</u>	<u>150</u>
FH-1 (Control)	11/19/2018	< 69.34	< 69.93	< 141.3	< 69.55	< 158.7	< 81.90	< 63.48
FH-2 (Indicator)	11/19/2018	< 50.48	< 56.55	< 143.7	< 57.49	< 100.9	< 49.85	< 55.66
FH-3 (Indicator)	11/16/2018	< 37.80	< 50.35	< 107.4	< 60.20	< 107.8	< 55.56	< 53.86
FH-1 (Control)	11/19/2018	< 58.30	< 47.22	< 153.1	< 67.05	< 121.6	< 59.90	< 55.85
FH-2 (Indicator)	11/19/2018	< 49.45	< 53.08	< 109.0	< 52.41	< 115.8	< 64.86	< 57.68
FH-3 (Indicator)	11/11/2018	< 70.68	< 85.17	< 129.4	< 75.91	< 162.3	< 84.21	< 68.37
FH-1 (Control)	11/19/2018	< 64.83	< 60.24	< 144.6	< 66.73	< 157.9	< 77.02	< 68.76
FH-2 (Indicator)	11/19/2018	< 76.72	< 83.92	< 180.7	< 82.71	< 145.0	< 77.43	< 73.14
FH-3 (Indicator)	11/16/2018	< 52.76	< 53.62	< 94.90	< 62.27	< 103.1	< 32.92	< 34.77
FH-1 (Control)	11/19/2018	< 56.90	< 66.59	< 141.5	< 52.40	< 100.7	< 54.19	< 50.49
FH-2 (Indicator)	11/19/2018	< 46.33	< 58.49	< 94.86	< 56.62	< 117.3	< 55.54	< 49.36
FH-3 (Indicator)	11/11/2018	< 77.22	< 60.25	< 132.0	< 62.77	< 147.0	< 74.08	< 72.86

Monitoring Results Tables

Table 22: Broad Leaf Vegetation - Gamma

Analysis: Gamma Isotopic		Units: pCi/kg (wet)		
Location	Collection Date	I-131	Cs-134	Cs-137
REQUIRED LLD →		60	60	80
BLQ-1 (Indicator)	03/14/2018	< 26.18	< 24.94	< 27.67
BLB-1 (Indicator)	03/14/2018	< 26.35	< 26.45	< 29.32
BLE-20 (Control)	03/14/2018	< 45.45	< 42.93	< 49.43
BLQ-1 (Indicator)	06/13/2018	< 18.54	< 26.40	< 22.08
BLB-1 (Indicator)	06/13/2018	< 26.54	< 20.27	< 24.11
BLE-20 (Control)	06/13/2018	< 25.81	< 29.71	< 26.03
BLQ-1 (Indicator)	09/11/2018	< 38.07	< 24.40	< 22.03
BLB-1 (Indicator)	09/11/2018	< 57.66	< 35.71	< 32.91
BLE-20 (Control)	09/11/2018	< 56.51	< 36.56	< 38.69
BLQ-1 (Indicator)	12/12/2018	< 22.31	< 15.94	< 21.87
BLB-1 (Indicator)	12/12/2018	< 42.43	< 35.01	< 35.05
BLE-20 (Control)	12/12/2018	< 46.95	< 33.57	< 32.27

Monitoring Results Tables

Table 23: Milk - Gamma and Iodine-131

Analysis: Gamma Isotopic, Iodine-131			Units: pCi/L			
Location	Collection Date	I-131	Cs-134	Cs-137	Ba-140	La-140
REQUIRED LLD →		1	15	18	15	15
MKE-3 (Indicator)	03/15/2018	(1)	(1)	(1)	(1)	(1)
MKA-31 (Control)	03/15/2018	(2)	< 2.67	5.53	< 11.41	< 3.07
MKE-3 (Indicator)	03/27/2018	(1)	(1)	(1)	(1)	(1)
MKA-31 (Control)	03/27/2018	< 0.467	< 3.65	< 3.92	< 12.3	< 3.67
MKE-3 (Indicator)	06/13/2018	(1)	(1)	(1)	(1)	(1)
MKA-31 (Control)	06/13/2018	< 0.432	< 4.20	5.65	< 14.7	< 4.04
MKE-3 (Indicator)	06/26/2018	(1)	(1)	(1)	(1)	(1)
MKA-31 (Control)	06/26/2018	< 0.878	< 2.90	< 2.87	< 9.11	< 2.84
MKE-3 (Indicator)	09/12/2018	(1)	(1)	(1)	(1)	(1)
MKA-31 (Control)	09/12/2018	< 0.499	< 2.13	3.31	< 9.75	< 2.42
MKE-3 (Indicator)	09/25/2018	(1)	(1)	(1)	(1)	(1)
MKA-31 (Control)	09/25/2018	< 0.416	< 2.24	4.49	< 10.4	< 3.54
MKE-3 (Indicator)	12/13/2018	(1)	(1)	(1)	(1)	(1)
MKA-31 (Control)	12/13/2018	< 0.260	< 1.82	< 2.03	< 7.12	< 2.20

