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0CAN052001

May 13, 2020

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

SUBJECT: Annual Radiological Environmental Operating Report for 2019

Arkansas Nuclear One – Units 1 and 2
NRC Docket Nos. 50-313 and 50-368
Renewed Facility Operating License Nos. DPR-51 and NPF-6

Reference: Entergy Operations, Inc. (Entergy) letter to the U. S. Nuclear Regulatory Commission (NRC), *Annual Radioactive Effluent Release Report for 2019*, Arkansas Nuclear One, Units 1 and 2 (0CAN042001), dated April 27, 2020.

In accordance with Arkansas Nuclear One (ANO), Unit 1 Technical Specification (TS) 5.6.2 and Unit 2 TS 6.6.2, the submittal of an annual radiological environmental operating report for the previous year is required by May 15 of each year. The subject ANO report for the calendar year 2019 is enclosed.

This report fulfills the reporting requirements of the TSs referenced above.

The radionuclides detected by the radiological environmental monitoring program during 2019 were significantly below the regulatory limits. The operation of the ANO station during 2019 had no harmful radiological effects nor resulted in any irreversible damage to the local environment.

Based on ANO's review, no environmental samples from the monitoring program equaled or exceeded the reporting levels for radioactivity concentration due to ANO effluents when averaged over any calendar quarter. A map of all sampling locations and a corresponding table providing the respective distances and directions from the reactor building is included in the Offsite Dose Calculation Manual submitted as part of the referenced Annual Radioactive Effluent Release Report.

This letter contains no new commitments.

If you have any questions or require additional information, please contact me.

Sincerely,

ORIGINAL SIGNED BY RILEY D. KEELE, JR.

RDK/rwc

Enclosure: Annual Radiological Environmental Operating Report for 2019

cc: NRC Region IV Regional Administrator
NRC Senior Resident Inspector – Arkansas Nuclear One
NRC Project Manager – Arkansas Nuclear One
Designated Arkansas State Official

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Annual Radiological Environmental Operating Report	

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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 Arkansas Nuclear One (ANO) Radiological Environmental Monitoring Program (REMP) for the period January 1 through December 31, 2019. This report fulfills the requirements of ANO, Unit 1 (ANO-1) Technical Specification (TS) 5.6.2 and ANO, Unit 2 (ANO-2) TS 6.6.2.

All required lower limit of detection (LLD) capabilities were achieved in all sample analyses during 2019, as required by the ANO's Offsite Dose Calculation Manual (ODCM). No measurable levels of radiation above baseline levels attributable to ANO operation were detected in the vicinity of ANO. The 2019 Radiological Environmental Monitoring Program thus substantiated the adequacy of source control and effluent monitoring at ANO with no observed impact of plant operations on the environment.

ANO established the REMP prior to the station's becoming operational (1974) to provide data on background radiation and radioactivity normally present in the area. ANO has continued to monitor the environment by sampling air, water, sediment, fish and food products, as well as measuring direct radiation. ANO 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 20-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. ANO personnel compare indicator results with control and preoperational results to assess any impact ANO operation might have had on the surrounding environment.

In 2019, 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 ANO operation and effect on the area around the plant. The review of 2019 data concluded that radioactivity levels in the environment were undetectable in many locations and near background levels in significant pathways.

1.2 Reporting Levels

No samples equaled or exceeded reporting levels.

1.3 Comparison to State and/or Federal Program

ANO 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 Arkansas Department of Health.

The NRC TLD Network Program was discontinued in 1998. Historically these results have compared to those from the ANO REMP. ANO 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 Arkansas Department of Health and the ANO 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 2019, environmental sampling was performed for eight (8) media types addressed in the ODCM and for direct radiation. A total of 292 samples of the 292 scheduled were obtained. Of the scheduled samples, 100% 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

No changes were made to ANO REMP Procedure EN-CY-130-01.

Changes made to ANO ODCM:

- (Page11) Editorial fixes to the 3.1.1.b setpoint calculation. Changed units for gas to µCi/cc instead of µCi/ml since SPING data is provided in µCi/cc. Changed ‘S’ monitor setpoint from "cpm" to "cpm or µCi/cc". These changes resolved a preexisting issue with units for calculation with respect o to how they are implemented in the plant.

- (Page 12) Editorial change removed 2RX-9840 PASS Building Ventilation from list of SPING allocations. This should have been removed from the ODCM with Revision 028 where it was removed from the rest of the document in accordance with EC-71778 and 74229.

- (Page 58) Editorial change resolved a reference in L2.4.1 Action ‘C’. Previously referenced L2.4.1.b.4 which does not exist. Reference was changed to L2.4.1.b.3.

These changes had no adverse impact to the stations ODCM, Technical Requirements Manual (TRM), Radioactive Effluents Control Program, or data trending. All changes made were enhancements.

2.0 INTRODUCTION

2.1 Radiological Environmental Monitoring Program

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

2.2 Pathways Monitored

The airborne, direct radiation, waterborne and ingestion pathways are monitored as required by ANO ODCM. 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 2019 sampling results with Section 5.0 providing a summary of results for the monitored exposure pathways.

2.3 Land Use Census

ANO conducts a land use census biennially, as required by Section B 2.5.2 of the ODCM. The purpose of this census is to identify changes in uses of land within five miles of ANO that would require modifications to the REMP and the ODCM. The most important criteria during this census are to determine the location of the nearest milk animal, the nearest residence, and the nearest garden of greater than 500 ft^2 producing fresh leafy vegetables in each of the 16 meteorological sectors within a 5-mile distance from one reactor (containment).

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**
RADIOIODINE AND PARTICULATES 3 samples close to the Site Boundary, in (or near) different sectors with the highest calculated annual average ground level D/Q.	**Station 2 (243° - 0.5 miles)** - South of the sewage treatment plant. **Station 56 (264° - 0.4 miles)** – West end of the sewage treatment plant. **Station 1 (88° - 0.5 miles)** - Near the meteorology tower.	Continuous sampler operation with sample collection every two weeks, or more frequently if required by dust loading.	• Radioiodine Canisters – I-131 analysis every two weeks. • Air Particulate – Gross beta radioactivity analysis following filter change.
RADIOIODINE AND PARTICULATES 1 sample from the vicinity of a community having the highest calculated annual average ground level D/Q.	**Station 6 (111° - 6.8 miles)** – Local Entergy office, 305 South Knoxville Avenue, Russellville	Continuous sampler operation with sample collection every two weeks, or more frequently if required by dust loading.	• Radioiodine Canisters – I-131 analysis every two weeks. • Air Particulate – Gross beta radioactivity analysis following filter change.
RADIOIODINE AND PARTICULATES 1 sample from a control location, as for example 15 - 30 km distance and in the least prevalent wind direction.	**Station 7 (210° - 19.0 miles)** – Entergy Supply Yard on Highway 10 in Danville. (Control)	Continuous sampler operation with sample collection every two weeks, or more frequently if required by dust loading.	• Radioiodine Canisters – I-131 analysis every two weeks. • Air Particulate – Gross beta radioactivity analysis following filter change.

Table 2 – Exposure Pathway – Direct Radiation			
Requirement	**Sample Point Description Distance and Direction**	**Sampling and Collection Frequency**	**Type and Frequency of Analyses**
TLDS 16 inner ring stations with two or more dosimeters in each meteorological sector in the general area of the site boundary.	**Station 1 (88° - 0.5 miles)** - On a pole near the meteorology tower. **Station 2 (243° - 0.5 miles)** - South of the sewage treatment plant. **Station 3 (5° - 0.7 miles)** – West of ANO Gate #2 on Highway 333 (approximately 0.35 miles) **Station 4 (181° - 0.5 miles)** – West of May Cemetery entrance on south side of the road. **Station 56 (264° - 0.4 miles)** - West end of the sewage treatment plant. **Station 108 (306° - 0.9 miles)** - South on Flatwood Road on a utility pole. **Station 109 (291° - 0.6 miles)** - Utility pole across from the junction of Flatwood Road and Round Mountain Road. **Station 110 (138° - 0.8 miles)** - Bunker Hill Lane on the first utility pole on the left. **Station 145 (28° - 0.6 miles)** - Near west entrance to the RERTC on a utility pole. **Station 146 (45° - 0.6 miles)** - South end of east parking lot at RERTC on a utility pole. **Station 147 (61° - 0.6 miles)** - West side of Bunker Hill Road, approximately 100 yards from intersection with State Highway 333. **Station 148 (122° - 0.6 miles)** - Intersection of Bunker Hill Road with Scott Lane on county road sign post. **Station 149 (156° - 0.5 miles)** – On a utility pole on the south side of May Road. **Station 150 (205° - 0.6 miles)** – North side of May Road on a utility pole past the McCurley Place turn. **Station 151 (225° - 0.4 miles)** – West side of sewage treatment plant near the lake on a metal post. **Station 152 (338° - 0.8 miles)** – South side of State Highway 333 on a road sign post.	Once per 92 days.	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**
TLDS 8 stations with two or more dosimeters in special interest areas such as population centers, nearby residences, schools, and in 1 - 2 areas to serve as control locations.	**Station 6 (111° - 6.8 miles)** - Entergy local office in Russellville (305 South Knoxville Avenue). **Station 7 (210° - 19.0 miles)** – Entergy Supply Yard on Highway 10 in Danville. **Station 111 (120° - 2.0 miles)** – Marina Road on a utility pole on the left just prior to curve. **Station 116 (318° - 1.8 miles)** - Highway 333 and Highway 64 in London on a utility pole north of the railroad tracks. **Station 125 (46° - 8.7 miles)** - College Street on a utility pole at the southeast corner of the red brick school building. **Station 127 (100° - 5.2 miles)** - Arkansas Tech Campus on a utility pole across from Paine Hall. **Station 137 (151° - 8.2 miles)** – On a speed limit sign on the right in front of the Morris R. Moore Arkansas National Guard Armory. **Station 153 (304° - 9.2 miles)** - Knoxville Elementary School near the school entrance gate on a utility pole.	Once per 92 days.	mR exposure quarterly.

Table 3 – Exposure Pathway – Waterborne			
Requirement	**Sample Point Description Distance and Direction**	**Sampling and Collection Frequency**	**Type and Frequency of Analyses**
SURFACE WATER 1 indicator location (influenced by plant discharge) 1 control location (uninfluenced by plant discharge)	**Station 8 (166° - 0.2 miles)** - Plant discharge canal. **Station 10 (95° - 0.5 miles)** – Plant intake canal.	Grab samples every 92 days.	Gamma isotopic analysis and tritium analysis quarterly.
Drinking Water 1 indicator location (influenced by plant discharge) 1 control location (uninfluenced by plant discharge)	**Station 14 (70° - 5.1 miles)** - Russellville city water system from the Illinois Bayou. **Station 57 (208° - 19.5 miles)** - Danville public water supply treatment on Fifth Street.	Once per 92 days.	I-131, gross beta, gamma isotopic and tritium analyses once per 92 days.
GROUNDWATER a control location up gradient from the protected area 2 sample locations of Groundwater from indicator locations down gradient from the protected area.	**Station 58 (GWM-1, 22° - 0.3 miles)** – North of Protected Area in Owner Control Area (OCA). West of Security North Check Point, east side of access road. **Station 62 (GWM-101, 34° - 0.5 miles)** – North of Protected Area in OCA. East of outside receiving building. **Station 63 (GWM-103, 206° - 0.1 miles)** – South of Protected area in OCA. North- east of Stator Rewind Bldg. near wood line. **Station 64 (GWM-13, 112° - 0.1 miles)** – South of Oily Water Separator facility, northwest corner of U-2 Intake Structure. Inside Protected area.	Grab samples every 92 days.	Gamma isotopic, gross beta, and tritium analysis quarterly.
SEDIMENT FROM SHORELINE 1 indicator location (influenced by plant discharge) 1 control location (uninfluenced by plant discharge)	**Station 8 (243° - 0.9 miles)** - Plant discharge canal. **Station 16 (287° - 5.5 miles)** - Panther Bay on south side of Arkansas River across from mouth of Piney Creek.	Once per 365 days.	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**
MILK • If commercially available, 1 sample from milking animals within 8 km distance where doses are calculated to be greater than 1 mrem per year. • 1 sample from milking animals at a control location 15 – 30 km distance when an indicator location exists.	Currently, no available milking animals within 5 miles of ANO.	Gamma isotopic and I-131 analyses once per 92 days.	Gamma isotopic and I-131 analyses once per 92 days.
FISH AND INVERTEBRATES • 1 sample of a commercially and/or recreationally important species in vicinity of plant discharge area. • 1 sample of similar species in area not influenced by plant discharge.	**Station 8 (212° - 0.5 miles)** – Plant discharge canal. **Station 16 (287° - 5.5 miles)** - Panther Bay on south side of Arkansas River across from mouth of Piney Creek.	Once per 365 days.	Gamma isotopic analysis on edible portions annually
FOOD PRODUCTS • 1 sample of one type of broadleaf vegetation grown near the SITE BOUNDARY location of highest predicted annual average ground level D/Q if milk sampling is not performed. • 1 sample of similar broadleaf vegetation grown 15 – 30 km distant, if milk sampling is not performed.	**Station 13 (273° - 0.5 miles)** - West from ANO toward Gate 4 onto Flatwood Road. **Station 55 (217° - 13.1 miles)** – Ozark National Forest north of Danville	Three per 365 days.	Gamma. isotopic and I-131 analyses three times per 365 days

