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W3F1-2017-0037

April 24, 2017

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

Subject: Annual Radiological Environmental Operating Report -2016
Waterford Steam Electric Station, Unit 3 (Waterford 3)
Docket No. 50-382
License No. NPF-38

Dear Sir or Madam:

Attached is the Annual Radiological Environmental Operating Report for the period of January 1 through December 31, 2016. 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 John P. Jarrell, Regulatory Assurance Manager, at (504) 739-6685 if you have questions regarding this information.

Sincerely,

A handwritten signature in black ink, appearing to read "JPJ/LLB".

JPJ/LLB

Attachment: Annual Radiological Environmental Operating Report – 2016 (Including DVD)

IE25
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Attachment to

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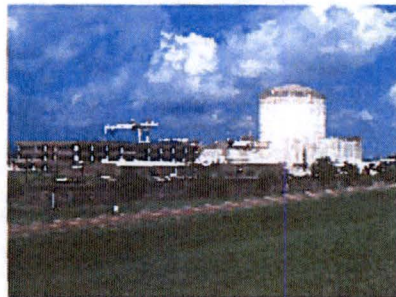
Annual Radiological Environmental Operating Report - 2016

(57 pages)



**Annual
Radiological Environmental Operating
Report**

January 1, 2016 - December 31, 2016



**Waterford 3 Steam Electric Station
Entergy Operations, Inc.**

Docket Number 50-382

License Number NPF-38

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Summary

The Annual Radiological Environmental Operating Report presents data obtained through analyses of environmental samples collected for Waterford 3's (W3) Radiological Environmental Monitoring Program (REMP) for the period January 1 through December 31, 2016. This report fulfills the requirements of W3 Technical Specification 6.9.1.7.

During 2016, gross beta radioactivity was detected in air and drinking/surface water locations. Results obtained at the indicator locations were similar to those obtained at the control location. Therefore, levels continue to remain at background.

Cesium-137 was detected during 2016 at control milk location MKA-31. This is consistent with results obtained from the preoperational program and previous years of operation. The level of Cesium-137 in the sample was below the reporting level required by the W3 TRM.

Radiological Environmental Monitoring Program

W3 established the REMP prior to the station becoming operational (1985) to provide data on background radiation and radioactivity normally present in the area. W3 has continued to monitor the environment by sampling air, water, sediment, milk, fish and broad leaf vegetation, as well as measuring radiation directly.

The REMP includes sampling indicator and control locations within a 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. W3 compares indicator results with control, preoperational, and previous years operational results to assess any impact W3 might have on the surrounding environment.

In 2016, W3 collected environmental samples for radiological analysis. Based on the comparison results of indicator locations with control locations and previous studies, it was concluded that overall W3 operations had no significant impact on plant environs. The review of 2016 data, in many cases, showed undetectable radiation levels in the environment and near background levels in significant pathways associated with W3.

Harmful Effects or Irreversible Damage

The REMP did not detect any harmful effects or evidence of irreversible damage in 2016. Therefore, no analysis or planned course of action to alleviate problems was necessary.

Reporting Levels

W3'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 W3 effluents. Therefore, 2016 results did not trigger any radiological monitoring program special reports.

Radioactivity Not Attributable to W3

The W3 REMP detected radioactivity attributable to other sources three times. These include the 25th Chinese nuclear test explosion in 1980, the radioactivity plume release due to reactor core degradation at the Chernobyl Nuclear Power Plant in 1986, and the airborne release from Dai-ichi, Fukushima following the Tohoku earthquake on March 11, 2011.

Comparison to State Program

W3 compared REMP data to the monitoring program of the Environmental Radiological Laboratory – Department of Environmental Quality Laboratory Services Division (ERL-DEQLSD). The ERL-DEQLSD and the W3 REMP entail similar radiological environmental monitoring program requirements. Both programs have obtained similar results over previous years.

Sample Deviations

◆ Milk Samples

Since milk samples for indicator location MKE-3 were unavailable for all quarters of 2016, broad leaf vegetation sampling was performed as required by TRM Table 3.12-1. Broad leaf vegetation results are in section 2.7. Milk samples were collected from one control location and analyzed for Iodine-131 and gamma radionuclides. Results for Iodine-131 indicate that all measurements were below the calculated LLDs. Cesium-137 was detected during 2016 at control milk location MKA-31. This is consistent with results obtained from the preoperational program and previous years of operation. The level of Cesium-137 in the sample was below the reporting level required by the W3 TRM. Therefore, W3 concluded that plant operations had no significant impact on this pathway during 2016.

◆ Air Samples

The air sample location listed below failed to meet the requirement for sample continuity. As described in footnote (1) of TRM Table 3.12-1, deviations are permitted from the required sampling schedule due to malfunction of sampling equipment and other legitimate reasons.

Location	Sample Period	Explanation of Deviation
APQ-1	08/29/16 – 09/12/16	Sample pump running at low capacity

◆ **Missed Samples**

TLDs located at stations G-4 and H-8 were missing at the time of the first quarter exchange. TLDs located at station A-5 were missing at the time of the second quarter exchange. TLDs located at station A-2 were missing at the time of the third quarter exchange. TLDs located at station N-1 were missing at the time of the fourth quarter exchange.

◆ **Required Lower Limit of Detection (LLD) Values**

All LLDs during this reporting period were within the acceptable limits required by the W3 TRM.

◆ **Unavailable Results**

W3 received analytical results in adequate time for inclusion in this report. In addition, W3's review identified no missing results.

◆ **Program Modifications**

No program modifications were made during 2016.

Attachments

Attachment 1 contains results of air, TLD, water, sediment, milk, fish and broad leaf vegetation collected in 2016. TLDs were analyzed by Stanford Dosimetry. All remaining samples were analyzed by Teledyne Brown Engineering, Inc. Attachment 1 also contains Teledyne's participation in the interlaboratory comparison program during 2016.

Attachment 2 contains statistical comparisons of:

- TLD measurements from stations grouped by distance
- TLD radiation dose to historical data by location
- Gross beta activity measurements on air particulate filters
- Gross beta activity measurements in surface/drinking water samples

1.0 Introduction

1.1 Radiological Environmental Monitoring Program

W3 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 important 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 W3.
- Correlating levels of radiation and radioactivity in the environment with radioactive releases from station operation.

1.2 Pathways Monitored

The airborne, direct radiation, waterborne and ingestion pathways are monitored as required by W3 TRM Table 3.12-1. A description of the W3 REMP utilized to monitor the exposure pathways is described in Table 1.1 and shown in Figures 1-1, 1-2 and 1-3.

Section 2.0 of this report provides a discussion of 2016 sampling results with Section 3.0 providing a summary of results for the monitored exposure pathways.

1.3 Land Use Census

W3 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 W3 that would require modifications to the REMP and the Offsite Dose Calculation Manual (ODCM). 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.

W3 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 W3 and recording results on data sheets.
- Comparing current census results to previous results.

Table 1.1
Radiological Environmental Sampling Program

Exposure Pathway	Requirement	Sample Point Description, Distance and Direction	Sampling and Collection Frequency	Type and Frequency Of Analyses
Airborne	<p>Radioiodine and Particulates Three samples from close to the three SITE BOUNDARY locations, in different sectors, in or near sectors having the highest calculated annual average ground level D/Q.</p>	<p>APQ-1 (NW, 0.81 Miles) – (West bank) Located in soybean/sugarcane field off LA 18 east of LA 18/3141 intersection.</p> <p>APF-1 (ESE, 0.35 Miles) – (West bank) Located on north side of Secondary Meteorological Tower.</p> <p>APC-1 (NE, 0.67 Miles) – (East bank) Located inside Little Gypsy Cooling Water Intake Structure fence.</p>	Continuous sampler operation with sample collection bi-weekly, or more frequently if required by dust loading.	<p>Radioiodine Canister – I-131 analysis bi-weekly.</p> <p>Particulate Sampler – Gross beta radioactivity analysis following filter change. Gamma isotopic analysis of composite (by location) quarterly.</p>
	<p>Radioiodine and Particulates One sample from the vicinity of a community having the highest calculated annual average ground level D/Q.</p>	<p>APP-1 (WNW, 0.84 Miles) – (West bank) Located in soybean/sugarcane field on Short St. in Killona.</p>		
	<p>Radioiodine and Particulates One sample from a control location, as for example 15 -30 km distant and in the least prevalent wind direction.</p>	<p>APE-30 (E, 25.2 Miles) – (West bank) Located on roof of Entergy Office building on Delaronde St. in Algiers. (Control)</p>		

Table 1.1
Radiological Environmental Sampling Program

Exposure Pathway	Requirement	Sample Point Description, Distance and Direction	Sampling and Collection Frequency	Type and Frequency Of Analyses
Direct Radiation	<p>TLDS An inner ring of stations, one in each meteorological sector in the general area of the SITE BOUNDARY.</p>	<p>A-2 (N, 1.27 Miles) – (East bank) Located on pole on LA 628 at Zephirin L. Perriloux Fire House.</p> <p>B-1 (NNE, 0.75 Miles) – (East bank) Located on fence west of Little Gypsy.</p> <p>C-1 (NE, 0.67 Miles) – (East bank) Located on fence at Little Gypsy Cooling Water Intake structure.</p> <p>D-2 (ENE, 1.24 Miles) – (East bank) Located on pole on levee at west entrance to Bonnet Carre Spillway.</p>	Quarterly	Gamma dose quarterly.

Table 1.1
Radiological Environmental Sampling Program

Exposure Pathway	Requirement	Sample Point Description, Distance and Direction	Sampling and Collection Frequency	Type and Frequency Of Analyses
Direct Radiation	<p>TLDs An inner ring of stations, one in each meteorological sector in the general area of the SITE BOUNDARY.</p>	<p>E-1 (E, 0.41 Miles) – (West bank) Located on pole on LA 18 east of Waterford 3 plant entrance.</p> <p>F-2 (ESE, 1.15 Miles) – (West bank) Located on fence on LA 3142 south of LA 18.</p> <p>G-2 (SE, 1.26 Miles) – (West bank) Located on fence on LA 3142 north of railroad overpass.</p> <p>H-2 (SSE, 1.54 Miles) – (West bank) Located on fence on LA 3142 north of LA 3127/3142 intersection.</p>	Quarterly	Gamma dose quarterly.

Table 1.1
Radiological Environmental Sampling Program

Exposure Pathway	Requirement	Sample Point Description, Distance and Direction	Sampling and Collection Frequency	Type and Frequency Of Analyses
Direct Radiation	<p>TLDs An inner ring of stations, one in each meteorological sector in the general area of the SITE BOUNDARY.</p>	<p>J-2 (S, 1.38 Miles) – (West bank) Located on fence south of LA 3127 west of LA 3127/3142 intersection.</p> <p>K-1 (SSW, 1.06 Miles) – (West bank) Located on stop sign at entrance to Entergy Education Center on LA 3127.</p> <p>L-1 (SW, 1.06 Miles) – (West bank) Located on gate on LA 3127 west of LA 3127/3142 intersection.</p> <p>M-1 (WSW, 0.76 Miles) – (West bank) Located on south gate of Waterford 1 and 2.</p> <p>N-1 (W, 0.98 Miles) – (West bank) Located on pole at corner of Railroad Avenue and School House Road.</p>	Quarterly	Gamma dose quarterly.