(1) See Attachment 1, Table 7, Samples Deviations Table, Comment 1

(2) See Attachment 1, Table 7, Samples Deviations Table, Comment 2

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Interlaboratory Comparison Program Results

1.0 Summary

For the Teledyne Brown Engineering (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.

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.

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 Bq/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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Interlaboratory Comparison Program Results

6. The 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 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 that the laboratories are producing accurate and reliable data.

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**Table 24: Analytics Environmental Radioactivity Cross Check Program
Teledyne Brown Engineering Environmental Services**

Month/Year	Identification Number	Matrix	Nuclide	Units	TBE Reported Value	Known Value ^(a)	Ratio of TBE to Analytics Result	Evaluation ^(b)
March 2018	E12133	Milk	Sr-89	pCi/L	76.1	90.1	0.84	A
			Sr-90	pCi/L	12.2	12.5	0.98	A
March 2018	E12134	Milk	Ce-141	pCi/L	77.8	77.0	1.01	A
			Co-58	pCi/L	105	114	0.92	A
			Co-60	pCi/L	181	187	0.97	A
			Cr-51	pCi/L	298	326	0.92	A
			Cs-134	pCi/L	150	180	0.84	A
			Cs-137	pCi/L	164	172	0.95	A
			Fe-59	pCi/L	140	139	1.01	A
			I-131	pCi/L	105	108.0	0.97	A
			Mn-54	pCi/L	133	131	1.01	A
			Zn-65	pCi/L	242	244	0.99	A
			March 2018	E12135	Charcoal	I-131	pCi	93.7
March 2018	E12136	AP	Ce-141	pCi	92.6	85.3	1.09	A
			Co-58	pCi	130	126	1.03	A
			Co-60	pCi	237	207	1.14	A
			Cr-51	pCi	411	361	1.14	A
			Cs-134	pCi	194	199	0.98	A
			Cs-137	pCi	200	191	1.05	A
			Fe-59	pCi	160	154	1.04	A
			Mn-54	pCi	152	145	1.05	A
March 2018	E12137	Water	Fe-55	pCi/L	1990	1700	1.17	A
March 2018	E12138	Soil	Ce-141	pCi/g	0.148	0.118	1.26	W
			Co-58	pCi/g	0.171	0.174	0.98	A
			Co-60	pCi/g	0.297	0.286	1.04	A
			Cr-51	pCi/g	0.537	0.498	1.08	A
			Cs-134	pCi/g	0.274	0.275	1.00	A
			Cs-137	pCi/g	0.355	0.337	1.05	A
			Fe-59	pCi/g	0.243	0.212	1.15	A
			Mn-54	pCi/g	0.228	0.201	1.14	A
March 2018			Zn-65	pCi/g	0.395	0.374	1.06	A

(a) The Analytics known value is equal to 100% of the parameter present in the standard as determined by gravimetric and/or volumetric measurements made during standard preparation

(b) Analytics evaluation based on TBE internal QC limits:

A = Acceptable - reported result falls within ratio limits of 0.80-1.20

W = Acceptable with warning - reported result falls within 0.70-0.80 or 1.20-1.30

N = Not Acceptable - reported result falls outside the ratio limits of < 0.70 and > 1.30

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**Table 24: Analytics Environmental Radioactivity Cross Check Program
Teledyne Brown Engineering Environmental Services**