Figure 1 – Exposure Pathway

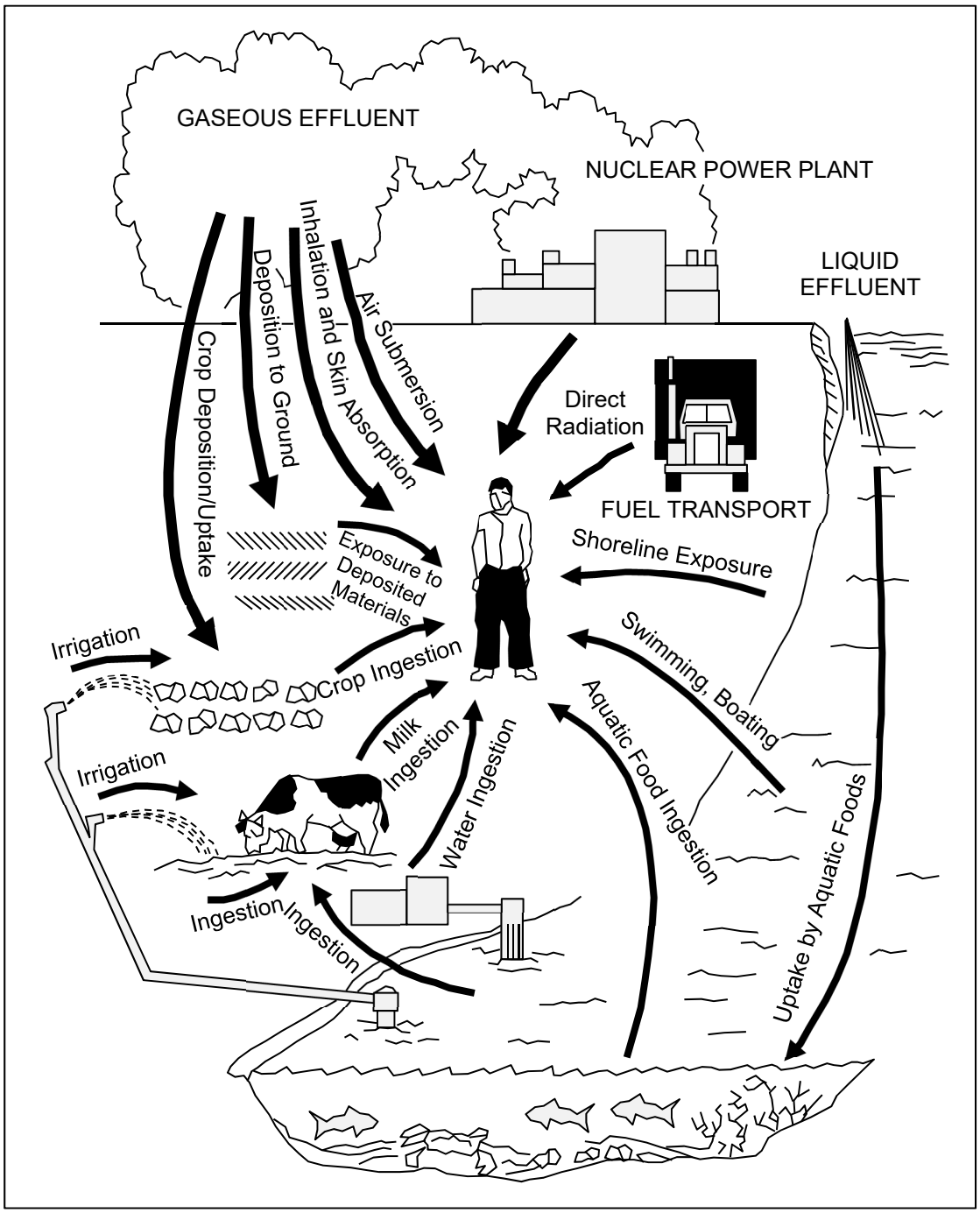


Figure 2 – Sample Collection Sites – Near Field

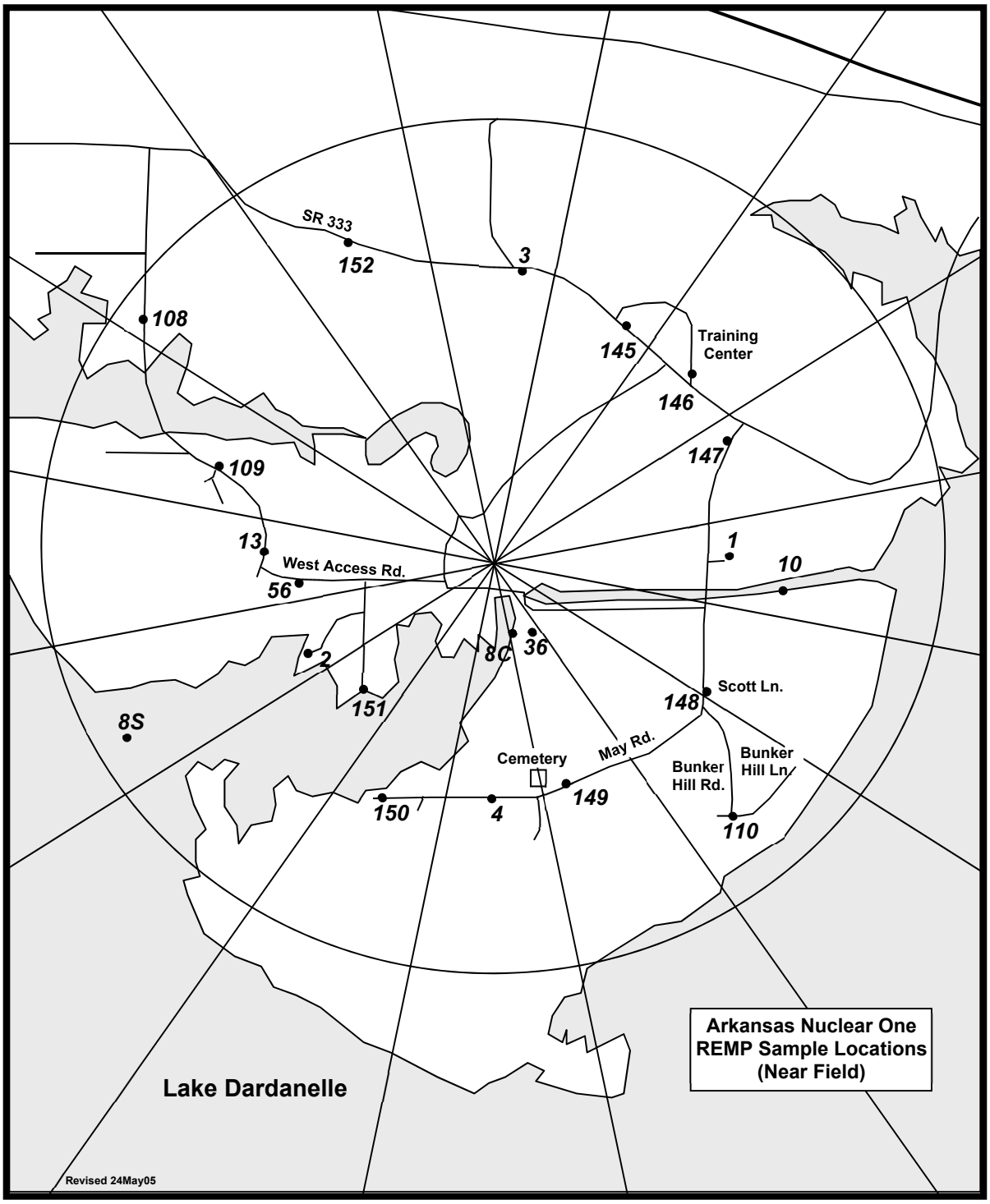


Figure3 – Sample Collection Sites – Far Field

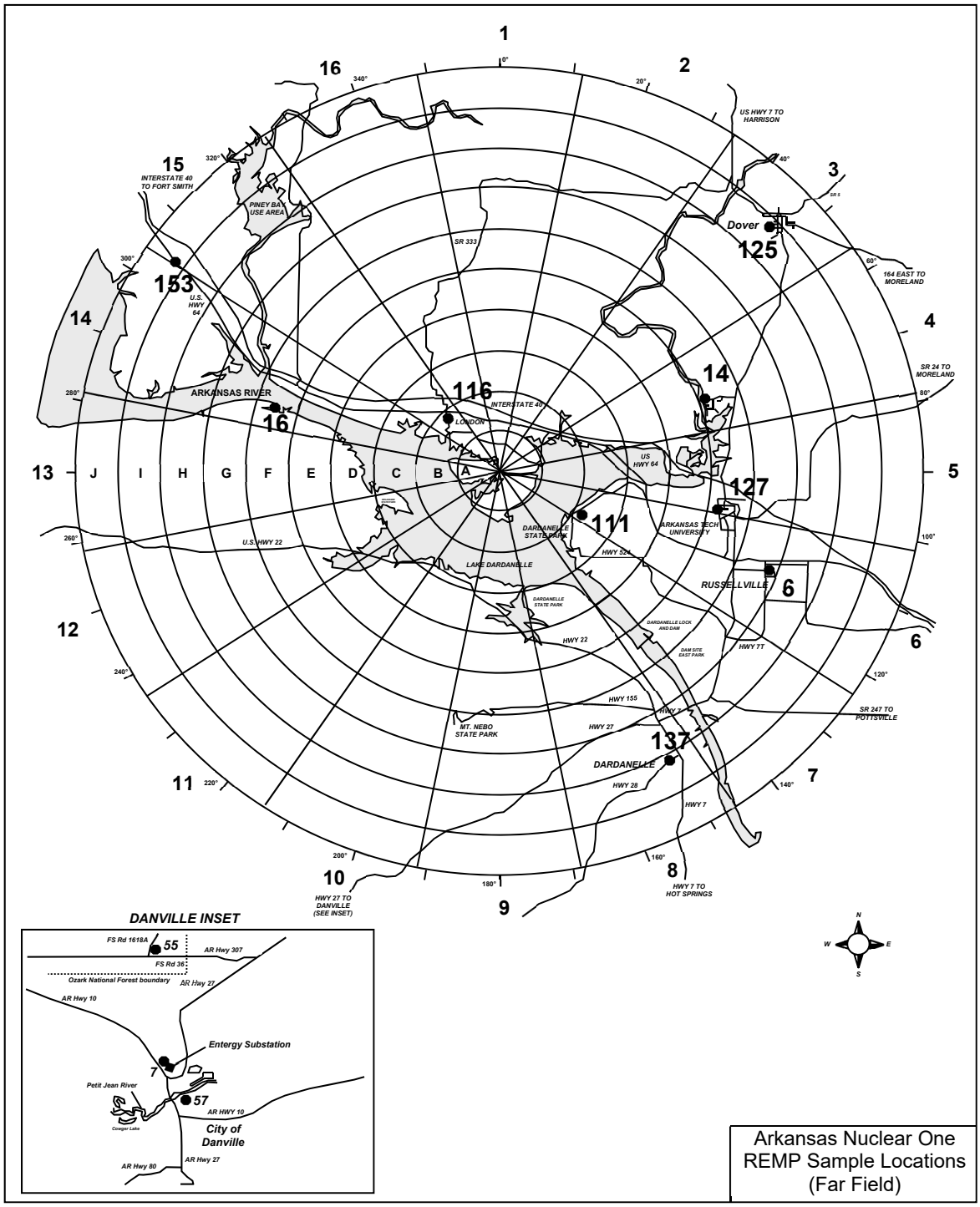
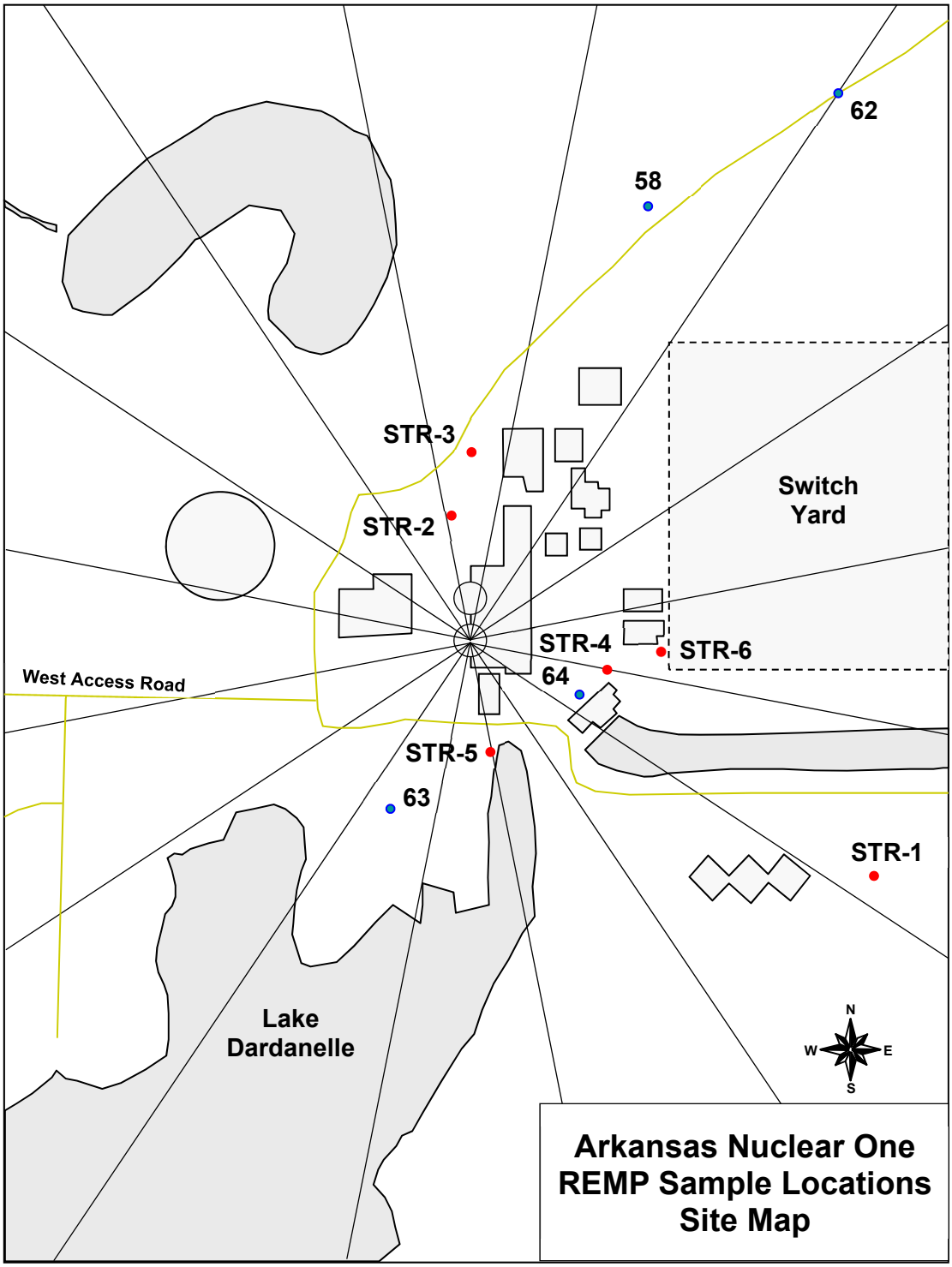


