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0CAN101701

October 10, 2017

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

SUBJECT: Revised Annual Radiological Environmental Operating Report for 2016
Arkansas Nuclear One – Units 1 and 2
Docket Nos. 50-313 and 50-368
License Nos. DPR-51 and NPF-6

REFERENCES:
1. Entergy letter dated April 28, 2017, "Annual Radioactive Effluent Release Report for 2016" (0CAN041702) (ML17118A011)
2. Entergy letter dated May 4, 2017, "Annual Radiological Environmental Operating Report for 2016" (0CAN051702) (ML17276B200)

Dear Sir or Madam:

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 (AREOR) for the previous year is required by May 15 of each year. The subject ANO report for the calendar year 2016 was submitted on May 4, 2017, as noted in Reference 2 above.

Historically, Attachment 2 of the report, "Interlaboratory Comparison Program," has contained a summary of analyses that did not meet specified acceptance criteria. However, due to a change in departmental personnel responsible for AREOR development, Attachment 2 of the Reference 2 report included the specific detailed analyses (instead of a summary of the results), which contained information marked as confidential to the associated vendor. Therefore, the ANO AREOR for 2016 is hereby resubmitted in its entirety (for convenience), replacing the detailed and confidential information previously included in Attachment 2 with a summary of the analysis comparison results, consistent with historical ANO AREOR reports. Entergy Operations, Inc. (Entergy) requests the NRC replace the previous May 4, 2017 (Reference 2) correspondence accordingly. Except for Attachment 2 of the report, no data contained in the Reference 2 correspondence has been changed or revised.

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

The radionuclides detected by the radiological environmental monitoring program during 2016 were significantly below the regulatory limits. The operation of the ANO station during 2016 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 Reference 1 correspondence.

This letter contains no new commitments.

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

Sincerely,

ORIGINAL SIGNED BY STEPHENIE L. PYLE

SLP/dbb

Enclosure: Annual Radiological Environmental Operating Report for 2016

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Enclosure to

0CAN101701

Annual Radiological Environmental Operating Report for 2016

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Summary

The Annual Radiological Environmental Operating Report (AREOR) presents data obtained through analyses of environmental samples collected for Arkansas Nuclear One's (ANO's) Radiological Environmental Monitoring Program (REMP) for the period January 1, 2016, through December 31, 2016. This report fulfills the requirements of ANO Unit 1 Technical Specification (TS) 5.6.2 and Unit 2 TS 6.6.2.

During 2016, as in previous years, ANO detected tritium attributable to plant operations at the discharge location (Station 8) where previously monitored liquid radioactive effluent from the plant is periodically discharged in accordance with the regulatory criteria established in the Offsite Dose Calculation Manual (ODCM). ANO personnel routinely monitor results from this area in order to note any trends. The review of results from this area indicates tritium levels in the surface water media continue to be below regulatory reporting limits and are consistent with concentrations that would typically be seen at this location as discussed in Section 2.3 of this AREOR.

Gross beta concentrations at the Station 14 (City of Russellville) indicator drinking water location continue to remain consistent with previous operational measurements and similar to the levels detected at the Station 57 (City of Danville) control drinking water location. Slightly elevated levels of gross beta were observed in 2016 samples. These samples were low in activity and occurred in both indicator and control locations. There are no trends of concern from these results. Data from 2014 and 2015 are included in this report.

Radiological Environmental Monitoring Program

ANO established the REMP prior to the station 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 radiation directly. ANO also samples milk, if milk-producing animals are present commercially within five miles 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 2016, ANO personnel collected environmental samples for radiological analysis. Personnel compared results of indicator locations with control locations and previous studies and concluded that overall no significant relationship exists between ANO operation and effect on the plant environs. The review of 2016 data, in most cases, showed undetectable radiation levels in the environment and in all instances, no definable trends related to significant pathways associated with ANO.

Harmful Effects or Irreversible Damage

The REMP monitoring 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

ANO's review indicates that no samples equaled or exceeded reporting levels for radioactivity concentration in environmental samples due to ANO effluents, as outlined in ODCM Table 2.5-2, when averaged over any calendar quarter. Therefore, 2016 results did not trigger any Radiological Monitoring Program special reports.

Radioactivity Not Attributable to ANO

The ANO REMP has detected radioactivity attributable to other sources. These include the 25th Chinese nuclear test explosion in 1980 and the radioactivity plume release due to reactor core degradation at the Chernobyl Nuclear Power Plant in 1986. Prior to 1981, the ANO REMP detected radioactivity resulting from nuclear weapons testing, with Cesium-137 continuing to be periodically detected. In 2011, ANO detected I-131 radioactivity attributed to the Fukushima Daiichi Nuclear Power Plant accident (March 11, 2011).

Comparison to Federal and State Programs

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 (ADH).

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 ADH 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.

Sample Deviations

- Milk

  The REMP did not include milk sampling within five miles of ANO in 2016 due to unavailability. The ODCM requires collection of milk samples, if available commercially within 5 miles of the plant. ANO personnel collected vegetation samples to monitor the ingestion pathway, as specified in the ODCM, because of milk unavailability.

- Lower Levels of Detection (LLDs) during this reporting period were within the acceptable limits required by Table 2.5-1 of the ODCM.

- Air Samples

Listed below are air sampler deviations that occurred during 2016 due to electrical power outages and equipment failure. These deviations did not result in exceeding LLD values specified in the ODCM. As described in ODCM, B 2.5.1, Actions A.1 and A.2, deviations are permitted from the required sampling schedule due to malfunction of sampling equipment and other legitimate reasons.

Station	Sampling Period	Comment
7	02/9/2016 – 02/23/2016	As documented on 02/23/2016, totalizer run time for the listed sampling period was approximately 48 hours less than expected. The totalizer was verified to be not advancing as required. (CR-ANO-C-2016-00886)
2	05/03/2016 – 05/17/2016	As documented on 05/17/2016, the sample pump was not working at the time of sample collection. The run time for this station was approximately two hours less than expected. (CR-ANO-C-2016-02187)
7	08/23/2016 – 09/06/2016	As documented on 09/06/2016, the totalizer run time for the listed sampling period was approximately six hours less than expected. (CR-ANO-C-2016-03639)
56	09/06/2016 – 09/20/2016 and part of 09/20/2016 – 10/04/2016	As documented on 10/01/2016, ANO Chemistry was notified by the contracted lab for analyzing REMP samples that the air filter from Station #56 was unusually light implying no air flow through the filter. Investigations by ANO Chemistry revealed a broken air tube that was repaired on 10/01/2016. (CR-ANO-C-2016-04112)
56	10/04/2016-10/18/2016	As documented on 10/18/2016, the air pump was found to be non-functional on 10/17/2016. The pump was replaced on 10/18/2016. (CR-ANO-C-2016-04428)
6	11/29/16 – 12/12/16	As documented on 12/13/16, the air pump was found to be non-functional on 12/12/16. The pump was replaced on 12/12/16. (CR-ANO-C-2016-05352)
6	12/12/16 – 12/22/16	As documented on 12/22/16, the air pump was found to be non-functional on 12/22/16. The pump was replaced on 12/22/16. (CR-ANO-C-2016-05453)

- Missed Samples

  First quarter environmental TLD Station #149 missing (CR-ANO-C-2016-01646).

  Second quarter environmental TLD Station #150 missing (CR-ANO-C-2016-02488).

  Third quarter environmental TLD Station #109 missing (CR-ANO-C-2016-04191).

  Located missing third quarter TLD at the correct location for Station #109. Also determined that fourth quarter TLD was in wrong location for Station #109 (CR-ANO-C-2017-00124).

  Fourth quarter environmental TLD Station #127 missing (CR-ANO-C-2017-00106).

- Unavailable Results

  None

Program Modifications

The following revisions were made to OP-1608.005, "Radiological Environmental Monitoring Program (REMP)" in 2016. Collectively, these changes were made through revision to the procedure, OP-1608.005, and Revisions 43 and 44 and to the ODCM.