Month/Year	Identification Number	Matrix	Nuclide	Units	TBE Reported Value	Known Value ^(a)	Ratio of TBE to Analytics Result	Evaluation ^(b)			
June 2018	E12205	Milk	Sr-89	pCi/L	74.9	84.6	0.89	A			
			Sr-90	pCi/L	10.5	11.4	0.92	A			
June 2018	E12206	Milk	Ce-141	pCi/L	89.2	82.2	1.08	A			
			Co-58	pCi/L	94.8	89	1.07	A			
			Co-60	pCi/L	125	113	1.10	A			
			Cr-51	pCi/L	256	239	1.07	A			
			Cs-134	pCi/L	112	114	0.99	A			
			Cs-137	pCi/L	107	98.8	1.08	A			
			Fe-59	pCi/L	95.9	86.0	1.12	A			
			I-131	pCi/L	69.8	71.9	0.97	A			
			Mn-54	pCi/L	138	130	1.06	A			
			Zn-65	pCi/L	186	157	1.18	A			
			E12207	Charcoal	I-131	pCi	69.6	72.2	0.96	A	
			June 2018	E12208	AP	Ce-141	pCi	151	165	0.92	A
						Co-58	pCi	174	178	0.98	A
Co-60	pCi	290				227	1.28	W			
Cr-51	pCi	452				478	0.95	A			
Cs-134	pCi	215				227	0.95	A			
Cs-137	pCi	206				198	1.04	A			
Fe-59	pCi	180				172	1.05	A			
Mn-54	pCi	265				260	1.02	A			
Zn-65	pCi	280				315	0.89	A			
E12209	Water	Fe-55	pCi/L	1790	1740	1.03	A				
June 2018	E12210	AP	Sr-89	pCi	77.8	90.3	0.86	A			
			Sr-90	pCi	9.54	12.2	0.78	W			

(a) The Analytics known value is equal to 100% of the parameter present in the standard as determined by gravimetric and/or volumetric measurements made during standard preparation

(b) Analytics evaluation based on TBE internal QC limits:

A = Acceptable - reported result falls within ratio limits of 0.80-1.20

W = Acceptable with warning - reported result falls within 0.70-0.80 or 1.20-1.30

N = Not Acceptable - reported result falls outside the ratio limits of < 0.70 and > 1.30

**Table 24: Analytics Environmental Radioactivity Cross Check Program
Teledyne Brown Engineering Environmental Services**

Month/Year	Identification Number	Matrix	Nuclide	Units	TBE Reported Value	Known Value ^(a)	Ratio of TBE to Analytics Result	Evaluation ^(b)
September 2018	E12271	Milk	Sr-89	pCi/L	79.4	81.7	0.97	A
			Sr-90	pCi/L	12.2	14.8	0.82	A
	E12272	Milk	Ce-141	pCi/L	152	128	1.19	A
			Co-58	pCi/L	161	144	1.12	A
			Co-60	pCi/L	208	190	1.10	A
			Cr-51	pCi/L	244	265	0.92	A
			Cs-134	pCi/L	124	123	1.01	A
			Cs-137	pCi/L	166	147	1.13	A
			Fe-59	pCi/L	158	119	1.32	N ⁽¹⁾
			I-131	pCi/L	83.1	58.2	1.43	N ⁽²⁾
			Mn-54	pCi/L	191	167	1.14	A
			Zn-65	pCi/L	229	201	1.14	A
			E12273	Charcoal	I-131	pCi	83.0	80.7
	E12274	AP	Ce-141	pCi	101	85.6	1.18	A
			Co-58	pCi	92.7	96.0	0.97	A
			Co-60	pCi	142	127	1.12	A
			Cr-51	pCi	218	177	1.23	W
			Cs-134	pCi	81.2	81.9	0.99	A
			Cs-137	pCi	99.0	98.5	1.01	A
			Fe-59	pCi	93.7	79.7	1.18	A
			Mn-54	pCi	116	112	1.04	A
	Zn-65	pCi	139	134	1.04	A		
	E12302	Water	Fe-55	pCi/L	2120	1820	1.17	A
	E12276	Soil	Ce-141	pCi/g	0.259	0.221	1.17	A
			Co-58	pCi/g	0.279	0.248	1.12	A
			Co-60	pCi/g	0.367	0.328	1.12	A
			Cr-51	pCi/g	0.597	0.457	1.31	N ⁽³⁾
Cs-134			pCi/g	0.261	0.212	1.23	W	
Cs-137			pCi/g	0.376	0.330	1.14	A	
Fe-59			pCi/g	0.248	0.206	1.20	A	
Mn-54			pCi/g	0.317	0.289	1.10	A	
Zn-65	pCi/g	0.407	0.347	1.17	A			

(a) The Analytics known value is equal to 100% of the parameter present in the standard as determined by gravimetric and/or volumetric measurements made during standard preparation

(b) Analytics evaluation based on TBE internal QC limits:

A = Acceptable - reported result falls within ratio limits of 0.80-1.20

W = Acceptable with warning - reported result falls within 0.70-0.80 or 1.20-1.30