Figure 4 – Sample Collection Sites



4.0 INTERPRETATION AND TRENDS OF RESULTS

4.1 Air Particulate and Radioiodine Sample Results – Example

The REMP has detected radioactivity in the airborne pathway attributable to other sources. These include the 25th Chinese nuclear test explosion in 1980, the radioactive plume release due to reactor core degradation at Chernobyl Nuclear Power Plant in 1986, and the Fukushima Daiichi Nuclear Power Plant accident (March 11, 2011).

In 2019 there were no samples above the LLD for I-131. Indicator gross beta air particulate results for 2019 were comparable to results obtained from 2009-2018 of the operational REMP, but less than 2013 when the annual average was 0.043. Also, the 2019 gross beta annual average was less than the average for preoperational levels. Results are reported as annual average picocuries per cubic meter (pCi/m^3).

Monitoring Period	Result
2009 – 2018 (Minimum Value)	0.018
2019 Average Value	0.017
2009 – 2018 (Maximum Value)	0.043
Preoperational	0.050

In the absence of plant-related gamma radionuclides, gross beta activity is attributed to naturally occurring radionuclides. Table 9, "Air Particulate Data Summary," includes gross beta concentrations and provides a comparison of the indicator and control means and ranges emphasizing 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 ANO operations.

4.2 Thermoluminescent Dosimetry (TLD) Sample Results – Example

ANO reports measured dose as net exposure (field reading less transit reading) normalized to 92 days and relies on comparison of the indicator locations to the control as a measure of plant impact. ANO's comparison of the inner ring and special interest area TLD results to the control, as seen in Table 5, "Direct Radiation Annual Summary," identified no noticeable trend that would indicate that the ambient radiation levels are being affected by plant operations. In addition, the inner ring value of 7.7 millirem (mrem) shown in Table 5 for 2019 is within the historical bounds of 2009 – 2018 annual average results, which have ranged from 7.5 to 8.5 mrem. Overall, ANO concluded that the ambient radiation levels are not being affected by plant operations.

Table 5 – Direct Radiation Annual Summary			
Year	**Inner Ring (mR/Qtr)**	**Special Interest (mR/Qtr)**	**Control Location (mR/Qtr)**
2009	8.3	7.2	6.5
2010	8.3	7.4	6.9
2011	8.5	7.6	6.9
2012	8.0	7.2	7.0
2013	8.3	7.6	6.8
2014	7.8	6.9	6.1
2015	7.6	6.9	6.1
2016	8.0	6.7	6.5
2017	8.2	7.2	6.7
2018	7.7	6.4	5.7
2019	7.7	6.9	6.9

4.3 Waterborne Sample Results – Example

Analytical results for 2019 drinking water and ground water samples were similar to those reported in previous years. Gamma radionuclides analytical results for 2019 surface water samples were similar to those reported in previous years. Tritium in ANO surface water indicator samples continues to be detected, but at levels below those experienced in 2013 and below the ODCM-required LLD. These results are further explained below.

4.3.1 Surface Water

Samples were collected and analyzed for gamma radionuclides and tritium. Gamma radionuclides were below detectable limits which is consistent with results seen in previous operational years. Tritium continues to be detected at the indicator location (Station 8) where previously monitored liquid radioactive effluent from the plant is periodically discharged in accordance with the regulatory criteria established in the ODCM and, for 2019, at levels considerably lower than the ODCM-required LLD of 3000 pCi/l. Furthermore, unlike the elevated tritium levels observed in 2013 attributable to particular plant events, no elevated levels attributable to particular events were observed in 2019. Results are reported as annual average pCi/l.

Monitoring Period	Result
2009 – 2018 (Minimum Value)	427.0
2019 Value	963.5
2009 – 2018 (Maximum Value)	2940*
Preoperational	200.0

* Indicates value from 2013

ANO personnel have noted no definable increasing trends associated with the tritium levels at the discharge location. Levels detected during 2019 and previous operational years have been well below regulatory reporting limits. Therefore, the operation of ANO had no definable impact on this waterborne pathway during 2019 and levels of radionuclides remain similar to those obtained in previous operational years.

4.3.2 Drinking Water

Samples were collected from two locations (indicator and control). Although ANO personnel utilize Station 14 (City of Russellville) as an indicator location due to the potential for the drinking water pathway to exist, the City of Russellville has not withdrawn water from Lake Dardanelle in the past several years.

Drinking water samples were analyzed for gross beta radionuclides, I-131, gamma radionuclides and tritium. Gamma radionuclides, gross beta radionuclides, I-131, and tritium concentrations were below the LLD limits at the indicator and control locations, which is consistent with the preoperational and operational years as shown below. Results from 2019 are summarized in table below. Results are reported as annual average pCi/L. The control location has historically shown gross beta above MDC but less than LLD, while the indicator location is below MDC and LLD.

Radionuclide	2019	2018	2009 – 2017**	Preoperational
Gross Beta	1.97*	3.59	2.17	2.0
Iodine-131	< LLD	< LLD	< LLD	< LLD
Gamma	< LLD	< LLD	< LLD	< LLD
Tritium	< LLD	< LLD	< LLD	200.0

* Average for the control sample during 2019, gross beta was 1.97 pCi/L which is > MDC, but < LLD.

*** Average of the results from the years 2009-2017.

ANO personnel have noted no definable trends associated with drinking water results at the indicator location. Therefore, the operation of ANO had no definable impact on this waterborne pathway during 2019 and levels of radionuclides remain similar to those obtained in previous operational years.

4.3.3 Groundwater

Samples were collected from four REMP locations (2 control, and 2 indicator locations). During 2011, ANO incorporated sixteen additional groundwater monitoring wells into the Groundwater Protection Initiative (GPI) site program. Sample data are compiled, organized and reviewed annually to:

- Analyze for increasing or decreasing trends at individual sample points, wells or groups of wells.
- Review the radionuclides detected to determine whether changes should be made to the analysis sites or sampling frequencies for each sampling location.

- Evaluate the locations of radionuclides in ground water to determine if changes should be made to the sampling locations.
- Review current investigation levels and determine if changes should be made.
- Determine if any change to the ODCM is required.
- Determine if a corrective action/remediation is required.

Groundwater samples from the four REMP locations were analyzed for tritium and gamma radionuclides. Tritium, gamma, and gross beta concentrations were below the LLD limits at all four locations. Listed below is a comparison of 2019 indicator results to past operational years. Results are reported as annual average pCi/l. REMP Groundwater data are captured in the table below. ANO operations had no significant impact on the environment or public by this waterborne pathway.

Radionuclide	2019	2009 – 2087
Iodine-131	< LLD	< LLD
Gamma	< LLD	< LLD
Tritium	< LLD	< LLD
Gross Beta	3.12*	< LLD**

* Average for Indicator wells for 2019.

** Only 2014-2019 gross beta data available for review as historical data.

4.4 Soil Sample Results – Example

Sediment samples were collected from two locations in 2019 and analyzed for gamma radionuclides. Listed below is a comparison of 2019 indicator results to the 2009 – 2018 operational years. ANO operations had no significant impact on the environment or public by this waterborne pathway. Results are reported as pCi/kg.

Monitoring Period	Result
2009 – 2018 (Minimum Value)	41.79
2019 Value	253
2009 – 2018 (Maximum Value)	661.0

Sediment samples were collected from two locations in 2019 and analyzed for gamma radionuclides. Cesium-137 has been detected in years prior to 2019, and gamma radionuclides from 2019 samples from the indicator location were above LLD. This is likely attributable to flooding of the Arkansas River in late spring of 2019 which removed sediment from the shoreline exposing underlying contaminated layers from previous years. No gamma radionuclides were observed at the control location. Therefore, ANO operations had no significant impact on the environment or public by this waterborne pathway.

4.5 Ingestion Sample Results – Example

4.5.1 Milk Sample Results

Milk samples were not collected during 2019 due to the unavailability of indicator locations within five miles of ANO.

4.5.2 Fish Sample Results

Fish samples were collected from two locations and analyzed for gamma radionuclides. In 2019, gamma radionuclides were below detectable limits which are consistent with the preoperational monitoring period and operational results since 1997. Therefore, based on these measurements, ANO operations had no significant radiological impact upon the environment or public by this ingestion pathway.

4.5.3 Food Product 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 2019, food product samples were collected when available from two locations and analyzed for Iodine-131 and gamma radionuclides. The 2019 levels remained undetectable, as has been the case in previous years. Therefore, based on these measurements, ANO operations had no significant radiological impact upon the environment or public by this ingestion pathway.

4.6 Land Use Census Results – Example

The latest land use census (performed in 2019) did not identify any new locations that yielded a calculated dose or dose commitment greater than those currently calculated Table 6, "Land Use Census – [2019] Nearest Residence Within Five Miles."

One cattle farm was observed in the NNE sector. An interview with the owner was performed and he stated that the cattle were for breeding.

ANO personnel chose not to perform a garden census in 2019, but instead to sample broadleaf vegetation which is allowed by ODCM Section L 2.5.2. As allowed by NRC Regulatory Guide 1.21, Revision 2, Section 3.2, broadleaf vegetation sampling in the meteorological sector (Sector 13) with a D/Q value within 10% of the sector with the highest D/Q (Sector 12) was performed.

Table 6 – Land Use Census – [2019] Nearest Residence Within Five Miles						
Sector	**Direction**	**Nearest Residence**	**Garden**	**Meat**	**Nearest Milk Animal**	**Comment**
1	N	0.9	N/A	> 5	> 5	None
2	NNE	1.3	N/A	2.8	> 5	1
3	NE	0.9	N/A	> 5	> 5	None
4	ENE	0.8	N/A	> 5	> 5	None
5	E	0.8	N/A	> 5	> 5	None
6	ESE	0.8	N/A	> 5	> 5	None
7	SE	0.8	N/A	> 5	> 5	None
8	SSE	0.8	N/A	> 5	> 5	None
9	S	0.8	N/A	> 5	> 5	None
10	SSW	0.7	N/A	> 5	> 5	None
11	SW	2.8	N/A	> 5	> 5	None
12	WSW	0.7	N/A	> 5	> 5	None
13	W	0.8	N/A	> 5	> 5	None
14	WNW	0.8	N/A	> 5	> 5	None
15	NW	1.0	N/A	> 5	> 5	None
16	NNW	0.9	N/A	> 5	> 5	None

Comment 1: While performing the land use census, a cattle farm was identified. A phone interview was performed with the owner of the farm. The owner stated the cattle were mainly for breeding purposes but could provide an animal for consumption. The meat pathway is not required per ANO ODCM.