ANO Site Procedure OP-1608.005

- Editorial changes throughout the procedure to improve place-keeping and clarity without changing the process or intent.
- Clarification was provided on the way to verify the composite sampler flow rate as 45 - 95 ml/hr. The procedure was changed to provide a place to document this verification.
- The reference to a bag holding post-accident snow or ice samples was deleted because container(s) holding collection of samples may be a box or plastic tote. No radiological requirements or controls were diluted or negatively affected by this change because field radiological checks are now required for each sample rather than a collection of samples in a bag.
- Deleted the steps that state: Process and analyze samples in accordance with OP-1905.002, "Offsite Emergency Monitoring". These samples are not analyzed by ANO Chemistry, but are instead the Offsite Team Coordinator's responsibility.
- Location of sampling Station #55 was changed due to disturbance of the previously used site.
- The TLD at Station 149 was moved from the former location to one across the road on a roadside utility pole. The move was made to minimize TLD disturbance due to vandalism.
- The TLD at Station 150 was moved from the former location to a utility pole on the south side of the parking lot entrance. The move was made to minimize TLD disturbance due to vandalism

- Added references that address the use of calibrated flow meters at the REMP air sampling stations.
- Added the requirement for the use of the installation of calibrated flow meters as opposed to periodic verification of installed, non-calibrated meters using a calibrated meter. Also calibrated meters should be changed out every 6 months.
- Replaced the use of poly bags with poly bottles to accommodate current counting geometries. Also 3.9 liter jugs replaced one-gallon sample containers. This change does not affect any process, but clarifies the containers required to conform to existing Chemistry counting capabilities.
- Clarified the existing process to give correct sequence of steps. This change was prompted by verbal comments from the reviewing NRC Inspector during environmental inspection, June 2016.

ODCM

- Rev 026 – Changed location of control broadleaf vegetation sample site from current location at intersection of Arkansas Highways 27 and 154 to within the Ozark National Forest at the intersection of Forest Service Roads 36 and 1618A. The change was performed due to forest and broadleaf eradication of previous control location.
- Rev 027 – Basis (B) 2.5.1, Radiological Environmental Monitoring, background data is updated to include explanation for sample location choice associated with Air Station #2. Revised explanation of air station samples in highest D/Q and also in the vicinity of a community. Defined community as it relates to this location.

Attachments

Attachment 1 contains results of air, TLD, water, sediment, fish, and food product samples collected in 2016. TLDs were analyzed by a vendor (Environmental Dosimetry Company - EDC). All remaining samples were analyzed by Teledyne Brown Engineering (TBE).

Attachment 2 contains TBEs participation in the inter-laboratory comparison program during 2016.

Attachment 3 contains dose calculations performed for sediment using a generalized equation from Regulatory Guide 1.109, “Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I,” Revision 1.

1.0 Introduction

1.1 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.

1.2 Pathways Monitored

The airborne, direct radiation, waterborne, and ingestion pathways are monitored as required by the ODCM. A description of the ANO REMP used 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 and Section 3.0 provides a summary of results for the monitored exposure pathways.

1.3 Land Use Census

ANO personnel conduct the land use census every 24 months as required by ODCM Surveillance (S) 2.5.2.1. The land use census was last conducted in 2015. This census serves to identify changes in land use within five miles of ANO that would require modifications to the REMP or ODCM. The most important concerns during this census are to determine location in each sector of the nearest:

1) Residence
2) Animal milked for human consumption
3) Garden of greater than 500 square feet producing fresh leafy (broadleaf) vegetables*

* ANO personnel did not perform a garden census since an ODCM Limitation (L) 2.5.2 Note allows the routine sampling of broadleaf vegetation in the highest D/Q sector near the site boundary in lieu of the garden census.

The method used by ANO personnel for conducting the land use census was as follows:

- ANO personnel conducted door-to-door (drive by) field surveys in order to locate the nearest resident in each meteorological sector.
- Consultation with local agricultural authorities was used to identify commercial milk providers within five-miles of the Unit 1 reactor building.
- As a result of these surveys, the following information was obtained in each meteorological sector:
    1) Nearest permanent residence
    2) Nearest milking animal
- ANO personnel identify locations on the map, measure distances to ANO (or use a GPS system), and record results.
- Locations, if any, are identified which yield a calculated dose or dose commitments greater than those currently calculated in the ODCM.
- ANO personnel compare results to previous census.

TABLE 1.1

RADIOLOGICAL ENVIRONMENT SAMPLING PROGRAM

Exposure Pathway	Requirement	Sample Point Description, Distance and Direction	Sampling and Collection Frequency	Type and Frequency Of Analyses
Airborne	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 operation of sampler with sample collection as required by dust loading but at least once per 14 days.	Radioiodine Canister – Analyze at least once per 14 days for I-131. Particulate Sampler – Analyze for gross beta radioactivity 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 2 (243° - 0.5 miles)** - South of the sewage treatment plant.		
	Radioiodine and Particulates 1 sample from a control location 15 - 30 km (10 - 20 miles) distance.	**Station 7 (210° - 19.0 miles)** – Entergy Supply Yard on Highway 10 in Danville.		
Direct Radiation	Thermoluminescent dosimetry (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.	Once per 92 days.	Gamma Dose – Once per 92 days.

TABLE 1.1 (continued)

RADIOLOGICAL ENVIRONMENT SAMPLING PROGRAM

Exposure Pathway	Requirement	Sample Point Description, Distance and Direction	Sampling and Collection Frequency	Type and Frequency Of Analyses
Direct Radiation	TLDs 16 inner ring stations with two or more dosimeters in each meteorological sector in the general area of the site boundary	**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.	Once per 92 days.	Gamma Dose – Once per 92 days.

TABLE 1.1 (continued)

RADIOLOGICAL ENVIRONMENT SAMPLING PROGRAM

Exposure Pathway	Requirement	Sample Point Description, Distance and Direction	Sampling and Collection Frequency	Type and Frequency Of Analyses
Direct Radiation	TLDs 16 inner ring stations with two or more dosimeters in each meteorological sector in the general area of the Site Boundary.	**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.	Gamma Dose – Once per 92 days.
	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.		

TABLE 1.1 (continued)

RADIOLOGICAL ENVIRONMENT SAMPLING PROGRAM

Exposure Pathway	Requirement	Sample Point Description, Distance and Direction	Sampling and Collection Frequency	Type and Frequency Of Analyses
Direct Radiation	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 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.	Gamma Dose – Once per 92 days.
Waterborne	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.	Once per 92 days.	Gamma isotopic and tritium analyses once per 92 days.
	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.
Waterborne	Sediment 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 once per 365 days.

TABLE 1.1 (continued)

RADIOLOGICAL ENVIRONMENT SAMPLING PROGRAM

Exposure Pathway	Requirement	Sample Point Description, Distance and Direction	Sampling and Collection Frequency	Type and Frequency Of Analyses
Ingestion	Milk 1 indicator sample location within five-mile distance if commercially available. 1 control sample location at a distance of > five-miles when an indicator exists.	Currently, no available milking animals within 5 miles of ANO.	Once per 92 days.	Gamma isotopic and I-131 analyses once per 92 days.
	Fish 1 sample of commercially and/or recreationally important species in vicinity of plant discharge. 1 sample of same 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 on edible portions once per 365 days.
	Food Products 1 sample of broadleaf (edible or non-edible) near the site boundary from one of the highest anticipated annual average ground level D/Q sectors, if milk sampling is not performed. 1 sample location of broadleaf vegetation (edible or non-edible) from a control location 15 – 30 km (10 – 20 miles) 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

TABLE 1.1 (continued)

RADIOLOGICAL ENVIRONMENT SAMPLING PROGRAM

Exposure Pathway	Requirement	Sample Point Description, Distance and Direction	Sampling and Collection Frequency	Type and Frequency Of Analyses
Ground water	2 sample locations of Groundwater from a control location up 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.	Once per 92 days	Control, Tritium, Gross Beta and Gamma Isotopic, once per 92 days.
		Station 62 (GWM-101, 34° - 0.5 miles) – North of Protected Area in OCA. East of outside receiving building.	Once per 92 days	Control, Tritium, Gross Beta and Gamma Isotopic, once per 92 days.
	2 sample locations of Groundwater from indicator locations down gradient from the protected area.	**Station 63 (GWM-103, 206° - 0.1 miles)** – South of Protected area in OCA. North-east of Stator Rewind Bldg. near wood line.	Once per 92 days	Indicator, Tritium, Gross Beta and Gamma Isotopic, once per 92 days.
		Station 64 (GWM-13, 112° - 0.1 miles) – South of Oily Water Separator facility, northwest corner of U-2 Intake Structure. Inside Protected area.	Once per 92 days	Indicator, Tritium, Gross Beta and Gamma Isotopic, once per 92 days.