N = Not Acceptable - reported result falls outside the ratio limits of < 0.70 and > 1.30

(1) See **NCR 18-20**

(2) See **NCR 18-24**

(3) See **NCR 18-21**

**Table 24: Analytics Environmental Radioactivity Cross Check Program
Teledyne Brown Engineering Environmental Services**

Month/Year	Identification Number	Matrix	Nuclide	Units	TBE Reported Value	Known Value ^(a)	Ratio of TBE to Analytics Result	Evaluation ^(b)
December 2018	E12313	Milk	Sr-89	pCi/L	71.9	91.9	0.78	W
			Sr-90	pCi/L	12.1	13.3	0.91	A
December 2018	E12314	Milk	Ce-141	pCi/L	124	133	0.93	A
			Co-58	pCi/L	110	119	0.93	A
			Co-60	pCi/L	202	212	0.95	A
			Cr-51	pCi/L	292	298	0.98	A
			Cs-134	pCi/L	146	171	0.85	A
			Cs-137	pCi/L	118	121	0.98	A
			Fe-59	pCi/L	120	114	1.05	A
			I-131	pCi/L	94.2	93.3	1.01	A
			Mn-54	pCi/L	151	154	0.98	A
			Zn-65	pCi/L	266	264	1.01	A
			December 2018	E12315	Charcoal	I-131	pCi	94.8
December 2018	E12316A	AP	Ce-141	pCi	92.3	94.0	0.98	A
			Co-58	pCi	73.4	83.8	0.88	A
			Co-60	pCi	137	150	0.91	A
			Cr-51	pCi	202	210	0.96	A
			Cs-134	pCi	115	121	0.95	A
			Cs-137	pCi	85.0	85.4	1.00	A
			Fe-59	pCi	83.1	80.8	1.03	A
			Mn-54	pCi	104	109	0.96	A
			Zn-65	pCi	168	187	0.90	A
December 2018	E12317	Water	Fe-55	pCi/L	2110	1840	1.15	A
December 2018	E12318	AP	Sr-89	pCi	81.1	83.0	0.98	A
			Sr-90	pCi	11.4	12.0	0.95	A

(a) The Analytics known value is equal to 100% of the parameter present in the standard as determined by gravimetric and/or volumetric measurements made during standard preparation

(b) Analytics evaluation based on TBE internal QC limits:

A = Acceptable - reported result falls within ratio limits of 0.80-1.20

W = Acceptable with warning - reported result falls within 0.70-0.80 or 1.20-1.30

N = Not Acceptable - reported result falls outside the ratio limits of < 0.70 and > 1.30

**Table 25: DOE's Mixed Analyte Performance Evaluation Program (MAPEP)
Teledyne Brown Engineering Environmental Services**

Month/Year	Identification Number	Matrix	Nuclide	Units	TBE Reported Value	Known Value ^(a)	Acceptance Range	Evaluation ^(b)
February 2018	18-MaS38	Soil	Ni-63	Bq/kg	9.94		(1)	A
			Sr-90	Bq/kg	0.846		(1)	A
	18-MaW38	Water	Am-241	Bq/L	0.785	0.709	0.496 - 0.922	A
			Ni-63	Bq/L	12.6	14.0	9.8 - 18.2	A
			Pu-238	Bq/L	0.0214	0.023	(2)	A
			Pu-239/240	Bq/L	0.544	0.600	0.420 - 0.780	A
	18-RdF38	AP	U-234/233	Bq/sample	0.111	0.124	0.087 - 0.161	A
			U-238	Bq/sample	0.123	0.128	0.090 - 0.166	A
	18-RdV38	Vegetation	Cs-134	Bq/sample	2.46	3.23	2.26 - 4.20	W
			Cs-137	Bq/sample	3.14	3.67	2.57 - 4.77	A
			Co-57	Bq/sample	4.12	4.42	3.09 - 5.75	A
			Co-60	Bq/sample	1.86	2.29	1.60 - 2.98	A
			Mn-54	Bq/sample	2.21	2.66	1.86 - 3.46	A
			Sr-90	Bq/sample				NR ⁽³⁾
Zn-65			Bq/sample	-0.201		(1)	A	
November 2018	18-MaS39	Soil	Ni-63	Bq/kg	703	765	536 - 995	A
			Sr-90	Bq/kg	137	193	135 - 251	W
	18-MaW39	Water	Am-241	Bq/L	0.0363		(1)	A
			Ni-63	Bq/L	6.18	7.0	4.9 - 9.1	A
			Pu-238	Bq/L	0.73	0.674	0.472 - 0.876	A
			Pu-239/240	Bq/L	0.89	0.928	0.650 - 1.206	A
	18-RdF39	AP	U-234/233	Bq/sample	0.159	0.152	0.106 - 0.198	A
			U-238	Bq/sample	0.162	0.158	0.111 - 0.205	A
	18-RdV39	Vegetation	Cs-134	Bq/sample	1.85	1.94	1.36 - 2.52	A
			Cs-137	Bq/sample	2.5	2.36	1.65 - 3.07	A
			Co-57	Bq/sample	3.53	3.31	2.32 - 4.30	A
			Co-60	Bq/sample	1.6	1.68	1.18 - 2.18	A
			Mn-54	Bq/sample	2.61	2.53	1.77 - 3.29	A
			Sr-90	Bq/sample	0.338	0.791	0.554 - 1.028	N ⁽⁴⁾
Zn-65			Bq/sample	1.32	1.37	0.96 - 1.78	A	