Table 1.1
Radiological Environmental Sampling Program

Exposure Pathway	Requirement	Sample Point Description, Distance and Direction	Sampling and Collection Frequency	Type and Frequency Of Analyses
Direct Radiation	<p>TLDs An inner ring of stations, one in each meteorological sector in the general area of the SITE BOUNDARY.</p>	<p>P-1 (WNW, 0.84 Miles) – (West bank) Located on fence enclosing air sample station APP-1.</p> <p>Q-1 (NW, 0.81 Miles) – (West bank) Located on fence enclosing air sample station APQ-1.</p> <p>R-1 (NNW, 0.51 Miles) – (West bank) Located at Waterford 1 and 2 Cooling Water Intake Structure.</p>	Quarterly	Gamma dose quarterly.
	<p>TLDs An outer ring of stations, 1 in 10 of the meteorological sectors in the 6 to 8 km ranges from the site.</p>	<p>A-5 (N, 4.59 Miles) – (East bank) Located on pole at intersection of Oswald Avenue and US 61.</p>		

Table 1.1
Radiological Environmental Sampling Program

Exposure Pathway	Requirement	Sample Point Description, Distance and Direction	Sampling and Collection Frequency	Type and Frequency Of Analyses
Direct Radiation	<p>TLDs An outer ring of stations, 1 in 10 of the meteorological sectors in the 6 to 8 km ranges from the site.</p>	<p>B-4 (NNE, 3.75 Miles) – (East bank) Located on pole near weigh station on US 61.</p> <p>D-5 (ENE, 4.09 Miles) – (East bank) Located on gate on shell road north of US61/LA48 intersection.</p> <p>F-4 (ESE, 3.53 Miles) – (West bank) Located on pole behind house at 646 Aquarius St. in Hahnville.</p>	Quarterly	Gamma dose quarterly.

Table 1.1
Radiological Environmental Sampling Program

Exposure Pathway	Requirement	Sample Point Description, Distance and Direction	Sampling and Collection Frequency	Type and Frequency Of Analyses
Direct Radiation	<p>TLDs An outer ring of stations, 1 in 10 of the meteorological sectors in the 6 to 8 km ranges from the site.</p>	<p>E-5 (E, 4.08 Miles) – (East bank) Located on fence on Wesco Street off LA 48.</p> <p>G-4 (SE, 3.30 Miles) – (West bank) Located on pole on LA 3160 north of railroad track.</p> <p>H-8 (SSE, 8.13 Miles) – (West bank) Located on pole in front of Hahnville High School.</p> <p>P-6 (WNW, 5.58 Miles) – (West bank) Located on fence at LA 640/railroad track intersection.</p> <p>Q-5 (NW, 5.01 Miles) – (West bank) Located on pole on LA 18 across from Mississippi River marker 137.</p>	Quarterly	Gamma dose quarterly.

Table 1.1
Radiological Environmental Sampling Program

Exposure Pathway	Requirement	Sample Point Description, Distance and Direction	Sampling and Collection Frequency	Type and Frequency Of Analyses
Direct Radiation	<p>TLDs An outer ring of stations, 1 in 10 of the meteorological sectors in the 6 to 8 km ranges from the site.</p>	<p>R-6 (NNW, 5.52 Miles) – (East bank) Located on fence on LA 3223 near railroad crossing.</p>	Quarterly	Gamma dose quarterly.
	<p>TLDs The balance of the stations to be in special interest areas such as population centers, nearby residences, schools, and in 1 or 2 areas to serve as control stations.</p>	<p>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.</p>		

Table 1.1
Radiological Environmental Sampling Program

Exposure Pathway	Requirement	Sample Point Description, Distance and Direction	Sampling and Collection Frequency	Type and Frequency Of Analyses
Direct Radiation	<p>TLDs The balance of the stations to be in special interest areas such as population centers, nearby residences, schools, and in 1 or 2 areas to serve as control stations.</p>	<p>J-15 (S, 11.7 Miles) - (West bank) Located on pole near LA 631/Hwy 90 intersection in Des Allemands.</p> <p>E-30 (E, 25.2 Miles) - (West bank) Located at entrance to Entergy office on Delaronde St. in Algiers. (Control)</p>	Quarterly	Gamma dose quarterly.
Waterborne	<p>Surface Water One sample upstream</p> <p>One sample downstream</p>	<p>SWP-7 (WNW, 7.37 Miles) - (West bank) Located at St. John Parish Waterworks in Edgard. (Control)</p> <p>SWF-2 (ESE, 1.51 Miles) - (West bank) Located at Dow Chemical Plant drinking water canal.</p> <p>SWE-5 (E, 4.59 Miles) - (East bank) Located at St. Charles Parish Waterworks in New Sarpy.</p> <p>SWK-1 (SSW, 0.49 Miles) - (West bank) Located at 40 Arpent Canal south of the plant.</p>	Composite sample over one quarter period.	Gamma isotopic analysis quarterly. Composite for tritium analysis quarterly.

Table 1.1
Radiological Environmental Sampling Program

Exposure Pathway	Requirement	Sample Point Description, Distance and Direction	Sampling and Collection Frequency	Type and Frequency Of Analyses
Waterborne	<p>Drinking Water One sample upstream</p> <p>One sample downstream</p>	<p>DWP-7 (WNW, 7.37 Miles) - (West bank) Located at St. John Parish Waterworks in Edgard. (Control)</p> <p>DWF-2 (ESE, 1.51 Miles) - (West bank) Located at Dow Chemical Plant drinking water canal.</p> <p>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.	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>Sediment from Shoreline One sample upstream</p> <p>One sample downstream</p>	<p>SHWQ-6 (NW, 5.99 Miles) – (East bank) Located on LA 628 east of Reserve ferry landing. (Control)</p> <p>SHWE-3 (E, 2.99 Miles) – (West bank) Located at Foot Ferry landing on LA 18.</p> <p>SHWK-1 (SSW, 0.49 Miles) – (West bank) Located at 40 Arpent Canal south of plant.</p>	Annually	Gamma Isotopic analysis annually.
Ingestion	<p>Milk 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.</p>	<p>MKE-3 (E, 2.35 Miles) - (West bank) Located at the Zeringue's house on LA 18 in Taft.</p>	Quarterly	Gamma Isotopic and I-131 analysis quarterly.

Table 1.1
Radiological Environmental Sampling Program

Exposure Pathway	Requirement	Sample Point Description, Distance and Direction	Sampling and Collection Frequency	Type and Frequency Of Analyses
Ingestion	<p><u>Milk</u> One sample from milking animals at a control location 15 – 30 km distant and in the least prevalent wind direction.</p>	<p>MKA-31 (N, 31.2 Miles) – (East bank) Located at 18736 Sisters Road, Ponchatoula, LA. (Control)</p>	<p>Quarterly</p>	<p>Gamma isotopic and I-131 analysis quarterly.</p>
	<p><u>Fish and Invertebrates</u> One sample of each commercially and recreational important species in vicinity of plant discharge area.</p> <p>One sample of same species in area not influenced by plant discharge.</p>	<p>FH-2 (Distance/Direction Not Applicable) – Downstream of the plant discharge structure.</p> <p>FH-3 (Distance/Direction Not Applicable) – (Westbank) Waterways downstream of plant discharge directed to 40 Arpent Canal.</p> <p>FH-1 (Distance/Direction Not Applicable) – Upstream of the plant intake structure. (Control)</p>	<p>Sample In season, or annually if they are not seasonal</p>	<p>Gamma isotopic analysis on edible portion.</p>
	<p><u>Broadleaf</u> Samples of one to three different kinds of broadleaf vegetation grown nearest each of two different off-site locations of highest predicted annual average ground level D/Q if milk sampling is not performed.</p> <p>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.</p>	<p>BLQ-1 (NW, 0.83 Miles) – (West bank) Located near air sample station APQ-1.</p> <p>BLB-1 (NNE, 0.81 Miles) – (East bank) Located west of Little Gypsy on LA 628.</p> <p>BLE-20 (E, 19.7 Miles) – (West bank) Located on property of Nine Mile Point in Westwego. (Control)</p>	<p>Quarterly</p>	<p>Gamma isotopic and I-131 analysis.</p>