FIGURE 1-1

TLD SAMPLE COLLECTION SITES – NEAR FIELD

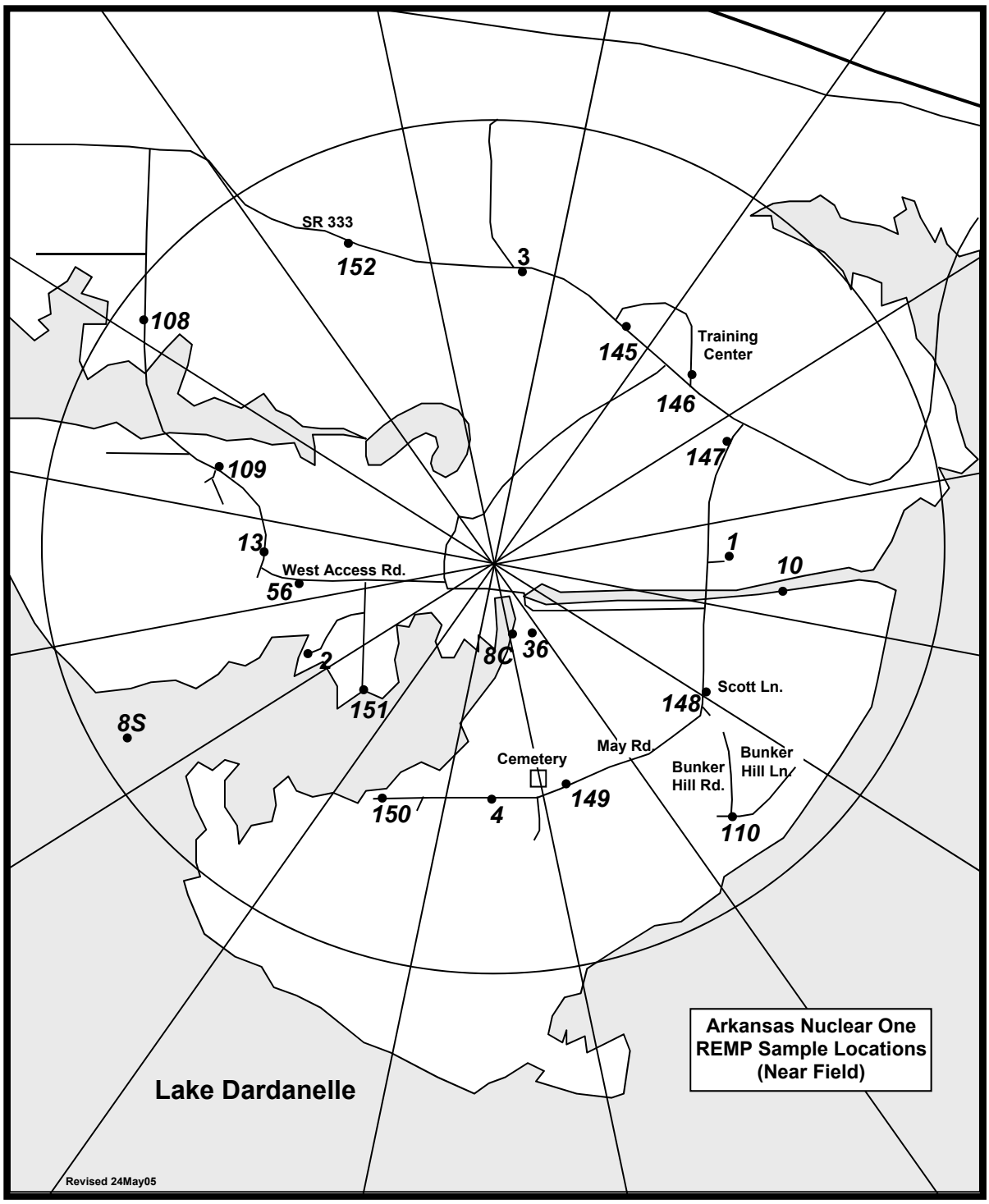


FIGURE 1-2

TLD SAMPLE COLLECTION SITES – FAR FIELD

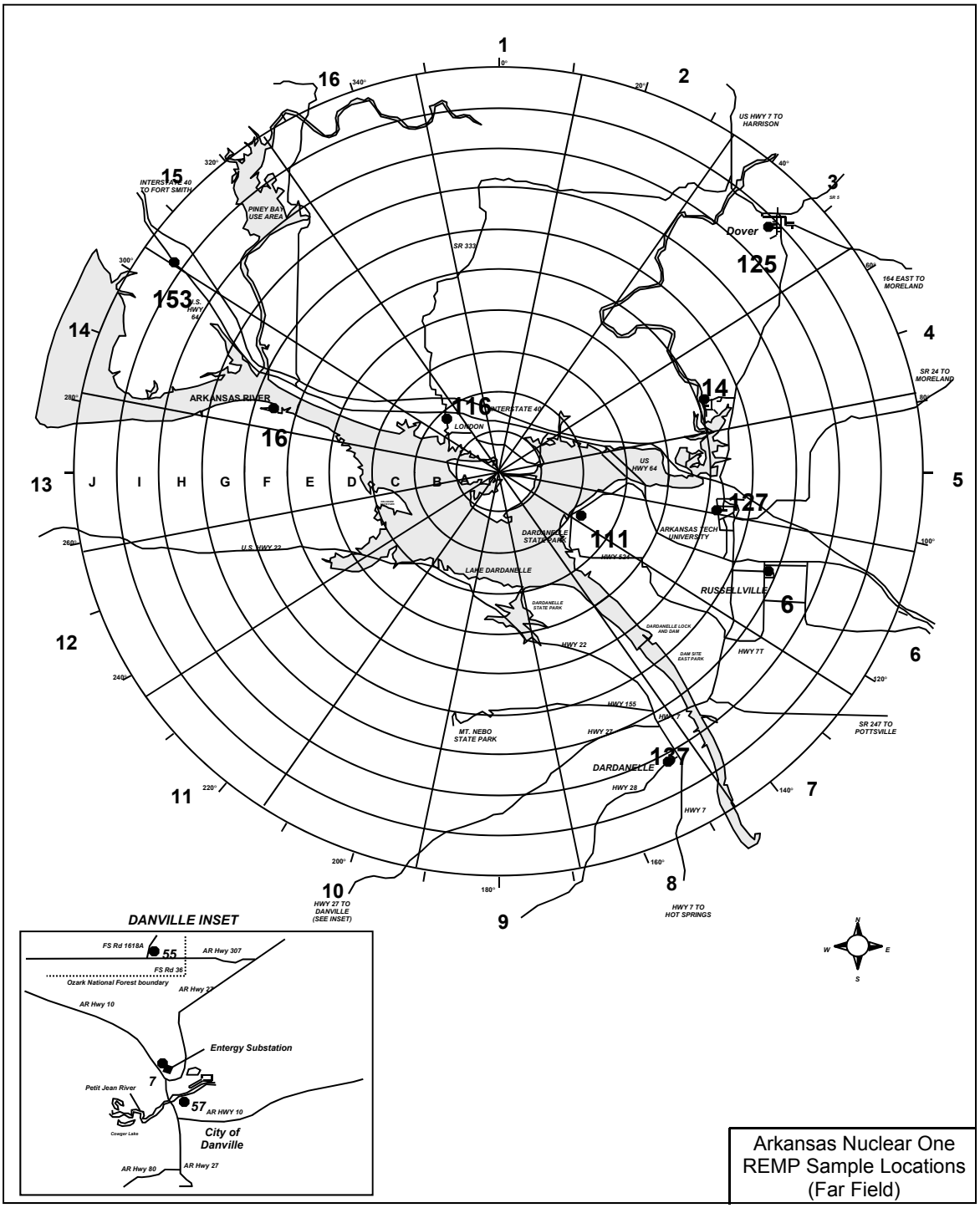
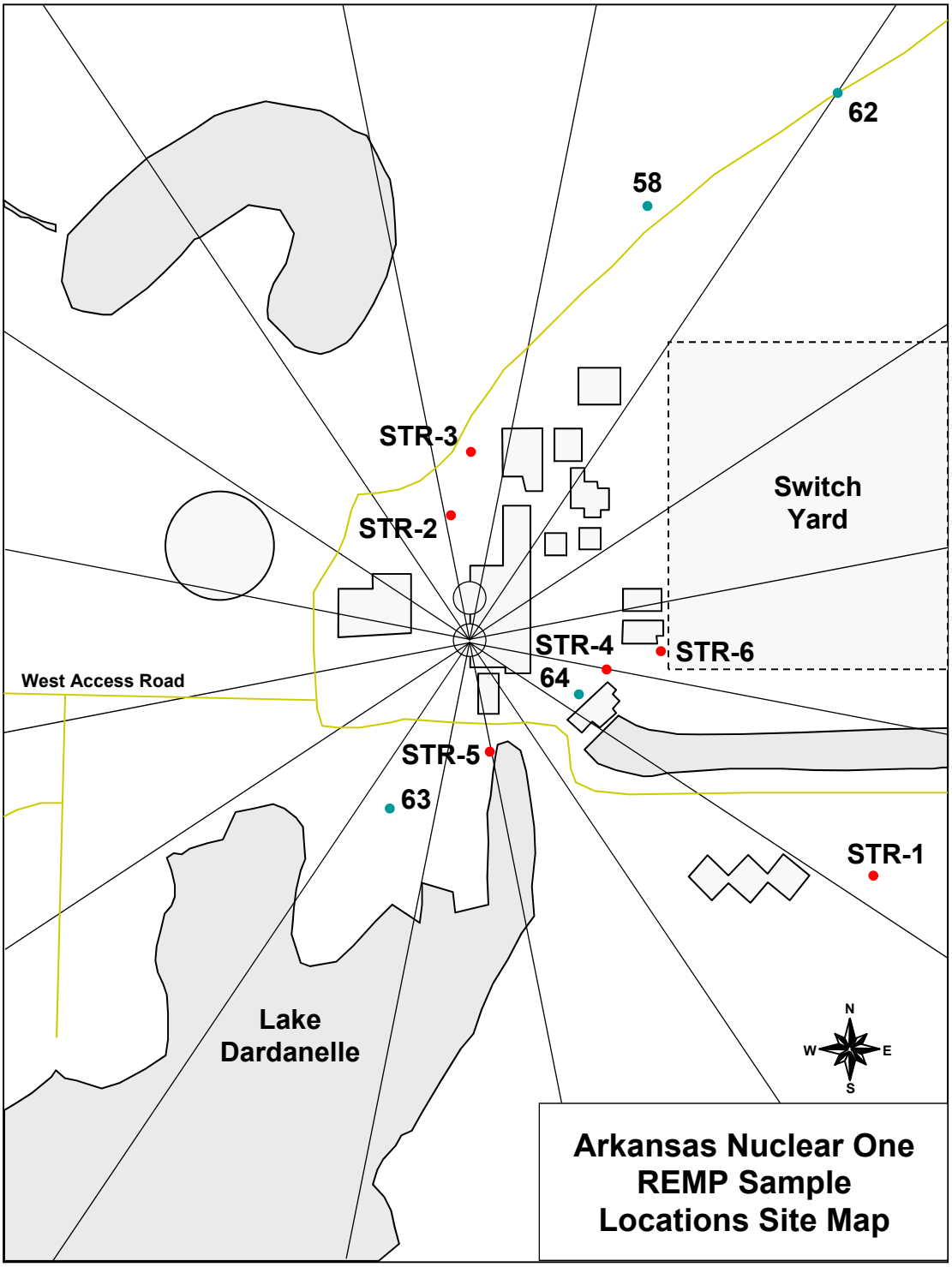


FIGURE 1-3

STORMWATER AND GROUNDWATER SAMPLE COLLECTION SITES – SITE MAP



- Stormwater run-off collection sites
- Groundwater collection sites

2.0 Interpretation and Trends of Results

2.1 Air Particulate and Radioiodine Sample Results

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 (Mach 11, 2011).

In 2016 there were no samples above the LLD for I-131. Indicator gross beta air particulate results for 2016 were comparable to results obtained from 2005-2015 of the operational REMP, but less than 2013 when the annual average was 0.043. Also, the 2016 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
2005 – 2015 (Minimum Value)	0.018
2016 Average Value	0.040
2005 – 2015 (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 3.1, which includes gross beta concentrations and provides a comparison of the indicator and control means and ranges, emphasizes the consistent trends seen in this pathway to support the presence of naturally occurring activity. Therefore, it can be concluded that the airborne pathway continues to be unaffected by ANO operations.

2.2 Thermoluminescent Dosimetry (TLD) Sample Results

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 3.1, 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 8.0 millirem (mrem) shown in Table 3.1 for 2016 is within the historical bounds of 2005 – 2015 annual average results, which have ranged from 6.9 to 8.5 mrem. Overall, ANO concluded that the ambient radiation levels are not being affected by plant operations.

2.3 Water Sample Results

Analytical results for 2016 drinking water and ground water samples were similar to those reported in previous years. Gamma radionuclides analytical results for 2016 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.

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 2016, 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 2016. Results are reported as annual average pCi/l.

Monitoring Period	Result
2005 – 2015 (Minimum Value)	554.5
2016 Value	932.25