4.7 Interlaboratory Comparison Results

Attachment 3 and Attachment 4 contain result summaries for Interlaboratory Comparison Program for Teledyne Brown Engineering and Environmental Dosimetry Group.

5.0 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM SUMMARY

Table 7, "Radiological Environmental Monitoring Program Summary," summarizes data for the 2019 REMP program.

Table 7 – Radiological Environmental Monitoring Program Summary

Sample Type (Units)	Type / Number of Analyses [Note 1]	LLD [Note 2]	Indicator Locations Mean (F) [Note 3] [Range]	Location [Note 4] [Highest Annual Mean]		Control Locations Mean (F) [Note 3] [Range]	Number of Non-Routine Results [Note 5]
				Location	Mean (F) [Note 3] [Range]		
Air Particulates (pCi/m^3)	GB / 130	0.01	0.0166 (81 / 81) [0.0152 – 0.0175]	Station 6 (88°, 0.5 mi)	0.0175 (27 / 27) [0.0106 - 0.0286]	0.0171 (54 / 54) [0.0166 - 0.0176]	6
Airborne Iodine (pCi/ m^3)	I-131 / 130	0.07	< LLD	N/A	N/A	< LLD	6
Inner Ring TLDs (mR/Qtr)	Gamma / 64	[Note 6]	7.69 (64 / 64) [5.6 – 9.4]	Station 56 (264°, 0.4 mi)	9.4 (4 / 4) [9.0 - 9.6]	N/A	0
Special Interest TLDs (mR/Qtr)	Gamma / 28	[Note 6]	6.90 (28 / 28) [4.9 – 8.4]	Station 116 (318° - 1.8 mi)	8.4 (4 / 4) [7.7 - 8.7]	N/A	0
Control TLD (mR/Qtr)	Gamma / 4	[Note 6]	N/A	N/A	N/A	6.90 (4 / 4) [5.8 – 9.0]	0

Table 7 – Radiological Environmental Monitoring Program Summary							
Sample Type (Units)	**Type / Number of Analyses** [Note 1]	**LLD** [Note 2]	**Indicator Locations Mean (F)** [Note 3] **[Range]**	**Location** [Note 4] **[Highest Annual Mean]**		**Control Locations Mean (F)** [Note 3] **[Range]**	**Number of Non-Routine Results** [Note 5]
				Location	**Mean (F)** [Note 3] **[Range]**		
Surface Water (pCi/l)	H-3 / 8	3000	963.5 (4 / 4) [707 – 1,220]	Station 8 (166°, 0.2 mi)	1,220 (4 / 4) [707 – 1,220]	< LLD	0
	GS / 24						
	Mn-54	15	< LLD	N/A	N/A	< LLD	0
	Fe-59	30	< LLD	N/A	N/A	< LLD	0
	Co-58	15	< 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
	Zr-95	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
	Cs-134	15	< LLD	N/A	N/A	< LLD	0
	Cs-137	18	< LLD	N/A	N/A	< LLD	0
	Ba-140	60	< LLD	N/A	N/A	< LLD	0
	La-140	15	< LLD	N/A	N/A	< LLD	0

Table 7 – Radiological Environmental Monitoring Program Summary

Sample Type (Units)	Type / Number of Analyses [Note 1]	LLD [Note 2]	Indicator Locations Mean (F) [Note 3] [Range]	Location [Note 4] [Highest Annual Mean]		Control Locations Mean (F) [Note 3] [Range]	Number of Non-Routine Results [Note 5]
				Location	Mean (F) [Note 3] [Range]		
Drinking Water (pCi/1)	GB / 8	4	1.975 (4 / 4) [1.83 – 2.12]	Station 57 (208°, 19.5 mi)	1.975 (4 / 4) [1.83 – 2.12]	1.975 (4 / 4) [1.83 – 2.12]	0
	I-131 / 8	1	< LLD	N/A	N/A	< LLD	0
	H-3 / 8	2000	< LLD	N/A	N/A	< LLD	0
	GS / 8						
	Mn-54	15	< LLD	N/A	N/A	< LLD	0
	Fe-59	30	< LLD	N/A	N/A	< LLD	0
	Co-58	15	< 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
	Zr-95	30	< LLD	N/A	N/A	< LLD	0
	Nb-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	60	< LLD	N/A	N/A	< LLD	0
	La-140	15	< LLD	N/A	N/A	< LLD	0

Table 7 – Radiological Environmental Monitoring Program Summary

Sample Type (Units)	Type / Number of Analyses [Note 1]	LLD [Note 2]	Indicator Locations Mean (F) [Note 3] [Range]	Location [Note 4] [Highest Annual Mean]		Control Locations Mean (F) [Note 3] [Range]	Number of Non-Routine Results [Note 5]
				Location	Mean (F) [Note 3] [Range]		
Fish (pCi/kg)	GS / 2						
	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
Food Products (pCi/kg)	I-131 / 6	60	< LLD	N/A	N/A	N/A	0
	GS / 6						
	Cs-134	60	< LLD	N/A	N/A	N/A	0
	Cs-137	80	< LLD	N/A	N/A	N/A	0

LEGEND:

[Note 1] - GB = Gross beta; I-131 = Iodine-131; H-3 = Tritium; GS = Gamma scan.

[Note 2] - LLD = Required lower limit of detection based on ANO-1 and ANO-2 ODCM Table 2.5-1.

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

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

[Note 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.

[Note 6] - LLD is not defined in ANO-1 and ANO-2 ODCM Table 2.5-1.

Attachment 1

Sample Deviations

Table 8 – Sample Deviations					
Comment No.	**Sample Media Affected**	**Sample Location**	**Date**	**Problem**	**Evaluation / Actions**
1	Air Sample	Air Station 2	02/12/2019	Hour meter not advancing	Hour totalizer at Air Station 2 was not advancing. Replaced the faulty hour totalizer and verified it was working properly. CR-ANO-C-2019-0489.
2	Air Sample	Air Station 1	04/23/2019	Hole in air particulate filter	Air Station 1 air particulate filter was found with a single hole and saturated with water and pollen. The air station sample flow, discharge line, and overall station integrity was found satisfactory as expected. CR-ANO-C-2019-1469.
3	Air Sample	Air Station 1, 2, & 56	07/16/2019	Power Loss	While performing bi-weekly Environmental Monitoring Sampling chemist discovered that Air Station locations 1, 2, & 56 runtimes were short by approximately two hours. This is due to the temporary loss of the London line on 7-5-19 from 21:35-23:45. CR-ANO-C-2019-2564.
4	Air Sample	Air Station 1	08/27/2019	Power Loss	While performing bi-weekly Environmental Monitoring Sampling chemist discovered that Air Station 1 runtime was short by approximately six hours. Suspect loss of power as the pump and totalizer were operable upon arrival and departure. CR-ANO-C-2019-3149.
5	Air Sample	Air Station 1	11/19/2019	Pump Failure	While performing the bi-weekly Air Particulate & Iodine Sampling, Air Station 1 sample pump was found not working. The run time for this station was approximately as expected, which indicates hour-meter working and no loss of power, but sample pump failed. CR-ANO-C-2019-4560.
6	Air Sample	Air Station 7	12/03/2019	Power Loss	While conducting the bi-weekly Environmental Monitoring Sampling, Air Station 7 had a 2-hour delta from deploy time and retrieve time. CR-ANO-C-2019-4671.

Attachment 2

Monitoring Results Tables

Table 9 – Air Particulate Data Summary						
Analysis: Gross Beta				Units: pCi/m^3		
Start Date	End Date	Station 1 (Indicator)	Station 2 (Indicator)	Station 56 (Indicator)	Station 6[Note 1] (Control)	Station 7 (Control)
REQUIRED LLD ➔		0.01	0.01	0.01	0.01	0.01
01/1/2019	1/15/2019	2.23E-02	2.35E-02	1.97E-02	2.01E-02	1.74E-02
1/15/2019	1/29/2019	1.69E-02	1.87E-02	1.27E-02	1.89E-02	1.35E-02
1/29/2019	2/12/2019	1.96E-02	1.83E-02[Note 2]	1.79E-02	1.52E-02	1.60E-02
2/12/2019	2/26/2019	2.49E-02	2.03E-02	1.75E-02	2.38E-02	2.01E-02
2/26/2019	3/12/2019	1.58E-02	1.66E-02	1.38E-02	1.55E-02	1.57E-02
3/12/2019	3/26/2019	1.17E-02	1.26E-02	7.36E-03	1.05E-02	1.07E-02
3/26/2019	4/9/2019	1.32E-02	1.27E-02	1.19E-02	1.05E-02	1.13E-02
4/9/2019	4/23/2019	1.35E-02[Note 2]	1.19E-02	9.36E-03	1.11E-02	1.05E-02
4/23/2019	5/7/2019	1.27E-02	1.31E-02	1.46E-02	1.37E-02	1.42E-02
5/7/2019	5/21/2019	1.36E-02	1.62E-02	1.22E-02	1.67E-02	1.58E-02
5/21/2019	6/4/2019	1.48E-02	1.62E-02	1.50E-02	1.66E-02	1.49E-02
6/4/2019	6/18/2019	1.75E-02	1.25E-02	1.23E-02	1.58E-02	1.50E-02
6/18/2019	7/2/2019	1.31E-02	1.16E-02	1.06E-02	1.51E-02	1.15E-02
7/2/2019	7/16/2019	1.25E-02[Note 2]	1.17E-02[Note 2]	8.81E-03[Note 2]	1.27E-02	1.03E-02
7/16/2019	7/30/2019	1.63E-02	1.48E-02	1.44E-02	1.58E-02	1.32E-02
7/30/2019	8/13/2019	2.35E-02	2.31E-02	1.65E-02	2.31E-02	2.26E-02
8/13/2019	8/27/2019	2.05E-02[Note 2]	1.73E-02	1.76E-02	2.12E-02	1.68E-02
8/27/2019	9/10/2019	2.78E-02	2.93E-02	2.32E-02	2.86E-02	3.21E-02
9/10/2019	9/24/2019	2.73E-02	2.45E-02	2.38E-02	2.41E-02	2.16E-02
9/24/2019	10/8/2019	1.68E-02	1.75E-02	1.52E-02	2.20E-02	2.03E-02
10/8/2019	10/22/2019	1.98E-02	2.01E-02	1.89E-02	2.08E-02	2.15E-02
10/22/2019	11/5/2019	1.33E-02	1.29E-02	1.23E-02	1.28E-02	1.58E-02
11/5/2019	11/19/2019	8.37E-03[Note 2]	2.00E-02	2.11E-02	1.71E-02	2.26E-02
11/19/2019	12/3/2019	1.25E-02	1.34E-02	1.10E-02	1.06E-02	1.24E-02[Note 2]
12/3/2019	12/17/2019	2.27E-02	2.33E-02	2.05E-02	1.85E-02	1.93E-02
12/17/2019	12/31/2019	2.24E-02	2.15E-02	1.58E-02	2.23E-02	1.62E-02
Station Yearly Average		**1.74E-02**	**1.74E-02**	**1.52E-02**	**1.75E-02**	**1.66E-02**

[Note 1] – Station with highest annual mean.

[Note 2] – Reference Attachment 1, Table 8, "Sample Deviations".