FIGURE 1-1

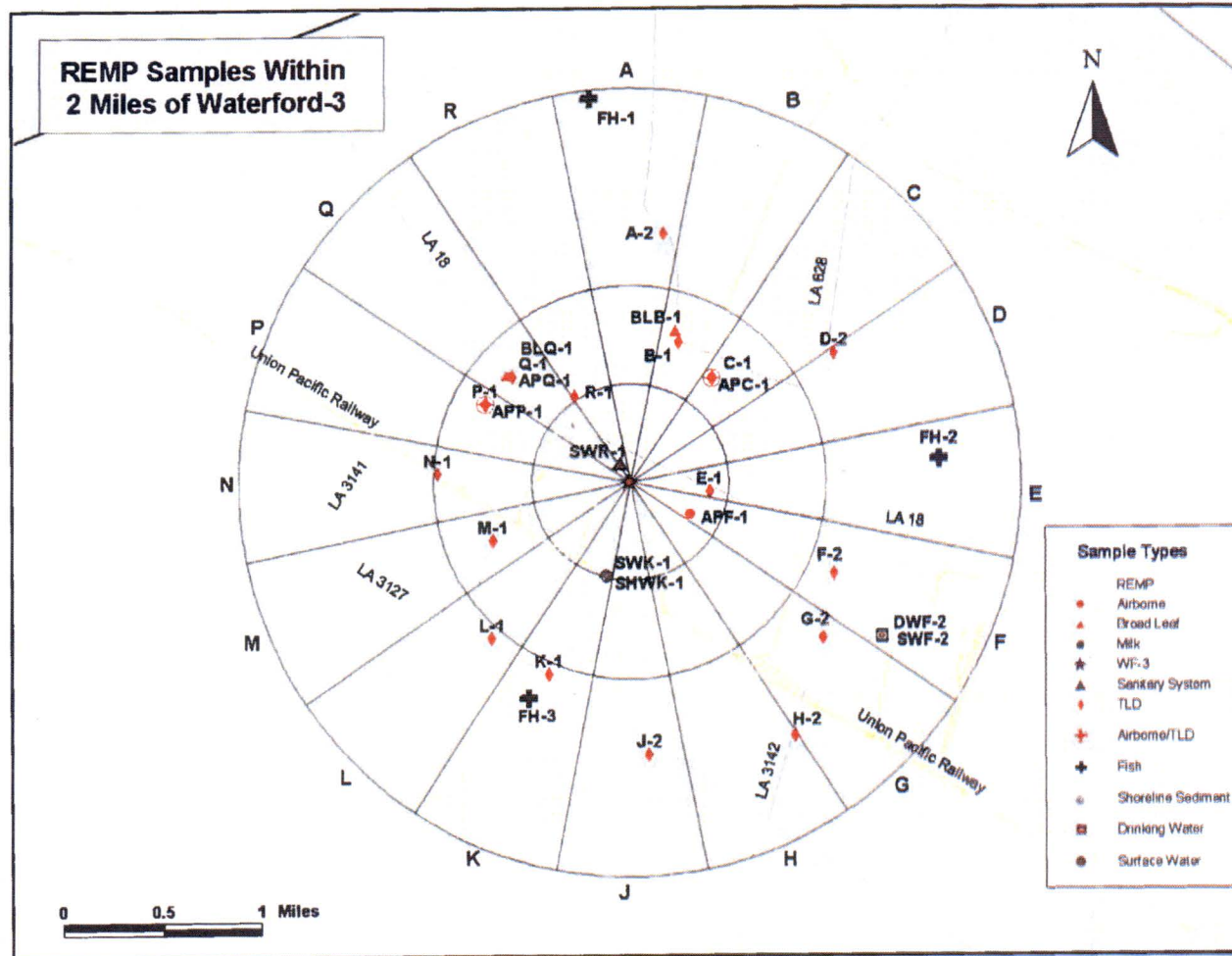


FIGURE 1-2

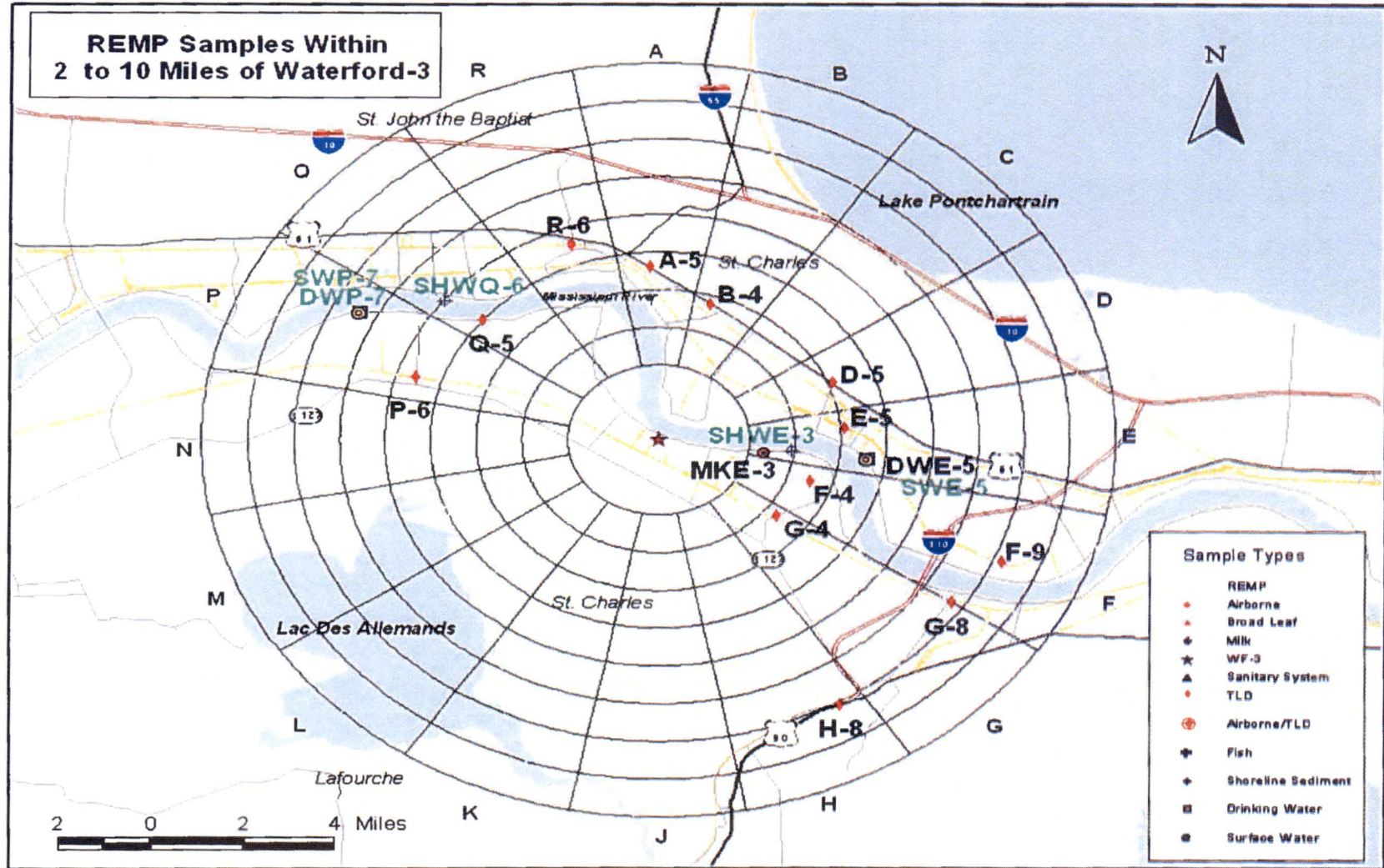
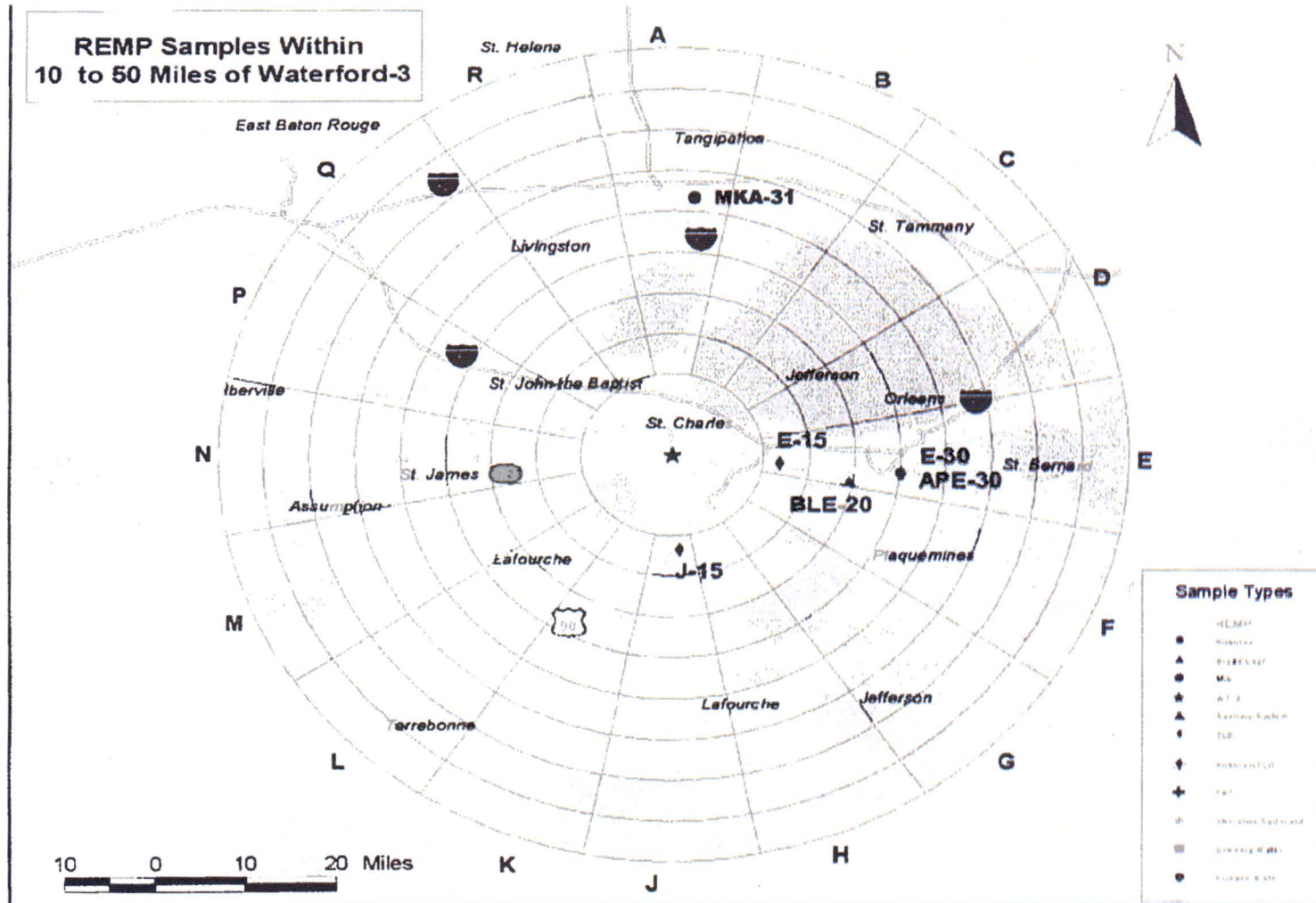


FIGURE 1-3



2.0 Interpretation and Trends of Results

2.1 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). W3 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 2016 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 $\mu\text{Ci}/\text{m}^3$.

<u>Monitoring Period</u>	<u>Result</u>
Preoperational	0.080
1983 – 2015	0.020
2016	0.019

Table 3.1, which includes gross beta concentrations for 2016, provides a comparison of the indicator and control means. It further emphasizes that the airborne pathway continues to remain at background levels. In addition, as shown in Attachment 2, the standard "t" test was used to compare average gross beta activity from each indicator station to the average gross beta activity at the control station. The results from this test show the average activity detected at all indicator stations is statistically the same as the average activity detected at the control station. Therefore, W3 concluded that plant operations had no significant impact on this pathway during 2016.

2.2 Thermoluminescent Dosimetry Sample Results

The average exposure rates during 2016 are consistent with those from the preoperational program and the previous five years of operation as seen in Figure 2-1. 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 8 to 16 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 3.1, shows that the average indicator is slightly higher than that of the control. As shown in Attachment 1, Table 2.1, several indicator locations are higher than the control by a few mrem with a maximum difference of five mrem.

As shown in Attachment 2, Table 2.1, the standard "t" test was used to compare average exposure rates for TLD stations located in groups 0-2 miles and 2-5 miles from the plant to those > 5 miles. The results indicate that the average exposure rates 0-2 miles and 2-5 miles from the plant are statistically the same as >5 miles.

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 W3 plant operations that can affect background radiation in the vicinity of each TLD station. Direct radiation measurements at each TLD station have remained statistically the same in 2016 as previous years of operation as evidenced on Attachment 2, Table 2.2. In addition, Radiological Gaseous Effluents for 2016 were only a small fraction of the limits and are not expected to have any impact on environmental TLD measurements.

2.3 Water Sample Results

Analytical results for 2016 drinking/surface water samples were similar to those reported in previous years.

Drinking/Surface Water

Drinking water samples also serve as surface water samples for W3. Therefore, monthly and quarterly gamma spectroscopy and tritium analyses of drinking water also satisfy the surface water sampling requirement.

Composite drinking/surface water samples were collected from two indicators and one control location and analyzed for Iodine-131, gamma radionuclides and tritium. Results indicate that all measurements were below the calculated LLDs.

Although gross beta was detected in the drinking/surface water samples, results for the indicator locations were below previous operational and preoperational years as seen below. Results are reported as annual average pCi/l.

<u>Monitoring Period</u>	<u>Result</u>
Preoperational	7.0
1983 – 2015	4.7
2016	4.4

Table 3.1, which includes gross beta concentrations for 2016, provides a comparison of the indicator and control means. It shows that the waterborne pathway continues to remain at background levels. In addition, as shown in Attachment 2, the standard "t" test was used to compare average gross beta activity from indicator stations to the average gross beta activity from the control station. The results from the test show the average activity detected at each indicator station is statistically the same as the average activity detected at the control station. Therefore, W3 concluded that plant operations had no significant impact on this pathway during 2016.

Surface Water

Surface water samples were collected from one indicator location and analyzed for gamma radionuclides and tritium. Results indicate that all measurements were below the calculated LLDs. Therefore, W3 concluded that plant operations had no significant impact on this pathway during 2016.

2.4 Sediment Sample Results

Sediment samples were collected from two indicator locations and one control location and analyzed for gamma radionuclides. Results indicate that all measurements were below the calculated LLDs. Therefore, W3 concluded that plant operations had no significant impact on this pathway during 2016.