2005 – 2015 (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 2016 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 2016 and levels of radionuclides remain similar to those obtained in previous operational years.

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 2013 and comparable to the 2005 – 2015 preoperational and operational years as shown below. Results from 2016 are summarized in Table 3.1. Results are reported as annual average pCi/L.

Radionuclide	2016	2015	2005 – 2014**	Preoperational
Gross Beta	< LLD	< LLD*	2.85	2.0
Iodine-131	< LLD	< LLD	< LLD	< LLD
Gamma	< LLD	< LLD	< LLD	< LLD
Tritium	< LLD	< LLD	< LLD	200.0

* For the control sample collected 1/15/15, gross beta was 3.16 pCi/L which is >MDC, but <LLD; documented via CR-ANO-C-2015-00351.

** Average of the results from the years 2005-2014

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 2016 and levels of radionuclides remain similar to those obtained in previous operational years.

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 2016 indicator results to past operational years. Results are reported as annual average pCi/l. REMP Groundwater data are captured in Tables 8.1 and 8.2. ANO operations had no significant impact on the environment or public by this waterborne pathway.

Radionuclide	**2016**	**2006 – 2015**
Iodine-131	< LLD	< LLD
Gamma	< LLD	< LLD
Tritium	< LLD	< LLD
Gross Beta	4.32*	< LLD**

* Value from first quarter sampling Station 58.

** Only 2014 and 2015 data available for review as historical data.

2.4 Sediment Sample Results

Sediment samples were collected from two locations in 2016 and analyzed for gamma radionuclides. Listed below is a comparison of 2016 indicator results to the 2005 – 2015 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
2005 – 2015 (Minimum Value)	41.79
2016 Value	< LLD
2005 – 2015 (Maximum Value)	666.8

Since reporting levels for radionuclides in sediment have not been established, an evaluation of potential dose to the public from this media was performed as shown in Attachment 3.

2.5 Milk Sample Results

Milk samples were not collected during 2016 due to the unavailability of indicator locations within five-miles of ANO.

2.6 Fish Sample Results

Fish samples were collected from two locations and analyzed for gamma radionuclides. In 2016, 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.