Monitoring Results Tables

Table 10 – Radioiodine Cartridge Data Table Summary						
Analysis: I-131				Units: pCi/m^3		
Start Date	**End Date**	**Station 1 (Indicator)**	**Station 2 (Indicator)**	**Station 56 (Indicator)**	**Station 6 (Control)**	**Station 7 (Control)**
01/1/2019	1/15/2019	< 2.73E-02	< 2.73E-02	< 2.74E-02	< 2.73E-02	< 1.14E-02
1/15/2019	1/29/2019	< 3.25E-02	< 3.26E-02[Note 1]	< 3.26E-02	< 1.37E-02	< 3.23E-02
1/29/2019	2/12/2019	< 1.56E-02	< 3.72E-02	< 3.72E-02	< 3.69E-02	< 3.70E-02
2/12/2019	2/26/2019	< 1.63E-02	< 3.89E-02	< 3.89E-02	< 3.88E-02	< 3.86E-02
2/26/2019	3/12/2019	< 1.43E-02	< 3.40E-02	< 3.43E-02	< 3.43E-02	< 3.42E-02
3/12/2019	3/26/2019	< 1.41E-02	< 3.37E-02	< 3.37E-02	< 3.36E-02	< 3.35E-02
3/26/2019	4/9/2019	< 1.67E-02[Note 1]	< 3.09E-02	< 3.10E-02	< 3.08E-02	< 3.08E-02
4/9/2019	4/23/2019	< 3.38E-02	< 3.38E-02	< 3.39E-02	< 3.37E-02	< 1.84E-02
4/23/2019	5/7/2019	< 1.08E-02	< 2.57E-02	< 2.56E-02	< 2.58E-02	< 2.59E-02
5/7/2019	5/21/2019	< 2.04E-02	< 2.04E-02	<2.04e-02	< 2.03E-02	< 1.12E-02
5/21/2019	6/4/2019	< 1.03E-02	< 2.46E-02	< 2.46E-02	< 2.45E-02	< 2.44E-02
6/4/2019	6/18/2019	< 1.13E-02	< 1.35E-02	< 1.35E-02	< 1.34E-02	< 1.34E-02
6/18/2019	7/2/2019	< 1.80E-02[Note 1]	< 1.80E-02[Note 1]	< 1.51E-02[Note 1]	< 1.79E-02	< 1.79E-02
7/2/2019	7/16/2019	< 2.10E-02	< 2.12E-02	< 1.78E-02	< 2.07E-02	< 2.06E-02
7/16/2019	7/30/2019	< 4.29E-02	< 4.30E-02	< 4.31E-02	< 1.51E-02	< 4.28E-02
7/30/2019	8/13/2019	< 1.15E-02[Note 1]	< 2.76E-02	< 2.76E-02	< 2.76E-02	< 2.73E-02
8/13/2019	8/27/2019	< 1.55E-02	< 1.85E-02	< 1.84E-02	< 1.82E-02	< 1.84E-02
8/27/2019	9/10/2019	< 1.79E-02	< 1.81E-02	< 2.88E-02	< 1.79E-02	< 1.79E-02
9/10/2019	9/24/2019	< 1.61E-02	< 1.92E-02	< 1.92E-02	< 1.91E-02	< 1.90E-02
9/24/2019	10/8/2019	< 4.06E-02	< 4.04E-02	< 1.69E-02	< 4.10E-02	< 4.09E-02
10/8/2019	10/22/2019	< 1.30E-02	< 1.30E-02	< 1.30E-02	< 1.28E-02	< 1.07E-02
10/22/2019	11/5/2019	< 1.90E-02[Note 1]	< 1.91E-02	< 1.92E-02	< 1.60E-02	< 1.90E-02
11/5/2019	11/19/2019	< 1.76E-02	< 2.10E-02	< 2.10E-02	< 2.07E-02	< 2.07E-02[Note 1]
11/19/2019	12/3/2019	< 2.74E-02	< 2.74E-02	< 2.74E-02	< 2.73E-02	< 1.25E-02
12/3/2019	12/17/2019	< 2.35E-02	< 1.07E-02	< 2.36E-02	< 2.35E-02	< 2.34E-02
12/17/2019	12/31/2019	< 1.70E-02	< 7.14E-03	< 1.71E-02	< 1.70E-02	< 1.70E-02
Station Yearly Average		**< LLD**	**< LLD**	**< LLD**	**< LLD**	**< LLD**

[Note 1] – Reference Attachment 1, Table 8, "Sample Deviations"

Attachment 2

Monitoring Results Tables

Table 11 – Thermoluminescent Dosimeters – Inner Ring					
Analysis: Gamma Dose				Units: mrem	
Station	**1st Qtr [2019]**	**2nd Qtr [2019]**	**3rd Qtr [2019]**	**4th Qtr [2019]**	**Annual Mean [2019]**
1	8.3	7.9	9.4	8.7	**8.6**
2	7.8	7.5	8.6	7.7	**7.9**
3	5.0	5.6	6.2	5.4	**5.6**
4	7.9	7.3	8.7	7.4	**7.8**
56[Note 1]	**9.2**	**9.0**	**9.6**	**9.6**	**9.4**
108	8.1	7.3	8.4	7.9	**7.9**
109	8.4	7.5	9.0	7.5	**8.1**
110	8.2	7.4	8.1	7.6	**7.8**
145	7.3	7.5	7.6	7.7	**7.5**
146	6.5	6.9	7.3	7.8	**7.1**
147	6.7	6.8	7.2	6.3	**6.8**
148	7.5	7.8	8.8	8.0	**8.0**
149	6.4	6.9	8.0	7.2	**7.1**
150	8.6	8.2	8.8	8.7	**8.6**
151	7.9	7.9	8.6	8.9	**8.3**
152	6.1	6.5	7.1	6.5	**6.6**

[Note 1] – Station with highest annual mean.

Monitoring Results Tables

Table 12 – Thermoluminescent Dosimeters – Special Interest Areas					
Analysis: Gamma Dose			Units: mrem		
Station	1st Qtr [2019]	2nd Qtr [2019]	3rd Qtr [2019]	4th Qtr [2019]	Annual Mean [2019]
6	6.9	6.7	7.5	7.2	**7.1**
111	5.6	5.5	5.5	5.0	**5.4**
116[Note 1]	**8.7**	**8.7**	**8.5**	**7.7**	**8.4**
125	4.8	4.4	5.1	5.4	**4.9**
127	6.5	7.3	7.2	7.1	**7.0**
137	8.2	7.5	8.6	7.6	**8.0**
153	7.4	7.4	7.9	7.1	**7.5**

[Note 1] – Station with highest annual mean.

Table 13 – Thermoluminescent Dosimeters – Control					
Analysis: Gamma Dose			Units: mrem		
Station	1st Qtr [2019]	2nd Qtr [2019]	3rd Qtr [2019]	4th Qtr [2019]	Annual Mean [2019]
7	9.0	6.1	6.7	5.8	**6.9**

Attachment 2

Monitoring Results Tables

Table 14 – 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	Zr-95	I-131	Cs-134	Cs-137	Ba-140	La-140
REQUIRED LLD ➔			**15**	**15**	**30**	**15**	**30**	**15**	**30**	**15**	**15**	**18**	**60**	**15**
Station 8 (Indicator)	05/31/2019	06/30/2019	< 1.63	< 1.66	< 3.80	< 1.62	< 3.24	< 1.78	< 3.11	< 7.02	< 1.67	< 1.60	< 13.7	< 4.65
Station 10 (Control)	05/31/2019	06/30/2019	< 8.68	< 7.21	< 11.3	< 9.90	< 15.6	< 7.64	< 16.2	< 9.33	< 7.92	< 8.17	< 32.6	< 11.0
Station 8 (Indicator)	06/30/2019	07/31/2019	< 2.01	< 2.22	< 4.86	< 1.95	< 4.04	< 2.33	< 3.99	< 11.7	< 2.14	< 1.97	< 20.4	< 5.93
Station 10 (Control)	06/30/2019	07/31/2019	< 4.64	< 4.47	< 9.85	< 5.84	< 9.37	< 5.19	< 8.70	< 7.46	< 4.78	< 4.97	< 20.7	< 7.44
Station 8 (Indicator)	7/31/2019	8/31/2019	< 1.71	< 1.96	< 4.47	< 1.94	< 3.77	< 2.15	< 3.42	< 9.60	< 1.90	< 1.85	< 16.9	< 5.60
Station 10 (Control)	7/31/2019	8/31/2019	< 7.94	< 8.11	< 14.7	< 8.45	< 9.77	< 9.73	< 13.9	< 12.8	< 6.23	< 7.76	< 31.5	< 12.7
Station 8 (Indicator)	08/31/2019	09/30/2019	< 2.11	< 2.20	< 5.01	< 2.16	< 4.48	< 2.38	< 4.21	< 10.2	< 2.20	< 1.97	< 19.0	< 5.90
Station 10 (Control)	08/31/2019	09/30/2019	< 5.55	< 5.79	< 12.4	< 6.62	< 13.3	< 6.40	< 11.7	< 7.69	< 6.78	< 5.80	< 21.0	< 8.18
Station 8 (Indicator)	09/30/2019	10/31/2019	< 2.48	< 2.65	< 6.16	< 2.53	< 4.92	< 2.59	< 4.64	< 12.6	< 2.41	< 2.36	< 22.9	< 7.38
Station 10 (Control)	09/30/2019	10/31/2019	< 6.65	< 8.10	< 12.2	< 8.45	< 14.2	< 7.26	< 9.95	< 9.61	< 6.72	< 6.44	< 31.8	< 7.70
Station 8 (Indicator)	10/31/2019	11/30/2019	< 1.73	< 1.82	< 4.51	< 1.77	< 3.52	< 1.99	< 3.54	< 8.94	< 1.82	< 1.79	< 16.2	< 5.82
Station 10 (Control)	10/31/2019	11/30/2019	< 7.13	< 8.79	< 12.2	< 9.19	< 14.1	< 6.30	< 14.7	< 10.6	< 6.76	< 7.59	< 35.3	< 6.67

Monitoring Results Tables

Table 14 – 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	Zr-95	I-131	Cs-134	Cs-137	Ba-140	La-140
REQUIRED LLD ➔			15	15	30	15	30	15	30	15	15	18	60	15
Station 8 (Indicator)	12/31/2018	01/31/2019	< 2.75	< 3.01	< 7.73	< 2.97	< 5.56	< 2.80	< 5.37	< 15.0	< 3.10	< 2.43	< 26.8	< 9.50
Station 10 (Control)	12/31/2018	01/31/2019	< 6.08	< 3.93	< 13.2	< 10.9	< 13.2	< 5.57	< 9.98	< 7.69	< 7.91	< 5.82	< 18.9	< 10.7
Station 8 (Indicator)	01/31/2019	02/28/2019	< 1.53	< 1.87	< 3.83	< 1.86	< 3.23	< 1.90	< 3.13	< 8.67	< 1.69	< 1.64	< 15.1	< 5.90
Station 10 (Control)	01/31/2019	02/28/2019	< 8.52	< 8.51	< 17.5	< 8.86	< 14.7	< 9.06	< 17.4	< 14.6	< 10.5	< 8.71	< 42.1	< 13.1
Station 8 (Indicator)	02/28/2019	03/31/2019	< 1.58	< 1.68	< 3.96	< 1.51	< 3.31	< 1.87	< 2.96	< 7.03	< 1.82	< 1.60	< 14.0	< 4.22
Station 10 (Control)	02/28/2019	03/31/2019	< 1.54	< 1.67	< 3.53	< 1.95	< 3.49	< 1.58	< 2.68	< 1.83	< 1.76	< 1.76	< 6.04	< 2.50
Station 8 (Indicator)	03/31/2019	04/30/2019	< 1.89	< 2.20	< 4.71	< 2.24	< 4.46	< 2.17	< 3.94	< 9.16	< 2.16	< 2.10	< 17.8	< 6.31
Station 10 (Control)	03/31/2019	04/30/2019	< 3.99	< 3.88	< 8.15	< 4.35	< 9.04	< 3.99	< 7.40	< 5.44	< 4.60	< 4.44	< 17.8	< 4.80
Station 8 (Indicator)	04/30/2019	05/31/2019	< 1.68	< 1.97	< 4.36	< 2.04	< 3.64	< 2.23	< 3.34	< 10.7	< 1.85	< 1.81	< 18.1	< 5.76
Station 10 (Control)	04/30/2019	05/31/2019	< 7.87	< 8.85	< 7.83	< 7.91	< 13.6	< 6.44	< 10.7	< 8.68	< 7.16	< 6.30	< 25.5	< 8.13
Station 8 (Indicator)	05/31/2019	06/30/2019	< 1.63	< 1.66	< 3.80	< 1.62	< 3.24	< 1.78	< 3.11	< 7.02	< 1.67	< 1.60	< 13.7	< 4.65
Station 10 (Control)	05/31/2019	06/30/2019	< 8.68	< 7.21	< 11.3	< 9.90	< 15.6	< 7.64	< 16.2	< 9.33	< 7.92	< 8.17	< 32.6	< 11.0

Attachment 2

Monitoring Results Tables

Table 14 – 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	Zr-95	I-131	Cs-134	Cs-137	Ba-140	La-140
REQUIRED LLD ➔			**15**	**15**	**30**	**15**	**30**	**15**	**30**	**15**	**15**	**18**	**60**	**15**
Station 8 (Indicator)	06/30/2019	07/31/2019	< 2.01	< 2.22	< 4.86	< 1.95	< 4.04	< 2.33	< 3.99	< 11.7	< 2.14	< 1.97	< 20.4	< 5.93
Station 10 (Control)	06/30/2019	07/31/2019	< 4.64	< 4.47	< 9.85	< 5.84	< 9.37	< 5.19	< 8.70	< 7.46	< 4.78	< 4.97	< 20.7	< 7.44
Station 8 (Indicator)	7/31/2019	8/31/2019	< 1.71	< 1.96	< 4.47	< 1.94	< 3.77	< 2.15	< 3.42	< 9.60	< 1.90	< 1.85	< 16.9	< 5.60
Station 10 (Control)	7/31/2019	8/31/2019	< 7.94	< 8.11	< 14.7	< 8.45	< 9.77	< 9.73	< 13.9	< 12.8	< 6.23	< 7.76	< 31.5	< 12.7
Station 8 (Indicator)	08/31/2019	09/30/2019	< 2.11	< 2.20	< 5.01	< 2.16	< 4.48	< 2.38	< 4.21	< 10.2	< 2.20	< 1.97	< 19.0	< 5.90
Station 10 (Control)	08/31/2019	09/30/2019	< 5.55	< 5.79	< 12.4	< 6.62	< 13.3	< 6.40	< 11.7	< 7.69	< 6.78	< 5.80	< 21.0	< 8.18
Station 8 (Indicator)	09/30/2019	10/31/2019	< 2.48	< 2.65	< 6.16	< 2.53	< 4.92	< 2.59	< 4.64	< 12.6	< 2.41	< 2.36	< 22.9	< 7.38
Station 10 (Control)	09/30/2019	10/31/2019	< 6.65	< 8.10	< 12.2	< 8.45	< 14.2	< 7.26	< 9.95	< 9.61	< 6.72	< 6.44	< 31.8	< 7.70
Station 8 (Indicator)	10/31/2019	11/30/2019	< 1.73	< 1.82	< 4.51	< 1.77	< 3.52	< 1.99	< 3.54	< 8.94	< 1.82	< 1.79	< 16.2	< 5.82
Station 10 (Control)	10/31/2019	11/30/2019	< 7.13	< 8.79	< 12.2	< 9.19	< 14.1	< 6.30	< 14.7	< 10.6	< 6.76	< 7.59	< 35.3	< 6.67
Station 8 (Indicator)	11/30/2019	12/31/2019	< 1.84	< 2.09	< 5.21	< 1.93	< 4.02	< 2.04	< 3.76	< 11.0	< 1.92	< 1.76	< 19.1	< 6.52
Station 10 (Control)	11/30/2019	12/31/2019	< 5.01	< 6.35	< 7.77	< 6.32	< 11.3	< 5.76	< 8.63	< 11.1	< 5.96	< 4.14	< 32.8	< 7.48