2.5 Milk Sample Results

Since milk samples for indicator location MKE-3 were unavailable for all quarters of 2016, broad leaf vegetation sampling was performed as required by TRM Table 3.12-1. Broad leaf vegetation results are in section 2.7. Milk samples were collected from one control location and analyzed for iodine-131 and gamma radionuclides. Results for iodine-131 indicate that all measurements were below the calculated LLDs. Cesium-137 was detected during 2016 at control milk location MKA-31. This is consistent with results obtained from the preoperational program and previous years of operation. The level of Cesium-137 in the sample was below the reporting level required by the W3 TRM. Therefore, W3 concluded that plant operations had no significant impact on this pathway during 2016.

2.6 Fish Sample Results

Fish samples were collected from two indicators and one control location and analyzed for gamma radionuclides. Results indicate that all measurements were below the calculated LLDs. Therefore, W3 concluded that plant operations had no significant impact on this pathway during 2016.

2.7 Broadleaf Vegetation Sample Results

Broadleaf vegetation samples were collected from two indicators and one control location and analyzed for iodine-131 and gamma radionuclides. Results indicate that all measurements were below the calculated LLDs. Therefore, W3 concluded that plant operations had no significant impact on this pathway during 2016.

2.8 Land Use Census Results

In compliance with the Waterford 3 ODCM and TRM, the land use census was conducted September 19 – September 21, 2016. 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.

Four new garden locations (sectors A, C, D, and Q), one new resident location (sector P), two new goat locations (sectors A and E), and two new beef cow locations (sectors B and E) were identified in 2016. Food product and milk cow locations remained unchanged for 2016. 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 W3, no REMP sampling location changes are necessary. Results of the 2016 biennial census are shown in Table 2.1.

2.9 Interlaboratory Comparison Results

Teledyne Brown Engineering, Inc. analyzed interlaboratory comparison samples for W3 to fulfill the requirements of Section 5.7.2 of the ODCM. Attachment 1 contains these results.

TABLE 2.1

Biennial Land Use Census Results

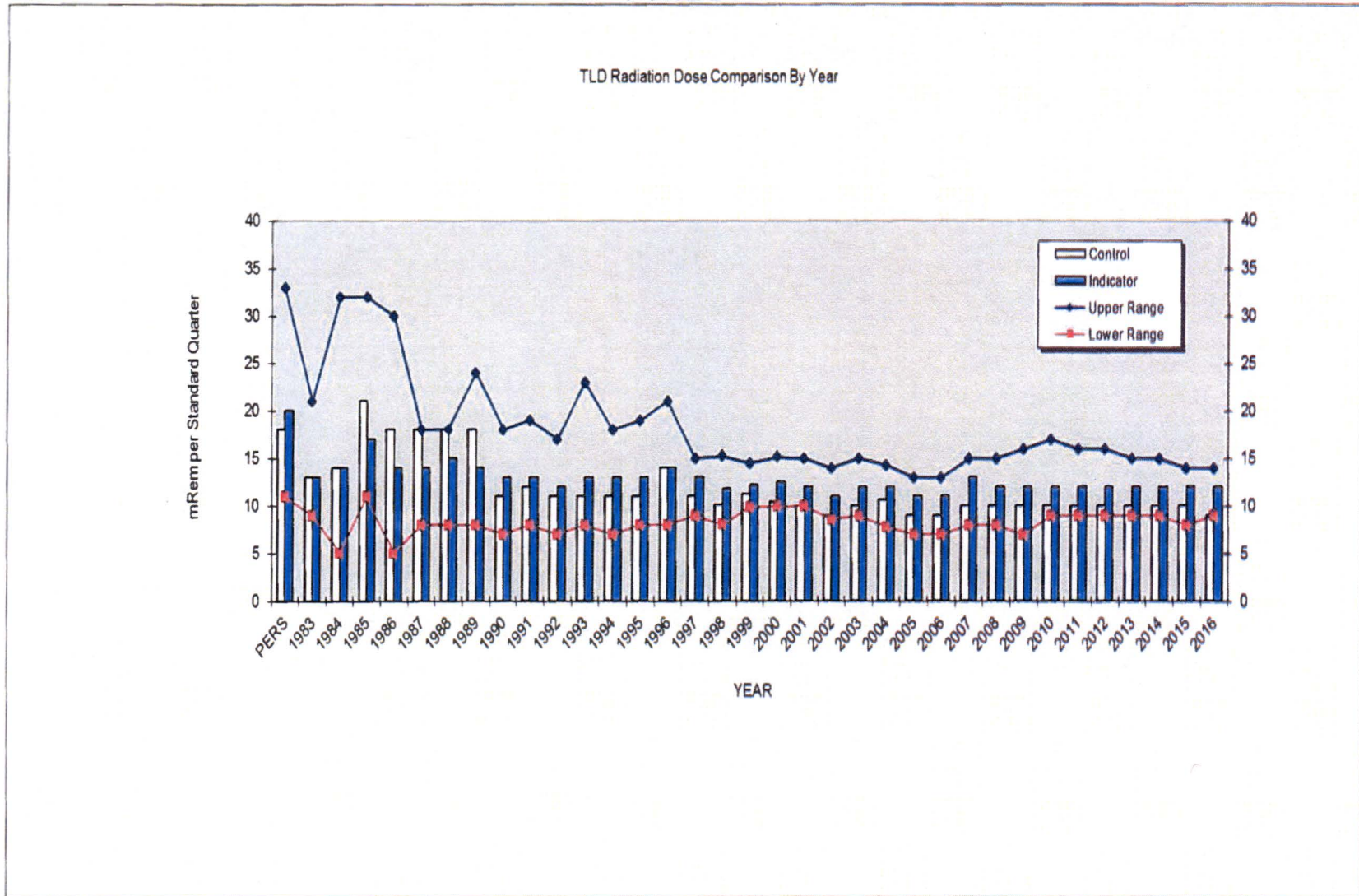
Sector	Direction	Distance from Plant in Miles					
		Residence	Garden	Milk Cows	Beef Cows	Goats	Food Products
A	N	1.3	1.7	^	4.8	*4.8	4.1
B	NNE	1.1	1.3	^	1.7	^	1.3
C	NE	0.9	1.0	^	^	^	^
D	ENE	0.9	0.8	^	^	^	^
E	E	2.2	2.3	**2.3	2.3	*2.4	0.3
F	ESE	3.1	2.3	^	2.3	^	0.3
G	SE	4.0	4.1	^	2.4	^	0.3
H	SSE	^	^	^	^	^	0.3
J	S	^	^	^	^	^	0.5
K	SSW	^	^	^	^	^	0.5
L	SW	^	^	^	^	^	0.5
M	WSW	^	1.4	^	1.2	^	0.5
N	W	1.0	1.1	^	1.0	^	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

^ Indicates that nothing was found in the sector within a five mile radius of Waterford 3

* Animals were located at this distance from Waterford 3, but the milk is not currently used for human consumption

** Samples are being obtained from animals at this location (MKE-3) for REMP

FIGURE 2-1



3.0 Radiological Environmental Monitoring Program Summary

3.1 2016 Program Results Summary

Table 3.1 summarizes the 2016 REMP results. W3 did not use values reported as less than the lower limit of detection (< LLD) when determining ranges and means for indicator and control locations.

TABLE 3.1

Radiological Environmental Monitoring Program Summary

Name of Facility: Waterford 3 SES Docket No: 50-382
Location of Facility: St. Charles, Louisiana Reporting Period: January - December 2016

Sample Type (Units)	Type & Number Of Analyses ^a	LLD ^b	Indicator Locations Mean (F) ^c [Range]	Location with Highest Annual Mean		Control Locations Mean (F) ^c [Range]	Number of Nonroutine Results ^e
				Location ^d	Mean (F) ^c [Range]		
Airborne Particulates (pCi/m ³)	GB 130	0.01	0.019(104 / 104) [0.009 - 0.036]	APF-1 (ESE, 0.35 mi.)	0.020 (26 / 26) [0.011 - 0.036]	0.019 (26 / 26) [0.009 - 0.034]	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
Indicator TLDs (mrem/Std. Qtr)	Gamma 120	(f)	12 (115 / 120) [9.0 - 14.3]	F-4 (ESE, 3.53 mi.)	14 (4 / 4) [13.0 - 14.3]	N/A	0
Control TLDs (mrem/Std. Qtr)	Gamma 4	(f)	N/A	N/A	N/A	9 (4 / 4) [8.9 - 9.5]	0

TABLE 3.1

Radiological Environmental Monitoring Program Summary

Name of Facility: **Waterford 3 SES** Docket No: **50-382**
Location of Facility: **St. Charles, Louisiana** Reporting Period: **January - December 2016**

Sample Type (Units)	Type & Number of Analyses ^a	LLD ^b	Indicator Location Mean (F) ^c [Range]	Location with Highest Annual Mean		Control Locations Mean (F) ^c [Range]	Number of Nonroutine Results ^e
				Location ^d	Mean (F) ^c [Range]		
Surface Water & Drinking Water (pCi/l)	Gross Beta 12	4	4.4 (7 / 8) [3.2 - 6.7]	DWF/SWF-2 (ESE, 1.51 ml.)	4.8 (4 / 4) [3.2 - 6.7]	3.8 (4 / 4) [2.1 - 5.7]	0
	I-131 40	1	<LLD	N/A	N/A	<LLD	0
	H-3 12	2000	<LLD	N/A	N/A	<LLD	0
	GS 12						
	Mn-54 15	15	<LLD	N/A	N/A	<LLD	0
	Fe-59 30	30	<LLD	N/A	N/A	<LLD	0
	Co-58 15	15	<LLD	N/A	N/A	<LLD	0
	Co-60 15	15	<LLD	N/A	N/A	<LLD	0
	Zn-65 30	30	<LLD	N/A	N/A	<LLD	0
	Zr-95 15	15	<LLD	N/A	N/A	<LLD	0
	Nb-95 15	15	<LLD	N/A	N/A	<LLD	0
	Cs-134 15	15	<LLD	N/A	N/A	<LLD	0
	Cs-137 18	18	<LLD	N/A	N/A	<LLD	0
	Ba-140 15	15	<LLD	N/A	N/A	<LLD	0
La-140 15	15	<LLD	N/A	N/A	<LLD	0	

TABLE 3.1

Radiological Environmental Monitoring Program Summary

Name of Facility: Waterford 3 SES Docket No: 50-382
Location of Facility: St. Charles, Louisiana Reporting Period: January - December 2016

Sample Type (Units)	Type & Number of Analyses ^a	LLD ^b	Indicator Locations Mean (F) ^c [Range]	Location with Highest Annual Mean		Control Locations Mean (F) ^c [Range]	Number of Nonroutine Results ^e
				Location ^d	Mean (F) ^c [Range]		
Surface Water (pCi/l)	H-3 4	3000	<LLD	N/A	N/A	N/A	0
	GS 13						
	Mn-54 15	15	<LLD	N/A	N/A	N/A	0
	Fe-59 30	30	<LLD	N/A	N/A	N/A	0
	Co-58 15	15	<LLD	N/A	N/A	N/A	0
	Co-60 15	15	<LLD	N/A	N/A	N/A	0
	Zn-65 30	30	<LLD	N/A	N/A	N/A	0
	Zr-95 15	15	<LLD	N/A	N/A	N/A	0
	Nb-95 15	15	<LLD	N/A	N/A	N/A	0
	Cs-134 15	15	<LLD	N/A	N/A	N/A	0
	Cs-137 18	18	<LLD	N/A	N/A	N/A	0
	Ba-140 15	15	<LLD	N/A	N/A	N/A	0
	La-140 15	15	<LLD	N/A	N/A	N/A	0
	I-131 15	15	<LLD	N/A	N/A	N/A	0
Shoreline Sediment (pCi/kg dry)	GS 3						
	Cs-134 150	150	<LLD	N/A	N/A	<LLD	0
	Cs-137 180	180	<LLD	N/A	N/A	<LLD	0