2.7 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 2016, food product samples were collected when available from two locations and analyzed for Iodine-131 and gamma radionuclides. The 2016 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.

2.8 Interlaboratory Comparison Results

Teledyne Brown Engineering analyzed interlaboratory comparison samples to fulfill the requirements of ODCM Section 2.5.3. Attachment 2 contains these results.

2.9 Land Use Census Results

The latest land use census (performed in 2015) did not identify any new locations that yielded a calculated dose or dose commitment greater than those currently calculated (see Table 2.1).

Also, the land use census identified no milk-producing animals within a five-mile radius of the plant site. ANO personnel chose not to perform a garden census in 2015, 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.

A land use census was not conducted for the year 2016. The next land use census is scheduled to be conducted in 2017.

TABLE 2.1

2015 LAND USE CENSUS

Nearest Residence Within Five Miles

Direction	Sector	Distance (miles)
N	1	0.9
NNE	2	1.3
NE	3	0.9
ENE	4	0.8
E	5	0.8
ESE	6	0.8
SE	7	0.8
SSE	8	0.8
S	9	0.8
SSW	10	0.7
SW	11	2.8
WSW	12	0.7
W	13	0.8
WNW	14	0.8
NW	15	1.0
NNW	16	0.9

3.0 Radiological Environmental Monitoring Program Summary

3.1 2016 Program Results Summary

Table 3.1 summarizes the 2016 REMP results.

TABLE 3.1

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM SUMMARY

Name of Facility: ANO - Units 1 and 2 **Docket No:** 50-313 and 50-368.
Location of Facility: Pope County, Arkansas **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 Non-Routine Results[e]
				Location[d]	Mean (F)[c] [Range]		
Air Particulates (pCi/m^3)	GB / 135	0.01	0.0182 (81 / 81) [0.015 – 0.072]	Station 6* (243°, 0.5 mi)	0.1305 (27 / 27) [0.020 - 0.070]	0.0182 (54 / 54) [0.019 - 0.079]	0
Airborne Iodine (pCi/ m^3)	I-131 / 135	0.07	< LLD	N/A	N/A	< LLD	0
Inner Ring TLDs (mR/Qtr)	Gamma / 64	(f)	7.70 (61 / 64) [5.4 – 10.5]	Station 56 (264°, 0.4 mi)	9.5 (4 / 4) [9.2 – 10.5]	N/A	3
Special Interest TLDs (mR/Qtr)	Gamma / 28	(f)	6.74 (28 / 28) [4.3 – 9.0]	Station 116 (318° - 1.8 mi)	8.9 (4 / 4) [8.0 – 9.7]	N/A	0
Control TLD (mR/Qtr)	Gamma / 4	(f)	N/A	N/A	N/A	6.5 (4 / 4) [5.4 – 8.3]	0

* As documented on 12/22/16, the air pump was found to be non-functional on 12/22/16. The pump was replaced on 12/22/16. As a result a volume could not be provided to laboratory and the results were given as pCi/Total instead of pCi/m^3. This has made the annual average high. Without using this data point, the Station 6 average would be 0.0175. Values listed in table do not factor in the 12/22/16 value.

TABLE 3.1 (continued)

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM SUMMARY

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 Non-Routine Results[e]
				Location[d]	Mean (F)[c] [Range]		
Surface Water (pCi/l)	H-3 / 8	3000	932 (4* / 4) [344 – 745]	Station 8 (166°, 0.2 mi)	555 (4* / 4) [344 – 745]	< 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

* Positive tritium results

TABLE 3.1 (continued)

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM SUMMARY

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 Non-Routine Results[e]
				Location[d]	Mean (F)[c] [Range]		
Drinking Water (pCi/1)	GB / 8	4	< LLD	N/A	N/A	< LLD	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
Bottom Sediment (pCi/kg)	GS / 2						
	Cs-134	150	< LLD	N/A	< LLD	< LLD	0
	Cs-137	180	< LLD	N/A	< LLD	< LLD	0

* Positive GB results.

TABLE 3.1 (continued)

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM SUMMARY

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 Non-Routine Results[e]
				Location[d]	Mean (F)[c] [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

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

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

[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 ANO Units 1 and 2 ODCM Table 2.5-1.

ATTACHMENT 1

SUMMARY OF MONITORING RESULTS

Table of Contents

Table 1.1

Sample Type: Air Particulate Analysis: Gross Beta Units: pCi/m^3

Start Date	End Date	Station 1* (Indicator)	Station 2 (Indicator)	Station 56 (Indicator)	Station 6 (Control)	Station 7 (Control)
Required LLD ➔		**0.01**	**0.01**	**0.01**	**0.01**	**0.01**
12/29/2015	01/12/2016	0.023	0.021	0.020	0.019	0.022
01/12/2016	01/26/2016	0.025	0.024	0.020	0.021	0.020
01/26/2016	02/09/2016	0.018	0.020	0.016	0.018	0.015
02/09/2016	02/23/2016	0.018	0.016	0.013	0.016	0.018
02/23/2016	03/08/2016	0.016	0.017	0.016	0.016	0.016
03/08/2016	03/22/2016	0.011	0.009	0.011	0.013	0.011
03/22/2016	04/05/2016	0.017	0.015	0.016	0.013	0.016
04/05/2016	04/19/2016	0.017	0.015	0.014	0.014	0.015
04/19/2016	05/03/2016	0.017	0.002	0.015	0.016	0.015
05/03/2016	05/17/2016	0.020	0.018	0.016	0.017	0.018
05/17/2016	05/31/2016	0.015	0.014	0.013	0.015	0.014
05/31/2016	06/14/2016	0.017	0.016	0.015	0.016	0.015
06/14/2016	06/28/2016	0.019	0.018	0.016	0.017	0.017
06/28/2016	07/12/2016	0.018	0.017	0.013	0.015	0.015
07/12/2016	07/26/2016	0.017	0.016	0.019	0.018	0.017
07/26/2016	08/09/2016	0.017	0.016	0.014	0.016	0.017
08/09/2016	08/23/2016	0.012	0.011	0.014	0.011	0.012
08/23/2016	09/06/2016	0.017	0.022	0.014	0.017	0.020
09/06/2016	09/20/2016	0.014	0.012	0.003	0.015	0.014
09/20/2016	10/04/2016	0.025	0.029	0.030	0.026	0.027
10/04/2016	10/18/2016	0.018	0.019	0.008	0.020	0.018
10/18/2016	11/01/2016	0.026	0.028	0.021	0.027	0.026
11/01/2016	11/15/2016	0.026	0.025	0.024	0.026	0.026
11/15/2016	11/29/2016	0.031	0.029	0.026	0.031	0.032
11/29/2016	12/13/2016	0.019	0.016	0.018	0.005	0.020
12/13/2016	12/22/2016	0.032	0.037	0.029	3.070**	0.037
12/22/2016	01/03/2017	0.017	0.019	0.014	0.018	0.015

* Station with highest annual mean.

** As documented on 12/22/16, the air pump was found to be non-functional on 12/22/16. The pump was replaced on 12/22/16. As a result a volume could not be provided to laboratory and the results were given as pCi/Total instead of pCi/m^3. This has made the annual average high. Without using this data point, the average would be 0.0175. See "Sample Deviations" in Summary.