Monitoring Results Tables

Table 15 – Surface Water – Tritium			
Analysis: H-3		Units: pCi/L	
Location	Start Date	End Date	H-3
REQUIRED LLD ➔			3000
Station 8 (Indicator)	12/31/2018	3/31/2019	< 390
Station 10 (Control)	12/31/2018	3/31/2019	< 387
Station 8 (Indicator)	3/31/2019	6/30/2019	1,220
Station 10 (Control)	3/31/2019	6/30/2019	< 196
Station 8 (Indicator)	6/30/2019	9/30/2019	< 391
Station 10 (Control)	6/30/2019	9/30/2019	< 391
Station 8 (Indicator)	9/30/2019	12/31/2019	707
Station 10 (Control)	9/30/2019	12/31/2019	< 384

Attachment 2

Monitoring Results Tables

Table 16 – Drinking Water –Gamma, GB, I-131

Analysis: Gamma Isotopic, Gross Beta, I-131 | **Units: pCi/L**

Location	Collection Date	Gross Beta	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Nb-95	Zr-95	I-131	Cs-134	Cs-137	Ba-140	La-140
REQUIRED LLD ➔		**4.0**	**15**	**15**	**30**	**15**	**30**	**15**	**30**	**1.0**	**15**	**18**	**60**	**15**
Station 14 (Indicator)	01/01/2019	< 1.59	< 1.54	< 1.49	< 3.06	< 1.71	< 3.08	< 1.51	< 2.68	< 0.328	< 1.64	< 1.61	< 6.14	< 2.02
Station 57 (Control)	01/01/2019	< 1.68	< 1.55	< 1.53	< 3.18	< 1.59	< 3.08	< 1.56	< 2.81	< 0.262	< 1.84	< 1.77	< 6.18	< 1.89
Station 14 (Indicator)	04/04/2019	< 1.56	< 7.93	< 5.35	< 12.0	< 7.86	< 15.2	< 6.48	< 13.5	< 0.687	< 8.01	< 7.46	< 32.6	< 8.22
Station 57 (Control)	04/04/2019	< 1.65	< 6.99	< 5.58	< 16.5	< 7.05	< 11.5	< 6.41	< 12.3	< 0.522	< 5.63	< 6.26	< 25.7	< 13.0
Station 14 (Indicator)	07/02/2019	< 1.57	< 4.70	< 6.67	< 11.0	< 5.91	< 9.30	< 5.47	< 9.10	< 0.846	< 5.05	< 6.37	< 20.2	< 9.20
Station 57 (Control)	07/02/2019	1.83	< 6.10	< 8.43	< 10.1	< 7.68	< 13.8	< 7.42	< 11.9	< 0.696	< 8.60	< 8.04	< 28.3	< 8.53
Station 14 (Indicator)	10/08/2019	< 1.78	< 5.74	< 4.20	< 11.5	< 3.36	< 8.78	< 5.07	< 8.56	< 0.779	< 6.20	< 5.83	< 25.4	< 9.95
Station 57 (Control)	10/08/2019	2.12	< 5.04	< 5.41	< 12.8	< 5.42	< 13.5	< 7.18	< 8.31	< 0.888	< 7.59	< 6.35	< 30.4	< 9.44

Monitoring Results Tables

Table 17 – Drinking Water – Tritium		
Analysis: H-3		Units: pCi/L
Location	Collection Date	H-3
	REQUIRED LLD ➔	2000
Station 14 (Indicator)	01/01/2019	< 377
Station 57 (Control)	01/01/2019	< 383
Station 14 (Indicator)	04/04/2019	< 328
Station 57 (Control)	04/04/2019	< 320
Station 14 (Indicator)	07/02/2019	< 324
Station 57 (Control)	07/02/2019	< 323
Station 14 (Indicator)	10/08/2019	< 341
Station 57 (Control)	10/08/2019	< 337

Table 18 – Sediment			
Analysis: Gamma Isotopic		Units: pCi/kg	
Location	Collection Date	Cs-134	Cs-137
	REQUIRED LLD ➔	150	180
Station 8 (Indicator)	08/23/2019	< 106	253
Station 16 (Control)	08/23/2019	< 106	< 91

Table 19 – Fish								
Analysis: Gamma Isotopic				Units: pCi/kg				
Location	Collection Date	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Cs-134	Cs-137
	REQUIRED LLD ➔	130	130	260	130	260	130	150
Station 8 (Indicator)	04/05/2019	< 29.5	< 30.4	< 52.4	< 40.8	< 74.1	< 28.2	< 28.6
Station 16 (Control)	06/14/2019	< 50.3	< 75.8	< 139	< 70.1	< 141	< 47.1	< 53.3

Monitoring Results Tables

Table 20 – Food Products				
Analysis: I-131, Gamma Isotopic		Units: pCi/kg		
Location	Collection Date	I-131	Cs-134	Cs-137
	REQUIRED LLD ➔	60	60	80
Station 13 (Indicator)	06/18/2019	< 50.6	< 47.1	< 43.1
Station 55 (Control)	06/18/2019	< 38.5	< 36.5	< 38.7
Station 13 (Indicator)	07/16/2019	< 44.3	< 29.9	< 33.6
Station 55 (Control)	07/16/2019	< 40.5	< 39.5	< 38.8
Station 13 (Indicator)	08/13/2019	< 42.4	< 24.9	< 33.0
Station 55 (Control)	08/13/2019	< 44.2	< 33.4	< 33.4

Monitoring Results Tables

Table 21 – Groundwater - Gamma and Iodine														
Analysis: Gross Beta, I-131, Gamma Isotopic										Units: pCi/L				
Location	Collection Date	Gr-B	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Nb-95	Zr-95	I-131	Cs-134	Cs-137	Ba-140	La-140
REQUIRED LLD ➔		N/A[Note 1]	15	15	30	15	30	15	30	15	15	18	60	15
Station 58 (Control)	3/13/2019	< 2.55	< 6.12	< 6.52	< 11.3	< 7.23	< 11.8	< 7.35	< 13.0	< 13.9	< 7.91	< 6.22	< 34.8	< 13.5
Station 62 (Control)	3/12/2019	4.01	< 5.54	< 6.76	< 15.8	< 5.76	< 14.2	< 6.97	< 8.45	< 14.2	< 7.78	< 7.35	< 34.7	< 12.2
Station 63 (Indicator)	3/12/2019	< 1.65	< 6.46	< 6.25	< 13.9	< 6.56	< 10.5	< 8.32	< 9.80	< 12.5	< 7.87	< 5.94	< 39.2	< 10.4
Station 64 (Indicator)	3/13/2019	< 2.26	< 5.09	< 5.91	< 14.1	< 6.13	< 11.3	< 7.98	< 11.4	< 11.3	< 5.33	< 5.06	< 29.1	< 14.3
Station 58 (Control)	6/11/2019	< 2.41	< 6.41	< 5.39	< 13.7	< 6.08	< 13.7	< 5.75	< 9.24	< 12.8	< 6.44	< 5.47	< 26.0	< 10.5
Station 62 (Control)	6/11/2019	< 3.75	< 5.45	< 5.27	< 12.1	< 5.71	< 11.3	< 4.75	< 11.3	< 14.0	< 6.52	< 7.24	< 31.4	< 10.3
Station 63 (Indicator)	6/11/2019	< 3.76	< 6.68	< 5.36	< 11.1	< 4.87	< 7.24	< 6.45	< 12.6	< 12.0	< 7.13	< 5.23	< 25.9	< 11.2
Station 64 (Indicator)	6/12/2019	< 3.27	< 6.08	< 6.99	< 11.5	< 6.30	< 15.3	< 6.80	< 9.58	< 11.5	< 6.15	< 5.94	< 27.1	< 11.4
Station 58 (Control)	9/10/2019	< 1.90	< 5.50	< 6.55	< 11.2	< 6.39	< 13.3	< 6.40	< 11.9	< 12.4	< 6.62	< 6.69	< 28.8	< 10.3
Station 62 (Control)	9/10/2019	< 3.64	< 3.91	< 3.78	< 8.38	< 4.90	< 6.91	< 4.04	< 6.80	< 7.92	< 4.04	< 4.24	< 17.1	< 6.96

Attachment 2

Monitoring Results Tables

Table 21 – Groundwater - Gamma and Iodine														
Analysis: Gross Beta, I-131, Gamma Isotopic										Units: pCi/L				
Location	**Collection Date**	**Gr-B**	**Mn-54**	**Co-58**	**Fe-59**	**Co-60**	**Zn-65**	**Nb-95**	**Zr-95**	**I-131**	**Cs-134**	**Cs-137**	**Ba-140**	**La-140**
REQUIRED LLD ➔		**N/A[Note 1]**	**15**	**15**	**30**	**15**	**30**	**15**	**30**	**15**	**15**	**18**	**60**	**15**
Station 63 (Indicator)	9/10/2019	< 3.62	< 4.82	< 7.27	< 12.3	< 7.37	< 11.1	< 6.88	< 10.5	< 12.7	< 7.24	< 7.15	< 28.5	< 11.2
Station 64 (Indicator)	9/11/2019	2.86	< 2.90	< 2.99	< 6.15	< 3.00	< 6.61	< 3.40	< 5.83	< 5.77	< 3.50	< 3.25	< 16.4	< 5.10
Station 58 (Control)	12/10/2019	2.52	< 7.74	< 6.81	< 12.8	< 6.62	< 13.2	< 7.38	< 12.7	< 10.7	< 8.52	< 6.12	< 33.0	< 13.0
Station 62 (Control)	12/10/2019	3.08	< 6.47	< 5.82	< 13.0	< 9.24	< 13.1	< 6.16	< 14.4	< 10.0	< 8.63	< 7.24	< 26.6	< 8.45
Station 63 (Indicator)	12/10/2019	< 3.91	< 7.31	< 6.03	< 12.3	< 8.49	< 14.8	< 7.26	< 11.8	< 11.1	< 6.76	< 7.18	< 24.3	< 12.4
Station 64 (Indicator)	12/11/2019	< 2.95	< 6.15	< 7.01	< 16.5	< 7.35	< 17.0	< 9.35	< 11.5	< 10.4	< 7.92	< 6.59	< 27.2	< 7.48

[Note 1] – Per ANO's ODCM there is no LLD for groundwater or a reportable detectable concentration.

Monitoring Results Tables

Table 22 – Groundwater – Tritium		
Analysis: H-3	**Units: pCi/L**	
Location	**Collection Date**	**H-3**
REQUIRED LLD ➔		**3000**
Station 58 (Control)	3/13/2019	< 300
Station 62 (Control)	3/12/2019	< 297
Station 63 (Indicator)	3/12/2019	< 299
Station 64 (Indicator)	3/13/2019	< 303
Station 58 (Control)	6/11/2019	< 360
Station 62 (Control)	6/11/2019	< 358
Station 63 (Indicator)	6/11/2019	< 355
Station 64 (Indicator)	6/12/2019	< 362
Station 58 (Control)	9/10/2019	< 361
Station 62 (Control)	9/10/2019	< 364
Station 63 (Indicator)	9/10/2019	< 358
Station 64 (Indicator)	9/11/2019	< 358
Station 58 (Control)	12/10/2019	< 368
Station 62 (Control)	12/10/2019	< 371
Station 63 (Indicator)	12/10/2019	< 369
Station 64 (Indicator)	12/11/2019	< 377

Attachment 3

Interlaboratory Comparison Program Results

1.0 SUMMARY

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

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

1. Analytics Evaluation Criteria

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

2. ERA Evaluation Criteria

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

3. DOE Evaluation Criteria

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

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

Note: The DOE MAPEP samples are created to mimic conditions found at DOE sites which do not resemble typical environmental samples obtained at commercial nuclear power facilities.