TABLE 3.1
Radiological Environmental Monitoring Program Summary

Name of Facility: **Waterford 3 SES** Docket No: **50-382**
Location of Facility: **St. Charles, Louisiana** Reporting Period: **January - December 2016**

Sample Type (Units)	Type & Number of Analyses ^a	LLD ^b	Indicator Location Mean (F) ^c [Range]	Location with Highest Annual Mean		Control Locations Mean (F) ^c [Range]	Number of Nonroutine Results ^e
				Location ^d	Mean (F) ^c [Range]		
Milk (pCi/l)	I-131 7	1	< LLD	N/A	N/A	<LLD	0
	GS 7						
	Cs-134 15		< LLD	N/A	N/A	<LLD	0
	Cs-137 18		< LLD	N/A	N/A	5.42 (4 / 7) [3.95 - 6.08]	0
	Ba-140 15		< LLD	N/A	N/A	<LLD	0
	La-140 15		< LLD	N/A	N/A	<LLD	0
Fish (pCi/kg wet)	GS 12						
	Mn-54 130		<LLD	N/A	N/A	<LLD	0
	Fe-59 260		<LLD	N/A	N/A	<LLD	0
	Co-58 130		<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
Broadleaf Vegetation (pCi/kg wet)	I-131 12	60	<LLD	N/A	N/A	<LLD	0
	GS 12						
	Cs-134 60		<LLD	N/A	N/A	<LLD	0
	Cs-137 80		<LLD	N/A	N/A	<LLD	0

^a GB = Gross beta; I-131 = Iodine-131; H-3 = Tritium; GS = Gamma scan.

^b LLD = required lower limit of detection based on Waterford 3 TRM.

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

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

^e 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.

^f LLD is not defined in Waterford 3 TRM.

Attachment 1
2016 Radiological Monitoring Report
Summary of Monitoring Results

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Table 1.1
Sample Type: Air Particulate Filter
Analysis: Gross Beta
Units: $\mu\text{Ci}/\text{m}^3$

End Date	APF-1 (Indicator)	APQ-1 (Indicator)	APP-1 (Indicator)	APC-1 (Indicator)	APE-30 (Control)
<u>Required LLD</u> →	<u>0.01</u>	<u>0.01</u>	<u>0.01</u>	<u>0.01</u>	<u>0.01</u>
01-05-16	0.0163	0.0165	0.0192	0.0135	0.0174
01-18-16	0.0254	0.0220	0.0226	0.0196	0.0247
02-01-16	0.0185	0.0216	0.0185	0.0210	0.0205
02-15-16	0.0185	0.0175	0.0158	0.0181	0.0175
02-29-16	0.0150	0.0142	0.0134	0.0152	0.0146
03-14-16	0.0172	0.0153	0.0147	0.0169	0.0153
03-28-16	0.0161	0.0176	0.0153	0.0144	0.0162
04-11-16	0.0168	0.0171	0.0172	0.0173	0.0210
04-25-16	0.0204	0.0150	0.0162	0.0190	0.0183
05-09-16	0.0162	0.0163	0.0197	0.0150	0.0170
05-24-16	0.0249	0.0189	0.0185	0.0173	0.0189
06-06-16	0.0147	0.0153	0.0148	0.0152	0.0137
06-20-16	0.0213	0.0180	0.0209	0.0182	0.0189
07-05-16	0.0278	0.0224	0.0215	0.0180	0.0194
07-18-16	0.0155	0.0158	0.0135	0.0138	0.0147
08-01-16	0.0120	0.0104	0.0127	0.0125	0.0127
08-15-16	0.0179	0.0154	0.0155	0.0163	0.0151
08-29-16	0.0107	0.0120	0.0090	0.0099	0.0093
09-12-16	0.0182	0.0219	0.0150	0.0163	0.0125
09-26-16	0.0119	0.0124	0.0109	0.0119	0.0119
10-10-16	0.0298	0.0271	0.0236	0.0271	0.0303
10-24-16	0.0169	0.0178	0.0196	0.0155	0.0168
11-07-16	0.0266	0.0262	0.0249	0.0251	0.0287
11-21-16	0.0355	0.0311	0.0316	0.0295	0.0338
12-05-16	0.0234	0.0282	0.0216	0.0225	0.0272
12-19-16	0.0229	0.0203	0.0190	0.0186	0.0194

Table 1.2
Sample Type: Radioiodine Cartridge
Analysis: Iodine-131
Units: pCi/m³

End Date	APF-1 (Indicator)	APQ-1 (Indicator)	APP-1 (Indicator)	APC-1 (Indicator)	APE-30 (Control)
<u>Required LLD</u> →	<u>0.07</u>	<u>0.07</u>	<u>0.07</u>	<u>0.07</u>	<u>0.07</u>
01-05-16	< 0.0138	< 0.0335	< 0.0334	< 0.0313	< 0.0336
01-18-16	< 0.0100	< 0.0242	< 0.0242	< 0.0219	< 0.0242
02-01-16	< 0.0127	< 0.0339	< 0.0337	< 0.0307	< 0.0342
02-15-16	< 0.0145	< 0.0324	< 0.0324	< 0.0293	< 0.0326
02-29-16	< 0.0322	< 0.0303	< 0.0303	< 0.0271	< 0.0127
03-14-16	< 0.0183	< 0.0408	< 0.0406	< 0.0363	< 0.0411
03-28-16	< 0.0239	< 0.0223	< 0.0222	< 0.0109	< 0.0224
04-11-16	< 0.0177	< 0.0304	< 0.0303	< 0.0273	< 0.0307
04-25-16	< 0.0164	< 0.0282	< 0.0282	< 0.0253	< 0.0287
05-09-16	< 0.0102	< 0.0249	< 0.0248	< 0.0222	< 0.0247
05-24-16	< 0.0076	< 0.0183	< 0.0184	< 0.0164	< 0.0186
06-06-16	< 0.0149	< 0.0330	< 0.0330	< 0.0295	< 0.0334
06-20-16	< 0.0447	< 0.0417	< 0.0160	< 0.0385	< 0.0415
07-05-16	< 0.0314	< 0.0292	< 0.0112	< 0.0269	< 0.0291
07-18-16	< 0.0221	< 0.0532	< 0.0524	< 0.0487	< 0.0525
08-01-16	< 0.0442	< 0.0411	< 0.0407	< 0.0158	< 0.0409
08-15-16	< 0.0182	< 0.0315	< 0.0311	< 0.0290	< 0.0313
08-29-16	< 0.0100	< 0.0242	< 0.0239	< 0.0219	< 0.0238
09-12-16	< 0.0319	< 0.0640	< 0.0294	< 0.0273	< 0.0295
09-26-16	< 0.0422	< 0.0438	< 0.0388	< 0.0150	< 0.0391
10-10-16	< 0.0298	< 0.0265	< 0.0274	< 0.0099	< 0.0277
10-24-16	< 0.0151	< 0.0321	< 0.0333	< 0.0307	< 0.0337
11-07-16	< 0.0329	< 0.0323	< 0.0141	< 0.0310	< 0.0340
11-21-16	< 0.0127	< 0.0263	< 0.0272	< 0.0252	< 0.0274
12-05-16	< 0.0150	< 0.0318	< 0.0330	< 0.0310	< 0.0334
12-19-16	< 0.0124	< 0.0265	< 0.0274	< 0.0269	< 0.0279

Table 1.3
Sample Type: Air Particulate Filter
Analysis: Gamma Isotopic
Units: pCi/m³

Location	Quarterly Composite	Cs-134	Cs-137
	<u>Required LLD</u> →	<u>0.05</u>	<u>0.06</u>
APF-1 (Indicator)	1st	< 0.004	< 0.004
APQ-1 (Indicator)	1st	< 0.002	< 0.002
APP-1 (Indicator)	1st	< 0.003	< 0.002
APC-1 (Indicator)	1st	< 0.004	< 0.003
APE-30 (Control)	1st	< 0.003	< 0.002
APF-1 (Indicator)	2nd	< 0.002	< 0.002
APQ-1 (Indicator)	2nd	< 0.002	< 0.002
APP-1 (Indicator)	2nd	< 0.003	< 0.003
APC-1 (Indicator)	2nd	< 0.002	< 0.002
APE-30 (Control)	2nd	< 0.002	< 0.002
APF-1 (Indicator)	3rd	< 0.003	< 0.003
APQ-1 (Indicator)	3rd	< 0.003	< 0.003
APP-1 (Indicator)	3rd	< 0.003	< 0.004
APC-1 (Indicator)	3rd	< 0.003	< 0.003
APE-30 (Control)	3rd	< 0.003	< 0.002
APF-1 (Indicator)	4th	< 0.002	< 0.002
APQ-1 (Indicator)	4th	< 0.002	< 0.002
APP-1 (Indicator)	4th	< 0.004	< 0.004
APC-1 (Indicator)	4th	< 0.004	< 0.003
APE-30 (Control)	4th	< 0.002	< 0.002

Table 2.1

Sample Type: Thermoluminescent Dosimeters

Analysis: Gamma Dose

Units: mrem/Std. Qtr.

Indicator Locations						
Station	1st Qtr '16	2nd Qtr '16	3rd Qtr '16	4th Qtr '16	Annual Mean '16	
A-2	12	13	(2)	12	12	
A-5	12	(2)	13	12	12	
B-1	13	13	14	13	13	
B-4	13	14	14	14	14	
C-1	9	9	10	10	9	
D-2	12	12	13	13	13	
D-5	11	11	13	12	12	
E-1	11	11	12	12	11	
E-5	12	12	13	13	13	
E-15	10	10	11	10	10	
F-2	11	12	12	12	12	
(1)F-4	13	14	14	14	14	
F-9	11	11	11	12	11	
G-2	10	11	10	11	10	
G-4	(2)	9	11	11	10	
G-8	11	13	11	14	12	
H-2	10	11	11	11	11	
H-8	(2)	13	14	13	13	
J-2	10	10	11	11	11	
J-15	13	13	13	13	13	
K-1	10	11	11	11	11	
L-1	13	14	14	14	14	
M-1	10	10	11	10	10	
N-1	11	11	11	(2)	11	
P-1	9	9	10	10	10	
P-6	13	14	14	13	13	
Q-1	12	13	12	12	12	
Q-5	12	13	13	13	12	
R-1	9	9	10	10	10	
R-6	10	10	10	11	10	
Control Location						
Station	1st Qtr '16	2nd Qtr '16	3rd Qtr '16	4th Qtr '16	Annual Mean '16	
E-30	9	9	10	9	9	