Table 1.2

Sample Type: Radioiodine Cartridge Analysis: Iodine-131 Units: pCi/m^3

Start Date	End Date	Station 1 (Indicator)	Station 2 (Indicator)	Station 56 (Indicator)	Station 6 (Control)	Station 7 (Control)
Required LLD ➔		**0.07**	**0.07**	**0.07**	**0.07**	**0.07**
12/29/2015	01/12/2016	< 0.010	< 0.024	< 0.024	< 0.024	< 0.024
01/12/2016	01/26/2016	< 0.018	< 0.034	< 0.034	< 0.034	< 0.034
01/26/2016	02/09/2016	< 0.027	< 0.027	< 0.027	< 0.027	< 0.011
02/09/2016	02/23/2016	< 0.013	< 0.031	< 0.031	< 0.031	< 0.036
02/23/2016	03/08/2016	< 0.035	< 0.019	< 0.035	< 0.035	< 0.035
03/08/2016	03/22/2016	< 0.025	< 0.010	< 0.025	< 0.025	< 0.025
03/22/2016	04/05/2016	< 0.032	< 0.031	< 0.032	< 0.032	< 0.018
04/05/2016	04/19/2016	< 0.012	< 0.030	< 0.030	< 0.029	< 0.029
04/19/2016	05/03/2016	< 0.019	< 0.019	< 0.019	< 0.019	< 0.007
05/03/2016	05/17/2016	< 0.009	< 0.024	< 0.024	< 0.024	< 0.024
05/17/2016	05/31/2016	<0.035	< 0.035	< 0.015	< 0.035	< 0.035
05/31/2016	06/14/2016	< 0.045	< 0.019	< 0.045	< 0.045	< 0.045
06/14/2016	06/28/2016	< 0.050	< 0.027	< 0.050	< 0.050	< 0.049
06/28/2016	07/12/2016	< 0.037	<0.036	< 0.020	< 0.037	< 0.037
07/12/2016	07/26/2016	< 0.012	< 0.023	< 0.023	< 0.023	< 0.022
07/26/2016	08/09/2016	< 0.022	< 0.022	< 0.022	< 0.012	< 0.022
08/09/2016	08/23/2016	< 0.022	< 0.008	< 0.022	< 0.022	< 0.022
08/23/2016	09/06/2016	< 0.033	< 0.033	< 0.033	< 0.033	< 0.014
09/06/2016	09/20/2016	< 0.047	< 0.047	< 0.020	< 0.047	< 0.047
09/20/2016	10/04/2016	< 0.026	< 0.026	< 0.070	< 0.026	< 0.010
10/04/2016	10/18/2016	< 0.017	< 0.032	< 0.032	< 0.032	< 0.032
10/18/2016	11/01/2016	< 0.060	< 0.032	< 0.060	< 0.059	< 0.059
11/01/2016	11/15/2016	< 0.029	< 0.029	< 0.029	< 0.029	< 0.011
11/15/2016	11/29/2016	< 0.047	< 0.021	< 0.016	< 0.040	< 0.040
11/29/2016	12/13/2016	< 0.035	< 0.035	< 0.035	< 0.034	< 0.014
12/13/2016	12/22/2016	< 0.038	< 0.038	< 0.038	< 7.99*	< 0.038
12/22/2016	01/03/2017	< 0.051	< 0.051	< 0.026	< 0.050	< 0.050

* Due to a pump issue at station 6 a volume could not be provided to the lab. This result is in pCi/Total. See "Sample Deviations" in Summary.

Table 2.1

Sample Type: Thermoluminescent Dosimeters Analysis: Gamma Dose Units: mrem/Qtr

Inner Ring (Indicators)					
Station	**1st Qtr '16 (mrem)**	**2nd Qtr '16 (mrem)**	**3rd Qtr '16 (mrem)**	**4th Qtr '16 (mrem)**	**Annual Mean '16 (mrem)**
1	8.3	8.2	8.9	9.1	**8.6**
2	7.8	6.9	7.9	10.0	**8.1**
3	5.5	4.9	4.7	6.8	**5.5**
4	7.9	7.1	7.3	8.5	**7.7**
***56**	**9.9**	**8.7**	**9.2**	**10.5**	**9.6**
108	8.2	7.6	8.3	9.4	**8.4**
109	8.4	8.2	8.6	7.6	**8.2**
110	7.4	7.4	8.2	9.6	**8.1**
145	7.8	7.0	8.0	9.8	**8.1**
146	8.6	7.7	7.7	8.9	**8.2**
147	6.5	5.8	6.9	8.1	**6.8**
148	7.0	8.0	7.1	9.3	**7.9**
149	Lost	7.0	7.4	9.1	**7.8**
150	7.2	Lost	8.6	9.5	**8.4**
151	9.3	8.6	9.2	9.7	**9.0**
152	6.5	6.3	5.7	7.8	**6.5**

* Station with highest annual mean.

Table 2.2

Sample Type: Thermoluminescent Dosimeters Analysis: Gamma Dose Units: mrem/Qtr

Special Interest Areas - (Population Centers & Schools)					
Station	**1st Qtr '16 (mrem)**	**2nd Qtr '16 (mrem)**	**3rd Qtr '16 (mrem)**	**4th Qtr '16 (mrem)**	**Annual Mean '16 (mrem)**
6	7.2	6.0	6.2	7.8	**6.8**
111	5.5	4.8	4.8	6.0	**5.3**
***116**	**9.5**	**8.0**	**8.2**	**9.7**	**8.9**
125	5.2	4.6	4.7	5.7	**5.0**
127	7.6	6.6	6.8	Lost	**7.0**
137	9.2	7.8	8.4	9.4	8.7
153	7.0	6.9	7.6	7.4	**7.2**

* Stations with highest annual mean.

Special Interest Areas – (Control)					
Station	**1st Qtr '16 (mrem)**	**2nd Qtr '16 (mrem)**	**3rd Qtr '16 (mrem)**	**4th Qtr '16 (mrem)**	**Annual Mean '16 (mrem)**
7	6.6	5.4	6.0	7.8	**6.5**