Interlaboratory Comparison Program Results

4. For the TBE laboratory, 119 out of 129 analyses performed met the specified acceptance criteria. Ten analyses did not meet the specified acceptance criteria for the following reasons and were addressed through the TBE Corrective Action Program. A summary is included below:

   a. The ERA April 2019 water Cs-134 result was evaluated as Not Acceptable. The reported value was 15.2 pCi/L (error 2.82 pCi/L) and the known result was 12.1 pCi/L (acceptance range of 8.39 - 14.4 pCi/L). With the error, the reported result overlaps the acceptable range. This sample was run as the workgroup duplicate on a different detector with a result of 10.7 pCi/L (within acceptable range). (NCR 19-10)

   b. The ERA April 2019 water Sr-89 result was evaluated as Not Acceptable. The reported value was 44.9 pCi/L and the known result was 33.3 pCi/L (acceptance range of 24.5 - 40.1 pCi/L). The sample was only counted for 15 minutes instead of 200 minutes. The sample was re-prepped in duplicate and counted for 200 minutes with results of 30.7 ± 5.37 pCi/L and 33.0 ± 8.71 pCi/L. This was the 1st "high" failure for Sr-89 in 5 years. (NCR 19-11)

   c. The MAPEP February 2019 soil Sr-90 result was not submitted and therefore evaluated as Not Acceptable. The sample was run in duplicate, with results of -1.32 ± 4.09 Bq/kg (< 6.87) and -1.030 ± 3.55 Bq/kg (< 5.97). The known result was a false positive test (no significant activity). TBE did not submit a result because it appeared that the results may not be accurate. TBE analyzed a substitute soil Sr-90 sample from another vendor, with a result within the acceptable range. (NCR 19-12)

   d. The MAPEP February 2019 water Am-241 result was evaluated as Not Acceptable. The reported value was 0.764 ± 0.00725 Bq/L with a known result of 0.582 Bq/L (acceptable range 0.407 - 0.757 Bq/L). TBE's result falls within the upper acceptable range with the error. It appeared that a non-radiological interference was added and lead to an increased mass and higher result. (NCR 19-13)

   e. The MAPEP February 2019 vegetation Sr-90 result was evaluated as Not Acceptable. The reported result was -0.1060 ± 0.0328 Bq/kg and the known result was a false positive test (no significant activity). TBE's result was correct in that there was no activity. MAPEP's evaluation was a "statistical failure" at 3 standard deviations. (NCR 19-14)

   f. The ERA October 2019 water Gross Alpha result was evaluated as Not Acceptable. TBE's reported result was 40.5 ± 10.3 pCi/L and the known result was 27.6 pCi/L (ratio of TBE to known result at 135%). With the associated error, the result falls within the acceptable range (14.0 - 36.3 pCi/L). The sample was run as the workgroup duplicate on a different detector with a result of 30.8 ± 9.17 pCi/L (within the acceptable range). This was the first failure for drinking water Gr-A since 2012. (NCR 19-23)

   g. The ERA October 2019 water Sr-90 result was evaluated as Not Acceptable. TBE's reported result was 32.5 ± 2.12 pCi/L and the known result was 26.5 pCi/L (ratio of TBE to known result at 123%). With the associated error, the result falls within the

acceptable range (19.2 - 30.9 pCi/L). The sample was run as the workgroup duplicate on a different detector with a result of 20.0 ± 1.91 pCi/L (within the acceptable range). Both TBE results are within internal QC limits. A substitute "quick response" sample was analyzed with an acceptable result of 20.1 pCi/L (known range of 13.2 - 22.1 pCi/L). (NCR 19-24)

h. The ERA October 2019 water Sr-90 result was evaluated as Not Acceptable. TBE's reported result was 32.5 ± 2.12 pCi/L and the known result was 26.5 pCi/L (ratio of TBE to known result at 123%). With the associated error, the result falls within the acceptable range (19.2 - 30.9 pCi/L). The sample was run as the workgroup duplicate on a different detector with a result of 20.0 ± 1.91 pCi/L (within the acceptable range). Both TBE results are within internal QC limits. A substitute "quick response" sample was analyzed with an acceptable result of 20.1 pCi/L (known range of 13.2 - 22.1 pCi/L). (NCR 19-24)

i. The MAPEP August 2019 water Am-241 result was not reported and therefore evaluated as Not Acceptable. Initial review of the results showed a large peak where Am-241 should be (same as the February, 2019 sample results). It is believed that Th-228 was intentionally added as an interference. The sample was re-prepped and analyzed using a smaller sample aliquot. The unusual large peak (Th-228) was seen again along with a smaller peak (Am-241). The result was 436 ± 22.8 Bq/L (acceptable range 0.365 ± 0.679 Bq/L). Th-228 is not a typical nuclide requested by clients, so there is no analytical purpose to take samples through an additional separation step. TBE will pursue using another vendor for Am-241 water cross-checks that more closely reflects actual customer samples. (NCR 19-26)

j. The Analytics September 2019 soil Cr-51 sample was evaluated as Not Acceptable. TBE's reported result of 0.765 ± 0.135 pCi/g exceeded the upper acceptance range (140% of the known result of 0.547 pCi/g). The TBE result was within the acceptable range (0.63 - 0.90 pCi/g) with the associated error. The Cr-51 result is very close to TBE's normal detection limit. In order to get a reportable result, the sample must be counted for 15 hours (10x longer than client samples). There is no client or regulatory requirement for this nuclide and TBE will remove Cr-51 from the reported gamma nuclides going forward. (NCR 19-27)

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

ENVIRONMENTAL DOSIMETRY COMPANY

ANNUAL QUALITY ASSURANCE STATUS REPORT

January - December 2019

10 Ashton Lane Sterling, MA 01564

1.0 EXECUTIVE SUMMARY

Routine quality control (QC) testing was performed for dosimeters issued by the Environmental Dosimetry Company (EDC).

During this annual period 100% (72/72) of the individual dosimeters evaluated against the EDC internal performance acceptance criteria (high-energy photons only) met the criterion for accuracy and 100% (72/72) met the criterion for precision (Table 1). In addition, 100% (12/12) of the dosimeter sets evaluated against the internal tolerance limits met EDC acceptance criteria (Table 2) and 100% (6/6) of independent testing passed the performance criteria (Table 3). Trending graphs, which evaluate performance statistic for high-energy photon irradiations and co-located stations, are given in Appendix A.

One internal assessment and one external audit were performed in 2019. There were no findings identified.

2.0 INTRODUCTION

The Thermoluminescent Dosimeter (TLD) systems at the EDC are calibrated and operated to ensure consistent and accurate evaluation of TLDs. The quality of the dosimetric results reported to EDC clients is ensured by in house performance testing and independent performance testing by EDC clients, and both internal and client directed program assessments.

The purpose of the dosimetry quality assurance (QA) program is to provide performance documentation of the routine processing of EDC dosimeters. Performance testing provides a statistical measure of the bias and precision of dosimetry processing against a reliable standard, which in turn points out any trends or performance changes. Two programs are used:

2.1 QC Program

Dosimetry quality control tests are performed on EDC Panasonic 814 Environmental dosimeters. These tests include: (1) the in house testing program coordinated by the EDC QA Officer and (2) independent test perform by EDC clients. In-house test are performed using six pairs of 814 dosimeters; a pair is reported as an individual result and six pairs are reported as the mean result. Results of these tests are described in this report.

Excluded from this report are instrumentation checks. Although instrumentation checks represent an important aspect of the quality assurance program, they are not included as process checks in this report. Instrumentation checks represent between 5-10% of the TLDs processed.

2.2 QA Program

An internal assessment of dosimetry activities is conducted annually by the Quality Assurance Officer (Reference 1). The purpose of the assessment is to review procedures, results, materials or components to identify opportunities to improve or enhance processes and/or services.

3.0 PERFORMANCE EVALUATION CRITERIA

3.1 Acceptance Criteria for Internal Evaluations

1. Bias

   For each dosimeter tested, the measure of bias is the percent deviation of the reported result relative to the delivered exposure. The percent deviation relative to the delivered exposure is calculated as follows:

$$\frac{(H_i' - H_i)}{H_i} 100$$

   Where:

   H'_i = the corresponding reported exposure for the ith dosimeter (i.e., the reported exposure)

   H_i = the exposure delivered to the ith irradiated dosimeter (i.e., the delivered exposure)

2. Mean Bias

   For each group of test dosimeters, the mean bias is the average percent deviation of the reported result relative to the delivered exposure. The mean percent deviation relative to the delivered exposure is calculated as follows:

$$\sum \left(\frac{(H_i' - H_i)}{H_i} \right) 100 \left(\frac{1}{n} \right)$$

   Where:

   H'_I = the corresponding reported exposure for the ith dosimeter (i.e., the reported exposure)

   H_i = the exposure delivered to the ith irradiated test dosimeter (i.e., the delivered exposure)

   n = the number of dosimeters in the test group

3. Precision

   For a group of test dosimeters irradiated to a given exposure, the measure of precision is the percent deviation of individual results relative to the mean reported exposure. At least two values are required for the determination of precision. The measure of precision for the ith dosimeter is:

$$\sum\left(\frac{(H_i' - H_i)}{H_i}\right)100\left(\frac{1}{n}\right)$$

   Where:

   H'_i = the reported exposure for the ith dosimeter (i.e., the reported exposure)

   H_i = the mean reported exposure; i.e.

   n = the number of dosimeters in the test group

4. EDC Internal Tolerance Limits

   All evaluation criteria are taken from the "EDC Quality System Manual," (Reference 2). These criteria are only applied to individual test dosimeters irradiated with high-energy photons (Cs 137) and are as follows for Panasonic Environmental dosimeters: ± 15% for bias and ± 12.8% for precision.

3.2 QC Investigation Criteria and Result Reporting

EDC Quality System Manual (Reference 2) specifies when an investigation is required due to a QC analysis that has failed the EDC bias criteria. The criteria are as follows:

1. No investigation is necessary when an individual QC result falls outside the QC performance criteria for accuracy.

2. Investigations are initiated when the mean of a QC processing batch is outside the performance criterion for bias.

3.3 Reporting of Environmental Dosimetry Results to EDC Customers

1. All results are to be reported in a timely fashion.

2. If the QA Officer determines that an investigation is required for a process, the results shall be issued as normal. If the QC results prompting the investigation have a mean bias from the known of greater than ± 20%, the results shall be issued with a note indicating that they may be updated in the future, pending resolution of a QA issue.

3. Environmental dosimetry results do not require updating if the investigation has shown that the mean bias between the original results and the corrected results, based on applicable correction factors from the investigation, does not exceed ± 20%.

4.0 DATA SUMMARY FOR ISSUANCE PERIOD JANUARY-DECEMBER 2019

4.1 General Discussion

Results of performance tests conducted are summarized and discussed in the following sections. Summaries of the performance tests for the reporting period are given in Tables 1 through 3 and Figures 1 through 4.

Table 1 provides a summary of individual dosimeter results evaluated against the EDC internal acceptance criteria for high-energy photons only. During this period 100% (72/72) of the individual dosimeters evaluated against these criteria met the tolerance limits for accuracy and 100% (72/72) met the criterion for precision. A graphical interpretation is provided in Figures 1 and 2.

Table 2 provides the bias and standard deviation results for each group (N=6) of dosimeters evaluated against the internal tolerance criteria. Overall, 100% (12/12) of the dosimeter sets evaluated against the internal tolerance performance criteria met these criteria. A graphical interpretation is provided in Figure 3.

Table 3 presents the independent blind spike results for dosimeters processed during this annual period. All results passed the performance acceptance criterion. Figure 4 is a graphical interpretation of Seabrook Station blind co-located station results.

4.2 Result Trending

One of the main benefits of performing quality control tests on a routine basis is to identify trends or performance changes. The results of the Panasonic environmental dosimeter performance tests are presented in Appendix A. The results are evaluated against each of the performance criteria listed in Section II, namely: individual dosimeter accuracy, individual dosimeter precision, and mean bias.

All of the results presented in Appendix A are plotted sequentially by processing date.

5.0 STATUS OF EDC CONDITION REPORTS (CR)

No condition reports were issued during this annual period.

6.0 STATUS OF AUDITS/ASSESSMENTS

1. Internal

   EDC Internal Quality Assurance Assessment was conducted during the fourth quarter 2019. There were no findings identified.

2. External

   None.

7.0 PROCEDURES AND MANUALS REVISED DURING JANUARY - DECEMBER 2018

No procedures or manuals were revised in 2019.

8.0 CONCLUSION AND RECOMMENDATIONS

The quality control evaluations continue to indicate the dosimetry processing programs at the EDC satisfy the criteria specified in the Quality System Manual. The EDC demonstrated the ability to meet all applicable acceptance criteria.

9.0 REFERENCES

1. EDC Quality Control and Audit Assessment Schedule, 2019.

2. EDC Manual 1, Quality System Manual, Rev. 3, August 1, 2017.

TABLE 1

PERCENTAGE OF INDIVIDUAL DOSIMETERS THAT PASSED EDC INTERNAL CRITERIA JANUARY – DECEMBER 2019[(1), (2)]

Dosimeter Type	Number Tested	% Passed Bias Criteria	% Passed Precision Criteria
Panasonic Environmental	72	100	100

(1) This table summarizes results of tests conducted by EDC.

(2) Environmental dosimeter results are free in air.