(a) The MAPEP known value is equal to 100% of the parameter present in the standard as determined by gravimetric and/or volumetric measurements made during standard preparation

(b) DOE/MAPEP evaluation:

A = Acceptable - reported result falls within ratio limits of 0.80-1.20

W = Acceptable with warning - reported result falls within 0.70-0.80 or 1.20-1.30

N = Not Acceptable - reported result falls outside the ratio limits of < 0.70 and > 1.30

NR = No result reported

(1) False positive test

(2) Sensitivity evaluation

(3) See **NCR 18-09**

(4) See **NCR 18-25**

**Table 26: ERA Environmental Radioactivity Cross Check Program
Teledyne Brown Engineering Environmental Services**

Month/Year	Identification Number	Matrix	Nuclide	Units	TBE Reported Value	Known Value ^(a)	Acceptance Limits	Evaluation ^(b)
March 2018	MRAD-28	AP	GR-A	pCi/sample	65.7	43.4	22.7 - 71.5	A
			GR-B	pCi/sample	57.2	52	31.5 - 78.6	A
April 2018	RAD-113	Water	Ba-133	pCi/L	91.2	91.5	77.1 - 101	A
			Cs-134	pCi/L	70.4	75.9	62.0 - 83.5	A
			Cs-137	pCi/L	122	123	111 - 138	A
			Co-60	pCi/L	64.8	64.3	57.9 - 73.2	A
			Zn-65	pCi/L	98.6	86.7	78.0 - 104	A
			GR-A	pCi/L	32.8	28.6	14.6 - 37.5	A
			GR-B	pCi/L	62.9	73.7	51.4 - 81.1	A
			U-Nat	pCi/L	6.7	6.93	5.28 - 8.13	A
			H-3	pCi/L	17100	17200	15000 - 18900	A
			Sr-89	pCi/L	38.6	48.8	38.3 - 56.2	A
			Sr-90	pCi/L	27.1	26.5	19.2 - 30.9	A
I-131	pCi/L	26.7	24.6	20.4 - 29.1	A			
September 2018	MRAD-29	AP	GR-A	pCi/sample	49.7	55.3	28.9 - 91.1	A
			GR-B	pCi/sample	75.3	86.5	52.4 - 131	A
October 2018	RAD-115	Water	Ba-133	pCi/L	15.2	16.3	11.9 - 19.4	A
			Cs-134	pCi/L	85.9	93.0	76.4 - 102	A
			Cs-137	pCi/L	229	235	212 - 260	A
			Co-60	pCi/L	81.9	80.7	72.6 - 91.1	A
			Zn-65	pCi/L	348	336	302 - 392	A
			GR-A	pCi/L	38.9	60.7	31.8 - 75.4	A
			GR-B	pCi/L	36.5	41.8	27.9 - 49.2	A
			U-Nat	pCi/L	17.48	20.9	16.8 - 23.4	A
			H-3	pCi/L	2790	2870	2410 - 3170	A
			I-131	pCi/L	26.9	27.2	22.6 - 32.0	A
			Sr-89	pCi/L	57.2	56.9	45.5 - 64.6	A
Sr-90	pCi/L	36.8	31.4	22.9 - 36.4	N ⁽¹⁾			

(a) The ERA known value is equal to 100% of the parameter present in the standard as determined by gravimetric and/or volumetric measurements made during standard preparation.

(b) ERA evaluation:

A = Acceptable - Reported value falls within the Acceptance Limits

N = Not Acceptable - Reported value falls outside of the Acceptance Limits

(1) See **NCR 18-23**