Table 3.1

Sample Type: Surface Water 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)	12/31/2015	01/31/2016	< 1.55	< 1.75	< 3.90	< 1.63	< 3.28	< 1.90	< 3.24	< 10.3	< 1.49	< 1.74	< 16.9	< 5.23
Station 10 (Control)	12/31/2015	01/31/2016	< 1.97	< 1.90	< 3.92	< 2.06	< 4.07	< 1.80	< 3.47	< 2.78	< 1.73	< 2.02	< 8.38	< 2.85
Station 8 (Indicator)	01/31/2016	02/29/2016	< 3.05	< 3.16	< 6.78	< 2.90	< 6.60	< 3.68	< 5.75	< 11.9	< 2.76	< 3.06	< 23.2	< 6.48
Station 10 (Control)	01/31/2016	02/29/2016	< 5.95	< 5.90	< 1.28	< 6.20	< 14.0	< 5.63	< 9.70	< 7.73	< 5.49	< 6.91	< 25.2	< 6.99
Station 8 (Indicator)	02/29/2016	03/31/2016	< 1.86	< 1.84	< 4.80	< 1.83	< 3.55	< 2.05	< 3.35	< 10.5	< 1.63	< 1.67	< 17.4	< 6.71
Station 10 (Control)	02/29/2016	03/31/2016	< 8.29	< 7.46	< 17.5	< 8.31	< 15.4	< 5.88	< 14.2	< 14.0	< 6.09	< 7.85	< 39.1	< 9.95
Station 8 (Indicator)	03/31/2016	04/30/2016	< 1.26	< 1.47	< 3.18	< 1.50	< 2.78	< 1.63	< 2.68	< 6.94	< 1.26	< 1.42	< 12.8	< 3.77
Station 10 (Control)	03/31/2016	04/30/2016	< 4.91	< 4.73	< 10.1	< 3.79	< 8.60	< 4.56	< 9.18	< 6.94	< 4.34	< 5.47	< 22.1	< 6.38
Station 8 (Indicator)	04/30/2016	05/31/2016	< 1.83	< 1.98	< 4.52	< 1.70	< 3.34	< 2.01	< 3.88	< 14.3	< 1.68	< 1.86	< 21.7	< 6.93
Station 10 (Control)	04/30/2016	05/31/2016	< 6.16	< 6.02	< 10.9	< 8.32	< 18.0	< 7.52	< 14.0	< 12.6	< 6.43	< 6.28	< 33.6	< 11.0
Station 8 (Indicator)	05/31/2016	06/30/2016	< 1.25	< 1.42	< 3.14	< 1.23	< 2.44	< 1.74	< 2.65	< 14.1	< 1.20	< 1.38	< 19.3	< 4.43
Station 10 (Control)	05/31/2016	06/30/2016	< 5.64	< 5.39	< 11.4	< 4.85	< 11.2	< 6.15	< 8.72	< 13.6	< 5.08	< 5.33	< 25.7	< 11.9
Station 8 (Indicator)	06/30/2016	07/31/2016	< 2.50	< 2.80	< 6.35	< 2.30	< 5.31	< 2.82	< 4.78	< 14.4	< 2.53	< 2.51	< 25.0	< 8.45
Station 10 (Control)	06/30/2016	07/31/2016	< 7.50	< 7.95	< 16.7	< 6.56	< 16.1	< 8.10	< 13.6	< 8.53	< 5.24	< 6.40	< 35.0	< 10.8
Station 8 (Indicator)	07/31/2016	08/31/2016	< 1.41	< 1.78	< 3.86	< 1.52	< 3.05	< 1.81	< 3.21	< 14.9	< 1.37	< 1.55	< 22.9	< 6.92
Station 10 (Control)	07/31/2016	08/31/2016	< 1.86	< 1.95	< 4.41	< 1.79	< 3.55	< 2.00	< 3.37	< 5.52	< 1.74	< 1.91	< 12.0	< 3.85
Station 8 (Indicator)	08/31/2016	09/30/2016	< 1.67	< 1.84	< 4.13	< 1.61	< 3.20	< 2.03	< 3.30	< 9.68	< 1.47	< 1.62	< 17.3	< 5.52
Station 10 (Control)	08/31/2016	09/30/2016	< 5.04	< 5.10	< 11.0	< 5.37	< 12.1	< 6.73	< 9.27	< 9.51	< 4.76	< 5.78	< 24.4	< 7.81
Station 8 (Indicator)	09/30/2016	10/31/2016	< 1.58	< 1.95	< 4.66	< 1.69	< 3.21	< 2.01	< 3.32	< 14.4	< 1.58	< 1.63	< 22.7	< 6.73
Station 10 (Control)	09/30/2016	10/31/2016	< 9.33	< 8.19	< 14.3	< 7.70	< 15.9	< 8.91	< 11.8	< 9.74	< 7.54	< 9.32	< 32.3	< 12.6
Station 8 (Indicator)	10/31/2016	11/30/2016	< 1.93	< 2.21	< 4.79	< 1.89	< 3.90	< 2.41	< 4.04	< 11.1	< 1.88	< 1.93	< 19.5	< 6.85
Station 10 (Control)	10/31/2016	11/30/2016	< 6.76	< 6.50	< 10.3	< 7.55	< 12.2	< 5.62	< 10.7	< 9.23	< 5.28	< 5.99	< 21.4	< 8.37
Station 8 (Indicator)	11/30/2016	12/31/2016	< 1.66	< 1.68	< 4.05	< 1.58	< 3.49	< 2.07	< 3.21	< 9.00	< 1.55	< 1.67	< 1.59	< 5.31
Station 10 (Control)	11/30/2016	12/31/2016	< 6.82	< 7.27	< 11.1	< 7.79	< 13.0	< 7.50	< 12.4	< 9.94	< 5.20	< 7.03	< 27.5	< 8.58

Table 3.2

Sample Type: Surface Water Analysis: Tritium Units: pCi/l

Location	Begin Date	End Date	H-3
		Required LLD ➔	**3000**
Station 8 (Indicator)	01/04/2016	03/31/2016	354
Station 10 (Control)	01/31/2016	03/31/2016	< 326
Station 8 (Indicator)	03/31/2016	06/30/2016	771
Station 10 (Control)	03/31/2016	06/30/2016	< 399
Station 8 (Indicator)	06/30/2016	09/30/2016	654
Station 10 (Control)	06/30/2016	09/30/2016	< 396
Station 8 (Indicator)	09/30/2016	12/31/2016	1760
Station 10 (Control)	09/30/2016	12/31/2016	< 321

Table 4.1

Sample Type: Drinking Water Analysis: Gross Beta, Iodine-131, Gamma Isotopic Units: pCi/l

Location	Collection Date	Gross Beta	I-131	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Nb-95	Zr-95	Cs-134	Cs-137	Ba-140	La-140
Required LLD →		**4.0**	**1.0**	**15**	**15**	**30**	**15**	**30**	**15**	**30**	**15**	**18**	**60**	**15**
Station 14 (Indicator)	01/12/2016	< 2.79	< 0.271	< 7.59	< 6.46	< 15.6	< 7.48	< 15.6	< 6.59	< 9.87	< 7.86	< 8.01	< 44.9	< 13.7
Station 57 (Control)	01/12/2016	< 1.65	< 0.260	< 7.10	< 6.66	< 14.5	< 9.16	< 12.7	< 6.48	< 14.8	< 6.21	< 7.82	< 28.7	< 15.0
Station 14 (Indicator)	03/29/2016	< 1.61	< 0.588	< 7.15	< 7.22	< 20.0	< 6.61	< 11.8	< 9.35	< 10.3	< 8.89	< 7.68	< 36.9	< 5.90
Station 57 (Control)	03/29/2016	< 1.51	< 0.437	< 7.67	< 8.62	< 13.5	< 6.80	< 16.3	< 9.76	< 11.7	< 7.53	< 8.15	< 35.8	< 11.5
Station 14 (Indicator)	06/28/2016	< 1.47	< 0.697	< 7.78	< 5.97	< 12.8	< 7.88	< 16.8	< 8.27	< 11.5	< 6.72	< 8.94	< 33.1	< 13.7
Station 57 (Control)	06/28/2016	< 2.31	< 0.603	< 5.34	< 12.1	< 24.2	< 4.25	< 18.2	< 8.22	< 14.4	< 8.97	< 6.76	< 28.9	< 14.9
Station 14 (Indicator)	09/20/2016	< 1.82	< 0.722	< 8.38	< 8.12	< 17.5	< 8.43	< 17.4	< 10.1	< 13.2	< 7.65	< 8.78	< 36.7	< 13.1
Station 57 (Control)	09/20/2016	< 1.88	< 0.502	< 4.99	< 4.83	< 14.4	< 6.10	< 12.6	< 7.92	< 7.71	< 5.93	< 6.86	< 33.6	< 7.56

Table 4.2

Sample Type: Drinking Water Analysis: Tritium Units: pCi/l

Location	Collection Date	H-3
	Required LLD ➔	**2000**
Station 14 (Indicator)	01/12/2016	< 393
Station 57 (Control)	01/12/2016	< 397
Station 14 (Indicator)	03/29/2016	< 358
Station 57 (Control)	03/29/2016	< 356
Station 14 (Indicator)	06/28/2016	< 356
Station 57 (Control)	06/28/2016	< 351
Station 14 (Indicator)	09/20/2016	< 305
Station 57 (Control)	09/20/2016	< 307

Table 5.1

Sample Type: Sediment Analysis: Gamma Isotopic Units: pCi/kg

Location	Collection Date	Cs-134	Cs-137
	Required LLD ➔	**150**	**180**
Station 8 (Indicator)	9/27/2016	< 64.90	< 83.90
Station 16 (Control)*	9/27/2016	< 71.30	< 74.10

Table 6.1

Sample Type: 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)	9/14/2016	< 49.20	< 39.60	< 135.0	< 42.90	< 118.0	< 41.70	< 39.40
Station 16 (Control)	9/14/2016	< 58.30	< 60.00	< 140.0	< 66.90	< 145.0	< 53.60	< 52.70

Table 7.1

Sample Type: Food Products Analysis: Iodine-131, Gamma Isotopic Units: pCi/kg

Location	Collection Date	I-131	Cs-134	Cs-137
	Required LLD ➔	**60**	**60**	**80**
Station 13 (Indicator)	06/28/2016	< 53.00	< 26.40	< 25.10
Station 55 (Control)	06/28/2016	< 55.10	< 25.50	< 32.80
Station 13 (Indicator)	07/12/2016	< 33.10	< 28.00	< 28.90
Station 55 (Control)	07/12/2016	< 46.20	< 35.30	< 31.60
Station 13 (Indicator)	08/23/2016	< 54.60	< 46.70	< 55.90
Station 55 (Control)	08/23/2016	< 53.40	< 48.90	< 49.10