(1) Location with highest annual mean

(2) No data - TLDs missing at time of exchange

Table 3.1
Sample Type: Drinking/Surface Water
Analysis: Gross Beta
Units: pCi/l

Quarterly Composite	DWF/SWF-2 (Indicator)	DWE/SWE-5 (Indicator)	DWP/SWP-7 (Control)
Required LLD →	<u>4</u>	<u>4</u>	<u>4</u>
1 st	3.15	< 2.03	2.14
2 nd	3.29	3.61	2.38
3 rd	5.91	4.52	5.66
4 th	6.70	3.53	4.86

Table 3.2
Sample Type: Drinking/Surface Water
Analysis: Iodine-131
Units: pCi/l

Collection Date	SWK-1 (Indicator)	DWF/SWF-2 (Indicator)	DWE/SWE-5 (Indicator)	DWP/SWP-7 (Control)
LLD	<u>15</u>	<u>1</u>	<u>1</u>	<u>1</u>
01-26-16 ⁽¹⁾		< 0.87		
01-26-16	< 3.93	< 0.94	< 0.93	< 0.91
02-23-16	< 4.44	< 0.81	< 0.74	< 0.67
03-22-16	< 4.54	< 0.64	< 0.77	< 0.78
04-19-16	< 2.49	< 0.44	< 0.31	< 0.33
05-17-16	< 3.98	< 0.27	< 0.31	< 0.30
06-14-16	< 4.51	< 0.28	< 0.26	< 0.39
07-12-16	< 4.60	< 0.34	< 0.57	< 0.40
08-09-16	< 4.04	< 0.55	< 0.44	< 0.50
09-06-16	< 2.38	< 0.41	< 0.35	< 0.33
10-04-16	< 3.39	< 0.60	< 0.96	< 0.76
11-01-16	< 4.54	< 0.85	< 0.84	< 0.78
11-29-16	< 4.24	< 0.60	< 0.63	< 0.70
12-27-16	< 5.54	< 0.72	< 0.51	< 0.69

⁽¹⁾ Duplicate sample

Table 3.3

Sample Type: Drinking/Surface Water

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
<u>Required LLD</u> →		<u>15</u>	<u>15</u>	<u>30</u>	<u>15</u>	<u>30</u>	<u>15</u>	<u>15</u>	<u>15</u>	<u>18</u>	<u>15</u>	<u>15</u>
DWF/SWF-2 (Indicator)	1st	< 2.60	< 2.70	< 5.83	< 2.61	< 5.96	< 3.05	< 4.46	< 2.29	< 2.56	< 13.50	< 4.64
DWE/SWE-5 (Indicator)	1st	< 1.54	< 1.62	< 3.27	< 1.66	< 3.10	< 1.63	< 2.87	< 1.53	< 1.65	< 9.12	< 2.80
DWP/SWP-7 (Control)	1st	< 1.98	< 2.03	< 4.56	< 1.83	< 3.98	< 2.26	< 3.78	< 1.87	< 2.12	< 11.40	< 3.21
DWF/SWF-2 (Indicator)	2nd	< 2.57	< 2.78	< 5.99	< 2.80	< 5.31	< 2.76	< 4.94	< 2.72	< 2.63	< 14.70	< 5.26
DWE/SWE-5 (Indicator)	2nd	< 2.86	< 2.91	< 5.82	< 2.94	< 5.30	< 3.27	< 4.86	< 2.21	< 2.64	< 15.00	< 4.12
DWP/SWP-7 (Control)	2nd	< 2.64	< 2.48	< 5.92	< 2.79	< 5.13	< 3.02	< 4.82	< 2.40	< 2.55	< 14.30	< 5.18
DWF/SWF-2 (Indicator)	3rd	< 2.08	< 2.00	< 4.02	< 1.86	< 4.14	< 2.26	< 3.68	< 2.27	< 2.22	< 10.30	< 2.63
DWE/SWE-5 (Indicator)	3rd	< 1.96	< 1.95	< 3.91	< 2.07	< 3.71	< 2.00	< 3.39	< 1.88	< 2.14	< 9.55	< 2.53
DWP/SWP-7 (Control)	3rd	< 2.02	< 2.08	< 4.07	< 1.90	< 3.82	< 2.08	< 3.61	< 1.97	< 2.13	< 9.70	< 3.22
DWF/SWF-2 (Indicator)	4th	< 1.69	< 1.52	< 3.32	< 1.61	< 3.12	< 2.03	< 1.01	< 1.76	< 2.07	< 13.30	< 3.07
DWE/SWE-5 (Indicator)	4th	< 2.52	< 2.36	< 4.33	< 2.20	< 3.15	< 2.52	< 4.88	< 2.01	< 2.08	< 14.90	< 4.06
DWP/SWP-7 (Control)	4th	< 1.86	< 2.29	< 2.59	< 1.48	< 3.62	< 2.32	< 2.16	< 1.99	< 1.88	< 14.30	< 3.20

Table 3.4
Sample Type: Drinking/Surface Water
Analysis: Tritium
Units: pCi/l

Quarter	DWF/SWF-2 (Indicator)	DWE/SWE-5 (Indicator)	SWK-1 (Indicator)	DWP/SWP-7 (Control)
<u>Required LLD</u> →	<u>2000</u>	<u>2000</u>	<u>3000</u>	<u>2000</u>
1 st	< 518	< 521	< 519	< 526
2 nd	< 489	< 490	< 497	< 499
3 rd	< 618	< 609	< 610	< 608
4 th	< 672	< 686	< 685	< 670

Table 3.5

Sample Type: Surface Water

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
	<u>Required LLD</u> →	<u>15</u>	<u>15</u>	<u>30</u>	<u>15</u>	<u>30</u>	<u>15</u>	<u>15</u>	<u>15</u>	<u>18</u>	<u>15</u>	<u>15</u>
SWK-1 (Indicator)	01-26-16	< 2.29	< 2.26	< 4.67	< 2.34	< 4.61	< 2.44	< 3.92	< 2.25	< 2.35	< 11.20	< 3.67
	02-23-16	< 3.69	< 3.74	< 8.02	< 3.98	< 7.05	< 3.82	< 5.43	< 3.39	< 3.79	< 14.50	< 4.83
	03-22-16	< 3.36	< 3.13	< 6.35	< 3.15	< 6.50	< 3.27	< 4.85	< 3.47	< 3.57	< 12.70	< 4.62
	04-19-16	< 1.77	< 1.53	< 3.64	< 1.94	< 3.47	< 1.68	< 3.23	< 1.69	< 1.83	< 8.06	< 2.05
	05-17-16	< 2.03	< 2.06	< 4.33	< 2.30	< 3.84	< 2.05	< 3.47	< 1.68	< 2.14	< 10.10	< 3.45
	06-14-16	< 3.50	< 3.13	< 6.06	< 3.39	< 7.97	< 3.95	< 6.64	< 3.51	< 4.16	< 14.80	< 4.53
	07-12-16	< 3.50	< 3.41	< 7.41	< 3.59	< 7.63	< 3.57	< 5.93	< 3.48	< 3.95	< 14.80	< 5.41
	08-09-16	< 2.27	< 2.41	< 4.96	< 2.65	< 4.70	< 2.41	< 4.42	< 2.21	< 2.67	< 11.50	< 4.29
	09-06-16	< 1.26	< 1.24	< 2.80	< 1.47	< 2.29	< 1.40	< 2.39	< 1.28	< 1.92	< 6.68	< 2.14
	10-04-16	< 1.78	< 1.80	< 3.65	< 2.04	< 3.69	< 2.09	< 3.10	< 1.79	< 1.86	< 9.16	< 2.85
	11-01-16	< 2.42	< 2.67	< 5.44	< 2.98	< 5.44	< 3.18	< 4.63	< 2.58	< 2.84	< 12.50	< 4.20
	11-29-16	< 3.62	< 3.89	< 5.56	< 4.62	< 7.10	< 3.10	< 5.55	< 3.36	< 2.96	< 12.60	< 4.67
12-27-16	< 3.57	< 3.11	< 9.61	< 4.87	< 6.83	< 3.55	< 6.25	< 4.12	< 4.19	< 14.70	< 5.71	

Table 4.1
Sample Type: Sediment
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 (Indicator)	03-16-16	< 114.0	< 111.0
SHWE-3 (Indicator)	03-16-16	< 83.5	< 90.0
SHWQ-6 (Control)	03-16-16	< 61.7	< 76.5

Table 5.1
Sample Type: Milk
Analysis: Iodine-131 and Gamma Isotopic
Units: pCi/l

Location	Collection Date	I-131	Cs-134	Cs-137	Ba-140	La-140
	<u>Required LLD</u> →	<u>1</u>	<u>15</u>	<u>18</u>	<u>15</u>	<u>15</u>
MKE-3 (Indicator) ⁽¹⁾	03-17-16	n/a	n/a	n/a	n/a	n/a
	06-16-16	n/a	n/a	n/a	n/a	n/a
	09-15-16	n/a	n/a	n/a	n/a	n/a
	12-08-16	n/a	n/a	n/a	n/a	n/a
MKA-31 (Control)	03-17-16	< 0.73	< 3.68	6.08	< 14.90	< 4.93
	04-14-16	< 0.45	< 2.71	< 3.09	< 12.00	< 3.52
	06-16-16	< 0.80	< 2.87	3.95	< 14.80	< 4.23
	07-07-16	< 0.53	< 3.32	< 3.69	< 14.60	< 4.21
	09-15-16	< 0.32	< 2.70	< 4.00	< 14.30	< 4.33
	12-08-16	< 0.35	< 3.58	5.63	< 14.80	< 4.45
	12-19-16	< 0.38	< 2.87	6.02	< 12.50	< 3.83

⁽¹⁾ Sample not available. Cows not producing enough milk. See page 2 for details.

Table 6.1
Sample Type: **Fish**
Analysis: Gamma Isotopic
Units: pCi/kg (wet)

Location	Collection Date	Species	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Cs-134	Cs-137
Required LLD	→		130	130	260	130	260	130	150
FH-1 (Control)	11-15-16	Buffalo	< 37.0	< 40.4	< 77.6	< 44.7	< 88.3	< 36.7	< 36.1
	11-15-16	Drum	< 59.6	< 61.6	< 82.1	< 52.3	< 124.0	< 50.3	< 60.6
	11-15-16	Catfish	< 43.2	< 38.7	< 85.8	< 37.1	< 100.0	< 46.3	< 50.7
	11-15-16	Bass	< 30.3	< 31.6	< 68.0	< 45.8	< 62.6	< 37.4	< 41.3
FH-2 (Indicator)	10-15-16	Buffalo	< 45.4	< 53.5	< 186.0	< 45.8	< 116.0	< 49.3	< 52.9
	10-15-16	Carp	< 37.2	< 44.3	< 147.0	< 40.1	< 102.0	< 41.9	< 35.3
	10-15-16	Catfish	< 49.6	< 62.9	< 145.0	< 42.4	< 104.0	< 55.5	< 51.7
	10-15-16	Mullet	< 56.9	< 57.4	< 134.0	< 37.0	< 112.0	< 40.1	< 43.1
FH-3 (Indicator)	10-06-16	Buffalo	< 56.7	< 84.8	< 164.0	< 45.4	< 133.0	< 53.2	< 49.7
	10-06-16	Carp	< 47.5	< 68.0	< 178.0	< 38.3	< 104.0	< 52.7	< 41.3
	10-06-16	Catfish	< 30.5	< 52.0	< 169.0	< 38.9	< 86.5	< 45.2	< 41.1
	10-06-16	Shad	< 42.2	< 56.3	< 153.0	< 39.7	< 80.6	< 43.2	< 41.6