TABLE 2

MEAN DOSIMETER ANALYSES (N=6)
JANUARY – DECEMBER 2019[1], [2]

Process Date	Exposure Level	Mean Bias %	Standard Deviation %	Tolerance Limit +/-15%
4/25/2019	26	1.8	1.7	Pass
4/29/2019	51	3.1	1.5	Pass
5/04/2019	85	-0.4	1.4	Pass
7/28/2019	75	5.9	1.1	Pass
7/30/2019	32	2.8	1.2	Pass
8/4/2019	107	-0.7	1.2	Pass
10/25/2019	64	1.8	1.2	Pass
11/04/2019	90	-0.5	1.8	Pass
11/05/2019	117	3.0	1.7	Pass
01/20/2020	45	1.0	2.0	Pass
01/30/2020	57	1.8	2.6	Pass
02/17/2020	121	-2.6	2.4	Pass

[1] This table summarizes results of tests conducted by EDC for TLDs issued in 2019.

[2] Environmental dosimeter results are free in air.

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TABLE 3

SUMMARY OF INDEPENDENT DOSIMETER TESTING
JANUARY – DECEMBER 2019[1], [2]

Issuance Period	Client	Mean Bias %	Standard Deviation %	Pass / Fail
1st Qtr. 2019	Millstone	0.6	2.6	Pass
2nd Qtr.2019	Seabrook	7.8	2.0	Pass
3rd Qtr. 2019	SONGS	0.1	2.4	Pass
3rd Qtr. 2019	Millstone	1.1	1.9	Pass
4th Qtr.2019	PSEG (PNNL)	-3.2	0.9	Pass
4th Qtr.2019	Seabrook	0.9	1.0	Pass

[1] Performance criteria are +/- 15%.

[2] Blind spike irradiations using Cs-137

APPENDIX A

DOSIMETRY QUALITY CONTROL TRENDING GRAPHS

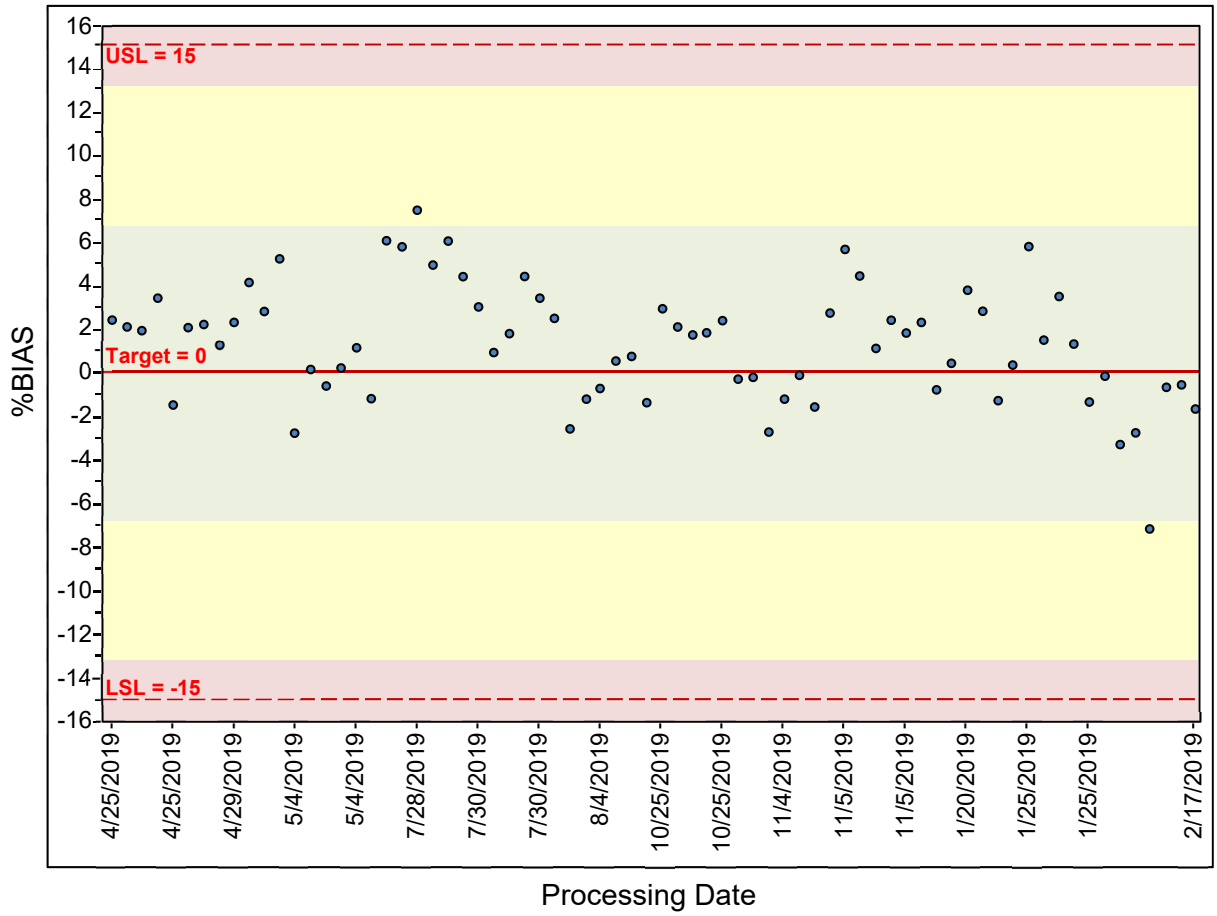
ISSUE PERIOD JANAURY - DECEMBER 2019

Attachment 4

Environmental Dosimetry Company Interlaboratory Comparison Program Report

FIGURE 1

INDIVIDUAL ACCURACY ENVIRONMENTAL



Attachment 4

Environmental Dosimetry Company Interlaboratory Comparison Program Report

FIGURE 2

INDIVIDUAL PRECISION ENVIRONMENTAL

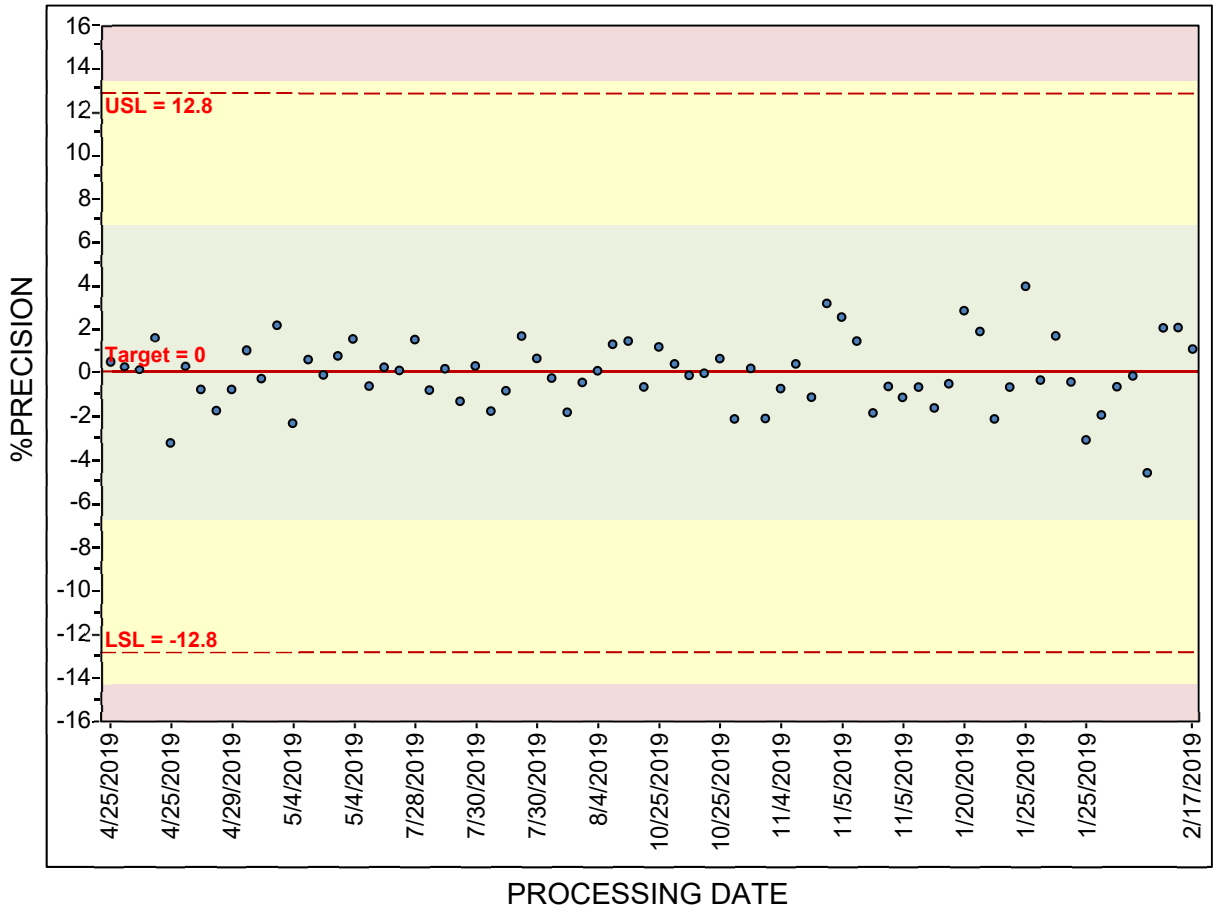


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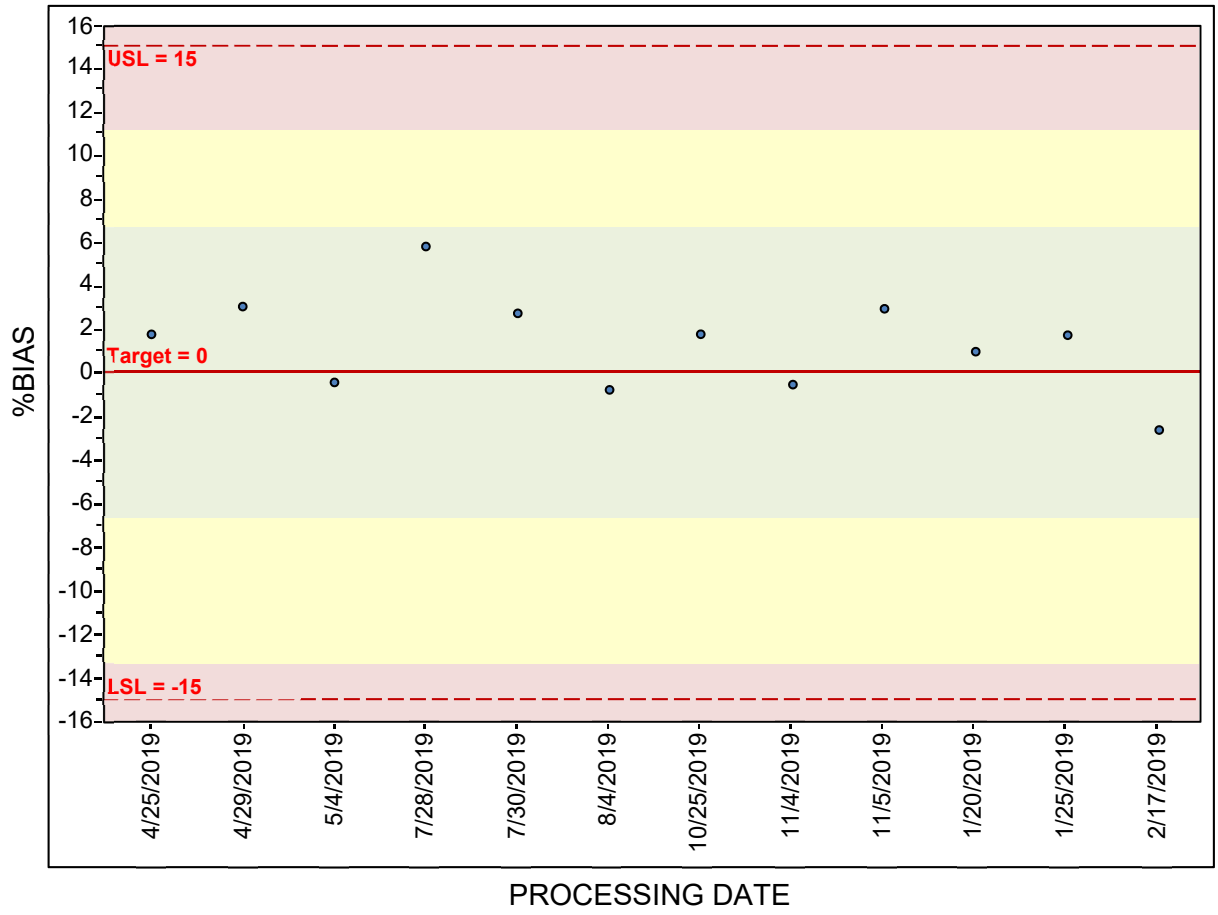
FIGURE 3

MEAN ACCURACY ENVIRONMENTAL



Attachment 4

Environmental Dosimetry Company Interlaboratory Comparison Program Report

FIGURE 4

SEABROOK CO-LOCATE ACCURACY