Table 8.1

Sample Type: Groundwater Analysis: Iodine-131, Gamma Isotopic Units: pCi/l

Sample #	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➔		**4.00**	**15**	**15**	**30**	**15**	**30**	**15**	**30**	**15**	**15**	**18**	**60**	**15**
58*	03/17/2016	< 2.37	< 4.29	< 3.74	< 8.12	< 3.32	< 9.51	< 5.03	< 6.99	< 10.50	< 3.88	< 5.10	< 24.00	< 7.53
62*	03/16/2016	< 3.48	< 2.92	< 2.93	< 6.97	< 3.11	< 7.70	< 3.21	< 6.04	< 7.21	< 3.20	< 3.57	< 17.10	< 4.97
63	03/17/2016	4.32	< 3.77	< 4.40	< 7.88	< 3.90	< 8.17	< 3.68	< 7.62	< 8.83	< 3.59	< 4.46	< 21.80	< 7.45
64	03/16/2016	< 2.66	< 4.04	< 3.82	< 9.07	< 3.82	< 9.18	< 4.88	< 8.12	< 9.23	< 4.15	< 4.58	< 22.80	< 7.66
58*	06/01/2016	< 2.21	< 5.88	< 7.41	< 16.30	< 8.70	< 13.60	< 8.12	<15.90	< 12.30	< 6.39	< 8.01	< 34.30	< 10.70
62*	06/01/2016	< 3.06	< 4.79	< 6.32	< 10.90	< 7.04	< 13.90	< 7.69	< 12.30	< 10.90	< 7.07	< 6.11	< 36.30	< 9.53
63	06/01/2016	< 3.19	< 6.19	< 5.97	< 11.90	< 6.08	< 9.51	< 8.51	< 12.20	< 12.10	< 7.33	< 7.59	< 34.10	< 4.70
64	06/02/2016	2.16	< 3.86	< 3.82	< 7.50	< 3.38	< 9.32	< 4.01	< 4.57	< 11.80	< 3.44	< 1.96	< 23.30	< 4.14
58*	09/13/2016	< 2.18	< 4.18	< 3.74	< 9.67	< 4.03	< 9.05	< 4.84	< 7.18	< 12.60	< 4.12	< 4.18	< 28.50	< 7.98
62*	09/13/2016	< 3.82	< 4.03	< 3.89	< 7.20	< 3.92	< 6.60	< 3.52	< 6.85	< 11.40	< 3.69	< 4.41	< 27.00	< 7.14
63	09/13/2016	< 3.95	< 3.76	< 4.02	< 9.58	< 5.19	< 8.16	< 4.48	< 6.81	< 14.80	< 3.87	< 4.53	< 31.30	< 9.65
64	09/14/2016	< 3.29	< 3.95	< 5.05	< 9.71	< 5.12	< 9.46	< 5.68	< 8.42	< 13.20	< 4.45	< 4.88	< 34.40	< 12.10
58*	12/14/2016	< 2.69	< 3.83	< 4.07	< 7.62	< 3.65	< 8.36	< 5.38	< 7.62	< 7.45	< 3.59	< 4.20	< 19.70	< 6.24
62*	12/14/2016	< 2.63	< 3.82	< 3.98	< 9.47	< 4.85	< 9.29	< 4.05	< 6.93	< 7.12	< 3.85	< 3.76	< 18.90	< 7.10
63	12/14/2016	3.87	< 4.28	< 4.53	< 9.83	< 4.04	< 9.37	< 5.00	< 9.16	< 8.25	< 4.23	< 4.65	< 23.10	< 6.86
64	12/15/2016	< 3.28	< 4.24	< 4.55	< 9.56	< 4.31	< 11.80	6.53	< 9.11	< 7.45	< 4.64	< 5.13	< 21.90	< 6.33

* Identifies Control Locations

Table 8.2

Sample Type: Groundwater Analysis: Tritium Units: pCi/l

Location	Collection Date	H-3
	Required LLD ➔	**3000**
Station 58 (Control)	03/17/2016	< 365
Station 62 (Control)	03/17/2016	< 369
Station 63 (Indicator)	03/16/2016	< 374
Station 64 (Indicator)	03/16/2016	< 364
Station 58 (Control)	06/01/2016	< 307
Station 62 (Control)	06/01/2016	< 312
Station 63 (Indicator)	06/01/2016	< 318
Station 64 (Indicator)	06/02/2016	< 298
Station 58 (Control)	09/13/0216	< 316
Station 62 (Control)	09/13/0216	< 312
Station 63 (Indicator)	09/13/0216	< 303
Station 64 (Indicator)	09/14/2016	< 312
Station 58 (Control)	12/14/2016	< 278
Station 62 (Control)	12/14/2016	< 285
Station 63 (Indicator)	12/14/2016	< 285
Station 64 (Indicator)	12/15/2016	< 285

ATTACHMENT 2

INTERLABORATORY COMPARISON PROGRAM

Interlaboratory Comparison Report provided by Teledyne Brown Engineering

For the Teledyne Brown Engineering (TBE) laboratory, 156 out of 160 analyses performed met the specified acceptance criteria. Four analyses (Milk - Sr-90, Vegetation - Sr-90, and Water - H-3 samples) did not meet the specified acceptance criteria for the following reasons and were addressed through the TBE Corrective Action Program.

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

1. Teledyne Brown Engineering's MAPEP March 2016 air particulate cross check sample is now being provided to TBE by Analytics. MAPEP's policy is to evaluate as failed non-reported nuclides that were reported in the previous study. Non-Conformance Report (NCR) 16-14

    1a. Since the Sr-90 was reported in the previous MAPEP study but not in this study, MAPEP evaluated the Sr-90 for Soil as failed. NCR 16-14

    1b. The MAPEP March 2016 Sr-90 in vegetation was evaluated as failing a false positive test. In reviewing the data that was reported vs. the data in LIMS (TBE's work management database), it was found that the error was incorrectly reported as 0.023 rather than the correct value of 0.230. If the value had been reported with the activity with the correct uncertainty of 0.301 ± 0.230, MAPEP would have evaluated the result as acceptable. NCR 16-14

2. Teledyne Brown Engineering's Analytics' March 2016 milk Sr-90 result of 15 ± 0.125 pCi/L was higher than the known value of 11.4 pCi/L with a ratio of 1.32. The upper ratio of 1.30 (acceptable with warning) was exceeded. After an extensive review of the data it is believed the technician did not rinse the filtering apparatus properly and some cross contamination from one of the internal laboratory spike samples may have been transferred to the analytics sample. We feel the issue is specific to the March 2016 Analytics sample. NCR 16-26

3. Teledyne Brown Engineering's Environmental Resource Associates (ERA) November 2016 sample for H-3 in water was evaluated as failing. A result of 918 pCi/L was reported incorrectly due to a data entry issue. If the correct value of 9180 had been reported, ERA would have evaluated the result as acceptable. NCR 16-34

4. Teledyne Brown Engineering's Analytics' December 2016 milk Sr-90 sample result of 14.7 ± .26 pCi/L was higher than the known value of 10 pCi/L with a ratio of 1.47. The upper ratio of 1.30 (acceptable with warning) was exceeded. The technician entered the wrong aliquot into the LIMS system. To achieve a lower error term, TBE uses a larger aliquot of 1.2 L (normally we use .6 L for client samples). If the technician had entered an aliquot of 1.2 L into the LIMS system, the result would have been 12.2 pCi/L, which would have been considered acceptable. NCR 16-35

ATTACHMENT 3

SEDIMENT DOSE CALCULATIONS

Sediment Sample Results

Sediment samples were collected from two locations in 2016 and analyzed for gamma radionuclides. Although Cesium-137 has been detected in previous years prior to 2016, all gamma radionuclides from 2016 samples were below detectable limits. These results are consistent with 2015 results where all gamma radionuclides were also below detectable limits. Therefore, ANO operations had no significant impact on the environment or public by this waterborne pathway.

In previous reports, ANO has included annual maximum dose calculations to the skin and total body. However since gamma radionuclides were below detectable limits, no calculation is being provided since there is no associated dose.