Table 7.1
Sample Type: Broad Leaf Vegetation
Analysis: Iodine-131 and Gamma Isotopic
Units: pCi/kg (wet)

Location	Collection Date	I-131	Cs-134	Cs-137
Required LLD	→	60	60	80
BLQ-1 (Indicator)	03-16-16	< 44.4	< 32.4	< 31.7
BLQ-1 (Indicator)	06-15-16	< 56.1	< 31.7	< 35.1
BLQ-1 (Indicator)	09-14-16	< 54.5	< 32.8	< 32.6
BLQ-1 (Indicator)	12-06-16	< 57.5	< 51.3	< 51.0
BLB-1 (Indicator)	03-16-16	< 37.6	< 24.6	< 28.3
BLB-1 (Indicator)	06-15-16	< 55.8	< 24.8	< 25.4
BLB-1 (Indicator)	09-14-16	< 50.6	< 27.9	< 29.9
BLB-1 (Indicator)	12-06-16	< 50.0	< 41.5	< 42.7
BLE-20 (Control)	03-16-16	< 31.9	< 23.8	< 25.4
BLE-20 (Control)	06-15-16	< 57.4	< 34.2	< 33.6
BLE-20 (Control)	09-14-16	< 56.0	< 29.2	< 36.4
BLE-20 (Control)	12-06-15	< 40.1	< 33.9	< 38.1

Table 8.1

Sample Type: Interlaboratory Comparison

Analysis: Gross Beta, Iodine-131, Tritium and Gamma Isotopic

Units: pCi/kg (wet)

ANALYTICS ENVIRONMENTAL RADIOACTIVITY CROSS CHECK PROGRAM
TELEDYNE BROWN ENGINEERING ENVIRONMENTAL SERVICES

Month/Year	Identification Number	Matrix	Nuclide	Units	Reported Known		Ratio (c) TBE/Analytics	Evaluation (d)
					Value (a)	Value (b)		
March 2016	E11476	Milk	Sr-89	pCi/L	97	86.7	1.12	A
			Sr-90	pCi/L	15	11.4	1.32	N(2)
March 2016	E11477	Milk	I-131	pCi/L	85.9	82.2	1.05	A
			Ce-141	pCi/L	106	98.4	1.08	A
			Cr-51	pCi/L	255	243	1.05	A
			Cs-134	pCi/L	134	130	1.03	A
			Cs-137	pCi/L	174	161	1.08	A
			Co-58	pCi/L	123	117	1.05	A
			Mn-54	pCi/L	141	117	1.21	W
			Fe-59	pCi/L	152	131	1.16	A
			Zn-65	pCi/L	193	179	1.08	A
			Co-60	pCi/L	259	244	1.06	A
	E11184	AP	Ce-141	pCi	69	81.1	0.85	A
			Cr-51	pCi	242	201	1.20	W
			Cs-134	pCi	98.1	107.0	0.92	A
			Cs-137	pCi	136	133	1.02	A
			Co-58	pCi	91.9	97	0.95	A
			Mn-54	pCi	98.6	96.2	1.02	A
			Fe-59	pCi	98.8	108	0.91	A
E11478	Charcoal	I-131	pCi	85.3	88.3	0.97	A	
		E11185	Water	Fe-55	pCi/L	1800	1666	1.08
June 2016	E11537	Milk	Sr-89	pCi/L	94.4	94.4	1.00	A
			Sr-90	pCi/L	13.4	15.4	0.87	A
June 2016	E11538	Milk	I-131	pCi/L	96.8	94.5	1.02	A
			Ce-141	pCi/L	129	139	0.93	A
			Cr-51	pCi/L	240	276	0.87	A
			Cs-134	pCi/L	157	174	0.90	A
			Cs-137	pCi/L	117	120	0.98	A
			Co-58	pCi/L	131	142	0.92	A
			Mn-54	pCi/L	128	125	1.02	A
			Fe-59	pCi/L	132	122	1.08	A
			Zn-65	pCi/L	235	235	1.00	A
			Co-60	pCi/L	169	173	0.98	A

(a) Teledyne Brown Engineering reported result.

(b) 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.

(c) Ratio of Teledyne Brown Engineering to Analytics results.

(d) 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.

(2) NCR 16-26 was initiated

Table 8.1
Sample Type: Interlaboratory Comparison
Analysis: Gross Beta, Iodine-131, Tritium and Gamma Isotopic
Units: pCi/kg (wet)

Month/Year	Identification Number	Matrix	Nuclide	Units	Reported/Known		Ratio (c) TBE/Analytics	Evaluation (d)	
					Value (a)	Value (b)			
June 2016	E11539	Charcoal	I-131	pCi	86.1	89.4	0.96	A	
				E11540	AP	Ce-141	pCi	105	99.8
	Cr-51	pCi	216	198.0		1.09	A		
	Cs-134	pCi	113	125		0.90	A		
	Cs-137	pCi	94.5	86.6		1.09	A		
	Co-58	pCi	101	102		0.99	A		
	Mn-54	pCi	88.8	90.2		0.98	A		
	Fe-59	pCi	82	87.5		0.94	A		
	Zn-65	pCi	174	169		1.03	A		
	Co-60	pCi	143	124		1.15	A		
	E11185	Water	Fe-55	pCi/L		164	186	0.88	A
	September 2016	E11609	Milk	Sr-89	pCi/L	90	90.9	0.99	A
				Sr-90	pCi/L	13.3	13.7	0.97	A
		Milk	I-131	pCi/L	80.4	71.9	1.12	A	
Ce-141			pCi/L	81.3	93	0.87	A		
Cr-51			pCi/L	198	236	0.84	A		
Cs-134			pCi/L	122	136	0.90	A		
Cs-137			pCi/L	119	119	1.00	A		
Co-58			pCi/L	92.2	97.4	0.95	A		
Mn-54			pCi/L	156	152	1.03	A		
Fe-59			pCi/L	97.5	90.6	1.08	A		
Zn-65			pCi/L	189	179	1.06	A		
Co-60		pCi/L	131	135	0.97	A			
E11611		Charcoal	I-131	pCi	52.4	59.9	0.87	A	
E11612		AP	Ce-141	pCi	67.5	63.6	1.06	A	
			Cr-51	pCi	192	161.0	1.19	A	
	Cs-134		pCi	91.4	92.6	0.99	A		
	Cs-137		pCi	93.9	80.8	1.16	A		
	Co-58		pCi	66	66.4	0.99	A		
	Mn-54		pCi	104	104	1.00	A		
	Fe-59		pCi	60.5	61.8	0.98	A		
	Zn-65		pCi	140	122	1.15	A		
Co-60	pCi	119	91.9	1.29	W				

(a) Teledyne Brown Engineering reported result.

(b) 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.

(c) Ratio of Teledyne Brown Engineering to Analytics results.

(d) 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 8.1
Sample Type: Interlaboratory Comparison
Analysis: Gross Beta, Iodine-131, Tritium and Gamma Isotopic
Units: pCi/kg (wet)

Month/Year	Identification Number	Matrix	Nuclide	Units	Reported/Known Value		Ratio (c) TBE/Analytics	Evaluation (d)
					(a)	(b)		
September 2016	E11613	Water	Fe-55	pCi/L	1990	1670	1.19	A
			E11614	Soil	Ce-141	pCi/g	0.153	0.175
	Cr-51	pCi/g	0.482		0.441	1.09	A	
	Cs-134	pCi/g	0.270		0.254	1.06	A	
	Cs-137	pCi/g	0.313		0.299	1.05	A	
	Co-58	pCi/g	0.177		0.182	0.97	A	
	Mn-54	pCi/g	0.340		0.285	1.19	A	
	Fe-59	pCi/g	0.206		0.17	1.21	W	
	Zn-65	pCi/g	0.388		0.335	1.16	A	
	Co-60	pCi/g	0.284		0.252	1.13	A	
December 2016	E11699	Milk	Sr-89	pCi/L	95	74.2	1.28	W
			Sr-90	pCi/L	14.7	10	1.47	N(3)
	E11700	Milk	I-131	pCi/L	97.5	97.4	1.00	A
			Ce-141	pCi/L	136	143	0.95	A
			Cr-51	pCi/L	247	280	0.88	A
			Cs-134	pCi/L	164	178	0.92	A
			Cs-137	pCi/L	120	126	0.95	A
			Co-58	pCi/L	139	146	0.95	A
			Mn-54	pCi/L	126	129	0.98	A
			Fe-59	pCi/L	114	125	0.91	A
	Zn-65	pCi/L	237	244	0.97	A		
	Co-60	pCi/L	168	178	0.94	A		
	E11701	Charcoal	I-131	pCi	95.6	98	0.98	A
	E11702	AP	Ce-141	pCi	91.7	97.7	0.94	A
			Cr-51	pCi	210	192.0	1.09	A
			Cs-134	pCi	122	122	1.00	A
			Cs-137	pCi	93.9	86.4	1.09	A
			Co-58	pCi	92	100	0.92	A
			Mn-54	pCi	93.7	88.5	1.06	A
			Fe-59	pCi	84.9	84.5	1.00	A
Zn-65			pCi	176	167	1.05	A	
Co-60	pCi	151	122	1.24	W			
E11703	Water	Fe-55	pCi/L	2180	1800	1.21	W	
E11702	AP	Sr-89	pCi	79.1	92	0.86	A	
		Sr-90	pCi	10	12.5	0.80	A	

(a) Teledyne Brown Engineering reported result.

(b) 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.

(c) Ratio of Teledyne Brown Engineering to Analytics results.

(d) 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.

(3) NCR 16-35 was initiated

Table 8.1
Sample Type: **Interlaboratory Comparison**
Analysis: Gross Beta, Iodine-131, Tritium and Gamma Isotopic
Units: pCi/kg (wet)

DOE's MIXED ANALYTE PERFORMANCE EVALUATION PROGRAM (MAPEP)

Month/Year	Identification Number	Media	Nuclide*	Units	Reported Value (a)	Known Value (b)	Acceptance Range	Evaluation (c)	
March 2016	16-MaW34	Water	Am-241	Bq/L	0.008		(1)	A	
			Ni-63	Bq/L	12.4	12.3	8.6-16.0	A	
			Pu-238	Bq/L	1.4900	1.2440	0.871-1.617	A	
			Pu-239/240	Bq/L	0.729	0.641	0.449-0.833	A	
	16-MaS34	Soil	Ni-63	Bq/kg	1140	1250.0	875-1625	A	
			Sr-90	Bq/kg	8.15		(1)	A	
	16-RdF34	AP	U-234/233	Bq/sample	0.1620	0.1650	0.116-0.215	A	
			U-238	Bq/sample	0.163	0.172	0.120-0.224	A	
	16-GrF34	AP	Gr-A	Bq/sample	0.608	1.20	0.36-2.04	A	
			Gr-B	Bq/sample	0.8060	0.79	0.40-1.19	A	
	16-RdV34	Vegetation	Cs-134	Bq/sample	10.10	10.62	7.43-13.81	A	
			Cs-137	Bq/sample	6.0	5.62	3.93-7.31	A	
			Co-57	Bq/sample	13.3000	11.8	8.3-15.3	A	
			Co-60	Bq/sample	0.013		(1)	A	
			Mn-54	Bq/sample	0.0150		(1)	A	
			Sr-90	Bq/sample	0.301		(1)	N(4)	
			Zn-65	Bq/sample	10.500	9.6	6.7-12.5	A	
	September 2016	16-MaW35	Water	Am-241	Bq/L	0.626	0.814	.570-1058	W
				Ni-63	Bq/L	12.4	17.2	12.0-22.4	A
Pu-238				Bq/L	1.23	1.13	0.79-1.47	W	
Pu-239/240				Bq/L	0.0318	0.013	(1)	A	
16-MaS35		Soil	Ni-63	Bq/kg	724	990	693-1287	A	
			Sr-90	Bq/kg	747	894	626-1162	A	
16-RdF35		AP	U-234/233	Bq/sample	0.160	0.15	0.105-0.195	A	
			U-238	Bq/sample	0.157	0.156	0.109-0.203	A	
16-RdV35		Vegetation	Cs-134	Bq/sample	-0.103		(1)	A	
			Cs-137	Bq/sample	5.64	5.54	3.88-7.20	A	
			Co-57	Bq/sample	7.38	6.81	4.77-8.85	A	
			Co-60	Bq/sample	4.81	4.86	3.40-6.32	A	
			Mn-54	Bq/sample	7.4	7.27	5.09-9.45	A	
			Sr-90	Bq/sample	0.774	0.80	0.56-1.04	A	
			Zn-65	Bq/sample	5.46	5.4	3.78-7.02	A	

(1) False positive test

(a) Teledyne Brown Engineering reported result.

(b) 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.

(c) DOE/MAPEP evaluation: A=acceptable, W=acceptable with warning, N=not acceptable.

(4)NCR 16-14 was initiated

Table 8.1
Sample Type: Interlaboratory Comparison
Analysis: Gross Beta, Iodine-131, Tritium and Gamma Isotopic
Units: pCi/kg (wet)

Month/Year	Identification Number	Media	Nuclide	Units	Reported/Known Value		Acceptance Limits	Evaluation (c)	
					(a)	(b)			
May 2016	RAD-105	Water	Sr-89	pCi/L	48.9	48.2	37.8 - 55.6	A	
			Sr-90	pCi/L	25.0	28.5	20.7 - 33.1	A	
			Ba-133	pCi/L	53.1	58.8	48.7 - 64.9	A	
			Cs-134	pCi/L	40.9	43.3	34.6 - 47.6	A	
			Cs-137	pCi/L	84.8	78.4	70.6 - 88.9	A	
			Co-60	pCi/L	108	102	91.8 - 114	A	
			Zn-65	pCi/L	226	214	193 - 251	A	
			Gr-A	pCi/L	38.9	62.7	32.9 - 77.8	A	
			Gr-B	pCi/L	41.9	39.2	26.0 - 46.7	A	
			I-131	pCi/L	24.1	26.6	22.1 - 31.3	A	
			U-Nat	pCi/L	4.68	4.64	3.39 - 5.68	A	
			H-3	pCi/L	7720	7840	6790 - 8620	A	
			November 2016	RAD-107	Water	Sr-89	pCi/L	43.0	43.3
Sr-90	pCi/L	30.0				33.6	24.6-38.8	A	
Ba-133	pCi/L	47.8				54.9	45.4-60.7	A	
Cs-134	pCi/L	72.9				81.8	67.0-90.0	A	
Cs-137	pCi/L	189				210	189-233	A	
Co-60	pCi/L	58.4				64.5	58.0-73.4	A	
Zn-65	pCi/L	243				245	220-287	A	
Gr-A	pCi/L	37.2				68.4	35.9-84.5	A	
Gr-B	pCi/L	35.1				33.9	22.1-41.6	A	
I-131	pCi/L	23.5				26.3	21.9-31.0	A	
U-Nat	pCi/L	49.2				51.2	41.6-56.9	A	
H-3	pCi/L	918				9820	8540-10800	N(5)	
	MRAD-25	AP				Gr-A	pCi/Filter	56.8	71.2

(a) Teledyne Brown Engineering reported result.

(b) 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.

(c) ERA evaluation: A=acceptable. Reported result falls within the Warning Limits. NA=not acceptable. Reported result falls outside of the Control Limits. CE=check for Error. Reported result falls within the Control Limits and outside of the Warning Limit.

(5) NCR 16-34 was initiated

ATTACHMENT 2

Statistical Comparisons

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Statistical Analyses

◆ Calculation of the Mean and Standard Deviation

The mean and standard deviation for different groups of analyses are calculated using the following equations:

$$\bar{X} = \sum_{i=1}^n \frac{X_i}{n}$$

and

$$S = \left(\frac{\sum_{i=1}^n (X_i - \bar{X})^2}{(n-1)} \right)^{0.5}$$

where:

- \bar{X} = mean of sample population,
- S = standard deviation of sample population,
- n = number of samples in sample population, and
- X_i = value of the i'th sample.

◆ **Comparing Two Sample Population Means**

The means of two sample populations are compared for statistical difference using the standard "t" test. The use of the test requires the assumption that the data within the populations are normally distributed and that the true standard deviations of the mean are equal for both populations. The standard "t" test tests the hypothesis that the true means of both populations are equal. The "t" value can be calculated from the equation below (obtained from the CRC Standard Mathematical Tables, 26th Edition (1981)):

$$t = \frac{\bar{X} - \bar{Y}}{\left(\frac{(n_x - 1)S_x^2 + (n_y - 1)S_y^2}{n_x + n_y - 2} \right)^{0.5} \left(\frac{1}{n_x} + \frac{1}{n_y} \right)^{0.5}}$$

where:

- $\frac{t}{}$ = calculated "t" value,
- \bar{X} = mean of first data set,
- \bar{Y} = mean of second data set,
- n_x = number of variables in first data set,
- S_x = standard deviation of first data set,
- n_y = number of variables in second data set, and
- S_y = standard deviation of second data set.

The calculated "t" value is used to test the hypothesis that the true mean of the first population (m_x) is equal to the true mean of the second population (m_y) assuming that the true standard deviation of both populations are equal ($m_x = m_y$). The calculated "t" value is compared to a tabular "t" value such that:

- a. if $t > t_{\mu, n}$ then reject the hypothesis when $m_x > m_y$,
- b. if $t < -t_{\mu, n}$ then reject the hypothesis when $m_x < m_y$,
- c. if $t > t_{\mu/2, n}$ then reject the hypothesis when $m_x = m_y$,

where $t_{\mu/2, n}$ and $t_{\mu, n}$ are the tabular "t" values, with a preselected error (5%), confidence level ($1 - \mu$) or ($1 - \mu/2$), and degrees of freedom $n = n_x + n_y - 2$. Tabular values of the "t" were obtained from the CRC Standard Mathematical Tables, 26th Edition (1981).

TABLE 2.1

STATISTICAL COMPARISON OF 2016 TLD MEASUREMENTS FROM STATIONS GROUPED BY DISTANCE			
	Stations Located 0-2 Miles from the Plant	Stations Located 2-5 Miles from the Plant	Stations Located more than 5 Miles from the Plant
Mean (mRem/std.qtr.)	11	13	12
Standard Deviation (mRem/std. qtr.)	1.33	1.20	1.42
Number in Sample	62	26	27
Calculated "t" Value (comparison of stations 0-2 and 2-5 miles from the plant to stations >5 miles from the plant)	1.95	1.86	NA*
Tabular "t" Value at 95% Confidence ($t_{0.025,n}$)	1.991(a)	2.009(b)	NA*

(a) Results indicate the mean for stations located 0-2 miles from the plant are statistically identical to the mean for stations located more than 5 miles from the plant.

* Not Applicable

TABLE 2.2

STATISTICAL COMPARISON OF 2016 TLD RADIATION DOSE TO HISTORICAL DATA BY LOCATION									
Station	Units: mrem/Std. Qtr.								
	1990 - 2015 Avg**	1990 - 2015 Std. Dev.**	1990 - 2015 Range**		2016 Avg**	2016 Std. Dev.**	2016 Range**		
A-2	13	1.3	10	18	12	0.5	12	13	
A-5	13	1.4	10	17	12	0.5	12	13	
B-1	13	1.3	10	19	13	0.4	13	14	
B-4	13	1.1	11	17	14	0.4	13	14	
C-1	9	1.2	7	13	10	0.5	9	10	
D-2	12	1.9	8	19	13	0.5	12	13	
D-5	12	1.4	9	18	12	0.8	11	13	
E-1	11	1.2	9	16	12	0.5	11	12	
E-5	12	1.6	9	17	13	0.5	12	13	
E-15	11	1.6	8	16	10	0.4	10	11	
E-30*	11	1.5	8	17	9	0.4	9	10	
F-2	12	1.1	10	17	12	0.4	11	12	
F-4	14	1.4	11	19	14	0.4	13	14	
F-9	12	1.3	7	17	11	0.4	11	12	
G-2	14	1.9	10	19	11	0.5	10	11	
G-4	11	1.2	9	16	10	0.9	9	11	
G-8	12	1.9	8	19	12	1.3	11	14	
H-2	13	1.3	10	18	11	0.4	10	11	
H-8	12	1.2	9	17	13	0.5	13	14	
J-2	12	1.5	10	17	11	0.5	10	11	
J-15	13	1.2	11	17	13	0.0	13	13	
K-1	11	1.2	9	16	11	0.4	10	11	
L-1	13	1.3	10	16	14	0.4	13	14	
M-1	12	1.5	9	18	10	0.4	10	11	
N-1	13	1.5	8	18	11	0.0	11	11	
P-1	10	1.2	7	15	10	0.5	9	10	
P-6	13	1.3	10	19	14	0.5	13	14	
Q-1	12	1.1	10	16	12	0.4	12	13	
Q-5	13	2.0	9	18	13	0.4	12	13	
R-1	10	1.9	6	15	10	0.5	9	10	
R-6	12	2.4	8	18	10	0.4	10	11	

* Control Location

** Significant outliers were removed from data sets.

PERS data indicates an average of 20 mrem for all indicator locations with a range of 11 to 33 and an average control of 18 mrem.

TABLE 2.3

STATISTICAL COMPARISON OF 2016 GROSS BETA ACTIVITY MEASUREMENTS ON AIR PARTICULATE FILTERS					
SAMPLE STATION	APF-1	APQ-1	APP-1	APC-1	APE-30
Mean (10^{-3} pCi/m ³)	20	19	18	18	19
Standard Deviation (10^{-3} pCi/m ³)	5.87	5.08	4.82	4.50	5.83
Number in Sample	26	26	26	26	26
⁶ Calculated "t" Value (comparison of the indicator stations to the control station)	0.59	0.05	0.44	0.75	NA*
Tabular "t" Value at 95% Confidence($t_{0.025,n}$)	2.011(a)	2.011(a)	2.011(a)	2.011(a)	NA*

(a) Results indicate the mean for the indicator stations is statistically identical to the mean for the control station.

* Not Applicable

TABLE 2.4

STATISTICAL COMPARISON OF 2016 GROSS BETA ACTIVITY MEASUREMENTS IN DRINKING/SURFACE WATER SAMPLES			
	DWF/SWF-2	DWE/SWE-5	DWP/SWP-7
Mean (pCi/liter)	4.8	3.9	3.8
Standard Deviation (pCi/liter)	1.57	0.45	1.53
Number in Sample	4	3	4
Calculated "t" Value (comparison of the indicator stations to the control station)	0.92	0.16	NA*
Tabular "t" Value at 95% Confidence($t_{0.025,n}$)	2.447(b)	2.571(a)	NA*

(a) Results indicate the mean for the indicator station is statistically identical to the mean for the control station.

* Not Applicable